RESEARCH ARTICLE

Private Ownership of Automobiles: A barrier to Sustainable Transportation - A Case of India

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ABSTRACT

In the process of becoming a highly mobile planet, a large number of Inequities has been caused due to Private Automobile Dependancy. Private Ownership of Automobiles ,has eventually increased the dispersion of Society, Sprawl and destruction of the Natural Areas. At the same time High Automobile Dependancy has minimized efficiency of Overall Resource Utilization, reduced live ability and degraded environment Consecutively. Whereas Sustainable transportation promotes efficient and healthier ways of commuting, in order to minimize disastrous effects on Public Realm. The frequent rise in private vehicle ownership has caused alarming rise in CO_2 emissions, increased demand for parking and an increase in road deaths. This research paper deals with the issues of private ownership of Automobiles, that have acted as a barrier to Sustainable Transportation.

Keywords: Sustainable Transportation, Automobile Dependancy, Private Ownership of Automobiles.

INTRODUCTION

The concept of automobile dependency emphasises automobility (based on one mode), whereas sustainable transportation focuses on plurality (multi-modality) and inter-modality. Talking of the scenario of India, it is the second most populated country in the world and has a steadily growing economy, which makes it a rapidly growing market for motorised vehicles. The total number of registered motor vehicles in India has increased by 157.5%, from 55.0 million in 2001 to 141.8 million in 2011 (Das, 2016). Rapid motorization in India and the growing inclination of its

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people towards private transport modes have made the country the fourth largest petroleum-consuming nation in the world after the US, China, and Japan, with a total petroleum consumption of 3,426 thousand barrels per day in 2011 (Das, 2016). The challenge of shifting from private automobiles to sustainable transportation is great. It will eventually affect various aspects such as the viability of societies, access to jobs and services, and the transportation of goods. Private ownership of automobiles, especially car culture, has become a controversial topic. These are the most preferred modes of transport in developed countries. The conventional transportation system is inequitable or lacks access to transportation for all economic classes,especially transit and good walking and bicycling facilities. Conventional transportation has various impacts, such as social equity, economics, environmental, cultural, land use, and urban form. Many of these impacts are extremely harmful, such as pollution-related health impacts and even the survival of life on the planet. Sustainable transportation deals with meeting basic access and mobility needs in modes that do not harm the environment.

Comparative Analysis of Private Ownership of Automobiles and Sustainable Transportation
A comparative analysis of Private Ownership of Automobiles versus Sustainable Transportation has been depicted in Table 1 below. This comparison has been done giving weight age to different aspects such as Mobility, Accesibility, Connectivity ,use of modes ,sustainability considerations etc. The challenge of shifting from Private owned Automobiles to sustainable transportation is great. It affects various aspects of life such as health of Ecosystem ,livability of communities ,access to workspaces, costs of various stuffs. Private Owned Vehicles have increased the trip length, frequency and dispersion of trips. Sustainable Transportation can be considered as a better alternative than Private Owned Automobiles as it is enhancing the accessibility with quality. At the same time it is providing cost savings on fuel and vehicles .Taking public transportation reduces CO2 emissions by 45%,as well as decreases pollutants in atmosphere and hence improves Air quality. (Mead, 2021)

India's Scenario of Automobile Dependence
India is having the third largest road network, the number of private automobiles in India in FY 2022 stood at 326.3 million. (Sun, 2023) Commutation via Road was the preferred mode having about 60% people choosing this mode., The industrial commuting of goods through roads has also risen over the years with nearly 2.7 billion metric tons of freight transported through roads in financial year 2019.Figure 1 depicts the growth of Automobiles from Financial Year 1951-2022. The automobile sector of India currently contributes greater that 7% to India's GDP. It is aspired that India will reach to 12% via Automotive Mission Plan 2016–26 By 2030,due to rapid urbanization more than 500 million people in the country will live in cities – 1.5 times the current number of U.S population (Gupta, 2018). Higher incomes will play a significant role, as around 60 million families could move into the consuming class by 2025.At the same time,more people will be joining the workforce. Participation is expected to reach 67 percent in 2025, as more women and youth will be entering the job market, that will eventually raise the demand for mobility. Some portion of population would leap straight to four-wheeler segment, and others will evolve from two- to four-wheelers over time.About 44 percent of the consuming-class households will be in 49 growth clusters—for example, the Delhi cluster is expected to have the same GDP per capita at purchasing power parity as the entire country of Russia in 2025. Metro cities like Delhi are a hub for Automobile sector to flourish.(Sun, 2023)

Problems of Automobile Dependence
Considering the Scenario of India an insatiable demand for vehicles is expected for an economy that is expected to grow at an average rate of 7% for the next 20 years, the automobile industry of India will needlarge amounts of natural resources which will not only lead to implications of economic cost, but also considerable environmental and social impacts. The future growth will be closely associated with increased raw material extraction, pollution arising from production, processing of primary materials for production of auto components, GHG emissions during the manufacturing phase, use/operation phase, traffic congestion, etc(Bhattacharjya, 2016). The Urban Land use Transport cycle associated with High levels of Automobile Dependance ,brought variety of Environmental, Social and Economic problems that act as a barrier to sustainability of cities . These have been summarized in the Table 2 below.

Environmental Problems

The environmental problems arising due to Automobile dependance have been shown in Column 1 of Table 2 .Urban Areas having a high private automobile dependency have higher levels of Transportation Energy Use. Due to high energy use ,large quantities of Greenhouse gases and carbon emissions are released, which contribute to Photochemical Smog. Whereas Sulphur Di-oxide when comes in contact with precipitation leads to Acid smog and Acid rain ,which in turn degrades the environment by acidification of water bodies and kills Native forests. This makes Cities loose a large portion of productive areas. Covering of Large Urban lands with Roads, Pavings and Parking spaces and low density housing can lead to huge water runoff ,that can eventually cause Flooding. The most adverse problem create by private automobile dependancy and resultant Land use is the Decline of the Transit Systems.

Economic Problems

Most basic economic impacts is the Congestion Cost i.e in the terms of Cost of time and cost of extra mile travel for connecting to Infrastructure systems. Transit Systems is the Urban areas also have lower operating cost recovery ratio due to private automobile dependancy. Large economic costs are associated with Road accidents and deaths .The resultant Health related issues ,occurring as a consequence of Environmental impacts act as economic problems.

Social Problems

The discussed environmental and economic problems have resultant social problems, one such problem can be disastrous effect on the public realm. The social life of man is impacted due to private automobile dependency ,as he does gets to interact. The walk ability feature of the high density areas is replaced by Low density Areas of Suburbs, giving rise to lack of we feeling in the community, this further gives rise to lack to interactive and Child friendly Neighbourhoods. On the broader scale the above listed issues are affecting the Livability parameter of Cities.

The Concept of Automobile Cities

Automobile Cities are a resultant of the increasing car culture, that developed because of greater dependance on Automobiles, due to which cities started expanding into the suburbs. Automobiles have brought a enormous change in the pattern of Urban Areas. The concept of Automobile cities led to enormous expansion of the developed area in comparison to the walking and Transit cities. As the dependency on the Public transport and Non-motorized transport reduced ,as uninhibited outward expansion of city was caused. The development of the cities became foot loose and could easily occur anywhere. Automobile cities brought back the concept of Hypermobility and the Land use was segregated into zones. Cars eventually displaced public transit modes which gave rise to 80-95% modal share of Car in cities of America and Australia. A large number of transport deaths are caused as a resultant of Automobile cities. Due to high traffic congestion cities such as Bangkok are referred to as Automobile cities but these are more likely traffic saturated cities.

Some of the Consequences of Automobile Cities are summed below.

- Footloose Development.
- Expansion of cities without limits
- Arterials defined the mobility instead of Transit Network.
- Cater great mobility for a segment of Population ,where as inquity and mobility issues for others.

Automobile Dependency as a Barrier to Sustainable Transportation

Through the research paper it can be summed that Automobile dependency has given rise to a wide range of problems. It is is turn reducing the available transportation choices. The reasons why Automobile Dependency acting as a barrier to Sustainable Transportation are:

- Increased automobile dependency, makes cycling and walking Difficult and unpleasant on the streets.
- Service quality of public transit declines due to fall in demand.
- Affects the affordability, live ability, accessibility, and economic well-being of a region. serious issues i.e road accidents, increased carbon and greenhouse gas emissions, pollution congestion, and energy security.

- In order to achieve hypermobility, accessibility and quality have been compromised
- More polarization in the society and inequity caused.
- Enforced car ownerships for low-income households.

Initiatives by Indian Government towards Sustainable Transportation

India through the Automotive Mission Plan and the National Electric Mobility Mission Plan (NEMMP), and various alternatives tends to achieve two objectives—facilitate long-term sustainable growth in the industry and reduction of emissions and dependance on oil. Through the Automotive Mission Plan 2026, the automobile industry and government has basically set a target to triple the industry revenues to $300 billion, and expand exports sevenfold, to $80 billion. The primary aim would be improving manufacturing competitiveness and reduced emissions. Some of the key strategies are listed below:

- To bring Indian standards at par with global standards, which aims to leapfrog from BS-4 to BS-6 emissions (which is equivalent to EURO 6) by 2020.
- Corporate Average Fuel Efficiency norms through which the fuel efficiency has to be improved 10 percent between 2017 and 2021 and by 30 percent or more from 2022.
- In order to address pollution from old vehicles, Government is working on Scrappage or End of life policy.It plans to adoption of these policies with the help of lower taxes, discounts on purchase prices, and simple compliance processes.
- For reducing dependency on oil imports, the government is promoting adoption of alternative fuels through FAME2, which is an extension of the original FAME (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) initiative. "FAME1" was created to offer incentives for EV buyers. The initiatives taken by the government will eventually lead to more sustainable approach towards transportation by Reduction in carbon emissions and bringing the scenario at par with the global scenario.

Policy Recommendations for Mobilizing Sustainable Transport via SDG 11

The aim of SDG 11.2 is to By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons. The primary way of achieving this is by Avoid-Shift-Improve approach

- **Avoiding** the inefficient and needless trips, where possible, by the means of improved urban planning, compact city growth, management of travel demand, less complex and extended supply chains, and depending on E-communication options.
- **Shifting** transit to improvise the efficiency of the trip via efficient or environmentally friendly mode or multi-modal travel, capable of meeting the travel/transport needs, and/or shifting the travel from the peak hours.
- **Improving** the overall performance of transport by operational, technical, operational, or pricing, and/or infra led improvements to make transportation sustainably efficient. Design and implementation of policies aligned with the 'Avoid-Shift-Improve' guidelines will depend on following considerations:
- Cross-sector integration and institutional cooperation
- Intermodality
- Governance frameworks for effective policy making.
- Short- and long-term planning taking into account the business case for sustainable transport and development.
- Capacity Building in Developing Countries.
- Creation of Public Awareness and Stakeholder engagement.
- Effective funding.
- Creation of efficient framework.

The above listed Avoid-shift-improve model will lead to shift to a sustainable system,basically away from conventional Transportation Modes.

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Road Map to Sustainable Transport

"The main motive of sustainable transportation is to ensure that the three pillars of sustainability environment, social and economic considerations are incorporated into the framework of transportation planning."(Mead, 2021)

Some of Sustainable transport indicators are listed below:
• Level of Service of Roadway(LOS): a higher rating is preferred more.
• Average traffic speeds: Higher speeds are preferred
• parking convenience and price: Parking at lower price is preferred more
• crash rates per vehicle mile: Least crash rates are preferred.
• Fuel consumption and Emissions: lesser values are preferred .
• per capita motor vehicle mileage: Lower values are preferred.
• modal split: higher transit ridership is preferred
• Traffic injuries and deaths: less is better
• Transportation Land consumption in Landuse: less is better

CONCLUSION

Private ownership of Automobiles has affected Sustainable Transport on all parameters of Sustainability i.e Social, Environmental and economic. On a broader scale, it has increased dispersion of society, sprawl ,decreased social and cultural diversity and created more danger for people on roads. Sustainable Transportation can be achieved by shifting towards public modes of transportation..A shift towards Sustainable transportation   will favour the achievement of Millenium Development goals and SDGs. Sustainability can also be achieved by resource-efficient model for the automobile sector Design of automobiles should integrate design for environmental aspects, Shifting towards resource efficient technologies in automobile Manufacturing Industry ,Extending the lifetime of a vehicle, A regulatory environment conducive to promoting innovation for new mobility, Promoting clean fuel technology for motorized modes, Strengthening infrastructure and access for public transport, and Support energy efficient and green modes of transport.

ACKNOWLEDGEMENTS

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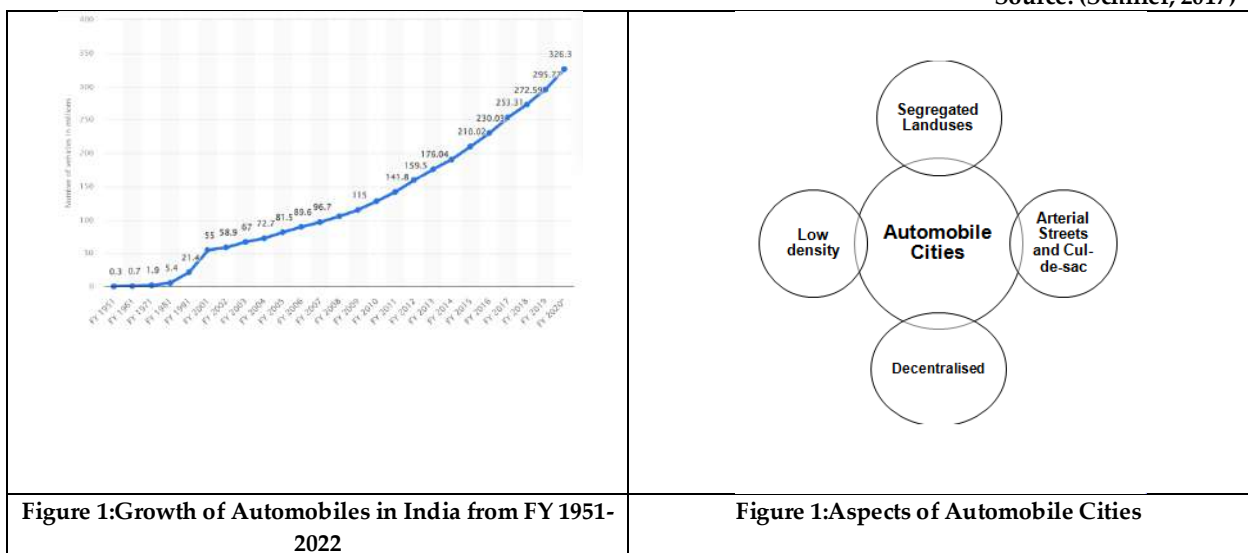**Table 1:Comparison of Private Ownership of Automobiles vs Sustainable Transportation**

Private Ownership of Automobiles	Sustainable Transportation
Emphasis on mobility and its quantity.	Emphasis on Accessibility and quality
Connection between different modes is acking.	Seemless connectivity between different modes(Inter-Modality).
Emphasis on One Mode.	Emphasis on Plurality.
Accepts and accommodates trends.	Reverses harmful trends.
Ignorance of Various Environmental and Economic costs.	Incorporates full costs,planning and provision.
Expansion of Road to meet Travel demand.	Manages mobility and transportation Demand.

Source: (Schiller, 2017)

Table 2:Problems associated with Automobile Dependancy

Environmental Problems	Economic Problems	Social Problems
Decimated Transit systems	Loss of Productive Road Infrastructure	Public Safety compromised
Issues such as photochemical smog,acid rain and High greenhouse gases	Loss of Productive agricultural land	Loss of Neighbourhood communities
Traffic issues such as Noise,Visual Intrusion and Physical danger	Physical and mental health issues due to lack of physical Activity.	Isolation in Remote suburbs
Oil Vulnerability	Road Congestion costs	Road Rage
Urban Sprawl	Economic and human costs of Transportation accident trauma and deaths	Enforced car ownership for Low-Income households

Source: (Schiller, 2017)

Figure 1:Growth of Automobiles in India from FY 1951-2022	**Figure 1:Aspects of Automobile Cities**

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Management of Asthimajjakshay (Avascular Necrosis of Femoral Head) through Panchkarmatherapy - A Case Report

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ABSTRACT

The most prevalent kind of bone necrosis is a vascular necrosis (AVN) of the femoral head. The goals of AVN management include pain alleviation and the preservation of structure and function. Most affected people are between the ages of thirty and fifty. In Ayurveda there is no directly corelation with a vascular necrosis. *Asthimjjagata Vata, Ubhyashrita Vatarakta,* and *Asthi Majjakshya,* among other *Lakshanas,* are associated with the femoral headnecrosis. In contemporary medicine, treatments include total joint arthroplasty, bone grafting, core decompression, and NSAIDS, each of which has unique complications, an expensive affair, and a very bad prognosis. In present casethe goal of the current case was to assess the *Ayurvedic panchkarma* therapy effectiveness in the conservative management of AVN. *Matra Basti* and *Patra pinda sweda* therapy of *Panchkarma* were used in a case of AVN with right femoral head and early AVN of left femoral head. Throughout the whole course of treatment, the patient was monitored for problems; none were observed. Based on the questionnaire's assessment of the patient's graded signs and symptoms both before and after therapy, the patient's symptomatic improvements were monitored. The outcomes were positive. Pain, soreness, stiffness, and an improvement in gait were all significantly relieved by the therapy. Ayurvedic principles applied to conservative management of AVN result in significant relief in sign and symptoms and an improvement in quality of life.

Keywords: Pain, soreness, stiffness, and an improvement in gait were all significantly relieved by the therapy.

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INTRODUCTION

Avascular necrosis (AVN), is osteonecrosis (dead bone) and is also called Osteochondritis Dissecans/Chandler's Disease in young adults with 60% of the cases being bilateral. This condition is one of the most challenging problems faced by orthopedic surgeons. The objectives of the treatment include the preservation of structure, function and relief from pain.[1]Avascular necrosis (AVN) is a disorder in which the subchondral blood supply is cut off, resulting in the cellular breakdown of bone, especially in the epiphyseal area of weight-bearing joints. [2]There have been a variety of traumatic and atraumatic factors that have been identified as risk factors for ON, but the etiology and pathogenesis still remains unclear. The estimated frequency of the most frequent risk factors for ONFH in the United States is alcohol (20%- 40%), corticosteroid therapy (35%-40%), and idiopathic (20%-40%).[3]In Ayurveda AVN can be correlated to the *Asthi-Majja Gatha Vata*. Its symptoms are *Bhedoasthiparvanam* (breaking type of pain in bones and joints), *Sandhishoola* (joint pain), *Mamsakshaya* (muscular wasting), *Balakshaya* (weakness), *Sandhi Shaithilayam* (laxity of joints), *Aswapanasantat Ruk* (sleeplessness due to continuous pain), *Shiryantiva Cha Asthinidurbalani*(destruction of bony tissue causing generalized weakness).**[4]** Most people who are affected are in the age range of 30 to 50. Usually, the head of the femur is affected. The patient's only symptoms in the early stages will be a slight soreness around the hip joint. The hip, buttocks, groin, and thigh will all experience excruciating pain in the later stages, and all hip joint movements will be restricted. The goal of the treatment is to lessen the bone deterioration. Surgery is usually the last step in the treatment. In addition, the outlook is terrible and all therapies are expensive. The goal of the current instance was to treat femur head avascular necrosis conservatively through *panchkarma* therapy and *shaman Ausadh.*

MATERIALS AND METHODS

Case report
A 38 years old male patient with Registration no. 62160/2383 visited OPD of *Panchakarma,* at Dr. *Sarvepalli Radhakrishanan* Rajasthan *Ayurved* University, Jodhpur with complaints of Hip joints pain and pelvic region radiating through lower back to B/L lower limbs in the last 1.5 year. Pt had problem in difficulty in walking due to severe pain.

History of present illness
Patient was apparently alright before 1.5 years, after which he had a gradual onset of stiffness, dull ache in groin and thigh region. After that gradually pain increase day by day. The pain was so severe that it was associated with difficulty while doing any activity. Patient has taken allopathy treatment but did not get any relief. So that's why patient came Ayurvedic hospital for further management.

History of past illness
H/O allopathic medicine and NSAIDS

Personal History

Name: xyz

Age: 38 yrs.

Sex: male

Marital Status: Married

Occupation: Electricity dept.

Appetite: low

Bowel: mild constipation

Bladder: Clear

Pulse:70/min

BP: 114/70 mm/Hg

Respiratory Rate: 18/min

Temperature: 98.2^{0}F

Systemic examinations
Musculoskeletal System:
Inspection: no swelling on both hip joints.
Palpation: Tenderness present on Right hip joint more than left hip joint.
Range of Movements: Painful movements of hip joints present during examination.

Investigations
MRI: MRI of right hip joint given in figure 1
Avascular necrosis of right femoral head – Ficat and Arlet stage II
Early avascular necrosis of left femoral head – Ficat and Arlet stage I

Treatment Plan
After proper clinical examination based on sign and symptoms and diagnosed based on MRI reports as AVN of femoral head patient was advised for matra basti and patrapinda sweda as given as shown in table no.1. Shaman Aausadh were also given for 2 months continuous and upon follow up also given medicine as shown in table no.2

OBSERVATIONS AND RESULTS

Observation in Range of Movement of Hip joint by goniometer shown in table no.3. Changes in subjective criteria sign and symptoms as shown in table no 4.

DISCUSSION

The line of management of *Vatavyadhi* was adopted. *Snehana* (internal and external oleation), *Swedana* (sudation), *Basti* (medicated enema therapy), *Nasya* (nasal therapy), *Abhyanga* (massage), *Utsadana* (specific massage with medicated paste), *Parisheka* (sprinkling of medicated liquid), etc. are the line of management for any *Vatavyadhi* [5]. Administration of *Bahya* (external) and *Abhyantara* (internal) Snehana (oleation therapy) form may be the best treatment modality in this disease. *Snehana*in the form External administration is by *Abhyaṅga* (massage) with medicated oils. After *Abhyanga, Patra pinda sweda* can be applied to the affected part of the body, whichis *Sandhichestakara, Srotosuddhikara ,Agnideepaka,* and *Kapha-Vatanirodhana,* it decreased the *Stambha* (stiffness).By administrating proper Snigdha Swedana, It helps in alleviating vitiated *Vata Dosha. Patra Pinda Swedana* may increases the local blood flow to the affected tissues, and *Swedana,* might produce a hypoanalgesic effect by diverting stimuli and helps in releasing pain, helps in eliminating *Dosha* imbalances, strengthens the muscles of the affected area by the release of toxins and reducing inflammation.[6] whereas Swedana produces *Mriduta* with in body parts and relieves stiffness. *Shoola Shanti* is one of the Samyak *lakshana* of *Swedana Karma. Swedana* also having its vasodilation effect which helps in improving the blood circulation to the affected joint.[7] According to Acharya Vaghbhata, with the action of *Basti,* the *veerya* of *Basti* being conveyed to *Apana* to *Samana* vata which may regulate the function of *agni,* then to *Udana, Vyana* and *Apana,* thus providing its efficacy all over the body. At the same time this effect of *Matra basti* by specifying *vata,* restores the displaced *kapha* and *pitta* at their original seats. The control gained over *vata* leads to the *Samprapti Vighatana* of the disease. That's why *basti* is best treatment for *Vataja*disorders [8,9] . *Mahatiktaghrita* is indicated in the treatment of *Maharoga* (grievous disorders) and is thus helpful in mitigating the pathology of any *Vatavyadhi* like this disease [10]. *Ashwagandha* (*Withania somnifera* Dunal) possesses *Rasayana* and *Brahmana* (anabolic) properties, so it is useful in all types of *Dhatukshya* [11]. It is also reported to have an anabolic effect on bone tissue [12]. *lakshadiguggulu* as told by aacharya in baisjyaratnavliin bhagnadhikar 49/13-14 The content of *Laksha guggulu* include purified *guggulu, Laksha, Asthisanharaka, Arjun, Ashwagandha* and *Nagabala.* Most of these drugs have properties like.- *Vatakaphanashaka, deepana, balya, rasayana, tridoshanashaka, pachana, shothaghna, vedanashamaka & shoolaprashamaka.* Capsule *Gandha tailam* enriched with calcium riched ingredients like

sesame, *sarjarasa,* and milk. It helps to ease pain and gives relief from ligament injuries,sprains, spasms nourishes the weak bones.

CONCLUSION

Patient of AVN with the bilateral femoral head was treated with matra basti and patra pinda sweda. The therapy provide marked relief from pain, tenderness and stiffness. so therapy is very effective in management of AVN through ayurvedic principles.

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Conflicts of interest
There are no conflict of interest

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Table .1 Panchkarm Therapy

Sr no	Therapy	Medicine	Duration
1	Matra basti	With mahatiktghrit	21 days
2	Patra pind sweda	With mahamasha and mahalakshadi taila	21 days

Table.2 Shaman Aausadh

Sr. No.	Drug	Dose	Anupana	Duration
1.	Lakshadigugglu	2bd	Luke warm water	2 months
2.	1.Mansrohini chuna 2. Satavaryadi churna 3.Ashwgandha churna 4.Vidarikhand churna	1gm 2gm 2gm 1 gm	With milk	2 months
3.	Cap. Hadod	1 bd	Luke warm water	2 months
4.	Cap.gandh taila	1 bd	Luke warm water	2 months
5.	Panchsakar churna	3 gm sleeping time	Luke warm water	2 months

Table.3 Observations in Range of Movements of B/L Hip Joints.

Range of movements		BT	AT
Abduction	Right	15	25
	Left	20	30
Adduction	Right	10	25
	Left	15	25
Extension	Right	10	20
	Left	20	25
Flexion	Right	60	100
	Left	90	110
Internal	Right	15	25
	Left	30	30
External	Right	20	25
	Left	25	30

Table .4 Observations in Sign and Symptoms.

S. No.	Sign &Symptoms	Before Treatment	After Treatment
1	PAIN	++++	NIL
2	TENDERNESS	+++	NIL
3	STIFFNESS	+++	NIL
4	GAIT	TRENDELENBERG	NORMAL GAIT

Figure 1. MRI of Hip Joint

RESEARCH ARTICLE
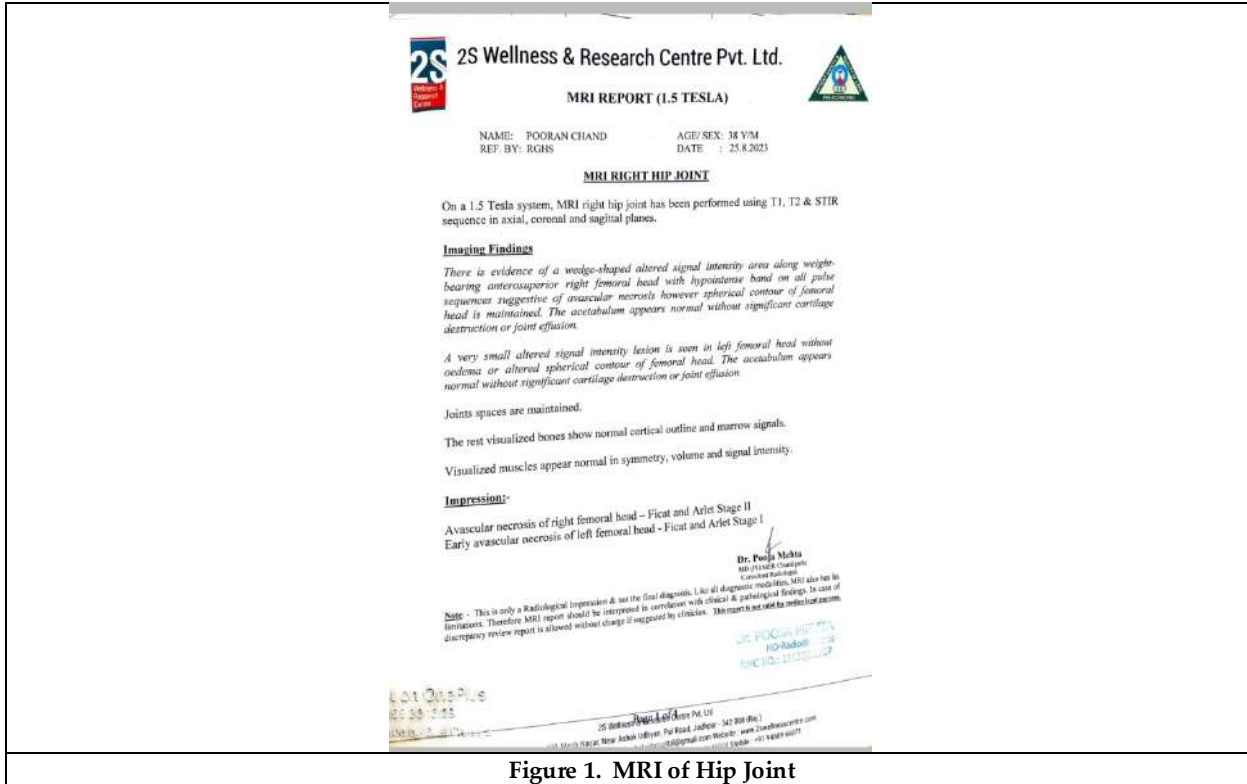
Social Media Platforms as a Potent Mediator in Building the Interpersonal Relationship among Higher Secondary School Students

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ABSTRACT

In India at present the usage of Social Media Platforms (SMPs) amongst school and college going students has vastly increased and the usage of SMPs has extensive influence on these students in numerous ways, particularly on their interpersonal relationships. Social media platforms influence the interpersonal relationships of school students with their parents, friends, and teachers and with others in innumerable ways. The purpose of the study is to investigate the student's interpersonal relationships with their parents and teachers when SMPs is used for interaction, communication and educational purposes. The design of the study was descriptive in nature and the tool used by the researcher was self constructed. In the present study simple random sampling technique was employed for the selection of sample in which 86 were males and 84 were female's higher secondary school students from different Kendriya Vidyalaya schools of Jammu District. The main findings revealed that the usage of SMPs has influenced interpersonal relationships of students with their parents but not with their teachers. Students spend most of the time in the school mainly with the teachers, so teachers can help the students to use the social media platforms in such a way that it does not influence their relations with their parents, friends relatives etc. Teachers have to channelize student's usage of SMPs in constructive way that they don't effect student's interpersonal relations with others.

Keywords: Social media platforms, interpersonal relationships, school students, communication and technology

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INTRODUCTION

An incredible and unprecedented growth in ICT was seen around the world in the latter part of the 20th century, and in India in particular (Manjunatha, 2013). Today, people from all over the world can instantly connect with one another and share ideas, facts, and insights because to the widespread availability of the internet. Since then, other new mediums have emerged, most notably social media (Khatib and Khan ,2017). Many different types of social media have emerged recently, including Facebook, Twitter, WhatsApp, Instagram, and YouTube. The most widely used medium of communication nowadays is undoubtedly the various social media websites. Many different kinds of people from all walks of life are using it (Workie et al, 2021). Youth, and especially college and university students are avid users of social media owing to the widespread adoption of information and communication technologies. The use of social media has become so pervasive that it is essentially impossible to avoid; it has completely transformed the ways in which students communicate, connect, and socialise; and it has become deeply ingrained in their society and culture. As a result, students are devoting an increasing amount of time to online social networks (Akakandelwa and Walubita, 2018). Because of the rapid advancements in technology that have taken place over the past few years, the use of social media has exploded in popularity all over the world. These social networking websites have become extremely popular among users of all types, including celebrities and the ordinary public alike. With the increased penetration of smart phones and the internet in India, social media is becoming a fast-growing phenomenon as more people, particularly the youth, become engaged. India's youth are overly reliant on social media for networking, education, and pleasure. In millions, the number of social network users in India from 2015 to 2022 is depicted in the graph (Figure 2). More than 250 million people use social media in India, making it the second-largest country in the world. Millennials use social media in large numbers all across the world (Nayak et al. 2022). Social media is also heavily used by Indian youth to carry out their activities. Students now routinely use these interactive social media sites for fun and study, and the sites account for a large portion of their time online. Students are able to engage with their friends, teachers, peers, and professionals in any field, anywhere, and at any time by using the many social media platforms. This allows for the possibility of extended contact times as well as more effective communication. Through the use of social media platforms, they are able to obtain a limitless variety of data and material for their research and academic studies (Manikandan and Raja, 2017).

Students can also share lectures of different universities available on You-tube and can clarify their concepts in order to enhance their grades or academic achievement. Students also arranged online conferences, workshops in order to talk regarding the projects after the school hours. As a result, schools now recognise the importance of addressing pupils' easy access to social media. Some schools have fully integrated the use of laptops, tablets, and other electronic media into their instructional methodology (Mathew et al. 2017). The use of social networking sites has been the focus of a large number of research studies. The review of literature clearly indicates that adequate scientific investigations are not carried out on the impact of social media platforms on interpersonal relations of higher secondary school students. Hence, the study assumes profound academic and social significance. The use of social media platforms is a growing trend in India, which is highly concerning. Students from colleges and universities are becoming increasingly interested in these social networking sites that facilitate communication and entertainment. This provides the context for the study's attempt to delve deeper into this phenomena. Human growth and learning are built on interpersonal relationships. Analysis of how social media platforms affect interpersonal connections among secondary school students is therefore vital (Sudha and Kavitha, 2016). As an additional bonus, social media helps keep alive bonds that would otherwise suffer from people living too far apart. It makes possible communication that otherwise would have been impossible (Beniwal, 2018). A social media platform is like a drug to the current generation and is certainly affecting the interpersonal relationships among students. The time spent on social media platforms may cause distance or even conflict among interpersonal relationships, when spending time at home together as a family unit. Individuals may be physically present in the same room, but they may be so focused on the information they are scrolling through on the SMS, that they could be missing important nonverbal communication cues due to inattentiveness (Britt, 2017). When utilising Facebook for engagement, Liu, Yin, and

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Huang (2013) looked into how the teenagers interacted with their friends, parents, and teachers. One-way analysis of variance and the paired-samples t-test were used to analyse the data. The analysis's findings showed that adolescents who use Facebook frequently for social contacts, whether in real life or online, are better able to deepen their friendships than those who use it less frequently. However, if they utilise Internet technologies excessively for interactions, their real-life interpersonal relationships with their parents can suffer. Manjunatha (2013) studied SNS's impact on college students' relationships. The researcher used questionnaires and interviews to obtain data from 500 college students in Bangalore and Mysore. He observed that SNS enhanced communication between college students and their family members and friends. Ngonidzash (2016) looked into the effects of excessive usage of SMS and found that it has a major impact on the emotional relationships and physical presence within families. According to research conducted by Britt (2017), the use of short message service (SMS) decreases the quality of home-based relationships and decreases participants' overall happiness. It has been hypothesised that increasing one's SMS use at home will lead to less time spent in interpersonal, face-to-face discussion. Barriers to sharing one's views and opinions on a wide range of topics have been eliminated thanks to the rise of social media.

Students and experts are able to exchange and communicate with like-minded people and can ask for the insight and opinion on a certain topic. Furthermore, the present study has multiple direct uses to different sections of the society. To begin with, the research raises students' consciousness about the ways in which their use of social media affects themselves and their connections with others. It's a great way to teach kids how to use social media responsibly. Students' social lives benefit from more communication with adults in their lives, including instructors, parents, and friends. As social media is the new area of research and is the current or need-based problem, In the words of Ani DiFranco, "every tool is a weapon if you hold it right." Instead of letting social media use people, people should use social media. It should also be used in moderation, meaning only when the benefits outweigh the risks (Beniwal, 2018). The work in this field has been done in some developed countries like USA, UK and others and the researcher felt that less work has been done in our country especially in the state of J&K and the researcher felt that there is a great scope of research in this respective field. In addition, there are hardly any studies conducted in Jammu district, which helps in assessing the interpersonal relationship of school students in relation to specific dimensions i.e., parents, friends and teachers. Secondly, the present study is unique and differs from the rest of the studies in terms of variables, population and sample.

Objectives of the Study
The objectives of the study were:
1.   To study the main effect of gender on SMPs influenced Interpersonal Relations among Higher Secondary School students with their Parents.
2.   To study the main effect of various streams on SMPs influenced Interpersonal Relations among Higher Secondary School students with their Parents.
3.   To study the main interactional effect of gender and streams on SMPs influenced Interpersonal Relations among Higher Secondary School students with their Parents.
4.   To study the main effect of gender on SMPs influenced Interpersonal Relations among Higher Secondary School students with their Teachers.
5.   To study the main effect of various streams on SMPs influenced Interpersonal Relations among Higher Secondary School students with their Teachers.
6.   To study the main interactional effect of gender and streams on SMPs influenced Interpersonal Relations among Higher Secondary School students with their Teachers.

Hypotheses of the Study
1.   There will be no main significant difference of gender on SMPs influenced Interpersonal Relations among Higher Secondary School Students with their Parents.
2.   There will be no main significant difference of various streams on SMPs influenced Interpersonal Relations among Higher Secondary School Students with their Parents.

3. There will be no significant interactional effect of gender and streams on SMPs influenced Interpersonal Relations among Higher Secondary School students with their Parents.
4. There will be no main significant difference of gender on SMPs influenced Interpersonal Relations among Higher Secondary School students with their Teachers.
5. There will be no main significant difference of various streams on SMPs influenced Interpersonal Relations among Higher Secondary School Students with their Teachers.
6. There will be no significant interactional effect of gender and streams on SMPs influenced Interpersonal Relations among Higher Secondary School students with their Teachers.

Research Design
The descriptive survey method was utilized in the present investigation.

Population
In the present study the population of the study constituted the students of Kendriya Vidyalaya Sangathan of Jammu district. There are 11 Kendriya Vidyalaya Schools in Jammu district.

Sample
The total sample consisted of 170 students 84 females and 86 males' students studying in Kendriya Vidyalaya of Jammu district. Random sampling technique was used to collect the data.

Tool used
For the present study, self-constructed tool was used by the investigator i.e; Social Media Platforms influenced Interpersonal Relationship Opinionnaire. The validity of the tool was established by the investigator.

Statistical Technique used
The investigator used Two-way ANOVA for the analysis and interpretation of the data.

RESULTS AND INTERPRETATION

The tabulated data is meaningless unless and until it is examined and analyzed using a sophisticated statistical technique in order to reach a meaningful conclusion. Two-way ANOVA was used to interpret the numbers. Hypotheses-wise interpretations were given below. The table 1 shows that the value of F-ratio for the main factor gender has came significant as 5.8 which is higher than the table value at 0.05 level of significance at degree of freedom (1, 54) and the table values for significance are 4.03 and 7.17 at 0.05 and 0.01 level of significance. It means that there are significant differences found on SMPs influenced interpersonal relations among higher secondary school students with their parents in relation to gender. Thus the null hypothesis stating "there will be no main significant difference of gender on SMPs influenced Interpersonal Relations among Higher Secondary School Students with their Parents" is rejected. This finding is in agreement with the Liu, Yin and Huang (2013) and Ngonidzashe (2016), where as it is in disagreement with the Manjunatha (2013). From the table it comes to know that, the mean value of male students i.e. 29.6 is higher than female students i.e. 25.8 which means that male students interpersonal relations influenced by usage of SMPs with their parents. The table 1 shows that the value of F-ratio for the main factor Stream has came significant with interpersonal scores. The f-ratio value for the stream has came significant as 4.0 which is higher than the table value at 0.05 level of significance at degree of freedom (2, 54) and the table values for significance are 3.18 and 5.11 at 0.05 and 0.01 level of significance. It means that there are significant differences found on SMPs influenced interpersonal relations among higher secondary school students with their parents in relation to their streams. Thus the null hypothesis stating "there will be no main significant difference of various stream on SMPs influenced Interpersonal Relations among higher secondary school students with their Parents" is rejected. From the table it comes to know that, the mean value of non-medical stream students 28.6 is higher than commerce and medical stream students i.e. 27.7 and 25.7 which mean non-medical stream students

interpersonal relations influenced by usage of SMPs with their parents. The value of f-ratio for interaction between gender and stream on interpersonal scores has come out to be significant as 4.17 which is higher than the table value at 0.05 level of significance at degree of freedom (2, 54). It shows that these variables i.e. gender and Stream combined play important role in interpersonal scores influenced by usage of SMPs among higher secondary school students with their parents. Thus the null hypothesis stating "there will be no significant interactional effect of gender and streams on SMPs influenced Interpersonal Relations among higher secondary school students with Parents" is rejected. The value of f-ratio for the main factor gender has not came significant with interpersonal relation scores. The f-ratio value for the gender came 2.32 which is less than the table value at 0.05 against (1, 54) df. It means that there is no significance difference found on SMPs influenced interpersonal scores among higher secondary school students with their teachers in relation to gender. Thus the null hypothesis stating "there will be no main significant difference of gender on SMPs influenced Interpersonal Relations among higher secondary school students with their teachers" is accepted. The f-ratio value for the main factor stream is not significant with the interpersonal relation scores. The calculated value for the various stream came 2.02 which is less than the table value i.e. 3.18 at 0.05 level against (2,54)df. It means that there is no significant difference found on SMPs influenced interpersonal scores among higher secondary school students with their teachers in relation to their streams. Thus the null hypothesis stating "there will be no main significant difference of various stream on SMPs influenced Interpersonal Relations among higher secondary school students with their teachers" is accepted. The value of f-ratio for the interaction of gender and stream has not come significant with the interpersonal relations. The f-ratio value for the interaction of gender and stream came 1.48 which is less than the table value i.e., 3.18 at 0.05 level against (2, 54) df. It means that there is no significant difference found on SMPs influenced interpersonal scores among higher secondary school students with their teachers in relation to their gender and streams. Thus the null hypothesis stating "there will be no significant interactional effect of gender and streams on SMPs influenced Interpersonal Relations among higher secondary school students with their teachers" is accepted.

MAJOR FINDINGS

The main conclusions arrived at after investigating the data with regard to usage of SMPs influenced interpersonal relations is summarized below.
It may be concluded that
1.   There is main significant difference of gender on SMPs influenced Interpersonal Relations among higher secondary school students with their Parents.
2.   There is main significant difference of various streams on SMPs influenced Interpersonal Relations among higher secondary school students with their Parents.
3.   There is significant interactional effect of gender and streams on SMPs influenced Interpersonal Relations among higher secondary school students with Parents.
4.   There is no main significant difference of gender on SMPs influenced Interpersonal Relations among higher secondary school students with their Teachers.
5.   There is no main significant difference of various streams on SMPs influenced Interpersonal Relations among higher secondary school students with their Teachers.
6.   There is no significant interactional effect of gender and streams on SMPs influenced Interpersonal Relations among higher secondary school students with their Teachers.

From the results of the study, it comes to know that the non-medical stream students interpersonal relations influenced by usage of SMPs with their parents. It may be due to the reason that non-medical stream students make maximum use of social media as compared to medical and commerce students for their academic activities. The students also used SMPs to obtain knowledge and information from different scientists, experts and other communicators of science. They use SMPs for stay informed of events and news, update knowledge of technology, allow ideas exchange and meet students from other universities, post projects or models. They also used SMPs to research colleges, universities and company to get information about all the fields they are interested in. And gender also influenced student's interpersonal relations with parents and not with teachers because students spend most of

the time in the school mainly with the teachers. It is possible for educators to devise instructional methodologies that make use of social media for the purposes of teaching and learning. This, in turn, increases student-teacher contact, which contributes to improved academic performance.

Educational Implications

A growing number of college students spend a lot of time on social media platforms and for many of them it has become an inseparable part of their lifestyle, beneficial for education, communication, finding jobs, business and entertainment. Students need to be trained in the right use of social media for the all-round development of their personality. The implications of the study are stated as follows:

1. Students should be encouraged by teachers, parents and relatives to use these platforms carefully and utilize the innovative features for social interaction and collaboration.
2. Teachers with the help of SMPs gave live lectures, increased support to student queries, to expand and explore their own possibilities, skills and knowledge, variety of teaching aids and also by teaching blogs and write ups.
3. SMP use should be encouraged among children by parents, school officials, teachers, and guidance counsellors because of the positive effects it has on students' interpersonal connections.
4. If the students interpersonal relationship with their parents influenced by SMP then teachers can also guide the students about how to use SMPs without effecting their relationships.
5. Teachers should channelize their students" usage of SMPs in the right direction so that they benefit from the merits of social media rather than be caught up in the evils of social media usage.
6. Students should utilise SMPs not merely for amusement and recreation, but also as a means of communicating with elders in their lives such as parents and instructors.
7. 7. The usage of social media platforms should be encouraged for the sake of personal development; using these sites can help students improve their information technology abilities and maintain in contact with professionals.
8. Social media platforms (SMPs) are the most effective means of disseminating information and should be utilised to raise awareness of social concerns among members of a society and its interconnected communities.
9. Students can balance their time between studies and their usage of these social media platforms socially and particularly for academic purposes.
10. 10 Social media should be seen as an informal learning tool by both educators and learners because of the relaxed atmosphere it fosters for both.
11. Teachers, administrators, and policymakers in the field of education can all benefit from using social media as an additional teaching tool.
12. Institutions of higher learning create their own social media pages and groups on various platforms, inviting students to join in the hopes that they may provide a forum for students to discuss and find solutions to issues they are facing in the classroom.

CONCLUSION

Students in higher education cannot function properly without the use and features of social media, which are both needed and of the utmost importance. In the same vein, students might benefit from using social media to improve their learning performance, facilitate the exchange of information, and work together. Students have access to a learning platform in the form of social media, where they may readily communicate with one another, as well as with their lecturers and subject matter experts. In addition, the utilisation of social media platforms is beneficial to the improvement of collaborative learning among students (Khan et al. 2021). Because of their accessibility and convenience, social networking services now have millions of active members. Students in today's society rely on social networking websites for the majority of their real-time communication needs. Examples of such websites are Facebook, Twitter, and YouTube. According to the findings of the study, students' social media presence had an effect on their relationships with their parents and siblings. The gender of the user does not play a significant role in

the interpersonal relations that are influenced by the use of social media platforms that include parent and sibling dimensions. This holds true for both medical and commerce stream students' interpersonal relations that are influenced by the use of social media platforms.

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Table 1: Summary of Two Way Anova for Parent Dimension in Interpersonal Relations

Source of variables	SS	Df	MS	F	Level of significance	Results
SS_A(gender)	62.0	1	62.0	5.84*	Significant	H1 is rejected
SS_B(stream)	84.95	2	42.47	4.00*	Significant	H2 is rejected
SS_{AXB}	83.45	2	41.72	4.17*	Significant	H3 is rejected
$SS_{With in}$	543.3	54	10.6			

Table 2: Summary of Two Way Anova for Teacher Dimension in Interpersonal Relations

Source of variables	SS	Df	MS	F	Level of significance	Results
SS_A(gender)	21.63	1	21.63	2.32	Not significant	H4 is accepted
SS_B(stream)	37.7	2	18.85	2.02	Not significant	H5 is accepted
SS_{AXB}	27.67	2	13.83	1.48	Not significant	H6 is accepted
$SS_{With in}$	502.8	54	9.31			
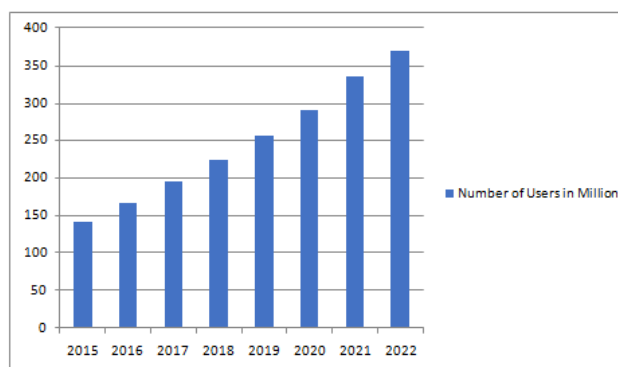
Source: www.statista.com
Figure 1: depicts the numbers of social network users in India from 2015-2022.

RESEARCH ARTICLE

Isolation, Production, Characterization and Optimization of Enzyme Collagenase from Marine Microorganisms

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ABSTRACT

Collagenase enzyme is a protein molecules made up of amino acids. It provides structural support to the extracellular space of connective tissues. Due to its rigidity and resistance to stretching, it is the perfect matrix for skin, tendons and also helps in the wound healing process. In the present study we worked on the isolation, production and optimization of collagenase enzyme from marine bacteria from different selected strains- Halomonas of sea water on Agar nutrient medium. Collagenase enzyme was collected from isolated Halomonas anticariensis and tested for enzyme activity through UV visible spectrophotometric analysis. The enzyme activity is optimized at 36^0C, PH-7, incubation period 48hrs and Moisture content 47% and study mainly concerned on the production of collagenase from solid substrate which have more high enzymatic activity.

Keywords: Enzymes, Extracellular collagenase, Cup assay, Biochemical assay

INTRODUCTION

Collagenase is an enzyme that breaks down collagen in damaged tissues within the skin and helps the body generate new healthy tissue. It is considered a virulence factor, facilitating the spread of gas gangrene. Collagen is a type of protein that connects and supports fibers in body tissues such as skin, tendons, muscles, and bone. Collagen, a key component of the animal extracellular matrix, is made through cleavage of pro-collagen by collagenase once it has been secreted from the cell. This stops large structures from forming inside the cell itself. Collagenase topical (for the skin) is applied to severe burns or skin ulcers to help remove dead skin tissue and aid in wound healing. It may also be used for other purposes not listed in this medication guide. The molecular and packing structures of collagen eluded scientists over decades of research. The first evidence that it possesses a regular structure at the molecular level was presented in the mid-1930s.[1,2] Research then concentrated on the conformation of the collagen monomer, producing several competing models, although correctly dealing with the conformation of each individual peptide chain. The triple-helical "Madras" model, proposed by G. N. Ramachandran ,1955, provided an accurate model of quaternary structure in collagen.[3,4] This model was supported by further studies of higher resolution in the late 20th century.[5,6] The packing structure of collagen has not been defined to the same degree outside of the fibrillar collagen types, although it has been long known to be hexagonal.[7] As with its monomeric structure, several conflicting models propose either that the packing arrangement of collagen molecules is 'sheet-like', or is microfibrillar.[8] The microfibrillar structure of collagen fibrils in tendon, cornea and cartilage was imaged directly by electron microscopy in the late 20th century and early 21st century.[9,10] The microfibrillar structure of rat tail tendon was modeled as being closest to the observed structure, although it oversimplified the topological progression of neighboring collagen molecules, and so did not predict the correct conformation of the discontinuous D-periodic pentameric arrangement termed microfibril.[11] collagen enzymes are able to effectively breakdown the peptide bonds found in collagen. Based on an increased interest in non-invasive therapeutic methods, collagenase enzymes are being studied for their ability to catalyze key chemical processes more specifically, collagen degradation. As seen in various in vivo and in vitro tests, injectable forms of collagenase have been shown to promote wound healing. With their unique ability to degrade collagen that is resistant to breakdown, collagenases can more effectively treat wounds, even those associated with third-degree burns. This is believed to be based on the fact that once collagen is degraded by collagenase, select inflammatory cells, including macrophages, are able to enhance migration and in turn, their efficiency. That is why ointments containing C. Collagenase are often applied to wounds, assisting in the removal of necrotic tissue. Since this type of dead tissue prolongs the inflammatory stage and enhances bacterial growth, collagenase supports proactive healing. While wound healing is imperative when aiming to reduce the risk of infection, the applications of collagenase enzymes are far-reaching in regards to scientific research and discovery.

Applications of Microbial Collagenase;
Enzyme Activity Reaction
The Collagenase are the enzymes necessary to initiate collagen turnover in normal connective tissue turnover and in diseases. Polyhydroxylated is a key enzyme in collagen synthesis acting by hydroxylation of proline residues in procollagen peptide, which is necessary for stabilizing collagen. More specifically, collagenase enzymes work by degrading the collagen found in the extracellular matrix. This collection of molecules is what essentially anchors cells to tissue, providing both biochemical and structural support. Depending on the class of collagenase, once the tissue is exposed to collagenase enzymes, it will bind to and cut either the ends of a collagen fibril or the middle of a collagen monomer. Once the structure of the triple helical is cut, they begin to unravel and denaturation takes place. At this point, it essentially becomes gelatin. From wound healing and scar contractures to research and disease prevention, collagenase enzymes will continue to play an important role within the scientific community, aiding and accelerating key.

Mechanism of action of collagenase

Collagenases are enzymes that break the peptide bonds in collagen. They assist in destroying extra cellular structures in the pathogenicity of bacteria such as clostridium. They are considering a virulence factor, facilitating the spread of gas gangrene. The normally target the connective tissue in muscle cells and other body organs. Collagen, a key component of the animal extra cellular Matrix is made through the cleavage of procollagen by collagenase once it has been secreted from the cell. The stops large structures from the forming inside the cell itself. In addition to being produced by the some bacteria. Collagenase can be made by the body as part of the it's normal immune response, this production is induced by the cytokines, which stimulates cells such as fibroblast and osteoblast, and can cause indirect tissue damage.

MATERIALS AND METHODOLOGY

Selection of Strains

The selected Halophilic strains were isolated from seawater, grown on Agar nutrition broth. The cultures were continuously maintained on petri plates. The cultures were every time cultured freshly on the Agar nutrients broth and incubated at 370c for 2 days before performing each experiment.

Raw Materials

Source: Sea Water collected from Machilipatnam, Krishna District; A.P.

Materials: Agar, Peptone, Meat extract, sodium chloride, was used to prepare Agar nutrition broth.

Preparation of Media
Preparation of Inoculum

The Sea water was inoculated in Agar nutrition broth with the help of loop and it was incubated in incubator for 48 hours. That supports the growth of Halomoans bacteria.

Preparation of Halomona. Anticariensis Production Media

The grown culture of Halomona.anticariensis was sub-cultured in the collagenase Enzyme rich media for increasing the production of enzyme.

Inoculum media Composition
Colleginase Enzyme Activity

After the 72 hrs of incubation period collect the culture broth and was centrifuged at 2000 rpm for 30 min and filter the solution for the separation of enzymatic fraction. The cell free supernatant was filtered through 0.45um cellulose acetate filter and the filtrate was considered as crude enzyme . The soluble protein content of the enzyme sample was measured at 520-540nm examined using UV.

Maintenance of Selected Strains

The organism in the present study Halomona.anticariensis was isolated from water and grown on Agar nutrition broth. The culture was continuously maintained on petri plates. The culture was every time cultured freshly on petri plates on the Agar nutrition broth and incubated at 37^{0}c for 2 days before performing each experiment.

Inoculum Media Components

Starch, Agar, Peptone, Yeast extract, Sodium chloride was used to prepare Agar nutrition broth.

Inoculum Media Composition

Starch-1gm, Agar-3g, Peptone-0.5gm, Yeast extract-0.3, Sodium chloridr 0.5gm, 1 litre of distilled water adjust the PH to 7.3 and autoclave the mixture for 25 min at 120^{0}c.

Preparation of Inoculum
The hallophlic culture bacteria was inoculated in Agar medium with the help of loop and it was incubated in incubator for 48 hours. Which supports the growth of Halomona. anticariensis bacteria.

Colleginase Enzyme Activity
Following incubation under optimized conditions, the culture was centrifuged at 2000 rpm for 30 min and filter the solution. The cell free supernatant was filtered through 0.45um cellulose acetate filter and the filtrate was considered as crude enzyme [Babashamsi]. The soluble protein content of the enzyme sample was measured at 520nm-54nm examined using UV.

Enzyme Activity Test
Weigh the 10ml of the water into the beaker and heat Weigh 2gm of gelatin add the above solution In this Solution , 5 ml of Ninhydrin solution is added.Finally Purple Colour is produced due to the Ninhydrin.
Observation: Collagenase activity is +ve

OPTIMIZATION OF COLLAGENASE ENZYME:
Results
Optimization of Collagenase Enzyme
a) Effect of Incubation Period on Enzyme Production:
5 gm of substrate was inoculated in mineral salt solution in 500ml Erlenmeyer flask and autoclaved. The suspended cultures were again inoculated as mentioned above and then incubated. The contents of flask were isolated and assayed at every 24 hrs; 48hrs and 72hrs of interval.

Enzyme Production
b) Effect of Temperature: The effect of temperature on the production of enzyme like collagenase was studied by incubating the culture at different temperatures ranging from 20oc-50oc.
c) Effect of Moisture Content: 5 gm of ground substrate was taken and dried at 60^0c for 6 hrs. cooled and weighed till a constant weight was obtained and moisture level was adjusted to 40%-80% by addition of required amount of salt solution and were sterilized.
d) Effect of pH: Substrate was mixed with mineral salt solution whose pH was adjusted; mineral salt solution was used as moistening agent which is used to adjust the pH. The pH was adjusted in the range of 2-7.5 with an increment of 0.5. The flasks which were prepared were sterilized, inoculated and incubated.

FORMULATION OF COLLAGINASE OINTMENT
Composition of Collagenase Formulation
Collaginase enzyme 0.5g;Arachis oil 1.5g;Methyl Salicylate 0.5g;Soft paraffin 10g.

Preparation of Ointment
Soft paraffin was taken and melted by heating process. After melting add arachis oil and mix well uniformly. And add methyl salicylate mix well finally add collagen enzyme followed by the tituration procedure. For this project we collected marine water for the isolation of halophillic strain and extraction of collagenase enzyme. For this firstly we prepared a nutrient media to that we inoculated sea water solution. And placed it in incubator until growth is observed.

Characterization of Isolated Halophilic Culture
After the growth of microorganisms enzyme is extracted by centrifugation process.
And the enzyme was assayed by biochemical tests. In that we got +ve results for staining tests, catalase test, motility test, and urease test.

CONCLUSION

The selected Halophilic culture showed more collagenase activity at an incubation period of 48hrs; temperature 55^0c and at pH 7. The collagenase as an enzyme with high therapeutic potential.

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Table : 1 standard collagenase products with codes

Code	Standard Collagenase Products
C-2819	Collagenase, Purified
C2821	Collagenase Vial, NCIS
C-2823	Collagenase, Type 1
C-2825	Collagenase, Type 2
C-2827	Collagenase, Type 3
C-2829	Collagenase, Type 4

Table-2 Composition of nutrient broth

Ingredients	Amounts
Agar	3.0 g
Peptone	0.5 g
Sodium chloride	0.5 g
Meat extract	0.3 g
Distilled water	Quantity sufficient to 1000 ml

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Table : 3 Inocculum media composition

Ingredients	Quantity(Wt in grams)
Agar	3.0g
Yeast extract	0.3g
Starch	1.0g
Peptone	0.5g
Sodium chloride	0.5g

Table 4. Result for Characterization of Isolated Halophilic Culture on staining and   Biochemical tests

Strain.	Simple staining	Gram staining	Catalyse activity	Urease activity	Motility test	Aerobic/ Anaerobic	Mannitol Fermen-tation	Glucose Fermen-tation	Lactose fermen tation
Halomonas. anticariensis	+	+	+	+	+	Aerobe	+-	+-	+-

Table 5. Effect of Incubation Period, Temperature, Moisture content and pH on Enzyme Production

| Enzyme activity	After 24hrs OD at 660 nm	After 48 hours OD at 660 nm	After 72 hrs OD at 660 nm
Collagenase at different incubation periods	0.05	0.38	0.3
Enzyme activity at different temperature	37 ℃	42 ℃	60 ℃
Enzyme activity	0.30	0.42	0.40
Collagenase at different pH	pH 6 OD at 660	pH 7 OD at 660	pH 8 OD at 660
Enzyme activity	0.12	0.66	0.25
Collagenase at Moisture content	20%OD at 660	40%OD at 660	80%OD at 660
Enzyme activity	0.35	0.65	0.25
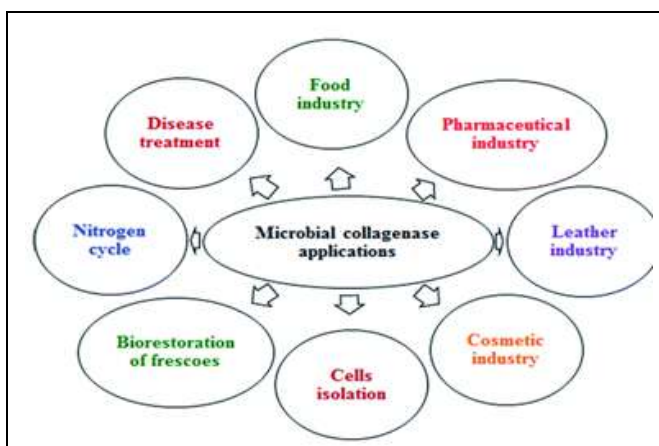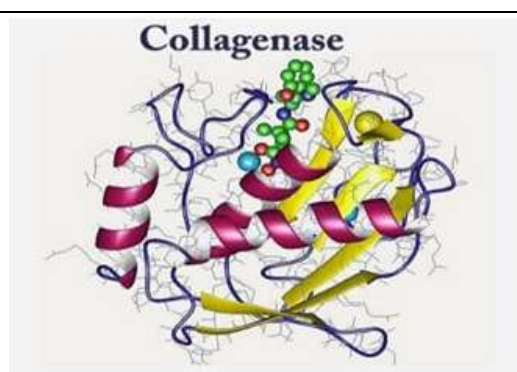
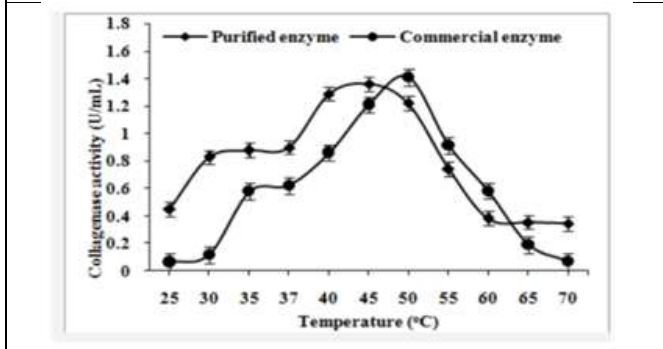| Figure:1	Figure 2: Collagenase

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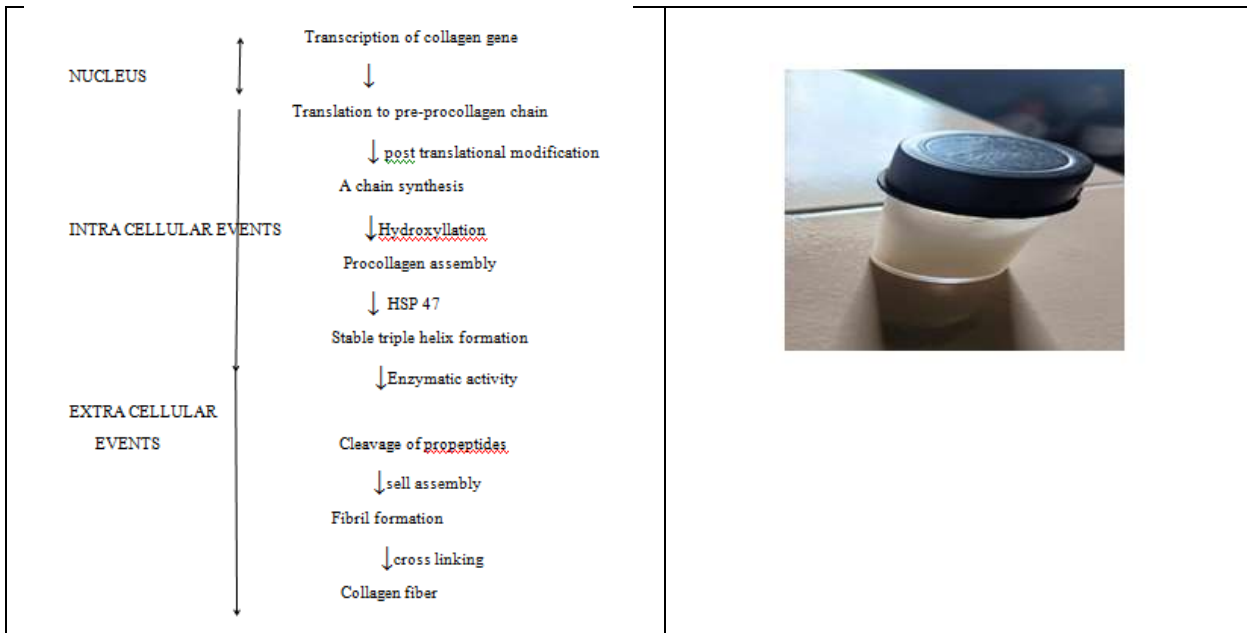
Figure 3: Mechanism of action of collagen

Figue 4: Collagenase ointment
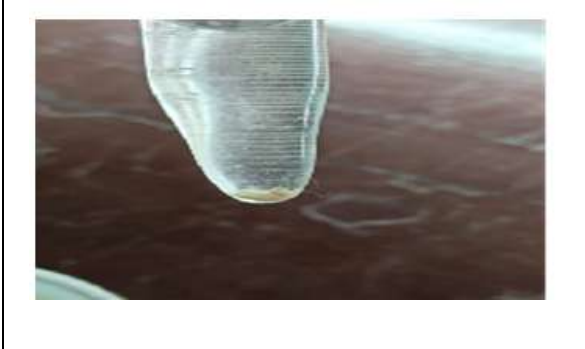
Figure 5 : Sea water solution

Figure 6 : Collagenase enzyme growth rate before and after Incubation Period

Figure 7 : Effect of Temperature on collagenase activity

Figure:8

RESEARCH ARTICLE

Comparative Analysis of Continuous Glucose Monitoring Levels: Non-Alcoholic and Alcoholic using the Five State Markov Model Probability Distribution

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ABSTRACT

The human body uses glucose as its primary fuel, and diabetes, which is characterized by elevated blood glucose levels, can have major negative effects on our health. In this work, we examined the relationship between glucose levels in individuals who drink alcohol (drinkers) and those who do not (non-drinkers) using the five-state Markov model and a novel mathematical technique. Significant parallels and differences between the glucose levels of drinkers and non-drinkers are highlighted by this study. The five-state probability mass function was formulated based occurrence or non-occurrence of particular state. The transition probability matrix provides evidence that the state is likely to remain the same for the next fifteen minutes. Normoglycemia and mildhyperglycaemia was shown to be the most prevalent blood glucose state for non-drinker and for drinker normoglycemia has high chance. Comparing the two scenarios, there isn't much indication that drinkers may have major problems. Once diabetes is affected, the chances of hyperglycaemia and normoglycemia are practically equal for drinkers and non-drinkers in long term behaviour of the model; in fact, those who drink are less likely to experience serve hyperglycaemia.

Keywords: Markov model, continuous glucose monitor, alcoholic, non-alcoholic, probability distribution

INTRODUCTION

A blood sugar (glucose) level that is too high results in diabetes. It arises when the body isn't reacting to the effects of insulin appropriately or when the pancreas produces too little or no insulin at all. People of all ages are affected by

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diabetes. All types of diabetes are treatable with medicine and/or lifestyle modifications, and the majority are chronic (lifelong). The primary source of glucose, or sugar, is found in the carbohydrate in food and beverages. It serves as the body's primary energy source. All of the cells in the body receive glucose from the blood to utilize as fuel. Once in the bloodstream, glucose need assistance a key to go where it needs to go. Insulin is a crucial hormone. Hyperglycemia, or elevated blood sugar, is brought on by an accumulation of glucose in the bloodstream due to insufficient insulin production or improper insulin utilization by the body. Consistently maintaining high blood sugar levels over time can lead to health complications like heart disease, nerve damage, and vision problems. India is the country most affected by diabetes worldwide, with an estimated 77 million Indians (1 in 11) officially diagnosed with the disease. This puts India second only to China. In addition, diabetes, hyperglycemia, Kidney failure, and other consequences of the disease claimed the lives of 700,000 Indians in 2020. India accounts for one in six (17%) of the global diabetes population. (As of October 2018, India accounted for roughly 17.5% of the world's population.) The International Diabetes Federation predicts that by 2045, there would be 134 million people with the condition. Worldwide, 537 million adult individuals suffer with diabetes. This number is expected to increase to 643 million by 2030 and 783 million by 2045, according to experts. A mathematical model that probabilistically depicts how a system evolves over time is called a stochastic process. Each random variable in the collection, is indexed by time or another parameter, represents the system's state at a certain moment in time. Numerous disciplines, including economics, engineering, physics, biology, and more, use stochastic processes extensively to model and evaluate systems that display uncertainty or randomness. If the future state of the system depends only on its current state and not on the preceding sequence of events, then a stochastic process possesses the Markov property. The process's modeling and analysis are made easier by this feature. A range of studies have explored the use of Markov models for understanding glucose levels among diabetes patients. Andreassen et al., (1994) implemented a probabilistic network model for predicting 24-hour blood glucose profiles with a mean error of 3.3 mmol/l[1]. Hovorka et al.,(2004) developed a nonlinear model predictive controller that uses a compartment model to maintain normoglycemia, with promising results [2]. Aibinu et al., (2010) suggested the use of artificial intelligent-based techniques for blood glucose level prediction, particularly the hybrid AI technique [3]. Stahl, (2012) investigated linear and Bayesian embedded models for short-term glucose prediction, focusing on low blood glucose detection [4]. Nath & Jain, (2012) proposed a hidden Markov model for predicting insulin charts, achieving positive results [5]. Varshney *et al.,* (2020) emphasized the higher risk of problems for patients with higher hemoglobin A1c levels by using an HMM to estimate transition probabilities between different diabetes states [6].

Zhou *et al.,* (2020) presents an improved deep neural network model that predicts diabetes with good accuracy in diabetes type classification [7]. Dey, (2020) introduced a novel neural network that outperformed other methods in terms of RMSE and adverse event detection [8]. S.Miyagi et al., (2021) speak about Moderate alcohol consumption contributes to impaired insulin secretion and glucose intolerance in lean/normal-weight non-diabetic Japanese men [9]. Dylag, (2023) found that a Hidden Markov Model can effectively predict glucose levels when used in conjunction with other machine learning models [10]. M.Ishohara et al., (2023) explores the relationship between habitual daily alcohol consumption and time-specific glucose levels in a non-diabetic population, revealing a time-dependent biphasic pattern in glucose levels associated with alcohol consumption [11]. Narendra & Padi (2024) discusses the use of Markov models to understand glucose levels in Type-1 diabetes patients, improvements in treatment, global diabetes prevalence, and the significance of stochastic models in various fields [12]. These studies collectively demonstrate the potential of Markov models and hidden Markov models for understanding glucose level. The goal of this work is to use a Markov model to understand glucose levels fluctuations at different times from drinker and non-drinker. It can be seen from the literature that most approaches for glucose levels rely on HMM and machine learning techniques to classify. However, very little work has been reported in the literature on speaking the holistic study mechanism by deriving the probability distributions of the specific state under study. In order to understand the overall behavior of the specific state of the diabetic patient, this study has given more focus on formulation of probability distribution's mass function. Their study has initiated with identification of appropriate stochastic processes by means of formulating the suitable Markov chains. Hence (i) deriving the probability mass function; (ii) developing the R-code from the derived mathematical relations; (iii) finding the statistical reports to the relative data; (iv) finding the statistical characteristics of Markov chain are the core activities of this study.

Markov model

A sequence of potential events where the probability of each event depends only on the state obtained in the preceding event is described mathematically as a Markov Chain. The process in question is stochastic and demonstrates the Markov property, which implies that the system's future state is contingent solely upon its present state and not on the preceding sequence of the events. The five state Markov chain model has developed based on glucose levels. The schematic diagram of the proposed Markov model is as follows. Consider the sequence of observations X_n where n is discrete time random process. In Markov chain X_{n+1} is conditional to the current state X_n and it is not dependent on $X_0, X_1, X_2 \dots X_{n-1}$. It is called memory less property. The chain behaviour that follows any state depends only on its current state, and this constraint is known as the Markovian assumption [11]. Let $O = \{o_1, o_2, \dots o_m\}$ be finite observable possible probabilistic state $X_n = o_i$ presents at discrete time t and $X_{n+1} = o_j$ at t+1 time, the Markov model written as, $a_{ij} = P(X_{n+1} = o_j | X_n = o_i)$ is the probability from moving $o_i \ to \ o_j$. The properties of Markov chain are: $\sum_{i=1}^{m} a_{ij} = 1 \ \& a_{ij} \geq 0$.

Probability mass function

In order to understand the model behavior, there is need of formulating the probability mass function for different states. The PMF formulated based on raw methods i.e. occurrence and non-occurrence of particular state in one step.

$$P(X_1(\omega) = x_1) = \begin{cases} \sum_{i=1}^{5} \sum_{j=2}^{5} \pi_i a_{ij} & x_1 = 0 \\ \sum_{i=1}^{5} \pi_i a_{i1} & x_1 = 1 \end{cases} \qquad P(X_2(\omega) = x_2) = \begin{cases} \sum_{i=1}^{5} \sum_{j=1, j \neq 2}^{5} \pi_i a_{ij} & x_2 = 0 \\ \sum_{i=1}^{5} \pi_i a_{i2} & x_2 = 1 \end{cases}$$

$$P(X_3(\omega) = x_3) = \begin{cases} \sum_{i=1}^{5} \sum_{j=1, j \neq 3}^{5} \pi_i a_{ij} & x_3 = 0 \\ \sum_{i=1}^{5} \pi_i a_{i3} & x_3 = 1 \end{cases} \qquad P(X_4(\omega) = x_4) = \begin{cases} \sum_{i=1}^{5} \sum_{j=1, j \neq 4}^{5} \pi_i a_{ij} & x_4 = 0 \\ \sum_{i=1}^{5} \pi_i a_{i4} & x_4 = 1 \end{cases}$$

$$P(X_5(\omega) = x_5) = \begin{cases} \sum_{i=1}^{5} \sum_{j=1}^{4} \pi_i a_{ij} & x_5 = 0 \\ \sum_{i=1}^{5} \pi_i a_{i5} & x_5 = 1 \end{cases}$$

In the PMF, x_1 represents hypoglycemia, x_2 represents normoglycemia, x_3 represents mild hyperglycemia, x_4 represents moderate hyperglycemia and x_5 represents serve hyperglycemia.

METHODOLOGY

Data collection

The data on two ShanghaiT2DM[13] individuals was taken from a secondary source. Of the 109 T2DM, 13 are drinkers and 96 are not. Thirteen samples were randomly selected from non-drinkers and thirteen from drinkers in order to preserve homogeneity. The average age of the 13 male drinkers is 62.76 years old, their height is 1.71 meters, their weight is 71 kg, their BMI is 24.23, and their duration of diabetes is 10.54 years. There are seven female and six male non-drinkers, with an average age of 59.54, height of 1.61 meters, weight of 60 kg, BMI of 22.97, and duration of diabetes of 7.23. The meal intake takes place three times a day, at 07:01, 11:01, and 17:16. Insulin is administered twice a day, at 06:05 before breakfast and 16:01 before dinner. For both drinkers and non-drinkers, the times are essentially the same every day with the occasional small change in minutes. The states represent different ranges of glucose levels they are: state-1: hyperglycemia (below 70); state-2: normoglycemia (70 to 130); state-3: mild hyperglycemia

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(130 to 180); state-4: moderate hyperglycemia (180 to 250); and state-5: serve hyperglycemia (250+). The summary of the data given here. A fascinating result can be found in the summary statistics that contrast the glucose levels of drinkers with non-drinkers. Drinkers have a mean glucose level of 145, while non-drinkers have a higher mean of 151.1. The median blood sugar levels for the two groups are closer together, though, with drinkers at 133.2 and non-drinkers at 142.2. This implies that although the average glucose level is greater in non-drinkers, the middle values are more similar in the two groups. Furthermore, the standard deviation for abstainers is somewhat lower (49.0634) than for alcohol consumers (51.0738), suggesting that abstainers had less variation in their blood sugar levels. Positive skewness is seen in both groups, suggesting that the glucose distribution's tail extends towards higher values. The coefficient of variation (CoV) is 0.3247 for non-drinker and 0.3522 for drinkers. This suggests that drinkers' blood glucose levels are slightly more variable than non-drinkers', relative to their respective means. By putting the data spread in perspective and comparing it to the mean, the CoV makes it possible to compare group variability more meaningfully even when the means of the groups disagree. According on the kurtosis values, both distributions appear to be leptokurtic, which means that they are more peaked and have heavier tails than a normal distribution.

Limitations

The main limitation of the data is physical activity, stress levels, occupation and sleep hours are not given. Physical activity is not discussed of the patient and this is important for diabetes patients. The stress levels play a vital role in diabetes patients. If occupation is given then it will be more accurate to understand the fluctuation of the data. The alcohol consumption time period is not there. The sleep timing is assumed based on information available on google.

Numerical illustration

The numerical analysis performed for the proposed model from dataset[13]. The Markov modelnumerical results and probability distribution discussed here.

Drinker data classification

The drinker initial probability vector is calculated by average of the 13 patients. IPV= $\begin{pmatrix} 0.0162 & 0.4492 & 0.3256 & 0.1685 & 0.0405 \end{pmatrix}$ .The initial probability vector (IPV)indicates the probability of beginning in each state and provides important information about the model initial conditions and likely future paths. States like normoglycemia have a significantly greater likelihood, suggesting a strong tendency for the system to start in this state. On the other hand, states such as hypoglycaemia and serve hyperglycaemia have lower probability, indicating relatively smaller chances of commencement in these states. Predictive Modeling and analysis rely on the IPV as a fundamental component, which allows for a thorough understanding of the model evolution over time and helps with decision-making about the model future behaviour and possible state transitions. The transition probability matrix (TPM) is calculated by average of the 13 patients like IPV and standard error matrix

(SEM) calculated by the average of TPM using the straight forward formula $\dfrac{p_{ij}}{\sqrt{n}}$. The stationarity matrix (SM) or long-term behaviour calculated by multiplying TPM.

$$\text{TPM} = \begin{pmatrix} 0.841269841 & 0.15873016 & 0 & 0 & 0 \\ 0.005732302 & 0.93694468 & 0.05674979 & 0.0005732302 & 0 \\ 0 & 0.07908264 & 0.86081455 & 0.0597073942 & 0.0003954132 \\ 0 & 0 & 0.11773700 & 0.8539755352 & 0.0282874618 \\ 0 & 0 & 0 & 0.1238095238 & 0.8761904762 \end{pmatrix}$$

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$$
SEM=\begin{pmatrix} 0.081711350 & 0.035493142 & 0 & 0 & 0 \\ 0.001281782 & 0.016387266 & 0.004033032 & 0.0004053349 & 0 \\ 0 & 0.005591987 & 0.018449321 & 0.0048589188 & 0.0003954132 \\ 0 & 0 & 0.009487518 & 0.0255516437 & 0.0046504301 \\ 0 & 0 & 0 & 0.0198253905 & 0.0527404690 \end{pmatrix}
$$

$$
SM=\begin{pmatrix} 0.01623937 & 0.4496758 & 0.3259473 & 0.1685801 & 0.03955743 \\ 0.01623937 & 0.4496758 & 0.3259473 & 0.1685801 & 0.03955743 \\ 0.01623937 & 0.4496758 & 0.3259473 & 0.1685801 & 0.03955743 \\ 0.01623937 & 0.4496758 & 0.3259473 & 0.1685801 & 0.03955743 \\ 0.01623937 & 0.4496758 & 0.3259473 & 0.1685801 & 0.03955743 \end{pmatrix}
$$

The model complex dynamics are captured by the transition probability matrix (TPM), Markov chain is irreducible, all states are recurrent andaperiodic. The glucose level states are hypoglycaemia and serve hyperglycaemia show substantial propensities to self-transition, suggesting some stability in these states. On the other hand, states such as mild hyperglycaemia and moderate hyperglycaemia show a tendency to change into other states, indicating a more dynamic behaviour. Subtle interdependencies between states are also revealed by the matrix; certain transitions are more common than others, indicating underlying patterns of systemic advancement. In the next state prediction (after 15 minutes) there is a high chance for the same state, means there is a less chance for changing glucose levels in 15 minutes. The standard error matrix calculated from TPM. It shows that these estimates have different degrees of precision; certain transitions show high confidence because of their low standard errors, while other transitions are linked to higher levels of uncertainty because of their higher standard errors. As an example, changes from mild hyperglycaemiato itself show accurate estimations, indicating a steady trend, whereas changes from hypoglycaemia to normoglycaemia show a considerable level of uncertainty, indicating possible fluctuations in this evolution. The equilibrium distribution or long-term behaviour are the estimated percentage of time the system will spend in a specific state following an endless series of transitions is reflected in likelihood. The most stable condition is indicated by the steady-state probability of roughly 44.97%, indicating that the system is expected to primarily live in the normoglycaemia state. On the other hand, states such as mild hyperglycaemia and moderate hyperglycaemia have smaller but statistically significant steady-state probability, suggesting that they remain in the system throughout time. The likelihoods also reveal more nuanced details, like the relatively small but less significant existence of the hypoglycaemia and serve hyperglycaemia states.

Mean recurrent time$=\begin{pmatrix} 61.578750 & 2.223824 & 3.067981 & 5.931898 & 25.279698 \end{pmatrix}$

The discrete-time Markov chain (DTMC), mean first passage times (MFPT) matrix provides important new information on the temporal dynamics of state transitions. Every entry represents the anticipated time steps needed for the system to transfer from one state to another for the first time, offering a numerical assessment of pathway traversal and transition efficiency. Interestingly, shorter MFPTs: for example, from hypoglycaemia to normoglycaemia indicate more straightforward and effective transitions, whereas longer MFPTs: for example, from hypoglycaemia to serve hyperglycaemia indicate more intricate or uncommon paths. With the use of these insights, person can more effectively make decisions and manage systems across a variety of domains by being able to recognize crucial transitions, predict system behaviours, and plan actions to optimize transition pathways or reduce delays. The discrete-time Markov chain has a vector that shows the mean recurrence times for each state. This vector gives important information on how long the system typically stays in each state before going back to it. The internal dynamics and stability of the system inside each state are gauged by these mean recurrence times. As an illustration, mild hyperglycaemia shows a comparatively short mean recurrence time of about 3.07-time steps, indicating that the

system regularly returns to this condition. On the other hand, the hypoglycaemia and serve hyperglycaemia states show longer average recurrence periods, which suggests less occurrences of these states being returned to. By knowing these average recurrence times, person may assess the system's durability and resilience within each state, which helps guide interventions and decision-making processes targeted at controlling system stability or maximizing state transitions.

TPM non drinker

The non-drinker data analysis performed like drinker here we taken average of 13 patients, IPV=
$(0.006449764 \quad 0.383474273 \quad 0.386412498 \quad 0.177655153 \quad 0.046008313)$ Initial probabilities of various states in a model are represented by the initial probability vector. In this case, the vector's elements hypoglycaemia, mild hyperglycaemia, moderate hyperglycaemia, normoglycaemia, and serve hyperglycaemia each represent a distinct condition. These states probably relate to different categories or circumstances within a certain domain. For example, in a medical setting, they can stand for various illnesses or diagnoses. A state's initial probabilities are represented by the values allocated to it; hypoglycaemia has the lowest likelihood (0.006), and mild hyperglycaemia (0.386) has high chance. These probabilities provide insight into the initial distribution of states prior to any transitions or changes occurring inside the, and they can be used as the basis for additional research. The transition probability matrix (TPM), standard error matrix(SEM) and stochastic matrix (SM) are given.

$$TPM = \begin{pmatrix} 0.766666667 & 0.22222222 & 0.01111111 & 0 & 0 \\ 0.003925234 & 0.92728972 & 0.06841121 & 0.0003738318 & 0 \\ 0 & 0.06862018 & 0.87592730 & 0.0554525223 & 0 \\ 0 & 0 & 0.12182332 & 0.8354175071 & 0.04275918 \\ 0 & 0 & 0 & 0.1651090343 & 0.83489097 \end{pmatrix}$$

$$SEM = \begin{pmatrix} 0.0922958207 & 0.049690399 & 0.011111111 & 0 & 0 \\ 0.0008565562 & 0.013165302 & 0.003575911 & 0.000264339 & 0 \\ 0 & 0.003567393 & 0.012745565 & 0.003206902 & 0 \\ 0 & 0 & 0.007010144 & 0.018357499 & 0.004153138 \\ 0 & 0 & 0 & 0.016036807 & 0.036061797 \end{pmatrix}$$

$$SM = \begin{pmatrix} 0.006465637 & 0.3843462 & 0.3863166 & 0.1770261 & 0.04584542 \\ 0.006465637 & 0.3843462 & 0.3863166 & 0.1770261 & 0.04584542 \\ 0.006465637 & 0.3843462 & 0.3863166 & 0.1770261 & 0.04584542 \\ 0.006465637 & 0.3843462 & 0.3863166 & 0.1770261 & 0.04584542 \\ 0.006465637 & 0.3843462 & 0.3863166 & 0.1770261 & 0.04584542 \end{pmatrix}$$

Given the probability of transitioning between discrete states, the Transition Probability Matrix (TPM) is a tool for deciphering the dynamics of a chain. The possibility of changing from one state to another is indicated by each item in the matrix, providing detailed insights on the behaviour of the system over time. For example, a greater probability in a given transition denotes a higher frequency of that change occurring in the system. Through examining the TPM in conjunction with the initial probability vector, one may comprehend the complex patterns of state transitions and, as a result, obtain a thorough knowledge of the system's evolution and the relative importance of each state as it progresses. An indicator of the degree of uncertainty around the transition probability estimates in a Transition Probability Matrix (TPM) is the Standard Error Matrix. The standard error of the associated transition probability estimate in the TPM is represented by each entry in the matrix. A larger standard error, for instance,

denotes increased uncertainty in the estimated transition probability and raises the possibility that the real transition probability may differ more from the estimated value. On the other hand, a smaller standard error indicates more faith in the projected transition probability's accuracy. The robustness of the inferred dynamics inside the system and the accuracy of the transition probability estimations can both be evaluated by comparing the Standard Error Matrix with the TPM. The equilibrium distribution of states in a Discrete-Time Markov Chain (DTMC), which captures the model stability and long-term behaviour, every element in the final vector represents the percentage of time that the DTMC is expected to be in a particular state following a large number of iterations. As an example, a steady-state probability of roughly 0.0065 for hypoglycaemia indicates that, throughout time, this condition is predicted to remain present for about 0.65% of the system's existence. In a similar vein, the odds allocated to other states reveal information on their individual long-term prevalences

$$\text{Mean first passage time} = \begin{pmatrix} 0 & 5.377348 & 18.37958 & 54.175266 & 180.2279 \\ 657.4675 & 0 & 14.79856 & 50.582277 & 176.6349 \\ 680.3918 & 22.924316 & 0 & 36.035041 & 162.0877 \\ 690.7262 & 33.258754 & 10.33444 & 0 & 126.0527 \\ 696.7828 & 39.315358 & 16.39104 & 6.056603 & 0 \end{pmatrix}$$

$$\text{Mean recurrent time} = \begin{pmatrix} 154.663791 & 2.601821 & 2.588551 & 5.648884 & 21.812432 \end{pmatrix}$$

The resulting matrix captures the expected time, expressed in discrete time steps, for an average Discrete-Time Markov Chain (DTMC) represented by matrix to transition from one state to another. The mean first passage time (MFPT) between each beginning state and the target state is represented by each element in the matrix, providing detailed information about the temporal dynamics and effectiveness of state transitions in the model. A smaller MFPT, for example, indicates a relatively quick transition between two states, whereas a larger MFPT indicates a more complex or drawn-out journey. Analysts can identify significant transition patterns, evaluate the navigational effectiveness of the system, and make informed decisions about how best to maximize system performance or operational efficiency by determining these average passage times. The average time before a Discrete-Time Markov Chain (DTMC), represented by matrix returns to each state. These values provide information about the system's internal temporal revisitation patterns of states. For example, a mean recurrence time of roughly 2.59-time steps for mild hyperglycaemia shows that this condition is revisited frequently, but a larger time, like 154.66 for hypoglycaemia indicates longer stays between revisits. Determining these recurrence times helps evaluate the stability and cyclic behaviour of the system, which helps with resource allocation and system optimization decisions.

Probability Mass Function
The probability mass function was formulated based on occurrence and non-occurrence of state by raw method. For drinker and non-drinker similar but variation present in values. The data suggests that non-drinkers are significantly less likely to experience hypoglycemia compared to drinkers, hinting at a potential protective effect associated with abstaining from alcohol. The chance of normoglycemia has higher chance for non-drinker compare to drinker. Similarly mild hyperglycemia non-drinker has high chance. The highest likelihood state occurrence for drinker and non-drinker is moderate hyperglycemia and less chance for hypoglycemia. So, there is a high possibility to occur moderate hyperglycemia in both cases.

RESULTS AND DISCUSSION

In this work we examined the T2DM glucose levels of 26 patients in this study; 13 of them were drinkers and 13 were not. For comparison, the time series stochastic model Markov model was employed. hypoglycaemia, normoglycemia,

mild hyperglycaemia, moderate hyperglycaemia, and severe hyperglycaemia were the five states that were taken into consideration. By using a raw method, the probability mass function was created based on the likelihood that a specific condition would occur. According to the initial probability vector, drinkers are more likely than non-drinkers to experience normoglycemia. According to the transition probability matrix, there is a good likelihood that the subsequent state will occur within fifteen minutes. Drinkers have a higher risk of normoglycemia than non-drinkers, according to the stationarity matrix. The average first transit time indicates that there is a low probability of hypoglycaemia to normoglycemia, moderate to mild hyperglycaemia, and medium to moderate hyperglycaemia when moving from one condition to another in the drinker and non-drinker matrix. In both scenarios, the mean initial passage time is comparable, but there are steps that differ. The average return time indicates the duration of a state at a specific state; a short mean indicates the majority of mean state occurrences. In the drinker matrix, mild hyperglycaemia in non-drinkers is more common than normoglycemia. In the discussion, our study compares glucose levels between drinkers and non-drinkers using a Markov model. We found that non-drinkers have higher average glucose levels than drinkers, suggesting that alcohol consumption may impact glucose regulation. These results align with prior studies linking alcohol intake to impaired glucose metabolism. The Markov model provided a good framework for understanding glucose level transitions over time. However, the study's limitations include potential confounding factors such as diet and physical activity not accounted for in the model. Future research should incorporate these variables to validate and extend our findings.

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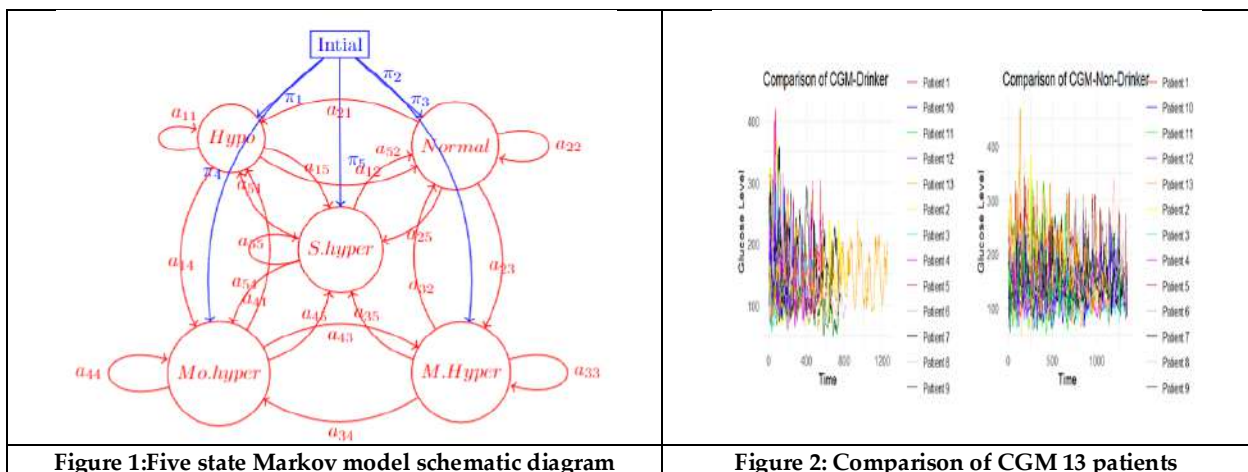
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Table 3:Summary of statistics

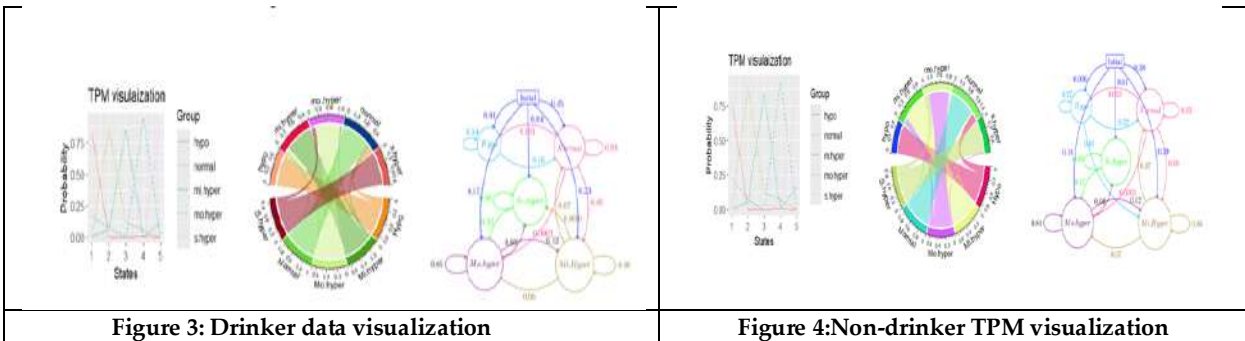| Measure	Sample	size	Mean	1st Qu	Median	3rd Qu	Min	Max	St.dev	Cov	Skewness	Kurtosis
Non-drinker	13	13954	151.1	115.2	142.2	174.6	48.6	468.0	49.0634	0.3247	1.1127	4.6907
Drinker	13	7768	145	108.0	133.2	172.8	50.4	419.4	51.0738	0.3522	1.2028	5.1184

Table 2: :Probability mass function table

State	Hypoglycemia		Normoglycemia		Mild. Hyperglycemia		Moderate. Hyperglycemia		Serve. Hyperglycemia	
	Non-occurrence	Occurrence	Non-occurrence	Occurrence	Non-occurrence	Occurrence	Non-occurrence	Occurrence	Non-occurrence	Occurrence
Drinker	0.9838	0.0162	0.5508	0.4492	0.6744	0.3256	0.8313	0.1686	0.9596	0.0404
Non-drinker	0.9934	0.0066	0.6164	0.3835	0.6059	0.3940	0.8300	0.1699	0.9540	0.0460

| **Figure 1:Five state Markov model schematic diagram** | **Figure 2: Comparison of CGM 13 patients** |

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Figure 3: Drinker data visualization	**Figure 4:Non-drinker TPM visualization**

REVIEW ARTICLE

Exploring Herbal Remedies: A Promising Frontier in Combatting Antimicrobial Resistance

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ABSTRACT

Exploring the potential of herbal remedies as a viable solution to combat antimicrobial resistance (AMR) underscores the urgency for innovative strategies amid the diminishing effectiveness of traditional antibiotics. Herbal medicine, deeply rooted in diverse cultural traditions, offers a rich repository of bioactive compounds renowned for their antimicrobial efficacy, presenting a promising avenue in the battle against AMR. This review examines a selection of herbs known for their historical uses in traditional medicine and their emerging roles in modern healthcare. Notable examples include extracts from plants such as *Eucalyptus globulus*, and *Ocimum sanctum. L, Terminalia chebula, Curcuma longa, Morinda citrifolia*, and *Allium sativum*, which have demonstrated antimicrobial activity against a spectrum of pathogens. These herbs contain bioactive compounds, such as Eucalyptol, Eugenol, chebulagic acid and chebulinic acid, curcumin, and Scopoletin which exhibit antimicrobial properties and, in some cases, act synergistically with conventional antibiotics. Furthermore, the review explores the mechanisms these herbal compounds operate, including disruption of bacterial cell membranes, inhibition of essential enzymes, and modulation of immune responses. Additionally, we discuss the potential challenges and opportunities associated with integrating herbal remedies into mainstream healthcare practices, emphasizing the importance of rigorous scientific investigation and standardized formulations. The findings suggest that herbal remedies may serve as adjuncts or alternatives to conventional antibiotics, offering a sustainable and holistic approach to mitigate the escalating threat of AMR. Further research is warranted to elucidate the efficacy, safety, and optimal usage of these herbal interventions, paving the way for a more diversified and resilient arsenal against microbial infections. As we confront the complex

landscape of AMR, harnessing the therapeutic potential of herbs holds promise for developing novel strategies to combat infectious diseases and preserve the efficacy of existing antimicrobial agents.

INTRODUCTION

Antibiotics, whether naturally occurring or synthesized, are antimicrobial agents employed to address bacterial infections by either eradicating the bacteria or impeding their growth. Healthcare professionals frequently prescribe these compounds to counteract bacterial infections in human and animal subjects[1–3].The term "antibiotic" originates from the 1890 term "antibiose," coined by Paul Vuillemin to describe the hostile actions of microorganisms. Initially, it referred to antagonistic interactions between microorganisms like fungi against bacteria or bacteria vs protozoa. Over time, it evolved to include naturally occurring secondary metabolites with inhibitory or lethal properties against bacteria or fungi, now including engineered compounds.[4]Antibiotics have saved lives and significantly impacted medicine and surgery by preventing or treating infections in patients undergoing chemotherapy, dealing with chronic conditions like diabetes, end-stage renal disease, or rheumatoid arthritis, and recovering from complex surgical procedures like organ transplants or joint replacements [5].

Anti-Microbial Resistance (AMR)
It stands as a pervasive global health challenge, imperiling the effective prevention and control of bacterial, viral, parasitic, and fungal diseases.[6] This phenomenon unfolds as microorganisms, encompassing bacteria, viruses, fungi, and parasites, adapt and develop resistance to antimicrobial interventions, a consequence of misguided or excessive usage in both human and animal communities.[7–9]. To effectively address the threat of antimicrobial resistance, we must understand its causes and factors. While resistance naturally occurs in microorganisms, human activities in healthcare, agriculture, and the environment contribute to its emergence. [10]The spread of resistance is influenced by factors like infection control, sanitation, water quality, access to reliable antimicrobials, and travel patterns. Simply removing antimicrobial use may not be enough, as resistance doesn't always come with a fitness cost. To tackle this issue, a comprehensive approach is needed, considering resistance at various levels-mechanism, micro-organism, drug, (11)host, and context. This requires broad research spanning healthcare, agriculture, and the environment, with integrated strategies mindful of potential unintended consequences. The goal is to ensure global access to effective antimicrobials while minimizing resistance.[12,13].

Global Prospective on AMR
Antimicrobial resistance (AMR) is a global health threat causing 700,000 deaths annually due to overuse and misuse of antibiotics in human health, agriculture, and animal husbandry. It could increase to 10 million deaths by 2050 if not addressed. The economic burden of AMR is substantial, with estimates estimating costs of up to $100 trillion by 2050 if left unchecked.[14]Developing countries face increased vulnerability to resistant infections due to limited healthcare and sanitation facilities, and the emergence of multidrug-resistant pathogens like MRSA and XDR-TB, complicating treatment and increasing mortality risk.(15)The antibiotic resistance crisis requires a multifaceted approach, including improved surveillance, stewardship of antimicrobial use, development of new drugs and therapies, and investment in healthcare infrastructure. Collaboration between governments, healthcare providers, pharmaceutical companies, and the agricultural sector is crucial for effective strategies. Public awareness campaigns are also needed to educate individuals about responsible antibiotic use and infection prevention. Future research into novel antimicrobial agents, precision medicine, and innovative technologies is promising. Global efforts and sustained investment are needed to mitigate the threat.[16]

Causes of Antimicrobial Resistance

Overuse: Antibiotic abuse is common due to its widespread availability and unprescribed nature, compounded by online shopping. Incorrect prescriptions promote the formation of resistant bacteria. 30-50% of cases involve incorrect prescriptions for treatment indication, agent selection, or therapy duration. The Karolinska Institute in Sweden found a pathogen in 89% of CAP patients. Additionally, 30%-60% of antibiotics in ICUs are deemed unnecessary or inappropriate [11].

Agricultural Usage: Antibiotics play a vital role in agriculture, accounting for 80% of total use in the United States for cattle growth and prevention. They support animal health, boost yields, and enhance product quality. However, human consumption of cured meat can propagate antibiotic-resistant bacteria across the food chain. Genetic identification studies suggest that up to 90% of drugs are excreted and spread through urine, skin, and agricultural runoff. Personal hygiene solutions may decrease the immune system's reaction to environmental antigens.[17]

Limited Supply of New Antibiotics: The pharmaceutical industry's efforts to create new antibiotics have been delayed due to financial and regulatory obstacles. Major firms have stopped studying antibiotics, and mergers have reduced research staff. Academic funding for antibiotic research has also been reduced due to budget cuts and economic disincentives. Affordability, medical community recommendations for cautious usage, and concerns about drug resistance all contribute to the lack of economic attraction [18].

Regulatory Obstacles: Between 1983 and 2007, new antibiotic approvals fell due to regulatory changes, ambiguous regulations, and poor communication. The FDA has rigorous standards for designing clinical trials, including ethical restrictions on placebo research. Phase 3 clinical research is more complex and expensive, necessitating the involvement of smaller companies. In 2013, the Infectious Illness Society suggested a Limited Population Antibiotic Drug (LPAD) protocol and issued guidelines to improve clinical trials for acute bacterial skin and skin-structure illnesses.[2,11]

Herbs Used to Prevent Amr: The primary focus in treating respiratory, urinary tract, gastrointestinal, and biliary infections, as well as skin issues, has been on utilizing the essential oils of certain plants, rather than their extracts. For instance, *Melaleuca alternifolia*, commonly known as tea tree oil, is widely employed as a therapeutic remedy for skin problems, including acne and various infectious conditions [20].

Mechanism of Action of Herbs: which contain bioactive substances such as alkaloids, flavonoids, terpenoids, and essential oils, have antibacterial properties because they can disrupt cell membranes, impede cell wall formation, block protein and nucleic acid synthesis, and produce reactive oxygen species (ROS) within microbial cells. These antioxidant activities contribute to the antibacterial characteristics. Some herbs also have immunomodulatory properties, which improve the host's immunological response and aid in the successful battle against microbial infections [22].

METHODOLOGY

A comprehensive literature review was conducted using the search terms: antimicrobial antibiotic or antibacterial and synergy and plant or herb or natural. The search encompassed electronic databases such as Ebsco HOST, Pub Med, and Science Direct, as well as specific journals including Planta Medica and Phytotherapy Research. Inclusion criteria comprised studies on synergy between plants exhibiting antibacterial properties, either alone or in combination with antibiotics, published in peer-reviewed English-language journals between January 2000 and May 2023. Notably, this review excluded the extensive body of synergy research from Traditional Chinese Medicine and investigations into the antimicrobial efficacy of essential oils. Additionally, the reference lists of identified studies were manually scrutinized, and supplementary research was pursued online.

Eucalyptus globulus

Eucalyptus, originating from Australia, is renowned for its potent antimicrobial qualities [23]. Derived from its leaves, eucalyptus essential oil contains eucalyptol, a compound effective against bacteria, viruses, and fungi. In respiratory distress syndromes (RDS) like pneumonia or influenza, eucalyptus oil's antimicrobial attributes aid in symptom relief and combatting infections [[24,25]. Inhaling eucalyptus oil vapours or utilizing it in steam therapy helps clear airways, reduce inflammation, and alleviate breathing difficulties associated with RDS.(26) The innate antimicrobial properties of eucalyptus render it widely utilized in both traditional and alternative medicine for managing respiratory ailments.[27,28] A study involving E. globulus, also known as fever tree, found that chewing gum containing 0.6% E. globulus ethanolic leaf extract significantly improved several gingivitis outcome indicators.[29]The study explores the antibacterial properties of crude plant extracts against Porphyromonas gingivitis, a periodontitis-causing bacterium. The extracts from the *Eucalyptus globulus* leaf, *Azadirachta indica* leaf, *Glycyrrhiza glabra* root, and Rheum palmatum root showed MICs ranging from 64 to 1024 mg/L. The study also identified the anthraquinone rhein and its antibacterial activity. *P. palmatum* root extracts showed an extremely low MIC of 0.125 mg/L, suggesting further research for periodontitis treatment.[30]. *Eucalyptus globulus* essential oil, along with xylitol and papain compounds, effectively inhibited *Pseudomonas aeruginosa*, *Salmonella* sp., *Staphylococcus aureus*, *Proteus vulgaris*, *Escherichia coli*, and *Candida albicans in in vitro* tests. The oil showed better inhibition than chlorhexidine, while papain 10% had lower effectiveness against *Candida albicans* [31]. The study investigated the antimicrobial potential of *Eucalyptus globulus* essential oil (EOEG) against seven fish pathogenic bacteria from cultivated olive flounder. The disc diffusion method, minimum inhibitory concentration (MIC), and minimum bactericidal concentration (MBC) were used to evaluate the inhibitory effects. The results showed a concentration-dependent increase in the size of the inhibitory zone with increasing EOEG concentrations. EOEG's MIC ranged from 7.8 to 125 mg/mL, with MBC values ranging from 62 to 250 mg/mL. The study indicates that EOEG, a natural phenolic compound, exhibits antibacterial properties against all seven bacteria, indicating its potential as a potent antimicrobial agent for treating bacterial infections in aquaculture fish.[32]

Ocimum sanctum. L.

Ocimum sanctum, also referred to as Holy Basil or Tulsi holds a cherished place in traditional Indian medicine for its therapeutic qualities.(33) Originating from Southeast Asia, it is globally cultivated for its fragrant leaves, cherished in herbal preparations, teas, and culinary delights.(34) Holy Basil is esteemed for its potent antimicrobial attributes, attributed to its abundant reserves of essential oils, flavonoids, and diverse bioactive compounds.[35] Research indicates that extracts derived from *Ocimum sanctum* exhibit extensive antimicrobial efficacy against a spectrum of pathogens, encompassing bacteria, fungi, and viruses.[36] This remarkable antimicrobial potency has spurred considerable interest in both pharmaceutical and herbal medicine circles.[37,38]O. *sanctum* L. (Tulsi) gel, a plant extract, demonstrated significant antibacterial action against anaerobic oral microorganisms at concentrations of 20 and 25%. A higher concentration was effective in treating periodontitis, proving its potential as an efficient supplement. The study suggests that O. sanctum L. gel could be a promising traditional supplement for treating periodontal diseases, despite limitations and resistance of traditional treatments, highlighting its potential as a viable option in oral healthcare.[39]Cancer research is exploring alternative therapies, with around 30 natural substances being tested in clinical studies. Tulsi, also known as Holy Basil, is a cost-effective and religiously significant medicinal plant in India. Its essential oil contains bioactive components like camphor, eucalyptol, eugenol, alpha-bisabolene, beta-bisabolene, and beta-caryophyllene, linked to antibacterial effects. Tulsi, also known as the "queen of herbs" and "elixir of life" in Ayurvedic medicine, has anticancer properties in its leaves, high in eugenol. Clinical trials are ongoing to explore Tulsi's anticancer, chemo-preventive, and antioxidant properties.[40]The study tested the antifungal and insecticidal properties of *Ocimum sanctum* L. essential oil using a model involving hazardous organisms. Toxigenic and pathogenic filamentous fungi were used as exemplary fungal groups, while *Spodoptera littoralis, Culex quinquefasciatus,* and *Musca domestica* were chosen as model insects. The study found that *Ocimum sanctum* L. essential oil, containing linalool, t-methyl cinnamate, and estragole as phenylpropanoids, is an efficient botanical insecticide with significant environmental benefits [41]. Dental caries is a common issue involving Streptococcus mutants and Lactobacillus acidophilus, but their side effects are significant. *Ocimum sanctum L.*, a plant with a long history in traditional medicine, has potential as an alternative. Despite limited research on its

antimicrobial effects, an ethanolic extract showed a significant inhibitory effect against these microorganisms. The minimum inhibitory concentration (MIC) for Streptococcus mutants was 2.5%, while for Lactobacillus acidophilus it was 10%. This suggests *Ocimum sanctum* L. is a promising antibacterial agent.[42]

Terminalia chebula

Terminalia chebula, commonly referred to as "Haritaki" or "Black Myrobalan," holds esteemed status in traditional Ayurvedic medicine for its multifaceted healing attributes.[43] Originating from Southeast Asia, this botanical gem is renowned for its potent arsenal of antioxidants, tannins, and polyphenols, which underpin its robust antimicrobial efficacy. Scientific inquiry has revealed that extracts derived from Haritaki possess a wide-reaching antimicrobial spectrum, combating bacteria, fungi, and viruses alike.[44,45] Its antimicrobial prowess is rooted in its adeptness at disrupting microbial membranes, impeding enzyme function, and disrupting microbial DNA replication.[46] This comprehensive profile renders *Terminalia chebula* a cherished natural ally in the battle against infections while nurturing holistic well-being.[47] *Terminalia chebula,* an Indian herb, is a highly effective therapeutic agent with diverse applications. The fruit, dubbed the "King of Medicines," contains phytochemicals such as sterols, resin, amino acids, flavonoids, and tannins. The plant's primary polyphenols exhibit antibacterial properties against both gram-negative and gram-positive bacteria. T. chebula fruit extract contains antioxidants, anticarcinogens, antidiabetics, and anti-aging compounds. [48] *Terminalia chebula* Retz, commonly known as Haritaki/Myrobalan, is a traditional herbal remedy with roots in Unani, Tibb, Ayurveda, and Siddha. It has a wide range of medicinal uses, including antioxidant, antiproliferative, antibacterial, proapoptotic, antidiabetic, anti-aging, hepatoprotective, anti-inflammatory, and antiepileptic characteristics. It affects glucose and lipid metabolism, which reduces atherogenesis and endothelial dysfunction. Its constituents include bioactive compounds with antioxidant, antiaging, anti-inflammatory, antidiabetic, and cardioprotective activities.[49]Antibiotic resistance is caused by the misuse of antimicrobial medications for treating infectious diseases. Herbal medications like *Terminalia chebula*, known for their medicinal activity and Ayurvedic use, have emerged as a potential solution. A study found that solvent-free organic and aqueous extracts from *T. chebula* fruits inhibit microorganism development, lowering infection risks and aiding healing. The methanol extract demonstrated notable bactericidal effects and robust antioxidant activity, while the aqueous extract had lesser antibacterial efficacy but moderate antioxidant activity.[50]This study compared the antibacterial and antioxidant properties of ethanolic extracts from *Terminalia chebula* fruits and leaves. The ethyl acetate fraction showed higher levels of TPC and TFC in both fruits and leaves. It also displayed higher antioxidant properties in DPPH radical scavenging and FRAP experiments. The ethyl acetate fraction of fruit extracts outperformed other fractions in terms of antibacterial activity.The ethyl acetate portion of *Terminalia chebula* leaf extracts demonstrated significant antibacterial activity, supporting its historic folk medicine use and scientific evidence for its antioxidant and antibacterial properties.[51]

Curcumin longa

Turmeric, scientifically known as *Curcumin longa* and belonging to the ginger family, originates from Southeast Asia and is widely grown for its rhizomes, utilized both as a culinary spice and in traditional medicine.[52]. Its primary bioactive component, curcumin, demonstrates robust antimicrobial attributes against a spectrum of pathogens, encompassing bacteria, viruses, and fungi. Research illustrates its effectiveness against prevalent microbes such as Staphylococcus aureus, Escherichia coli, Candida albicans, and even certain drug-resistant strains. Curcumin's antimicrobial prowess arises from its capacity to disrupt microbial cell membranes, hinder enzyme function, and intervene in microbial signaling pathways, thus holding promise as a natural remedy against infections.[52,53] Curcumin, a plant-derived polyphenolic chemical, exhibits diverse antibacterial properties due to its unique structural characteristics and antioxidation products. It stops bacterial growth, suppresses virulence factors, interrupts biofilm formation, and prevents adherence to host receptors. Curcumin also acts as a photosensitizer, inhibiting growth when exposed to blue light. Its synergistic properties are demonstrated when combined with other compounds. This analysis provides a theoretical foundation for natural antibacterial agents.[54]. The work aims to improve curcumin by producing Nano curcumin nanoparticles (2-40 nm) by a wet-milling approach. Nanocurcumin demonstrated better water dispersibility and increased antibacterial effectiveness against a variety of bacterial and fungal species, including *Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa*, Penicillium

notatum, and *Aspergillus niger.* It also shows greater antibacterial effects than antifungal properties.[55]. Curcumin, a bioactive compound in turmeric, has numerous therapeutic properties, including antioxidant, anti-inflammatory, antibacterial, antifungal, and antiviral activities. However, its effectiveness as an antimicrobial agent needs further investigation, particularly against clinical and multidrug-resistant (MDR) isolates. A study evaluated curcumin's effectiveness against over 100 strains across 19 species using the broth microdilution method. Gram-positive bacteria showed greater sensitivity, while MDR strains of certain bacteria displayed high MICs. Curcumin demonstrated selective antibacterial activity against specific species and strains, indicating its potential as a promising antibacterial agent.[56] Curcumin (CUR), a turmeric derivative, has antimicrobial properties and can be used as a photosensitizer in Photodynamic Therapy (PDT). However, its hydrophobicity, instability, and bioavailability limit its therapeutic potential. To address these issues, various drug delivery systems (DDSs) have been explored. The study evaluates various DDSs, including Colloidal formulations, metallic and mesoporous particles, graphene, quantum dots, and hybrid nanosystems. Both free and encapsulated CUR show broad-spectrum antibacterial action, low cytotoxicity, in vivo biocompatibility, and enhanced wound healing. Clinical trials are lacking, indicating the need for further research for practical infection clinical scenarios.[57]

Morinda citrifolia

Noni, scientifically known as *Morinda citrifolia*, is a tropical fruit-bearing shrub indigenous to Southeast Asia, Australia, and Polynesia. Revered in traditional medicine for its multifaceted health advantages, Noni boasts a nutritional profile brimming with vitamins, minerals, and antioxidants, which underpin its acclaimed therapeutic properties. [58] Studies indicate Noni's capacity to combat a spectrum of microbial threats including bacteria, fungi, and parasites, owing to its array of bioactive constituents such as anthraquinones, polysaccharides, and flavonoids. [59]. The antimicrobial prowess of Noni suggests promising avenues for infection management and holistic wellness, yet further investigation is essential to elucidate its mechanisms and clinical utility.[60] The study evaluated the antibacterial efficacy of extracts from *Morinda centifolia's* leaves, fruits, and seeds using the disc diffusion method. Five accessions were tested against five bacterial pathogens. The seed extract showed the most significant inhibitory effect (12.23 mm), surpassing leaf and fruit extracts. *E. coli* and Pseudomonas species were inhibited by all extracts, but Salmonella species, *Staphylococcus aureus*, and *Klebsiella* species did not. [61] The study investigates the prevention of bacterial spot, a major disease in passion fruit trees caused by *Xanthomonas axonopodis* pv. passiflorae, which leads to significant annual fruit production losses. Extracts and bioactive substances from endophytic fungus found in noni (*Morinda citrifolia*) are investigated. Nine fungi, including Guignardia mangiferae NF17, show the best inhibitory findings. Sydowinol and Sydowinin A, along with the acetonitrile extract from G. mangiferae NF17, show significant antibacterial action against X. axonopodis passiflorae strains.[62] *Morinda citrifolia,* a traditional Polynesian medicinal plant, was investigated for its antimicrobial potential. Extracts from dried and powdered leaves were prepared using solvents like benzene, chloroform, ethyl acetate, ethanol, and water. The antimicrobial activity was tested against *E. coli, Staphylococcus aureus, Candida albicans,* and *Aspergillus niger* using the disc diffusion method, showing inhibitory effects on all tested organisms.[63]Noni, a Pacific Island medicinal herb, has been shown to have strong antibacterial activity against *Escherichia coli* O157:H7 and *Salmonella Enteritidis*. The study extracted essential oil from ripe noni fruit using hydro-distillation and discovered a substantial inhibitory effect. The primary antibacterial components of noni EO were discovered by GC/MS analysis, with caprylic acid accounting for 82% of the volatile molecules. This study focuses on the antibacterial properties of noni EO.[64].

Allium sativum

Allium sativum, more commonly known as garlic, belongs to the onion genus and is esteemed not only for its culinary applications but also for its medicinal attributes.[65] Rich in allicin, a potent compound, garlic manifests remarkable antimicrobial characteristics upon crushing or chopping.[66] Allicin's release triggers antibacterial, antiviral, antifungal, and antiparasitic effects, as evidenced by studies demonstrating its efficacy against pathogens like E. coli, Staphylococcus aureus, and Candida albicans.[67] Garlic's widespread recognition as a natural remedy for diverse infections underscores its significance, although ongoing research endeavors persist in unraveling its complete therapeutic capacities.[68,69]Garlic is used as a medicinal plant by traditional practitioners in poor countries. The global drug resistance dilemma needs the search for alternative antibiotics, particularly those derived from natural,

plant-based sources. Allicin, a primary active component found in freshly crushed garlic, has numerous antibacterial effects. A study was done to determine garlic's antibacterial properties against typical strains of *S. aureus* and *E. coli.* Four solvents were utilized to extract the bioactive components from garlic. The highest inhibitory zone was discovered in chloroform, followed by water, ethanol, chloroform, and petroleum ether. E. coli was more susceptible to garlic extracts than *S. aureus*, showing garlic's potential as an efficient antibacterial agent against human pathogenic bacteria.[70,71] Garlic, a medicinal herb rich in sulphur compounds, is known for its antibacterial, anticancer, antioxidant, immunomodulatory, anti-inflammatory, and cardiovascular activities. The purpose of this study was to look into the in vitro antimycobacterial and antibacterial properties of several garlic extracts that had been enhanced with certain phytoconstituents. The extracts' activity was assessed using the Resazurin microtire plate test and the colony count method. The results showed that extracts rich in allicin and ajoene had significant antimycobacterial activity when compared to standard medicines. Garlic oil also shown strong antibacterial properties, particularly against methicillin-resistant *Staphylococcus aureus*. [73]An *in vitro* investigation on garlic extract's antibacterial effects on human dental plaque found that it suppressed all bacterial strains examined. The disk diffusion method was employed to test four different doses of garlic extract against *Streptococcus mutans*, *Streptococcus sanguis, Streptococcus salivarius, Pseudomonas aeruginosa*, and Lactobacillus spp. The results revealed that the 5%, 10%, and 20% doses produced similar inhibition zones that were much larger than the 100% extract. The study concluded that the 5% extract had equivalent effects, recommending more research into its potential benefits.(74)The study found that aged garlic has better antioxidant and antibacterial capabilities than fresh garlic. It exhibits higher total phenol and flavonoid content, increased DPPH, ABTS, FRAP, and H_2O_2 scavenging activities in the distilled water extract, and increased Fe_2 chelating activities in both fresh and aged garlic extracts.[75]

CONCLUSION

Exploring the realm of herbal remedies, which includes a variety of natural extracts such as *Terminalia chebula*, *curcumin* from turmeric, *lounga, eucalyptus, morinda citrifolia*, holy basil (*Ocimum sanctum*), and garlic (*Allium sativum*), reveals promising avenues for combating antimicrobial resistance. These botanicals have garnered attention due to their demonstrated antimicrobial efficacy in numerous scientific studies, coupled with their extensive historical use across diverse cultural settings. Despite the promising evidence, a comprehensive understanding necessitates rigorous scientific investigation, including thorough clinical trials. These trials are crucial for delineating the efficacy, safety profiles, and optimal dosages of herbal remedies against microbial infections, thereby addressing the growing challenge of antimicrobial resistance. This approach underscores the importance of evidence-based medicine in the development and deployment of herbal-based treatments. The fusion of ancestral knowledge with contemporary scientific methodologies represents a potent synergy that is poised to catalyze the emergence of ground-breaking herbal remedies. By integrating traditional wisdom with modern scientific rigor, researchers can unlock the full potential of herbal medicines in addressing antimicrobial resistance. Moreover, the augmentation of existing antimicrobial tactics with herbal remedies holds significant promise in global efforts to combat antibiotic resistance. Embracing this interdisciplinary synergy not only represents a transformative era for herbal solutions but also underscores the urgency of fortifying our collective response to the pressing issue of antimicrobial resistance. In essence, the exploration of herbal remedies as potential antimicrobial agents highlights the importance of evidence-based research, the fusion of traditional and modern knowledge, and the collaborative efforts needed to address the escalating challenge of antimicrobial resistance on a global scale.

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RESEARCH ARTICLE

Organ-on-a-chip Models: An Alternative in Experimental Pharmacology

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ABSTRACT

Experimental pharmacology examines the impact of various substances on animal species, identifying therapeutic agents, assessing toxicity, and understanding drug mechanisms and effects in pre-clinical and clinical settings. The complexity of biological processes and limited access to in vivo systems make it difficult to evaluate chemical harmful effects and potential therapeutic benefits on human health. Scientists use model systems like animals and simpler organisms, but these models are expensive, challenging to manage, and often have poor translational value due to interspecies differences. Organ-on-a-chip technology offers potential for clinical translation, drug development, and personalized intervention, addressing current pharmacological challenges, as microfluidic systems have advanced from basic sample handling to bioanalytical apparatuses. This review discusses microfluidic cell culture platforms for engineered tissue constructs, aiming to create a physiologically relevant microenvironment for drug screening studies. Recent developments focus on liver, heart, and lung, with progress in reproducing complex mechanical environments and developing electrical signals. Future studies should focus on creating complex architectures using human cells.

Keywords: Organ-on-a-chip, experimental pharmacology, lung-on-a-Chip, heart-on-a-chip, skin-on-a-chip, kidney-on-a-chip.

INTRODUCTION

In the field of experimental pharmacology, the impact of diverse pharmacological substances on diverse animal species is examined. Identifying a therapeutic agent acceptable for human use, researching a drug's toxicity, and learning more about a drug's mechanism and site of action are the three basic goals of experimental pharmacology. Finding new drugs or examining the effects of ones that already exist is the goal of experimental pharmacology. This is done in two main stages: pre-clinical experimental pharmacology, which identifies and optimizes novel chemical lead structures and tests them for biological effects on animals, animal tissues, and animal organs; and clinical pharmacology, which tests drugs on volunteers and patients to determine their pharmacokinetics, safety, and efficacy in humans. Organ-on-a-chip (OoC) technology has promise for enhancing clinical translation of fundamental research, expediting the development of pharmaceutical drugs, and offering tailored intervention approaches. The discussion of individual OoC systems centers on pertinent applications and emphasizes their capacity to address contemporary pharmacological research difficulties. Microfluidic systems have advanced from basic chemical sample handling instruments to bioanalytical apparatuses and complex cell culture systems in the past thirty years [1]. Because of the intricacy of the biological processes involved and the limited experimental accessibility to informative *in vivo* systems, evaluating the possible harmful effects of chemicals and the potential therapeutic benefits of medications on human health remains difficult. Because of this, scientists use model systems, which may be anything from single cells to animals like rats, mice, dogs, or primates as well as simpler model organisms like the worm *Caenorhabditis elegans* and the fruit fly Drosophila melanogaster. Although the most widely used animal models are very beneficial for studying (Patho)physiology in an *in vivo* setting and for supporting the preclinical development of therapeutics, they are also relatively expensive, challenging to manage, and, in the case of pharmaceutical preclinical testing, often have poor translational value because of interspecies differences [2,3]. Because of this, this review provides an overview and critical evaluation of recent developments in the area of OoC technology, including both single and multi-organ models, with an emphasis on their potential uses in experimental pharmacology. Figure 1 shows a model on OoC technology.

How might organ-on-chip decrease the need for animals while enhancing safety prediction?
OoC models are shown themselves to be more helpful in offering regulated *in vitro* environments for the study of intricate biological systems. Obviously, OoC adds complexity when compared to straightforward single-cell type *in vitro* tests. Larger biological domains seen in OoC often include a greater portion of another network, making it easier to analyze the relationships between each in the network that are relatively distantly linked. OoC's comparatively poor throughput, the intricacy of their kinetics (volume, duration, interactions between cell types), and the challenge of inter laboratory standardization are drawbacks for their use in regulatory toxicology, which exacerbates validation problems [4]. Furthermore, OoC do not provide definitive answers on detrimental health impacts at the level of the intact individual, akin to basic 2D *in vitro* tests. When utilized for hazard and risk assessment, OoC data still need interpretation in the larger context of physiology and toxicology [5]. The evolutionary strategy is similar to the current practice of swapping out individual animal tests with a group of non-animal techniques that collectively anticipate the endpoint that the animal test was intended to evaluate [6]. When standardized and approved non-animal methods are available, the evolutionary approach is used one step at a time. Comparing an alternative strategy to reference animal data is still used to see how well it predicts or can be used. The ICH (for medicines), the OECD (for chemicals), and EU guidelines (like the EMA) have already approved and validated a number of non-animal methods for testing for toxicity endpoints, such as genotoxicity, corrosion and irritation, and sensitization. For more complicated outcomes, such as acute toxicity, repeated-dose toxicity, carcinogenicity, reproductive toxicity, and neurotoxicity, there aren't enough approved non-animal approaches. On the other hand, the innovative method begins with the discovery of significant metabolic or molecular pathways associated with human illness. The purpose of the tests is to find important rate-limiting stages in physiological systems (networks) that cause toxicity by messing up chemicals [7,8]. This technique establishes relevance based on physiological relevance, which is a measure of how well a test strategy or method covers the key molecular network events that generate toxicity. A test procedure's

prognostic power is its ability to forecast whether a chemical may disrupt this network to the point where it causes long-term negative consequences [8]. The goal of both the evolutionary and revolutionary approaches is to shift the focus of toxicology and pharmacology from mostly using animal experimentation to primarily using human physiology. OoCs have the remarkable ability to mimic human physiology, which is one of their main advantages. This is particularly important when using whole tissues rather than isolated cells since it allows for direct interaction between cells as well as between cells and external elements like the extracellular matrix. Comparing these interactions to a suspension culture where individual cells do not have direct touch should result in a pharmacologic or toxic response that more closely mimics the in vivo environment. Additionally, the ability to apply shear stress, drain waste products, and have a dynamic supply of nutrients should improve compatibility with the in vivo environment. Furthermore, ongoing reaction monitoring is made possible by the OoC's sensor integration. using a variety of methods to provide a complete picture of the pharmacologic or toxic response, such as concurrently evaluating the impact on cell metabolism [9]. Sensor technology allows for online electrochemical detection of several biomarkers, such as albumin and glutathione S-transferase, which are liver biomarkers, and creatine kinase, which is a cardiac biomarker, in addition to continuous monitoring of temperature, pH, and oxygen [11]. However, modest quantities and concentrations of signaling molecules, as well as their dilution, may provide difficulties for further analytics (dynamic range, background issue).

One of the main benefits of OoC over animal models is the ability to incorporate targets particular to humans, allowing for the identification of chemicals that have distinct pharmacological or toxicological effects exclusively in humans. The ability to combine (i) exposure/treatment, (ii) kinetics, and (iii) impact is another significant advantage of OoC. In a suspension cell culture, exposure and effect are immediately correlated, eliminating the need to assess kinetics. It is crucial that *in vitro* data be stated quantitatively in order to extrapolate the concentration response *in vitro* to the dose-response *in vivo* and provide quantitative predictions of dose-dependent unfavorable outcomes *in vivo*. This calls for a more thorough *in vitro* evaluation than the typical positive-negative chemical effect determination [10]. To translate *in vitro* exposures to *in vivo* exposures, kinetic modeling is also necessary. In addition to the compound's effects on the cells that make up the barrier, including any deleterious effects on the barrier function itself, the chemical or pharmaceutical's ability to flow across the barrier may also be assessed. Exposure, kinetics, and effect may all be combined in these models. Should the detrimental impact indeed transpire in a tissue other than the barrier, details on the kinetics beyond the barrier could be necessary. The tissue that makes up the barrier and the tissue where the negative impact occurs may mix in OoC [11].

Toward coordinated development and implementation of organ-on-chips
Human biology, engineering, and biotechnology are just a few of the fields that must be merged in order to imitate tissue, organ, or organ system structure and function for the creation of OoC. Many stakeholders must be included in order to fully realize the benefits of Outcome of Care (OoC) for toxicology and pharmacology, as well as to determine the next steps for the practical use of OoC in the safety testing of chemicals and the effectiveness and safety testing of medicines [11]. The European Union's Horizon (EUR) 2020 research and innovation program is supporting EUROoC, an interdisciplinary training network that aims to advance OoC technology in Europe. Its primary goal is to establish a network of application-focused researchers that are proficient in the creation and use of OoC technology [11]. By doing this, it hopes to foster creative research endeavors that, in turn, progress the creation of cutting-edge OoC systems. The development of OoC to more precisely anticipate medication safety and effectiveness in people is the program's main emphasis. To drive OoC toward acceptability and implementation in regulatory decision making, NCATS and other stakeholders, including FDA regulators and the pharmaceutical sector, developed public-private partnerships [11,12]. Talks about building trust in the technology's performance are required, since OoC is used to provide data that demonstrates safety. As a consequence, OoC technology may need to be modified to meet regulatory requirements. One benefit is that it will encourage conversation about updating toxicity and make room for new ideas.

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Current and emerging methods in toxicology and regulatory pharmacology

Animal tests have been and continue to be the traditional method used to evaluate the safety of industrial chemicals as well as the safety and effectiveness of medications. When it comes to medications, thorough clinical testing on human volunteers in good health is often conducted after animal research, and then patient testing follows. Safety testing follows a methodical, tiered process. First-in-human trials employ the safety data from repeated-dose toxicity studies to determine the starting dosages. To provide a first indication of human relevance, exposure levels in animal studies are compared to human exposure at the estimated maximum recommended human dosage (MRHD). If you want to use a model, make sure it is pharmacologically relevant. This means that it expresses the drug target and changes downstream effects in a way that is similar to humans, that it is compatible with the drug's pharmacokinetics (having a similar metabolic profile and good bioavailability), and that it is safe for the test species. International Conference on Harmonization (ICH)highlights the need to consider product-specific factors such as the non-metabolization of monoclonal antibodies and the general restriction of the model of choice to non-human primates due to the target sequence. To enable longer and longer clinical studies, sub-acute and chronic toxicity testing is started later (i.e., phase 2 and 3 trials). It is generally accepted that for animals undergoing acute, subchronic, and chronic treatment, a dose selection limit of 1000 mg/kg/day is sufficient [13]. Mechanistic features have gained significance in assessing the safety of chemicals and pharmaceuticals for human use in recent years. In the past, adverse health effects and the exposure levels at which they were identified in animal studies have been the main basis for chemical hazard and risk assessment as well as pharmaceutical safety review. A deeper analysis of the differences between species and the application of findings from animal research to human situations are made possible by an understanding of the effects and processes of chemicals [14]. Pharmaceuticals are now used mostly for prescreening purposes in safety evaluation, in order to determine if a chemical is promising enough to proceed with animal safety research before being determined to have undesirable features. Furthermore, mechanistic studies for certain functional properties of substances and pharmacodynamic analyses for medications have been using in vitro research more and more [15]. To help with the creation of suitable in vitro models for both drug and toxicity testing, multi-OoC models that simulate the interactions between many organs have been created. When it comes to drug screening, OoCs may verify the efficiency of the medication in treating the desired target pathways as well as the lack of hazardous consequences (by evaluating, for example, liver, cardiovascular, or skin toxicity) [16].

Lung-on-a-Chip Systems: Enhancing Disease Models via Biomechanics

Inhaled air flows from the conducting zone (trachea, bronchi, bronchioles) to the respiratory zone (alveolar ducts to alveoli sacs) in the respiratory system for gas exchange [17].0 All things considered, the lung lobules are divided into segments, which are distinct functional units made up of an artery and a bronchus [18]. Lung and respiratory system pathologies include cystic fibrosis, bronchitis, lung cancer, chronic obstructive pulmonary disease (COPD), and asthma [19]. Preclinical models for lung disorders in humans are currently based on ex vivo lung tissue or in vivo rodent models, which can only partially replicate human pathologies [20,21]. Although tissue availability limits ex vivo approaches, they offer an interesting substitute for existing animal models by simulating the cellular architecture, structure, function, and dynamics of airway contraction relaxation in millimeter-thick lung slices of living lung tissue [22]. Moreover, the short experimental time frame of days to weeks for testing explant cultures poses a significant challenge for long-term research on chronic illness scenarios. Recent developments enable the in vitro reconstruction of human lung tissue and related disorders. Lung-on-a-chip models may stimulate epithelial development and physiologic functioning by simulating breathing movements using stretchy membranes [22].

The topic of "lung-on-a-chip systems," or micro-physiological models for human lungs, had its start in 2010 when Huh et al. created one of the first biomimetic microfluidic lung models that could subject alveolar cells to dynamic stretching. To make a copy of the alveolar-capillary interface, human alveolar epithelial cells are grown on top of a porous, flexible poly-dimethylsiloxane (PDMS) membrane, and microvascular endothelial cells are grown on the bottom. The gadget simulates breathing movements in the cell cultures by stretching them repeatedly and providing suction to pneumatic passages on each side of the membrane [23].

Valid Models for Pharmaceutical Screening

The liver is the biggest internal organ in humans and plays a role in detoxification, drug metabolism (first pass effect), and other metabolic processes that control blood sugar, bile formation, and the synthesis of several plasma proteins, including albumin. Anatomically speaking, the liver is composed of liver acini, which are the liver's functional units made up of liver sinusoids and linked to a sophisticated network system that includes the bile ducts, portal vein, hepatic artery, and central vein [24]. Pharmaceutical research focuses a lot of attention on the liver because of its general significance in drug metabolism [25]. The liver is an important organ that is highly regenerative and plays a crucial function in protein synthesis and xenobiotic metabolism. Notwithstanding, several factors such as medications, poisons, viral infections, cancer, and traumatic traumas may still cause irreversible tissue damage and reduction of liver function, ultimately culminating in end-stage liver disease or abrupt liver failure [26,27]. Human liver slices and mouse animal models have been utilized extensively up to this point in pharmaceutical research for drug screening, toxicity testing, and pathophysiology investigations on fatty liver disease, both alcoholic and non-alcoholic.For a variety of organotypic complexity, basic methods for recapitulating liver function utilizing liver on a chip devices may be identified. Kang et al. created an organotypic fusinusoid on a chip system to enhance biomimetic design. They did this by adding a simpler liver model taken from animals to study the propagation of the hepatitis B virus (HBV). The main features of the liver sinusoid, such as cellular architecture, biodynamic angiocrine stimulation, and parenchymal zonation, were demonstrated in a different study using a liver-like microfluidic device called "Exoliver culture." It also showed a different response to acute treatment with known hepatotoxic drugs than those observed in conventional culture platforms. Hepatocytes may also be co-cultured with other support cells, such as endothelial cells. Liver-on-a-chip platforms are organotypic models that recapitulate liver functions for basic science using a variety of cell types and co-culture techniques; however, because the biochips only have one or two individual liver units per chip, these biomimetic systems are not scalable for high-throughput experimental setups [28].

Heart-on-a-Chip: Determining the Positive and Negative Effects of Medicines in Health and Illness Heart

Maintaining cardiac physiological functioning is largely dependent on the biomechanical environment, structural complexity, and exposure to dynamic stimuli of the heart. We can carefully manipulate each of these parameters using microfluidic *in vitro* platforms, which allows us to investigate heart physiology and a variety of diseases such myocardial infarction, arrhythmia, or cardiomyopathy [29]. Nonetheless, the heart is a crucial target tissue for any drug development and interaction investigation because of the high morbidity of cardiac illnesses and the frequent side effects of medications. One of the main benefits of OoC technology over conventional *in vitro* systems is tissue for drug research and cardiac function monitoring utilizing on-chip and off-chip sensor techniques. Figure 2 shows a model of heart-on-a-chip platform.

Combined Epidermis Full Skin Thickness Models: Skin-on-a-Chip Systems

The skin, the largest organ of the integumentary system, is the body's first line of defense against external effects. *Ex vivo* skin models are used for drug testing due to their ability to represent the hierarchical structure of the barrier. However, their application is limited by tissue accessibility and short-term survival. To overcome these limitations, companies like StratiCELL, J-TEC, Cell Systems, Henkel AG, Biosolution KO, and Episkin have invested in creating full-skin and epidermis versions of these models. Additionally, significant progress has been made in the development of microfluidic skin-on-a-chip models, such as Alexander et al.'s skin-on-a-chip system that measures extracellular acidification rates and TEER in an air-liquid interface setting. Sriram et al. developed a mass-producible four-layer platform based on polymer polymethyl methacrylate (PMMA) to produce skin equivalents with minimal hydrogel shrinkage [30]. PEG-fibrin-embedded fibroblasts were used to generate dermal equivalents, followed by N/TERT-1 keratinocytes co-cultured on the apical side. It will be necessary for future on-chip skin models to take into consideration both the neurological and immunological systems in order to produce a miniature version that closely mimics physiological skin [31]. According to Lee *et al*. [32], organoid technology may be used to generate skin appendages such as follicles and glands, which should be taken into account when designing skin-on-a-chip systems from an anatomical perspective. The regulation of fluids, temperature, and external stress depends on these structures. Moreover, biomechanical cyclic strain should be taken into account for future models, much like the lung-

on-a-chip approach, because loading is essential for maintaining skin homeostasis and overuse may trigger fibrosis pathways [33,34].

Kidney-on-a-Chip: Assessing Drug Efficacy and Nephrotoxicity
The internal circulation's equilibrium is mostly maintained by the kidney. It controls blood pressure, preserves vital nutrients, keeps pH at a physiological level, and gets rid of waste products like medicines and their metabolites. As a result, the kidney experiences a high metabolic turnover rate, a big cardiac output volume, extended concentration abilities, and effective chemical trafficking, all of which may heighten the kidney's susceptibility to drug-induced unfavorable effects. Acute kidney damage occurs in a clinical context, and 20% of cases of acute kidney injury are brought on by kidney toxic medicines [35,36]. This indicates that the present protocols for evaluating drug toxicity need to be strengthened. Kidney dysfunction brought on by adverse drug reactions is still a crucial factor to take into account while developing new medications. It is crucial to note that because of the apparent differences in medication pharmacokinetics and pharmacodynamics between humans and animals, standard *in vivo* animal trials are especially restricted when it comes to assessing therapeutic effectiveness and nephrotoxicity. Human kidney-on-a-chip systems have recently been created in a number of forms that mimic the kidney tubule microenvironment and have shown similarities to *in vivo* medication nephrotoxicity outcomes. Researchers may assess and monitor different drug-induced biological reactions using kidney-on-a-chip systems [37], indicating possible advancements in disease modeling and drug lead optimization research. However, there are still some bioengineering obstacles, mostly related to recreating the intricate architecture, cellular makeup, and matrix composition required to accurately simulate kidney function at an organotypic level. Other kidney-on-a-chip technologies use milli fluidic systems to connect organoids while they are flowing to increase the body's supply of endothelial progenitor cells and build vascular networks with mural cells around perfusable lumens [38]. Compared to controls that didn't move, vascularized kidney organoids grown under flow had more mature podocyte and tubular compartments, as well as better adult gene expression and cell polarity. We can now study kidney development, illness, and regeneration in new ways because we can make kidney organoids much more vascularized and help them mature morphologically in a lab setting while they are flowing. Chemical substances are also eliminated via the kidney and/or biliary system, which is a factor that is often disregarded and affects the body's medication concentrations. Figure 3 discuss the active stimuli including fluid shear stress, compression and cyclic stretch that are incorporated into kidney-on-a-chip models.

Barrier Function, Transport Characteristics, and Neuroinflammatory Model: Blood-Brain- Barrier-on-a-Chip
A highly selective barrier, the blood-brain barrier (BBB) maintains the separation of the circulatory blood from the central nervous system (CNS). It is vital to preserve brain homeostasis by tightly regulating the movement of molecules and ions [39]. Nevertheless, the BBB is the largest barrier to cerebral medication delivery because of its complicated selectivity, which also prevents possible treatments from reaching their intended target in the brain [40]. Consequently, the goal of several investigations using OoC technology has been to decipher the BBB's Four different chip designs (sandwich, parallel, tubular structure, and vasculogenesis design) have been created for BBB-on-a-chip systems throughout the years. Using a porous membrane to divide the top and bottom channels, the sandwich design attempts to replicate the classic Transwell-type arrangement. Typically, astrocytes, pericytes, or other CNS cells are seeded in the bottom channel, while endothelial cells are sown in the top channel. Owing to its arrangement and the low transparency of porous membranes, only sophisticated confocal imaging methods are possible for imaging [40].

Multi-Organ on-Chip Models: Combining Tissue Models to Evaluate Pharmacokinetics, Pharmacodynamics, and Drug-Drug Interactions
Currently, over 70% of medication attrition and removal from the market are caused by drug-induced toxicities in the liver, heart, kidney, and brain. Off-target interactions or the medication's increased binding to toxicity-prone cells are common causes of adverse drug responses [41]. An effective method for examining the pharmacokinetic profiles of pharmacological molecules is the use of linked multi-tissue cell culture models, as deficient pharmacokinetics (PK) and pharmacodynamics (PD) are major contributors to therapeutic failure. For example, as described by Shinha et al

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[42], drug-to-drug interactions were examined by combining the experimental data obtained from the Multi-OoC (MOoC) with a mathematical PK–PD model. The effects of CPT-11 metabolites, an anti-cancer prodrug, on lung cancer cells were studied in depth. The ability of simvastatin and ritonavir to block the metabolism of CPT-11 was examined in order to assess drug drug interaction and the ensuing changes in drug concentration and metabolic capacity. The MOoC that was shown had a lung cancer component (A549 cells), a stirrer-based micropump coupled via micro-channels, and a pro-drug metabolizing liver portion (HepG2 cells). In the end, it was indicated that the combination of the PK–PD model and the MOoC is a helpful technique to anticipate adverse effects of medications. Drug-specific parameters were obtained by a combination of a simulated PK–PD model and the experimental data, exhibiting similar results. The effects of the anti-cancer drug 5-FU and the two pro-drugs of 5-FU (CAP and tegafur) were assessed in terms of intestinal absorption, hepatic metabolism, and growth inhibition in cancer and connective tissue in a more sophisticated, pneumatic, pressure-driven, four-organ system made up of intestine, liver, cancer, and connective tissue models [43]. Additionally, to replicate in vivo absorption, distribution, metabolism, and excretion behaviors, Maschmeyer *et al*. incorporated skin biopsies in a four-organ system made up of a liver, gut, skin, and kidney model [44]. These tissue types are very important to evaluate multi-organ medication interactions since cardiac and liver toxicity are the main reasons for post-approval drug withdrawals [45]. A MOoC platform, for example, was reported by Oleaga *et al*. [46] and enabled the investigation of a long-term co-culture of hepatocytes and cardiomyocytes.

CONCLUSION

This review discusses microfluidic cell culture platforms for engineered tissue constructs, which aim to create a physiologically relevant cell culture microenvironment for drug screening studies. Recent developments focus on the liver, heart, and lung, with progress in reproducing complex mechanical environments and developing electrical signals for monitoring cardiac cells. Future studies should address creating a physical microenvironment with complex architecture, using human cells, and minimizing in vivo animal experiments. Microscale engineering technologies can combine multiple organ constructs on a chip, making systems more physiologically relevant than current in vitro models.

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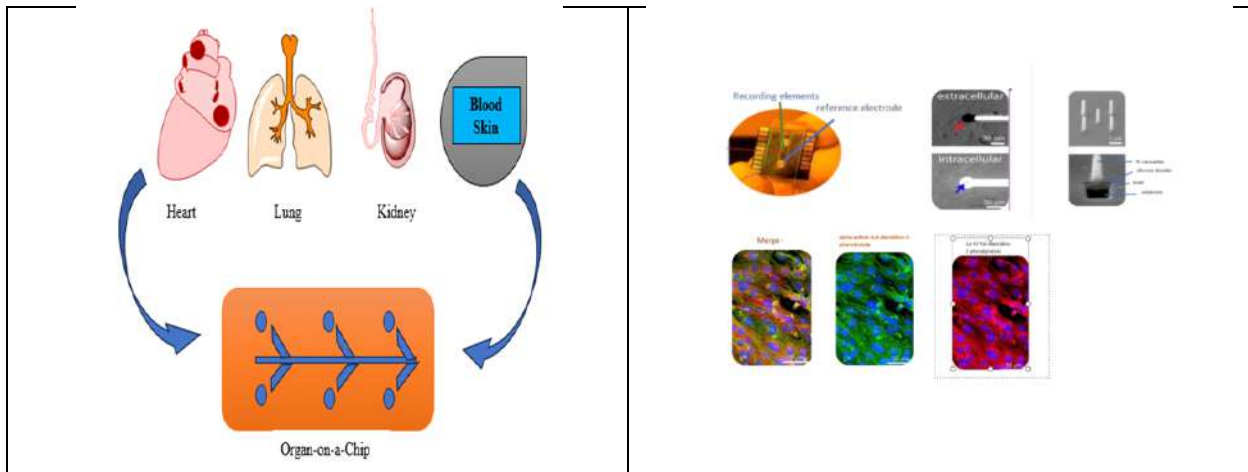
Hisana Thasneem *et al.,*

Figure 1: Organ-on-a-Chip model

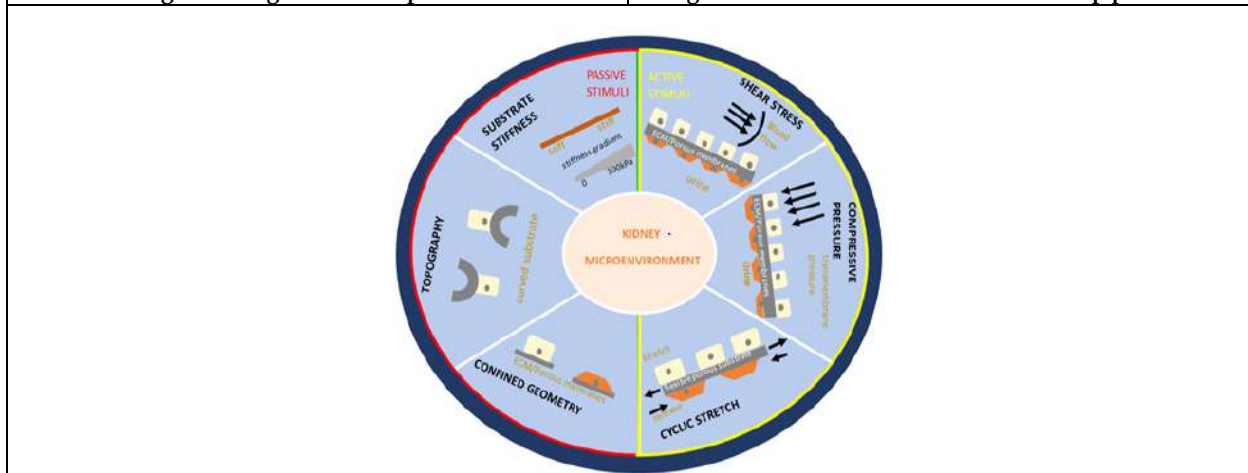**Figure 2: Overview of the heart-on-a-chip platform.**

Figure 3. The mechanical stimulation delivered to cells to replicate the physiological surroundings and the renal cell microenvironment. ECM: Extracellular Metrix [47].

REVIEW ARTICLE

A Comprehensive Review on the Recent Applications of Fuel Cells

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ABSTRACT

Fuel cells are an ingenuous environmentally friendly technology that has numerous uses across various fields and industries. These are electrochemical systems which convert chemical energy into electrical power in a way that is efficient and reduces emission. Fuel cells made of hydrogen are able to be used in a variety of application options ranging from portable energy sources to massive energy production. This makes hydrogen fuel cells excellent for use as mobile power sources as well as energy production in transport applications including zero-emission mobility vehicles that have a longer distance of travel. Fuel cells provide quick refueling time and less carbon dioxide emissions than conventional internal combustion engines. This makes they a cost-effective and greener alternative to the traditional engines. Technology for fuel cells is able to be used in a variety of applications in various industries and fields; it are a huge amount of writing on these technologies. This article provides a glimpse into certain of the key studies conducted in the development of fuel cells.

Keywords: Fuels Cells, Hydrogen, Regenerative, Bio, EV, PEMFC.

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INTRODUCTION

Fuel cells are the most cutting-edge, green technologies that have attracted significant attention because of their ability to change sectors and lead to the creation of a more sustainable energy future. Although traditional power generation using combustion methods generate emissions-intensive power generation, the fuel cells offer a green alternative to energy that has lower emissions output and are highly efficient in cost and emitting zero waste. This article provides an introduction and overview of what fuel cells are and their many uses across a variety of sectors and uses. They operate on the most simple of principles: changing the chemical energy of the oxidizer and fuel to electrical energy by electrochemical reactions. They are typically which are powered by hydrogen or oxygen in the air. Hydrogen serves as both the fuel source as well as an oxidizer. As hydrogen splits into protons and electrons, protons travel along proton-conductive electrolyte while electrons make their way out through external circuitry to form electrical current - until eventually reaching their cathode where these combinations will combine again to produce water and heat as byproducts of their reactions with protons/electrons/oxidizer combination as byproducts of their electrochemical reactions resulting in water and heat byproducts as byproducts of their combined actions. The fuel cells have proved their value in a variety of application areas due to their remarkable abilities: from marine transportation applications (ie propulsion for ships) and medical application to automotive and energy storage. Transport: Fuel cells have been leading the way in the transition to a zero-emissions transportation revolution.

Hydrogen fuel cells (FCVs) run on hydrogen fuel cells, which produce energy onboard to drive with electric motors that are driven through fuel cell technology. FCVs provide long driving distances and quick refueling time, as well as zero emissions from tailpipes, which makes them a desirable alternative to vehicles powered by internal combustion engines. Stationary power generation Fuel cells can be used in stationary power applications for producing electricity and heating for commercial, residential facilities, and industrial. Cogeneration systems that make use of CHP as well as cogeneration cells techniques improve efficiency of energy as well as providing useful heat for reducing the greenhouse gas emission. Backup Power Solutions The fuel cell technology are reliable power backup solutions for critical infrastructures such as data centers, data centers and other emergency operations. They are quick to start up and long-lasting operation makes the ideal tools for providing continuous electricity during grid interruptions. Fuel Cells for Off and Remote Energy: Fuel cells supply crucial electricity in areas that have access to electricity grid might be restricted or not available, such as telecom infrastructure remote monitoring devices as well as military equipment that requires continuous power 24 hours a day, 7 days a week. They are reliable sources of power that can provide vital solutions like monitoring the telecom infrastructure devices, as well as secure sources for power needs of military equipment. Manufacturing and Industry Fuel cells have been found to have wide-ranging applications in processes that need the highest temperatures to produce heat like the production of metals or chemical processing. The solid oxide fuel cell (SOFCs) as well as the molten carbonate fuel cell (MCFCs) are used in cogeneration as well as for process heating and process heating applications, respectively. Aerospace fuel cells are an integral part of aerospace technology, providing lightweight but energy efficient power to UAVs that are not piloted (UAVs) and spacecraft mission that require extended operation compared to combustion engines or batteries. Hydrogen Production A fuel cell plays vital roles in generating hydrogen which is a green and diverse energy source. Electrolysis that makes use of renewable energy breaks water down into oxygen and hydrogen, and any leftover is then put into fuel cells, or for future use. The fuel cells are an essential role in the transition to a low-carbon and sustainable energy sources, due to their flexibility, effectiveness as well as their low environmental footprint providing attractive alternatives across various sectors, and offering an opportunity for a sustainable and cleaner energy to come in the near future.

LITERATURE

Fuel Cell Vehicles incur higher expenses for capitalization as compared to Battery Electric Vehicles and also are susceptible to significant costs depleting in the future. When you distinguish the two types of Fuel Cell Vehicles and

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Battery Electric Vehicles. Battery Electric Vehicles can travel with greater speed ranges when compared with conventional automobiles and are fuel efficient with a brief fueling time, i.e. about three minutes[1].The idea behind this is to determine the specific area to particular resistance simultaneously using the solid Oxide Fuel Cell Interconnect issues in Fuel Cells, 2019, vol.19, no.5.This procedure supplies the complete method for working out the output of coatings as a specific area resistance. This method was supported by the 100 and 2000 hours of Area-specific resistance measurements of uncoated and coated 22 steel samples. It was intended to confirm the resistance perception and chromium capabilities, as well as the corrosion and coating of steel specimens coated with specified terms that replicate a realistic collection of a single structure[2]. It is widely known the fact that SOF cell systems are suggested for Ammonia applications. This study aims to study the operation and stability of Ammonia decomposition reaction using Nickel catalysts that are based on nickel and also the auto-thermal Ammonia cracker utilizing the Co-CeZr catalyst for composite oxides studied. It was found that direct NH3-fueled Solid Oxide fuel cell load was able to be regulated for 1,000 hours at 770°C, without major reductions[3].If the market expansion in micro-combined Heat power systems is examined, it could aid in achieving the energy goals of the strategy and meet atmospheric commitments. The research has shown that in the past and in the misperceptions given that the biological clock produces the greenhouse gas of a micro Combined Heat and Power systems can be found under a gas heat pump[4]. Production of power and the extended durability of solid oxide powered by ammonia fuel cell systems are studied using Solid Oxide Fuel Cell stacks comprised of 30 anode planar-powered cells. Three operating techniques are employed, which include direct ammonia, external decay, and auto-thermal decomposition. The result of auto thermal decomposition in conjunction with other methods using ammonia-fueled mass has an impressive strength when used in continuous methods and The efficiency of energy conversion is 57%[5]. Jacobson [6] conducted a study of components such as the solid oxide fuel cell that has an important function that demands operating temperatures between 500-800 degrees Celsius. Furthermore, it is important to know the type and characteristics investigated in this procedure. Fernandez et al.[7] studied the idea of carrying anode in H+-SOFC material that employs the triple conductor (H+/O2/e) oxide (TCO) for cathode for H+-SOFCs. The stability of single cells is demonstrated. Mermelstein *et al*. focused on the creation and demonstration of the reversible fuel cell. The extra grid energy, which is produced by renewable sources is delivered to the operating system via electrolysis, and it generates H2.Sunfire creates a variable element of the solid oxide cell with an efficiency of 50 kW for SOFC or 120 kW for the electrolysis process and generates 3.5 kg of H2 every hour. Wiebe in collaboration with [9] studied ways to increase the advantages of fuel cells in reducing hydrogen consumption.

This article outlines the functioning of electrochemical hydrocarbon compressors that facilitate the retransformation of hydrogen. It is found that installing an electrochemical blower that has hydrogen compressors can reduce the amount of hydrogen waste, removing approximately 95% of the waste and the production of a fuel cell can be increased. Debruijn et al.[10] have stated that with the modification of flow designs and stack design, voltage debasement is reduced to the minimum level that is possible. It is possible to achieve this by using those who have constant load conditions with fuel that operates at to evaporation of nearly 100 percent, as well as a temperature of a maximum of 75 degrees Celsius. The result will be greater profit and reduce your financial prudence as well as strength. the primary factor to figure out how to achieve profits. Pivac et al.[6] prove that it is possible to decrease the time spent in soak. Evaluation of the temperature of cells using Ice resulted in high-yielding and improved results. The outcomes of the increased stress test set-ups comprise the efficiency of voltage, followed by specific electro catalyst debasement, and returns each 2,500 voltage cycle for a previously-conditioned 50cm2 fuel cell. Varcoe et al.[11] have validated the use of radial approaches for making use of membranes that exchange anion with alkali to overcome the problems with direct methanol fuel cells. the advantages and disadvantages of the direct electrochemical oxidation process of the backup fuel are also discussed, as is the use of alkaline membranes in these fuel cells, which could improve effectiveness and productivity. This paper discusses the debasement mechanisms made up of nickel-yttria stabilized zirconia electrodes used in solid oxide cells, predominantly electrolysis cells of solid oxide. The investigation of the writing data reveals several different and at times, contesting the debasement status is a consequence of the cooperation between the and the loss contacts between Nickel and **particles of** Yttria stabilized zirconia electrodes as well as Nickel-Nickel particles[12-13[12-13]. Durability is the most important issue to be resolved before the materialistic proton exchange membrane-based fuel cells can develop. This article examines

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the techniques for debasement of membranes, electrodes, as well as bipolar plates[14and 14.Tai et al.[15] focused on the advantages and the approach to additive manufacturing that allows for an advantage in the output of fuel cells. Principally, the dares and assignments to improve performance are suggested. Taner et al.(16) attempted to make hydrogen gas energy by using innovative technology that charges reactions through electrolytic motions and to research a device that generates electricity using hydrogen. Viitakangas et al.[18] have demonstrated that the deficiency effects of toluene Proton Exchange Membrane Fuel Cell are ignored up to at least 20ppm. Then it goes up to 50ppm for toluene within hydrogen fuel. The principal goal of increasing the efficiency of fuel-cell electric vehicles is to increase their endurance. To allow for the development of Pt deposition, a process of debasement begins. The spaces between MPL and a catalyst layer saturated with water can be recommended to serve as the point from which to begin the Pt deposition[8].Energy balance in a Ballard proton exchange fuel cell membrane is examined in this study. A transient phenomenon occurs when the PEMFC stack loads when it is a result of warming up it is triggered when you connect the Proton Exchange Membrane Fuel Cell stack to a direct current or Alternate Current inverter. The results of experiments on a higher PEMFC stack's performance are also discussed[9]. The capability of MECs to react 0.9 million cubic meters of wastewater every day, to meet the European Standard for Chemical Oxygen Demand removal during winter temperature is being debated. The cathode's efficiency is below ten percent, and the hydrogen that is produced was generated for more than a hundred and twenty-seven days [20].Winkler et al.[21] described the creation of heat engines for fuel cell hybrids and combustors using different techniques being studied and developed. A combination of two subsystems creates hybrid fuel cells like fuel cells and heat engines. create hybrids from fuel cells[21]. Energy is a major component of human existence. is a key element as a factor, the need for energy rises and forms an integral part of energy generation.

Energy sources that are required include a fuel cell, which is a natural resource. This means that energy is generated at a lower cost than conventional electricity grids. In MATLAB, the modeling of fuel cells is carried out. The purpose of this research is to analyze and model the properties that the hydrogen fuel cells provide as well as the efficiency of the Product Identity controller for the fuel cell that uses hydrogen is the goal of this study[22].Tao *et al.* The study concludes the study by investigating the possibility of using liquid tin as a technique to lessen the harmful effects of pollution from coal, so if a method for reducing risks in a technological solution that directly converts coal by using fuel cells [23].Reinert et al.[24] presented a method to determine the use of fuel for a cell's load using the voltages of cells for different fuel types. The method used to determine the fuel usage in most of the tests isn't the same as that of the fuel used. Dimitrova et al.[25] examined the impression of electric vehicles equipped with range extenders that follow that allow the freedom of the vehicle to be expanded. Also, it examines the stability of the energy produced by different species of fuel cells that are charged with bioethanol. There are three ways to achieve the conversion of ethanol. These are Form 1: improvement of the bio-ethanol inside the outside refiners and hydrogen, as well as its transformation into an alkaline fuel cell. Form 2. : enhancing bio-ethanol within the refiner's outer layer to hydrogen and the transformation it undergoes in the fuel cell made of solid oxide Form 3: In the solid oxide fuel cell, you can see directly altering the bioethanol. As a result, we know that the most efficient design is form 3.The version 3 is more efficient in delivering power to the fuel cell. A fuel cell that is paired using a small quantity of oxidant and fuel is the ideal battery.

The fuel cell which is stationary from several angles is believed to last for 40,000 hours as a primary battery. They are employed for continuous tasks or work and are the most common type of battery used is used for short-term use. In the course of battery dispensing for a single cycle, debasement is not completely separated from the power generation. Debasement in a battery could be observed clearly, more than the process of processing. For the fuel cell, may be different from a battery, the process that causes debasement can't be controlled by the current efficiency of its density. The lifespan, as well as the capacity that a fuel cell loses capacity cell, is dependent on how the cell operates[26]. Three ways to define the manufacturing of fuel cells.1)thermal efficiency is a measure of the efficiency of exegetics, and 2)Area Specific Resistance is measured through the rate of variation of the exergetic efficiency.3)It is power density, which could be correlated with the potential economic value of the fuel cell [27].Wachsman et al..[28] observed that if hydrogen is considered a fuel cell, the majority of fuel cells increase in size and expand. Fuel cell machinery is now akin to hydrogen-related machinery from a general perspective. As a result of the study, the

development of equipment for fuel cells has risen as well as decreased in general an economy that is based on hydrogen which has restored the fossil fuel subordination. For this efforts are focused on the aggregation process of metal-supported cells, direct deposition including seal and stack technology, and low-temperature sintering low temperatures ceramic. The elements are being incorporated in low loads that are being developed at IFCI to help carry the power of materialistic technology. In the meantime, Direct deposition technology has been developed rapidly and has reached the point that 5x5 metal cells can be made with sintering temperatures that are below 800 degrees C. The outcomes of this work will be presented, along with the path of progress at IFCI [29].The purging control scheme of action as well as the thermal management mechanism for the fuel cell was proposed by Wei and al.[30] .We can now determine how fast the fuel cell can initiate the fuel cell in thirty degrees Celsius. Experimental results indicate that the power output of the fuel cell ranges between 42 to 75 percent of capacity, while the wasted heat usage accounts for 32 to 100 percent of total power. The fuel cell made of solid oxide was 10 micrometers thick, and also a Nickel Secondary Domain Controller anode that had a thickness of 15 micrometers. The thickness was reduced by screen printing, co-firing and casting. Cells that had a cathode surface of 16cm2 demonstrated the highest electrochemical capability at temperatures of 600°C and a maximum power density 0.9W/cm2 that was achieved with hydrogen fuel[31The thickness was replaced by co-firing, screening printing and casting. Narayana et al.[32] concentrated on three novel fuels for direct-oxidation-type fuel cells.

They are trioxane dimethoxyethane, and trimethoxymethane. The fuel cells by oxidation process uses carbon dioxide as well as Methanol. Modern fuels are utilized with no further process to direct-feed electrolyte fuel cell. Shanbhag et al.[33] focused on studying aspects that impact the production of the future as well as longevity of the fuel cell according to the different views of the present. Based on the research currently conducted that is conducted in the cells that produce fuel, variables like pressure, temperatures and other topics like corrosion fuel and oxidant insufficiency the chemical reaction, humidity and insufficient management of water are among the major factors that result in poor production. In the process of making fuel cells, there is to overcome the problems and methods that could increase the efficiency and longevity of fuel cells. Solid-state supporting metal oxide semiconductor-compatible glucose fuel cells, with carbon nano broadcasts with various ratios of Carbon-Nitrogen-Hydrogen and glucose solution were inquired in this paper. The fuel cell has been built using materials which are biocompatible with humans. It has OCVs of 442 mV as well as an CNH ratio of 3 weight percent. advancements in the manufacturing of fuel cells that are CMOS compatible are being made as well as the variables that impact the fabrication of these fuel cells have been identified[34]. The method is employed to investigate the openwork power output as well as the efficacy of various solid oxide fuel cell technologies. The results of this inspection are part of the investigation are the capacity to perform and the efficiency of Energy Conversion Networks of interest and the various liquid fuel cells made of solid oxide in multi-loop electrical networks, intelligent grids, and microgrids.

Energy Conversion Network topology is an important factor in determining the overall system efficiency of the solid oxide fuel cell which is why the technique used during this research is used. The process is an excellent instrument to analyze the primary role that of role that solid oxide fuel cells perform in the present [35-36].This research explores various kinds of micro-electro-mechanical Systems of microfluidic fuel cells as they demonstrate direct formic acids in microfluidic fuel cells which consume oxygen as an antioxidant. Three-dimensional micro-fluid fuel cell design was analyzed with Computational Modeling the transport and electrochemical processes were portrayed using the absorption media flow and hydrodynamic equations. Then, the electrochemical reactions, charge equation, and mass transport. The solid oxide fuel cell provide the most effective method to meet additional energy needs. Solid oxide fuel cells that operate in single chamber mode have shown various advantages over single-oxide fuel cells because of their complex, compact and sealed structure. This model is able to be employed to create a single-chamber system with solid oxide fuel[37].Single-chamber solid oxide fuel model is applicable to every. With the immense demands on energy, it's been recognized that scientists face global demands to answer the problem. Wind and solar energy is the primary source of fossil fuels' capability to be used as an alternative. The research has created models that could be considered as the largest engineered system that can reconstruct the temperature of fuel cells in addition to energy circulation. It was found how the energy density is dependent on the fuel cell's mode is as high as the flow rate of oxygen and hydrogen and hydrogen [38]. The simulation of proton exchange fuel cell are presented in this paper and

is applicable to various transport-related applications. The simulation was conducted by using MICROSIM PSPICE for modeling the fuel cell, thereby reducing costs of testing. The fuel cell has been paired with a converter that regulates the output voltage. Additional circuit ideas are proposed that can allow for the creation of a practical and efficient fuel cell vehicle[39].Proton Exchange Membrane fuel cells perform in a different manner unlike the phosphoric acid fuel cell. They function by making distinction between similar events and also to differentiate. The process of development is slow with Proton Exchange Membrane Fuel Cells. Insufficient membranes, as demonstrated in the Plans prevented the PEM device from being chosen for a successor to the space programme. In this piece we'll discuss the main debasement issues regarding Proton Exchange Membrane fuel cells and in particular the necessity of balancing the application of Phosphoric Acid Fuel Cells as well as those found that are used in Proton Exchange Membrane fuel cells[40]. Biotechnology research has shown that there are many opportunities for the production of gaseous and liquid fuels. Ethyl alcohol production was extensively conducted and studied using fluid fuels. This research focuses on the implementation of modern technology for the study of biotechnological methods and techniques that can be used to make liquid transportation fuels[41].Motwani et al.[41] devised an idea for the microbial production of 2,3-butanediol using water hyacinth the weed of nuisance that is composed of WH dried in sunlight which is then crushed, followed by the alkaline reaction at high temperatures as well as fermentation, and finally an enzyme-driven hydrolysis process. Vaccarino et al.[42] have demonstrated the use of the worn-out grape marc and vinasse, which is a hazardous waste of alcohol that results in grape marc.

A thorough and extensive analysis will be necessary to assess the viability of the entire process [43].Navarro et al.[44] examined research on Linear as well as quadratic equations to determine the relationships between carbon and organic matter and found that high r values, important at a 99 percent level, were found. Hydrocracking dimers are lignin-related to each other including benzyl-phenyl ether, 4hydroxydiphenyl diphenyl ether, and diphenyl ether. methane diphenylmethane biphenyl, dibenzyl, and 2-hydroxyphenyl in and out of catalysts. It was conducted at various temperatures. These results demonstrate the importance of the relationship between scented rings that have a catalyst or without one. catalyst that has phenolic hydroxyl collections that do not have biphenyl relationship availability. It is possible to split them in temperatures from 450 to 600 degrees Celsius[45].The principal goal of Felseghi et al.[46] research is to demonstrate the practicality factors and potential of using hydrogen as a substitute for energy sources to be used in applications, as well as to identify the possibility of expanding the use of hydrogen for stationary use. The research process was a SWOT analysis. cell that produces electric power through the chemical process of converting hydrogen and oxygen to water is called a fuel cell. It's a more eco-friendly and green alternative to energy, which is why it's an indispensable subject for study. This article offers a quick analysis of two types of fuel cells, as well in their connection to the sustainable management of resources i.e.,1) Electrolyte-based polymer membrane fuel cell 2.)Reversible Fuel Cell[47].This study was conducted in Libya which is also called" the Renewable Energy Authority of Libya created to help support the development of energy resources that are renewable in Libya in order to boost the use of renewable energy to between 6 and 10 percent over the next year. The research offers information for anyone who is looking for information on energy sources.

The research paper says that there's an abundance of progress in the development of alternative energy resources in Libya especially wind and solar[48] . WangaKen *et al.*The work [49] demonstrates the use of a polymer electrolyte membrane fuel cell, that converts the energy contained in hydrogen in an efficient and timely manner to electrical energy, with only one byproduct – water .A lot of effort has been taken to advance polymer electrolyte membrane fuel cell technology as well as basic research issues such as heat and water control. This analysis is (1)showcasing the current state of the development of PEM fuel cells and its applications to stationary, transportation, as well as portable/micro power generation fields with a comprehensive overview of current state of the art and latest technological developments; (2) to describe the necessity for research fundamental on this subject and provide a solution to the fundamental role that research plays on fuel cell technology as well (3) to identify the main issues in the field of the development of fuel cell technologies as well as the requirements to conduct fundamental research shortly, and before commercialization of fuel cell technology[49]. Reversible fuel cells, commonly referred to as unitized fuel cells are reversible electrochemical systems that are efficient in fuel cell technology for the production of electricity as well as electrolysis to produce hydrogen or chemicals production. This article discusses the principles

and the development of electrolysis and describes the working principles, components as well as materials used in various Reversible Fuel Cells [50]Jonathon *et al.* The work [51] demonstrates the possibility that Renewable energy could be the answer to reducing global warming by less than two degrees Celsius. This paper points out the problems by thermo-electrochemical modeling and simulation of reversible solid oxide fuel cells. The reasoning behind the release of gas by equilibrium reactors that utilize electrolysis was investigated. The research was conducted and showed that increasing working temperature, as well as pressure may enhance the efficiency. Therefore, the efficiency of the entire cell varies in relation to temperature, which is dependent upon the pressure that is optimal[5252.Mayyas et al.[53] research cites for an example cost of depository energy in reverse-reversible fuel cell. Sabato et al.[54] have presented the characteristics of a new Na-containing glass-ceramic sealant with excellent thermomechanical properties. Mortazavi et al.[55] have recognized the 2-phase liquid gas pressure drop as an official trademark which is utilized for small passages. Pressure drops that are sustained by research are assessed against three types of pressure drop that are both two-phase. Kdoddathimmaiah et al.[56] reviewed Regenerative Fuel Cells. Regenerative fuel cells are available in two forms: Discrete Regenerative Fuel Cells, as well in Unitized Regenerative Cells. An URFC is a unit gadget which can operate simultaneously in Electrolyzer as well as fuel cell modes. The configuration enables permanent swapping of liquids as well as gases and heat between the two piles. This is the reason PEM URFCs have been the focus of numerous studies. This research article focuses on URFCs.

The alkaline fuel cell electrodes carry porous nickel and Polytetrafluoroethylene They can also be used as anodes. Electrodes are assessed under a range of situations throughout this initial process by using X-ray photoelectronscopy, as well scan electron microscopy that includes energy-dispersive X-ray spectrum and nitrogen adsorption [57]and nitrogen adsorption[57].Fuel cells that convert the energy of chemical reactions into electricity tend to be arranged based on the guidelines set by the electrolyte's function. The five most common kinds of technology include membrane-based electrolyte polymer cells, Alkaline fuel cell fuel cells that contain sulfuric acid, molecular carbonate fuel cells as well as solid-oxide fuel cell [58].The fuel cell is a solid oxide. Mesoporous carbon-carrying Platinum nanocatalyst was identified as a cathode and anode catalyst in the Polymer Electrolyte Membrane fuel cell.Oxygen depletion was detected by rotating disk electrodes as well as the rotating ring electrode method within acid media. Membrane electrode assemblies were arranged with Platinum used on MP for cathode and anode activators as well as the effectiveness of fuel cells was assessed [59]. Chinda et al.[60]research focused on studying tiny replicas of the Solid Oxide Fuel Cell which incorporates electrochemical reactions as well as Mass conveyance, which was technologically developed. The replicas were then evaluated using a method of comparing previous expectations from the technical ones.For the ionic and electronic conductor particles, the optimal volumetric ratio has been as well recommended. Research results prove that the solid Oxide Fuel Cell excess potential may be reduced productively by manipulating temperatures and pressure. This research has revealed the working techniques of the solid oxide fuel cells on the smallest scale and helps increase their Solid Oxide Fuel Cell production.

CONCLUSIONS

The fuel cells have a lot of promise and have the potential to transform many key industries. Below are some general findings regarding their application: Fuel cells play an integral part in the current green energy revolution. Transportation Change: Hydrogen fuel cell vehicles (FCVs) are an emission-free alternative to cars with internal combustion engines with extended driving distances that allow for faster refilling and helping to reduce pollution within urban environments. Effective Stationary Power Generation In the field of stationary power generation fuel cells have swiftly been recognized for their reliability in power and heating delivery with incredible energy efficiency. They are used in the combined power and heat (CHP) systems allows factories and buildings to become more energy-efficient while still being eco-friendly. Resilience and Backup Power: Fuel cells play a crucial role in protecting vital infrastructures by providing stable energy backup during grid disruptions. Remote and Off-Grid Solutions in remote areas or those that are off grid fuel cells can provide stable power solutions to support communication services as well as remote monitoring devices and even military applications. They offer a variety of advantages for manufacturing industries which rely on high temperatures for production to increase productivity

and require very extreme temperatures for the production process. Aerospace Progress Fuel cells have also been able to make progress in the aerospace industry, by powering UAVs and spacecraft during extended missions by using renewable sources such as hydrogen. Hydrogen Production: The fuel cells serve two functions in the production of hydrogen, both as a source of energy to fuel combustion, and also to aid in the electrolysis of water to produce hydrogen gas. There are still challenges to overcome There are numerous benefits, however the advancement for hydrogen infrastructure cost-cutting strategies, as well as finding safe sources for hydrogen remain challenges to their use. Resilience and Sustainability Energy-efficient fuel cells can contribute to sustainable goals through reducing carbon dioxide emissions and wasting energy resources and increasing the resilience of grids. The fuel cells have the potential to change the energy sector, offering low-cost green solutions for many applications. As technology improves and investments are made in the field of research and development PEM fuel cells have the potential that they can lead to sustainable practices and reducing environmental impacts and enhancing the durability of infrastructures that are critical and advancing green practices for energy consumption and production.

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REVIEW ARTICLE

Use of Metal Nanoparticles to Treat Periodontitis – A Review Article

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ABSTRACT

Periodontitis, a chronic multifactorial inflammatory disease, is hypothesized to be produced by the colonization of dysbiotic plaque biofilms in a susceptible host, which gradually deteriorates the supporting periodontal tissues. Periodontitis, one of the world's most common dental disorders, is currently the main cause of adult tooth loss. When periodontitis develops, it is treated by scraping mineralized deposits and dental biofilm off the tooth surfaces. Several studies suggest that non-surgical therapy considerably improves clinical and microbiological indices in persons with periodontitis. Despite dramatic improvements in periodontal parameters, some bacterial reservoirs frequently remain on root surfaces even after regular periodontal treatment. Periodontitis was treated with local or systemic antibiotics, as well as scaling and root planing. Because there are few new antibiotics on the market, many researchers are focusing on developing other means of treating periodontal bacteria. There is a delay in a research on the issue of nanoparticle (NP) toxicity, which is particularly concerned with mechanisms of action, while the field of nanomedicine develops. Metal nanoparticles are the most promising because of their strong antibacterial properties. Metal nanoparticles can be used as effective growth inhibitors in a range of bacteria, making them valuable in the treatment of periodontitis. In this approach, the new metal nanoparticles helped greatly to the creation of effective anti-inflammatory and antibacterial platforms for the treatment of periodontitis. This paper summarizes the existing therapeutic efficacy of different metallic nanoparticles on periodontitis. This information might be utilized to develop NP-based therapeutic solutions for treating periodontal infections.

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Keywords: Metal, Nanoparticles, Periodontitis, treatment, infection Nanodentistry

INTRODUCTION

Periodontitis is an inflammatory gum disease that damages the supporting tissue of teeth. It is characterized by the deterioration of periodontal ligaments (PDLs), the formation of periodontal pockets, and the resorption of alveolar bone. [1]This is frequently associated with a number of clinical conditions, such as gingivitis, loss of alveolar bone, PDL, and dental cementum degeneration. Gingivitis, the early stage of the disease, has the potential to progress into periodontitis, a more serious condition that causes cavities to form, a loss of clinical connection, and degradation of the alveolar bone.[2] Recent advancements in nanotechnology have made it possible to employ immunomodulatory nanoparticles (NPs) in regenerative dentistry techniques.[3]NPs' minuscule size allows them to infiltrate biological entities with great efficiency. Additionally, NPs are essential to antiviral therapy because they increase medication effectiveness and make it easier for hydrophobic medicines to be transferred.[4-6]Because of their tiny size (1–100 nm), NPs are able to enter tiniest lumen without difficulty and not killed, extending their duration of action and enabling greater progressive deliver of the medication.[5]NPs are used in a variety of applications, including as precise drug administration, sensors, antimicrobial agents in dentistry, antioxidants, larvicides, anti-cancer medications, mouthwashes, antibacterial agents in dentistry, and more.[7]Nanotechnology is used extensively in dental equipment, including enamel and dentin protection[8]. Metallic nanoparticles (NPs) initiate biomineralization by encouraging the remineralization of demineralized (caries-ridden) dental tissues[9]. Based on their capacity against inflammation of substances , metal nanoparticles have been shown in many studies to be an attractive new treatment option for periodontitis[10]. The use of metal nanoparticles (NPs) in the management of periodontitis was covered in this review article.

DEVELOPMENTAL FACTORS OF PERIODONTITIS
The main cause of periodontal disease is plaque biofilm on the dental and gingival surfaces. This condition is influenced by unhygienic behavioral factors, the oral cavity's internal environment, and the development of dental and gingival plaque. The primary keystone pathogen of the periodontal biofilm is *Porphyromonasgingivalis (P. gingivalis)*, which causes host immune responses that damage gingival tissues and resorb bone[11]. A person's response to a periodontal infection is heavily impacted by risk factors. Lifestyle factors that are distinct but modifiable risk factors for periodontal disease include things like drinking and smoking. Included are ailments like osteoporosis, metabolic syndrome, diabetes mellitus, obesity, and insufficient calcium and vitamin D consumption[12].

PERIODONTITIS TREATMENT METHODS
Opportunistic infections are the primary cause of periodontal disease in the majority of patients. The advantage of local delivery is that it can produce higher concentrations of drug at the intended site of action with lower doses, meaning fewer adverse effects. Syringes, irrigation equipment, dental gels, mouthwashes, and gentrifiers are a few examples. Individualized oral hygiene instructions, quit smoking initiatives, dietary changes, subgingival instruments for calculus and plaque removal, and local and systemic medication, and various surgical procedures are just a few examples of the strategies that fall under the category of therapeutic intervention[13].Another non-surgical periodontal treatment method is to control supragingival plaque with manual, sonic, and/or ultrasonic instruments. NPs can deliver specific drugs to certain tissues, cells, or pathogens inside periodontal pockets because of their small size. Moreover, they display antibacterial qualities by rupturing the membranes of bacteria, which eliminates the microbes [13,16].

NANOPARTICLES IN PERIODONTITIS
In general, smaller nanoparticles are more efficient in eliminating microbes. Metal nanoparticles (NPs) including gold (Au), silver (Ag), silver oxide (Ag_2O), titanium dioxide (TiO_2), silicon (Si), copper oxide (CuO), zinc oxide (ZnO), calcium oxide (CaO), and magnesium oxide (MgO) have been found to have antimicrobial action [17]. These NPs

produce reactive oxygen species (ROS), which can break down proteins, RNA, and DNA, making them harmful to microorganisms. Compared to other nanometals, Au NPs appear to be less hazardous to human cells due to their antibacterial effect not being dependent on reactive oxygen species[18]. Metal NPs eliminate the biofilm[19]. When it comes to metal nanoparticles, the negative membrane charges of the microbes interact with the positive metal ions. Bacterial membranes are permeable to metal ions, which can then penetrate the cells. They do this by interacting with the sulfhydryl group (-SH) on microbial proteins, preventing the synthesis of proteins and nucleic acids. The antibacterial efficacy of NPs is influenced by their surface charge and size[20]. They are also inexpensive and can be produced easily[21,22]. Fig. 1 [23]shows the effect of metals NPs on periodontitis

PROPERTIES OF GOLD NANOPARTICLES

Gold nanoparticles (AuNPs), a therapeutic carrier with exceptional bioavailability and functionality, range in diameter from 50 to 150 nm[24]. It is an excellent choice for usage as an antimicrobial[25]. AuNPs are added to other biomaterials to enhance their capabilities because of their antifungal and antibacterial characteristics. Because of these qualities, AuNPs are a common filler for biomaterials[26].

Gold nanoparticles in periodontitis

According to the findings, 45 nm AuNPs reduced discomfort and improved the periodontal inflammatory milieu by modulating the production of pro- and anti-inflammatory cytokines and macrophage polarization, which influenced the development of human PDL cells (hPDLCs).. It has been demonstrated that using 45nm AuNPs may significantly decrease the advancement of periodontitis and enhance the quantity of new cementum, bone, and periodontal attachment that forms in periodontal defects. 45nm AuNPs may directly affect hPDLCs with modifying the initial irritational symptoms of periodontium tissues via altering cell morphologies. This led to a milieu containing comparatively small levels of reparative and inflammatory cytokines, such as bone morphogenetic protein-2 (BMP-2), which induced the formation of periodontal tissue regeneration, PDLC, and the halting of the periodontitis[27].Fig. 2[23] shows various mechanisms of NPs to destroy microorganisms.

Gold nanoparticles as a photothermal agent in periodontitis

Due of its light-induced localized surface plasmon resonance (LSPR), AuNPs have attracted a lot of attention. Because of the strong instantaneous electric field present in the absorption band of photosensitizers in LSPR, the absorption rate of the photosensitizers is significantly increased. This process can therefore rising the photosensitizer excitation rate, ultimately increasing the ROS production. Au nanoparticles coupled with methylene blue(MB-AuNPs)were shown to be very efficient at photoin activating biofilms of methicillin-resistant Staphylococcus aureus (MRSA) that were four days old. After being exposed to radiation, the biofilm treated with MB-AuNPs showed a decrease of more than 5 log10, while the biofilm medicated with methylene blue alone showed a decrease of less than 1 log10. Therefore, photosensitizers on the surface of AuNPs turned out to be a very successful way to increase the effectiveness of antibacterial photodynamic treatment[28,29].

PROPERTIES OF SILVER NANOPARTICLES

AgNPs with a size range of 1 to 100 nm are made from pure crystalline Ag. They have recently gained popularity for a wide range of biological applications because to their enhanced and unique physical-chemical properties, such as reduced particle size, higher surface area, and quantum confinement effects . Because AgNPs prevent microbes from generating biofilms, hence used in the dental field[30,31].

Silver nanoparticles in periodontitis treatment

Researchers examined the biological effects of Oroxylum indicum (L) Kurz (OI) stem bark extracts as a reducing agent (OI/AgNPs) in biosynthetic process of AgNPs. The OI/AgNPs were stable spherical NPs with a size range of 21.49 0.32^ nm, and their biological and anti-oxidant capabilities were enhanced by biosynthesis. Biosynthesized OI/AgNPs have the potential to protect hPDLSCs from oxidative stress and inflammatory stimuli, stimulate osteoblastic growth, and not be cytotoxic. For these reasons, they can be used in the restorative therapy of peri-implantitis[32].AgNPs were utilized to make a novel mouthwash, which was tested for safety and efficacy. AgNPs

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showed a 93.15% inhibition rate. The mouthwash containing AgNPs shown antibacterial effectiveness at a concentration of 100 L/mL[33]. Biosynthesized AgNPs were utilized in the current study to treat periodontal disease instead of topical antiseptics and antimicrobial agents; they may be combined with other antimicrobial agents to provide a synergistic effect and are also used to administer specific medications[34].*In vitro*, hydrogels doped with AgNPs and based on poly (2-hydroxyethyl methacrylate) have demonstrated encouraging antibacterial activity against S. aureus and E. coli. Ag ions have been demonstrated to affect bacterial cell structures in a number of ways, one of which being an increase in membrane permeability that leads to cell lysis[35].(Figure 3)

ZINC NANOPARTICLES

Zinc oxide nanoparticles (ZnONPs) are among the most widely used nanoparticulate materials worldwide due to their antibacterial properties. The antibacterial properties of Zn NPs also help to slow down the growth of biofilms[36].ZnNPs that are biofabricated from renewable resources are thought to be environmentally friendly. If brackets are covered in CuO and ZnONPs, they can be utilized to stop S. mutans from spreading while receiving orthodontic treatment[37]. A study by Rai et al., on 20 chronic periodontitis patients concluded that ZnONPs have been demonstrated to enhance ALT enzyme activity in people with periodontal illness, and those with chronic periodontitis had greater levels of ALT enzyme activity in their saliva when compared to healthy controls[60].Hence, more studies are needed to be done.

TITANIUM DIOXIDE NANOPATICLES

Titanium dioxide nanoparticles, or TiO2NPs, are smaller than 100 nm.Among metal oxide NPs, TiO2NPs are unique due to their widespread application in photocatalysis, antibacterial, and antiparasitic applications[38,39].Due to their remarkable chemical stability and photocatalytic activity, TiO2NPs are appropriate supplements to enhance the properties of polymer materials employed in periodontal therapy[40,41].Although there are very few reports of antibacterial photodynamic therapy utilizing nanomaterials, the nanosurface layer has demonstrated potential in reducing peri-implantitis. Ag, TiO2, and hydroxyapatite (HA) nanocoatings were prepared for implants by Ag plating, anodization, and sintering. The Ag-nHA nanocoating completely inhibited bacterial growth in the surrounding medium and reduced biofilm on the implant surface by 97.5%. This novel nano-coating for titanium alloy implants has the advantages of less infection risk, enhanced osseointegration, and accelerated bone repair[42].TiO2NPs boosted COX-2 mRNA and protein expression in PDL cells, and ERK1/2 and Akt were rapidly activated, perhaps upstream of NF. -B TiO2NPs also increased intracellular ROS generation in PDL cells, therefore halting the progression of periodontitis [63].

MAGNETIC NANOPARTICLES

In dentistry, NPs and magnetic forces have been used recently to transfer medications for the avoidance and therapy of dental conditions. Because MNPs are used in various dental medicine delivery systems, there has been a decrease in dental cavities as well as endodontic and periodontal illnesses. It has been demonstrated that dental composites and adhesives containing MNPs inhibit the formation of biofilm[43,44].

NICKEL NANOPARTICLES

It has been demonstrated that NiNPs have anti-microbial capabilities against S. aureus and E. coli.In dental compounds, nickel is frequently used to increase the success rate of root fillings[45].Numerous studies have demonstrated that the occurrence of adverse reactions, such as contact allergies therefore, its usage is less[46].

BISMUTH NANOPARTICLES

Bismuth NPs are bactericidal, antifungal and prevents biofilm formation [47,48]. According to a recent study, BiNPs' low MIC, strong effectiveness, and affordable price point make them a potential medicine substitute or mouthwash for oral infections [49]. One of the defensing properties of BiNPs is their capacity to prevent S. mutans, the bacterium that causes the majority of tooth decay, from forming biofilms[50].It was demonstrated that the primary dimensions of BSS-nano have a polygonal shape and range from 4 to 22 nm. Antimicrobial BSS-nano can be used to antiseptics and dental fillings[61].

COBALT NANOPARTICLES

During the evaluation of the synthetic Co oxide NPs' antibacterial properties, formation of investigated bacteria was considerably decreased. By chemically contacting Co oxide NPs, a beneficial antibacterial action against gram-negative bacteria is demonstrated[51]. By suppressing the expression of P. gingivalis survival genes, the substance has potential as a treatment for chronic periodontitis[52].

COPPER NANOPARTICLES

Copper (Cu) nanoparticles (NPs) have great biological activity, low cost, environmental safety, and promise as strong multipurpose antibacterial agents[53].Chitosan having CuNPs have the potential to treat periodontitis[54].When compared to bulk Co, oxytetracycline, and gentamicin, CoNPs were superior[62].

ADVANTAGES OF METAL NPsFOR DEVELOPMENT OF THERAPEUTIC METHODS

The advantages of employing metal nanoparticles is because of its potency for bacteria resistant to antibiotics, their adaptability to different types of microorganisms, and their use as efficient carriers of antibiotics. NPs have the ability to disperse and break apart bacterial biofilms[55].They also have the potential to eradicate periodontal bacteria enclosed in biofilms. *Prevotella intermedia, F. nucleatum,* and *P. gingivalis* are among the gram-positive and gram-negative bacteria responsible for periodontal diseases and NPs are effective against them [56]. In-vitro studies have demonstrated that AgNPs suppress the growth, adhesion, and biofilm generation of S. *mutans*[57].ZnO and TiO_2NPs might be employed as nano-antibiotics in the production of mouthwashes and dental pastes[58].Magnetic nanoparticles (NPs) may be remotely steered to specific areas by applying an external magnetic field[59]. More research is necessary to understand how metal nanoparticles (NPs) enter cells and how their antibacterial properties affect periodontitis patients.(Fig . 4 shows various effect of popular metal NPs in treating periodontitis)

DISADVANTAGESOF METAL NPSIN THERAPEUTIC METHODS

The high concentrations of the any metal can be fatal. The main mechanism underlying TiO_2NPs' potential for toxicity appears to be the generation of ROS, which can result in the development of cancer. The incidence of adverse responses such as contact allergies to nickel has also been shown. Many cases has shown even deaths linked to the use of Bi medicines throughout the past century. When Bi compounds are used at dangerous dosages, acute renal impairment results. Besides the biological toxicities the physical preparation of these nanoparticles requires a lot of high temperature and pressure while the chemical is dangerous so leaving us with the biochemical techniques of preparation only.

SUMMARY

Table 1 summarizes the effect of various NPs on periodontitis

CONCLUSION

There are several conventional therapies for periodontitis. Medication resistance and the onset of undesirable effects render established treatments ineffective. The NPs' small size allows them to potentially penetrate the biofilm matrix and come into direct touch with the bacterial cells, inhibiting the biofilm. It is anticipated that the broad use of research techniques and their commercial applications in the fields of medicine and healthcare will show to be extremely advantageous in the years to come.

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Table 1: Summarizes the effect of various metal NPs on periodontitis

NPs	properties	Periodontitis effect	Type of study	references
AuNPs	45nm Anti-inflammatory effect Heals periodontal inflammation	AuNPs could produce a microenvironment with low levels of inflammatory cytokines and reparative cytokines like BMP-2 by directly modulating hPDLCsand indirectly and in vitro modulating macrophage phenotypes. This would induce PDLC differentiation, periodontal tissue regeneration, and the prevention of periodontitis progression.	In vivo	[27]
AgNPs	1-100nm Smaller size , larger surface area,	There is a window of opportunity for more research in the field when using AgNPs in place of topical antiseptics and antimicrobial agents, as well as when combined with other antimicrobial agents for a synergistic effect and local drug delivery during periodontal therapy.	In vitro	[34]
ZnONPs	Antimicrobial properties	ZnONPs have been demonstrated to enhance ALT enzyme activity in people with periodontal illness, and those with chronic periodontitis had greater levels of ALT enzyme activity in their saliva when compared to healthy controls.	20 patients with chronic periodontitis	[60]
MNPs	Less toxic more versatile	The antibacterial MNPs were able to remove bacterial biofilms in in vitro antibacterial investigations, resulting in a clearance rate that approached 80%.	In vivo and in vitro	[44]
NiNPs	inexpensive, safer, size is less	The study demonstrated that all clinical isolates of S. epidermidis were capable of producing biofilms. It has	In vitro	[45]

	than 25nm	been demonstrated that NiNPs inhibit the formation of biofilm.		
BiNPs	Bactericidal, fungicidal, antibiofilm agent	It was demonstrated that the primary dimensions of BSS-nano have a polygonal shape and range from 4 to 22 nm.	In vitro	[61]
CoNPs	Antibacterial, cheaper	By chemically contacting Co oxide NPs, a beneficial antibacterial action against gram-negative bacteria is demonstrated [51]. By suppressing the expression of P. gingivalis survival genes, the substance has potential as a treatment for chronic periodontitis [52].	In vitro	[62]
CuNPs	Cheaper, safer, antibacterial	Using CuNPs/chitosan gel nanocomposites.These compounds inhibited the growthof A. Actinomycetemcomitans. It has been used as a foundation for developing periodontitis therapies tailored to individual patients' needs.	In vitro	[54]
TiO₂NPs	Biocompatible cheaper safer	TiO2NPs boosted COX-2 mRNA and protein expression also increased intracellularROS generation in PDL cells.	In vitro	[63]
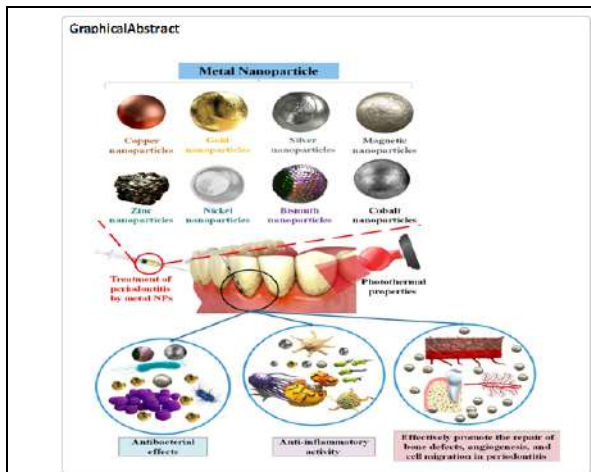
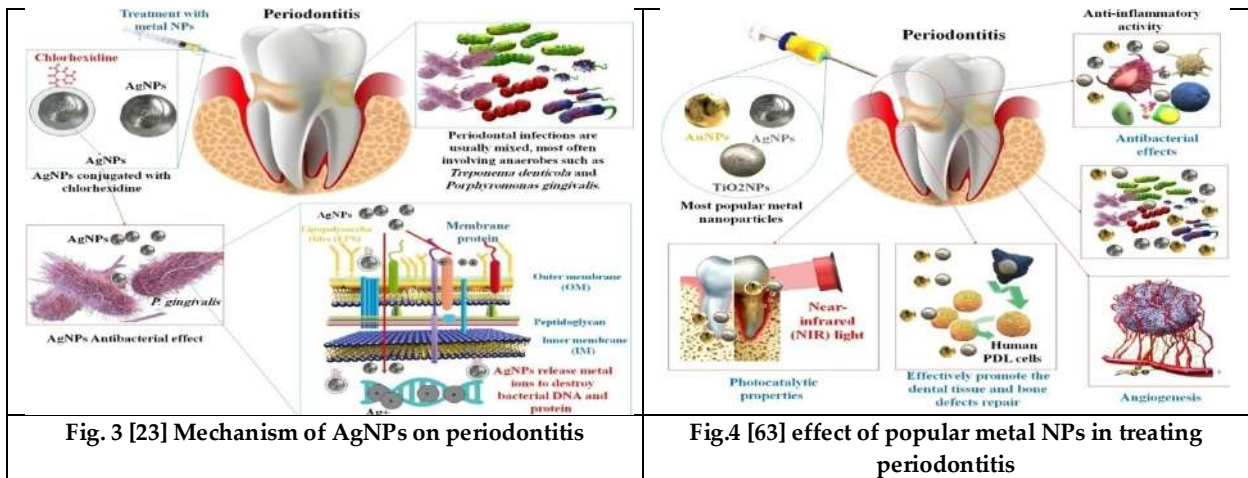| Fig. 1[23] effect of various metal NPs on periodontitis	Fig.2 [23] various mechanisms of metal NPs for the antimicrobial effect
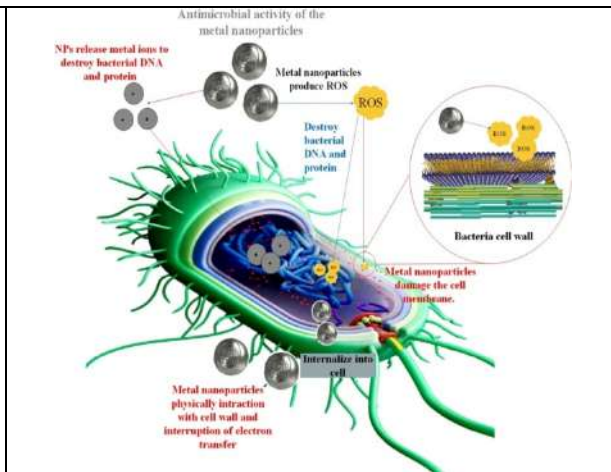
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| Fig. 3 [23] Mechanism of AgNPs on periodontitis | Fig.4 [63] effect of popular metal NPs in treating periodontitis |

RESEARCH ARTICLE

On Various Lucky Labeling on Some Algebraic Graphs

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ABSTRACT

In this article Lucky labeling is coloring of vertices arbitrarily such that sum of labels of all adjacent vertices of a vertex is not equal to the sum of labels of all adjacent vertices of any vertex which is adjacent to it. The concept of lucky labeling has been used in transportation network, where pair wise connections are given some numerical values. And also in computational biology to model protein structures. In this research article concepts of different lucky labeling like square sum lucky labeling and 2-divisor lucky labeling have been observed for some algebraic graphs like zero-divisor graphs, identity graph and order prime of finite groups.

Keywords: 2- divisor lucky labeling, 2- divisor lucky number, Square sum lucky labeling, zero-divisor graphs, identity graphs, order prime graphs.
AMS Subject Classification: 05C25, 05C78.

INTRODUCTION

Graph labeling was introduced by Alexander Rosa in the year 1967[12]. Rosa identified three types of labeling which was later renamed by Solomon Golomb[8].Lucky labeling was studied by Ahai.et.al and Akbari.et.al[1][2]. Lucky labeling is coloring of vertices arbitrarily such that sum of labels of all adjacent vertices of a vertex is not equal to the sum of labels of all adjacent vertices of any vertex which is adjacent to it. It has been used in transportation network,

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where pair wise connections are given some numerical values. And also in computational biology to model protein structures[6],[7].There are two variations of the zero-divisor graph. One is in the Beck definition in the year 1988, in which the vertices represent all elements of the ring [5]. In the year 1999, Anderson and Livingston slightly varied the graph, in which the vertices represent only the zero-divisor of the given ring [4]. A study on identity graph was studied in the book Groups as graphs[9].Order prime graph was introduced by M. Sattanathan and Kala R[13]. Inspiring d-lucky labeling[11] square sum lucky labeling and 2-divisor lucky labeling have been investigated in this paper for some algebraic graphs of finite group.

PRELIMINARIES

Definition2.1: [13]Order Prime Graphs: Let Γ be a finite group. The order prime graph(Γ)of a group Γ is a graph with V ((Γ)) = Γ and two vertices are adjacent in (Γ) if and only if their orders are relatively primein Γ.

Definition 2.2[4][5]: Zero-Divisor Graph: Let R be a commutative ring with identity 1 and let $Z(R)$ be its set of zero-divisors. We associate a $\Gamma(R)$ to R with vertices$Z^* = Z(R) - \{0\}$, the set nonzero zero-divisor of R, and for distinct $x, y \in Z(R)^*$, the vertices x and y are adjacent if and only if $xy = 0$. We denote their zero-divisor graph of R by $\Gamma_0(R)$ if we take vertex set as Z (R). In $\Gamma_0(R)$, the vertex 0 is adjacent to every other vertex. $\Gamma(R)$is a induced subgraph of $\Gamma_0(R)$.

Definition 2.3[9]: Identity Graph: Let g be a group. The identity graph $G = (V, E)$ with vertices as the elements of group and two elements $x, y \in g$ are adjacent or can be joined by an edge if $x.y = e$, where e is the identity element of g.

SQUARE SUM LUCKY LABELING FOR SOME ZERO-DIVISOR GRAPHS

Definition: Square Sum Lucky Labeling
A graph $G = (V, E)$ be a graph with n vertices and m edges. A graph G admits square sum lucky labeling if $f: V(G) \to \{1,2,\dots,n\}$ be a labeling of vertices of graph G from$\{1,2,3,\dots,n\}$. Define$c(u) = \lceil \sum_{v \in N(v)}(f(v))^2 \rceil$, where $N(v)$ is the neighborhood of v such that $c(u) \neq c(v)$ for every pair of adjacent vertices u and v in G.Thesquare sum lucky number is the least number from the set $\{1,2,\dots,n\}$ that has been used to label the graph G. It is denoted by η_{ssl}.

Theorem3.1: For the prime number $p \geq 3$, square sum lucky number of zero-divisor graph $\mathbf{\Gamma(Z_{2p})}$**,** is one.

Proof: Let graph $G = \Gamma(Z_{2p})$ and $p \geq 3$ be a prime number.
The vertex set of G is $V(G) = \{x_1, x_2, \dots, x_{p-1}, x_p\} = \{2,4,\dots,2(p-1), p\}$
The edge set of G is $E(G) = \{x_i x_p / 1 \leq i \leq p - 1\}$
$|V(G)| = p$; $|E(G)| = p - 1$
Define $f: V(G) \to N$ such that $f(x_i) = 1, 1 \leq i \leq p$
$c(x_p) = (f(x_1))^2 + (f(x_2))^2 + \cdots + \left(f(x_{p-1})\right)^2 = p - 1$
$c(x_i) = (f(x_p))^2 = 1$ where$1 \leq i \leq p - 1$
such that $c(x_p) \neq c(x_i)$ for all $1 \leq i \leq p - 1$.
Therefore graph G admits square sum lucky labeling. To label this graph only one label used and so the square sum lucky number of graph G is one i.e. $\eta_{ssl}(G) = 1$.

Theorem 3. 2: For prime number $p > 3$, the zero-divisor graph of $\mathbf{\Gamma(Z_{3p})}$ has square sum lucky number to be one.

Proof: Let graph G= $\Gamma(Z_{3p})$ and $p > 3$, be a prime number.

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The vertex set of G is $V(G) = \{t_1, t_2, x_1, x_2, x_3, \ldots, x_{p-1}\} = \{p, 2p, 3, 6, 9, \ldots, 3(p-1)\}$

The edge set of G is $E(G) = \{t_i x_j / 1 \leq i \leq 2, 1 \leq j \leq p - 1\}$

$|V(G)| = p + 1$; $|E(G)| = 2p - 2$.

Define $f : V(G) \to N$ such that $f(t_i) = 1$, $1 \leq i \leq 2$ and $f(x_j) = 1$, $1 \leq j \leq p - 1$

$c(t_i) = (f(x_1))^2 + (f(x_2))^2 + \cdots + \left(f(x_{p-1})\right)^2 = p - 1$ where $i = 1, 2$

$c(x_j) = (f(t_1))^2 + (f(t_2))^2 = 2$ where $1 \leq j \leq p - 1$

such that $c(t_i) \neq c(x_j)$ for all $1 \leq i \leq 2$ and $1 \leq j \leq p - 1$.

Therefore graph G admits square sum lucky labeling. To label this graph only one label used and so the square sum lucky number of graph G is one i.e. $\eta_{ssl}(G) = 1$.

Theorem 3.3: The square sum lucky number for the zero-divisor graph$\mathbf{\Gamma(Z_{5p})}$, $p \geq 3$ and $p \neq 5$ be a prime number is one.

Proof: Let graph $G = \Gamma(Z_{5p})$, $p \geq 3$ and $p \neq 5$ be a prime number.

The vertex set of G is $V(G) = \{t_1, t_2, t_3, t_4, x_1, x_2, x_3, \ldots, x_{p-1}\} = \{p, 2p, 3p, 4p, 5, 10, 15, \ldots, 5(p-1)\}$

The edge set of G is $E(G) = \{t_i x_j / 1 \leq i \leq 4, 1 \leq j \leq p - 1\}$

$|V(G)| = p + 3$; $|E(G)| = 4p - 4$.

Define $f : V(G) \to N$ such that $f(t_i) = 1$, $1 \leq i \leq 4$ and $f(x_j) = 1$, $1 \leq j \leq p - 1$

$c(t_i) = (f(x_1))^2 + (f(x_2))^2 + \cdots + \left(f(x_{p-1})\right)^2 = p - 1$ where $1 \leq i \leq 4$

$c(x_j) = (f(t_1))^2 + (f(t_2))^2 + (f(t_3))^2 + (f(t_4))^2 = 4$ where $1 \leq j \leq p - 1$

such that $c(t_i) \neq c(x_j)$ for all $1 \leq i \leq 4$ and $1 \leq j \leq p - 1$.

Therefore graph G admits square sum lucky labeling. To label this graph only one label used and so the square sum lucky number of graph G is one i.e. $\eta_{ssl}(G) = 1$.

Theorem 3.4: For the prime number $p, q \geq 3$ and $p < q$ and $p \neq q$ the zero-divisor graph $\mathbf{\Gamma(Z_{pq})}$ has square sum lucky number to be one.

Proof: Let graph $G = \Gamma(Z_{pq})$, $p, q \geq 3$ and $p < q$ and $p \neq q$ where p, q are prime numbers.

The vertex set of G can be partitioned in to two sets $V_1(G)$ and $V_2(G)$

$V_1(G) = \{x_1, x_2, x_3, \ldots, x_{q-1}\} = \{p, 2p, \ldots, (q-1)p\}$

$V_2(G) = \{t_1, t_2, t_3, \ldots, t_{p-1}\} = \{q, 2q, 3q, \ldots, (p-1)q\}$

The edge set of G is $E(G) = \{x_i t_j / 1 \leq i \leq q - 1 \text{ and } 1 \leq j \leq p - 1\}$

$|V(G)| = p + 3$; $|E(G)| = 4p - 4$.

Define $f : V(G) \to N$ such that $f(x_i) = 1$, $1 \leq i \leq q - 1$ and $f(t_j) = 1$, $1 \leq j \leq p - 1$

$c(x_i) = (f(t_1))^2 + (f(t_2))^2 + \cdots + \left(f(t_{p-1})\right)^2 = p - 1$ where $1 \leq i \leq q - 1$

$c(t_j) = (f(x_1))^2 + (f(x_2))^2 + \cdots + \left(f(x_{q-1})\right)^2 = q - 1$ where $1 \leq j \leq p - 1$

such that $c(x_i) \neq c(t_j)$ for all $1 \leq i \leq q - 1$ and $1 \leq j \leq p - 1$.

Therefore graph G admits square sum lucky labeling. To label this graph only one label used and so the square sum lucky number of graph G is one i.e. $\eta_{ssl}(G) = 1$.

Square Sum Lucky Labeling for Identity graph

Theorem: 4.1 The **identity graph of** $(\mathbf{Z_n}, \oplus_n)$ for $n > 3$ be an odd number then the square sum lucky number is two.

Proof: Let graph $G = Identity\ graph\ of\ Z_n$, $n > 3$ be an odd number.

The vertex set of G is $V(G) = \{0, 1, 2, \ldots n - 1\} = \left\{x_0, x_1, x_2, \ldots, x_{\frac{n-1}{2}}, x_{\frac{n+1}{2}}, \ldots, x_{n-1}\right\}$.

The edge set of G is $E(G) = \{x_0 x_i,\ x_1 x_{n-1}, x_2 x_{n-2}, \ldots, x_{\frac{n-1}{2}} x_{\frac{n+1}{2}}\}$, $1 \leq i \leq n - 1$.

$|V(G)| = n$; $|E(G)| = \frac{3n-3}{2}$

Define $f: V(G) \to N$ such that $f(x_0) = 1$, $f(x_1) = f(x_2) = \cdots = f\left(x_{\frac{n-1}{2}}\right) = 2$ and

$f(x_{\frac{n+1}{2}}) = f\left(x_{\frac{n+3}{2}}\right) = \cdots = f(x_{n-1}) = 1$.

$c(x_0) = (f(x_1))^2 + (f(x_2))^2 + \cdots + \left(f(x_{n-1})\right)^2$

$c(x_1) = (f(x_0))^2 + (f(x_{n-1}))^2$

$c(x_2) = (f(x_0))^2 + (f(x_{n-2}))^2$

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$c\left(x_{\frac{n-1}{2}}\right) = (f(x_0))^2 + (f\left(x_{\frac{n+1}{2}}\right))^2$

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$c(x_{n-1}) = (f(x_0))^2 + (f(x_1))^2$

such that $c(x_0) \neq c(x_1) \neq c(x_2) \neq \cdots \neq c\left(x_{\frac{n-1}{2}}\right) \neq c(x_{n-1})$.

Therefore graph G admits square sum lucky labeling. To label this graph two labels used and so the square sum lucky number of graph G is two i.e. $\eta_{ssl}(G) = 2$.

Theorem 4.2: The **identity graph of** $(Z_n, \oplus_n)$ for $n > 2$ be an even number then the square sum lucky number is two.

Proof: Let graph $G = Identity\ graph\ of\ Z_n$, $n > 2$ be an even number.

The vertex set of G is $V(G) = \{0,1,2,\dots n-1\} = \left\{x_0, x_1, x_2, \dots, x_{\frac{n}{2}}, \dots, x_{n-1}\right\}$.

The edge set of G is $E(G) = \{x_0 x_i, \ x_1 x_{n-1}, x_2 x_{n-2}, \dots, x_0 x_{\frac{n}{2}} / 1 \leq i \leq n-1\}$

$|V(G)| = n$; $|E(G)| = \frac{3n-3}{2}$

Define $f: V(G) \to N$ such that $f(x_0) = 1$, and $f(x_i) = \begin{cases} 1\ if\ n = odd \\ 2\ if\ n = even \end{cases}$

$c(x_0) = (f(x_1))^2 + (f(x_2))^2 + \cdots + \left(f(x_{n-1})\right)^2$

$c(x_1) = (f(x_0))^2 + (f(x_{n-1}))^2$

$c(x_2) = (f(x_0))^2 + (f(x_{n-2}))^2$

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$c\left(x_{\frac{n}{2}}\right) = (f(x_0))^2$

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$c(x_{n-1}) = (f(x_0))^2 + (f(x_1))^2$

such that $c(x_0) \neq c(x_n) \neq c\left(x_{\frac{n}{2}}\right)$.

Therefore graph G admits square sum lucky labeling. To label this graph two labels used and so the square sum lucky number of graph G is two i.e. $\eta_{ssl}(G) = 2$.

Theorem 4.3: For **identity graph of Klein-4 group** (K_4) under composition the square sum lucky number is one.

Proof: Let graph $G = Identity\ graph\ of$ Klein-4 group

The vertex set of G is $V(G) = \{x_0, x_1, x_2, x_3\} = \{e, a, b, ab\}$.

The edge set of G is $E(G) = \{x_0 x_i / 1 \leq i \leq 3\}$.

Define $f:V(G) \to N$ such that $f(x_0) = 1$ and $f(x_i) = 1$ for all $1 \le i \le 3$.

$c(x_0) = (f(x_1))^2 + (f(x_2))^2 + (f(x_3))^2$

$c(x_i) = (f(x_0))^2$ for all $1 \le i \le 3$.

such that $c(x_0) \ne c(x_i)$ for all $1 \le i \le 3$.

Therefore graph G admits square sum lucky labeling. To label this graph only one label used and so the square sum lucky number of graph G is one i.e. $\eta_{ssl}(G) = 1$.

Theorem :4.4 For the **identity graph of Quaternion group (Q_8)** has square sum lucky number to be two.

Proof: Let graph $G = Identity\ graph\ of\ Q_8$.

The vertex set of G is $V(G) = \{0,1,2,\dots 7\} = \{x_0, x_1, x_2, \dots, x_4, \dots, x_7\}$.

The edge set of G is $E(G) = \{x_0x_i,\ x_1x_7, x_2x_5, \dots / 1 \le i \le 7\}$

Define $f:V(G) \to N$ such that $f(x_0) = 1$, and $f(x_i) = \begin{cases} 1\ if\ n = odd \\ 2\ if\ n = even \end{cases} 1 \le i \le 7$

$c(x_0) = (f(x_1))^2 + (f(x_2))^2 + \cdots + (f(x_7))^2$

$c(x_1) = (f(x_0))^2 + (f(x_7))^2$

$c(x_2) = (f(x_0))^2 + (f(x_5))^2$

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$c(x_4) = (f(x_0))^2$

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$c(x_7) = (f(x_0))^2 + (f(x_1))^2$

such that $c(x_0) \ne c(x_n) \ne c\left(x_{\frac{n}{2}}\right)$.

Therefore graph G admits square sum lucky labeling. To label this graph two labels used and so the square sum lucky number of graph G is two i.e. $\eta_{ssl}(G) = 2$.

DIVISOR LUCKY LABELING

Definition: 2- Divisor Lucky Labeling

A graph $G = (V, E)$ be a graph with n vertices and m edges. A graph G admits 2-divisor lucky labeling if $f:V(G) \to \{1,2,\dots,n\}$ be a labeling of vertices of graph G from $\{1,2,3,\dots,n\}$. Define $c(u) = \lceil \sum_{v \in N(v)} \frac{f(v)}{2} \rceil$, where $N(v)$ is the neighborhood of v such that $c(u) \ne c(v)$ for every pair of adjacent vertices u and v in G. The 2-divisor lucky number is the least number from the set $\{1,2,\dots,n\}$ that has been used to label the graph G. It is denoted by η_{vdl}.

Theorem: 5.1: For the $OP(\Gamma(Z_n)), n = 2p, p \ge 3$ where p is a prime number under addition modulo n has $\eta_{vdl}(G) = 1$.

Proof: Let graph $G = OP(\Gamma(Z_n)), n = 2p, p \ge 3$ where p is a prime number

The vertex set of G is $V(G) = \{x_0,\ x_1,\ x_2, \dots, x_{\frac{p}{2}-1},\ x_{\frac{p}{2}},\ x_{\frac{p}{2}+1}, \dots, x_{n-1}\}$.

The edge set of G is $E(G) = \{x_0x_i, x_{\frac{p}{2}-1}x_{\frac{p}{2}},\ x_{\frac{p}{2}}x_{\frac{p}{2}+1} / 1 \le i \le n-1\}$

$|V(G)| = n$ and $|E(G)| = n + 1$.

Define $f:V(G) \to \{1,2,3,\dots,n\}$ such that $f(x_i)=1; 0 \le i \le n-1$

$c(x_0) = \left\lceil \dfrac{f(x_1) + f(x_2) + \cdots + f(x_{n-1})}{2} \right\rceil$

$c(x_i) = \left\lceil \frac{f(x_0)}{2} \right\rceil 1 \le i \le n-1$ except $i = \frac{p}{2}-1, \frac{p}{2}, \frac{p}{2}+1$

$c\left(x_{\frac{p}{2}-1}\right) = \left\lceil \dfrac{f(x_0) + f(x_{\frac{p}{2}})}{2} \right\rceil$

$$c\left(x_{\frac{p}{2}}\right) = \left|\frac{f(x_0) + f\left(x_{\frac{p}{2}-1}\right) + f\left(x_{\frac{p}{2}+1}\right)}{2}\right|$$

$$c\left(x_{\frac{p}{2}+1}\right) = \left|\frac{f(x_0) + f(x_{\frac{p}{2}})}{2}\right|$$

Such that $(x_0) \neq c(x_i) \neq c\left(x_{\frac{p}{2}-1}\right) \neq c\left(x_{\frac{p}{2}-1}\right) \neq c\left(x_{\frac{p}{2}+1}\right); 1 \leq i \leq n-1$

except $i = \frac{p}{2}-1, \frac{p}{2}, \frac{p}{2}+1$

Graph admits 2-divisor lucky labeling. Therefore 2-divisor lucky number is one i.e $\eta_{vdl}(G) = 1$.

Theorem: 5.2 : 2-divisor lucky number for the $OP(\Gamma(Z_n)), n = 3p, p > 3$ where p is a prime number under addition modulo n is two.

Proof: Let graph $G = OP(\Gamma(Z_n)), n = 3p, p > 3$ where p is a prime number

The vertex set of G is $V(G) = \{0,1,2,\ldots,n-1\} = \{x_0, x_1, x_2,\ldots,x_{n-1}\}$.

The edge set of G is $E(G) = \{x_0 x_i, x_p x_{\frac{j}{3}}, x_{2p} x_{\frac{k}{3}}/1 \leq i \leq n-1; \frac{pj}{3} \cong 0 \mod 3$ and $\frac{2pk}{3} \cong 0 \mod 3p\}$

$|V(G)| = n$ and $|E(G)| = n + 1$.

Define $f: V(G) \to \{1,2,3,\ldots,n\}$ such that $f(x_i)=1; 0 \leq i \leq n-1$ except

$j = $ multiples of p and $f(x_j) = 2; j = $ multiples of p

$$c(x_0) = \left|\frac{f(x_1) + f(x_2) + \cdots + f(x_{n-1})}{2}\right|$$

$$c(x_i) = \left\lceil\frac{f(x_0)}{2}\right\rceil \; 1 \leq i \leq n-1 \text{ except } i = \frac{p}{3}, \frac{2p}{3}, p, 2p$$

$$c\left(x_{\frac{p}{3}}\right) = \left\lceil\frac{f(x_0)+f(x_j)}{2}\right\rceil \frac{pj}{3} \cong 0 \mod 3p.$$

$$c\left(x_{\frac{2p}{3}}\right) = \left\lceil\frac{f(x_0)+f(x_k)}{2}\right\rceil \frac{2pk}{3} \cong 0 \mod 3p.$$

$$c(x_j) = \left|\frac{f(x_0) + f(x_{\frac{p}{3}})}{2}\right| \frac{pj}{3} \cong 0 \mod 3p$$

$$c(x_k) = \left|\frac{f(x_0)+f(x_{\frac{2p}{3}})}{2}\right| \frac{2pk}{3} \cong 0 \mod 3p.$$

Such that $(x_0) \neq c(x_i) \neq c\left(x_{\frac{p}{3}}\right) \neq c\left(x_{\frac{2p}{3}}\right) \neq c(x_j) \neq c(x_k); 1 \leq i \leq n-1;$

except $i = \frac{p}{3}, \frac{2p}{3}, p, 2p$

Graph admits 2-divisor lucky labeling. Therefore 2-divisor lucky number is one i.e $\eta_{vdl}(G) = 2$.

Theorem:5.3 The $OP(\Gamma(Z_n))$, $n \neq 2p$ and $n \neq 3p$ under addition modulo n has 2-divisor lucky number to be one.

Proof: Let graph $G = OP(\Gamma(Z_n))$, $n \neq 2p$ and $n \neq 3p$

The vertex set of graph G is $V(G) = \{x_0, x_1, x_2, \ldots, x_{n-1}\}$

The edge set of graph G is $E(G) = \{x_0 x_i/1 \leq i \leq n-1\}$

Define $f: V(G) \to \{1,2,3,\ldots,n\}$ such that $f(x_i)=1; 0 \leq i \leq n-1$

$$c(x_0) = \left|\frac{f(x_0) + f(x_1) + f(x_2) + \cdots + f(x_{n-1})}{2}\right|$$

$$c(x_i) = \left\lceil\frac{f(x_0)}{2}\right\rceil ; 1 \leq i \leq n-1$$

Such that $c(x_0) \neq c(x_i); 1 \leq i \leq n-1$

Graph admits 2-divisor lucky labeling. Therefore 2-divisor lucky number is one i.e $\eta_{vdl}(G) = 1$.

Theorem: 5.4 The $OP(\Gamma(K_4))$ under composition has 2-divisor lucky number to be 1.

Proof: Let graph $G = OP(\Gamma(K_4))$ under composition

The vertex set of graph G is $V(G) = \{x_0, x_1, x_2, x_3\} = \{e, a, b, ab\}$.

The edge set of graph G is $E(G) = \{x_0 x_i / 1 \le i \le 3\}$

Define $f: V(G) \rightarrow \{1,2,3,4\}$ such that $f(x_i)=1; 0 \le i \le 3$

$$c(x_0) = \left| \frac{f(x_0) + f(x_1) + f(x_2) + f(x_3)}{2} \right|$$

$$c(x_i) = \left\lceil \frac{f(x_0)}{2} \right\rceil ; 1 \le i \le 3$$

Graph admits 2-divisor lucky labeling. Therefore 2-divisor lucky number is one i.e $\eta_{vdl}(G) = 1$.

Theorem: 5.5 The $OP(\Gamma(Q_8))$ under composition has 2-divisor lucky number to be one.

Proof: Let graph $G = OP(\Gamma(Q_8))$ under composition

The vertex set of G is $V(G) = \{x_0, x_1, x_2, x_3, x_4, x_5, x_6, x_7\}$

The edge set of G is $E(G) = \{x_0 x_i / 1 \le i \le 7\}$

Define $f: V(G) \rightarrow \{1,2,3,4,5,6,7,8\}$ such that $f(x_i)=1; 0 \le i \le 7$

$$c(x_0) = \left| \frac{f(x_0) + f(x_1) + f(x_2) + f(x_3)}{2} \right|$$

$$c(x_i) = \left\lceil \frac{f(x_0)}{2} \right\rceil ; 1 \le i \le 7$$

Graph admits 2-divisor lucky labeling. Therefore 2-divisor lucky number is one i.e $\eta_{vdl}(G) = 1$.

CONCLUSION

In this paper square sum lucky labeling and 2-divisor lucky labeling and its numbers have been observed for some algebraic graphs like zero-divisor graphs of commutative ring, identity graphs and order prime graph of finite group. Further this work will be extended to some network related graphs.

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RESEARCH ARTICLE

Survey on Medicinal Plants from Botanical Garden of St. Ann's Campus, Visakhapatnam, India

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ABSTRACT

Medicinal plants are vital sources of easily used in the countryside healthcare system. Survey of medicinal plants plays a pivotal role in the drug research programme of the Indian systems of medicine. In this study, we investigated the medicinal plants present in the campus of St. Ann's college for women, Visakhapatnam. We also analysed the measures that can be taken to protect these plants. Overall 144 plant species from 69 families were identified. Therapeutic uses of these plants provide basic information that can aid scientists to conduct additional research to conserve these species and pharmacological studies with the greatest significance.

Keywords: Survey, Medicinal plants, Healthcare and Therapeutic

INTRODUCTION

Slokam says "Na manthram aksharam nasthi, nasthi mulam anowshadham, ayogyaha purusho nasthi, yojakathathra durbalaha"Medicinal plants have been a vital source of both curative and preventive medical therapy preparations for human beings, which also has been used for the extraction of important bioactive compounds [1,2,3]. Health care which was a part of the traditions and culture of the people has been a profession in the modern industrial world. Synthetic drugs are giving side effects which are dangerous than the diseases which they care. Traditional medicines are usually cheaper than modern medicines, and probably the only natural remedies available and accessible in the remote rural communities in developing countries [4].The world's attention turned towards traditional medicines. The plant extracts are providing wonderful remedies against human diseases. Identifying the curing power of natural remedies. The plants contain natural sustainable and harmless substances which can cure various illnesses and promote health in a natural way without side effects. Indian climate, atmosphere and soils are very rich and can accommodate rich biodiversity. Indiscriminate trade of plant resources, uncontrolled collecting methods, habitat

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change, overexploitation, and climate change pose great threats to availability of plant medicine in most third world countries, thus, creating a pressing need for better methods of conservation and viable use of priority plant resources [5]. It is important to identify the healing power of extract of medicinal plants and their future use.

MATERIALS AND METHODS

Study Area
The Present survey of medicinal plants were done at campus of St. Ann's college for women, Visakhapatnam. Our campus all together 62,76,581 acres with about 180 trees around it(Fig 1).

Data Collection and Plant Identification
Ethnobotanical information were gathered from January 2023 to December 2023by interviewing, using methodological ways designed in ethnopharmacological in field data collection. The students were informed afore about the initiation of the survey and permission was allowed. Interviews, discussions, formal and informal conversations, as well as field visits were conducted. More information was sourced from literature studies including journal articles and books. The plants were identified with the help of floras. The species and family names are mentioned according to the APG 3 system of classification.

Preparation of herbarium specimens
The preparation of the specimens was followed by methods stated in Lawrence (1967), Jones and Luchinger (1987), Anonymous (1996) and Manilal and Kumar (1998)

Collection
The specimen material (plants) which you are interested in should be collected as whole (if they are herbs) or part of plant along with flowers and fruits/carpels. Before putting your specimens in the collection with carefully remove all the insects, spider-webs and foreign bodies attached to your specimens.

Pressing and Processing
Then the specimens mounted in 42 cm x 29 cm(16 ½" x 11 ½") size blotting paper. If the plant specimen larger than the specimen blotting paper they can mounted in V or N or M shape to accommodate the entire plant material in above size. Also the leaves mounted in dorsiventral position. The half-size of the regular newspaper can fit this size and economical. Put the mounted specimens in between cardboards/wooden-frames.

RESULT

Diversity of Medicinal Plant Use
This study was based on a review of the literature published in scientific journals, books, reports from national, regional and international organizations, theses, conference papers and other grey materials. This study compiled 144 plants herbs are 55, shrubs are 43, trees are 36 and climbers and stragglers are 10(Fig: 2).Out of these 69 families Asteraceae and Euphorbiaceae are the dominated families. After wards Fabaceae, Apocynaceae and Malvaceae are dominated (Fig: 3). The largest percentage of medicinal plants obtained belonged to the family Asteraceae(13), followed by Fabaceae (6), Apocynaceae (6), Acanthaceae (5), Lamiacea (4), Caesalpiniaceae (4), Liliaceae (4), Solanaceae (3), Oleaceae (3)and with the rest of the families treated less than 2 in number of the ailments (Table 1)

DISCUSSION

Now a days growing population and their health problems are demanding simple and alternate medicine along with allopathic medicines. People are now going for ayurvedic medicine. Ayurvedic medicine are prepared from various parts of plants to treat different local diseases. In India many plant species were used for this purpose. The study

shows that every plant species have medicinal importance. The climate conditions also favour for the growth of the herbs, shrubs and trees. Even though it is the industrial area, the pollutants are not inhibiting the growth of these plants and they require minimum herbal care. Local people use to collect various part of these plants for their purpose of use. Various plants parts like roots, stem, leaves, flowers, fruits and seeds used for different disorders. Many plants are useful to cure ailments like cough, cold, diabetes and skin problems. Even they can be used to cure poisonous effect of insect, rat, and snake bites. Some are useful to cure even cancer and HIV.

CONCLUSION

Many plants are useful to cure dysentery, diarrhoea, stomach disorders and kidney stones even. Simple direct oral intake is sufficient to cure many diseases. Important aim of this study is to collect the information of medicinal plants, and their medicinal uses and preservation of this information for future generations. This information may lead to the extraction of drugs from these plants may become easier and cheaper as they are abundantly available here. Traditional medicines still play an important role in meeting basic health care of local communities. There is a tremendous potential for the commercialization of these medicinal plants

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Table:1 List of medicinal plants and their uses

S.NO	BOTANICAL NAME	IMAGE	MEDICINAL USES
1	*Ruellia tuberose.* Acathaceae		Diuretic, antipyretic, Analgesic, Antihypertensive, Abortifacient, Emetic, Kidney disorders, Bronchitis, Gonorrhea, Syphilis.
2	*Coleus ambonicus.* Asteraceae		antitumor, antibacterial, antifungal, antiprotozoal, anti-inflammatory, antioxidant, antidiabetic, wound healing analgesic, antirheumatic.

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3	*Gulphimia glauca.* Malpighiacae		Sedative, anxiolytic, anticonvulsant, antiasthma, antiallergic, nervous diseases, relieves coronary pains, anxiety, fear, phobia and stress.
4	*Jasminum officinale* Oleaceae		Liver diseases pains, relaxation, aphrodisiac, wounds, skin disease, cancer, ulcers in oral cavity.
5	*Ixora coccinea.* Rubiaceae		Dysentery, diarrhea, ulcers, gonorrhea, fever, hiccups, loss of appetite, nausea, antibacterial, gastroprotective, hepatoprotective, contosions.
6	*Pseudoranthemum reticulatum.* Acanthaceae		fever, headache, cold and back pain
7	*Plectranthus amboinicus.* Lamiaceae		cold, asthma, constipation, headache, cough, fever and skin diseases
8	*Terminalia catappa* Combretaceae		Scabies, leprosy wounds, skin diseases, diarrhea, fever, headache, hepatoprotective, antidiabetic, anticancer.
9	*Crossandra infundibuliformis* Acanthaceae		fever, headache, aperitisand pain

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10	*Croton bonplandianum* Euphorbiaceae				Liver disorders, skin Diseases including ringworm infection, Tourette swelling of body, bronchitis and asthma.
11	*Ficus religiosa* Moraceae				antiulcer, antibacterial, antidiabetic, in treatment of gonorrhea and skin diseases
12	*Gomphrena globose* Amaranthaceae				Antibacterial, antifungal, antioxidant, detoxifying, purifying properties, high blood pressure, diabetic, anti-inflammatory, leucorrhea.
13	*Clitoria ternatea* Fabaceae				Memory enhancers, nootropic, antistress, anxiolytic, antidepressant, anticonvulsant, tranquilizing, sedative agent.
14	*Tabernaemontana divaricata* Apocynaceae				Snake and scorpion poisoning, antiepileptic, anyimania, brain tonic, fever, pain, ringworms, antitumor saction.
15	*Acalypha lanceolata* Euphorbiaceae				Vermicide, carminative, jaundice, hypertension, fever, liver inflammation, asthma, pains, antimicrobial, diabetes, skin conditions.
16	*Tridax procumbens* Asteraceae				Wound healing, anticoagulant, antifungal, insect repellent, antianemia, antiinflammatory, antidiabetic, treats high blood pressure, malaria,
17	*Ocimum sanctum* Lamiaceae				coughs, asthma, diarrhoea, fever, dysentery, arthiritis, eye diseases, indigestion, gastric ailments.

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18	*Calotropis procera* Asclepiadaceae			Digestive disorders including diarrhoea, toothache, jointpains, parasitic infections, worms, cramps.
19	Hibiscus Rosa sinensis. Malvaceae			Treating wounds, Inflammation, coughs, diabetes, gastric ulcers, fever.
20	*Chlorophytum comosum* Asparagaceae			Antitumor, Anti-proliferative, indoor air purifier, Phytoremidative
21	*Chrysanthemum indicum* Asteraceae			Chest pain, high blood pressure, type 2 diabetes, fever, cold, headache, dizziness, swelling prostate cancer, anti bacterial, anti viral, cardiovascular health, inxiety improves, earing stress.
22	*Tagetus patula* Asteraceae			digestive poor problems, poor apetite, stomach pains, intestinal worms, dysentry to start menstruation, protect6s against miscarriage, sedative.
23	*Rosa indica* Rosaceae			Diarrohea, inflammation of mouth, dry skin, antibacterial, anti fungal, anti septic, anti inflammatory, cough.
24	*Tradescantia pallid* Commelinaceae			Anti oxidant, anti cancer, anti inflammatory, anti microbial, antifungal, antiviral, analgesic.

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25	*Cosmos bipinnatus* Asteraceae			Antioxidant, antidiabetic, antihypertensive, anti-inflammatory, bone protective, antimicrobial.
26	*Lagerstromia indica* Lythraceae			Antiinflammation, ant analgesic, antipyretic, antioxidant, anticancer, antimicrobial, antialzheimers, antidiabetic.
27	*Nerium odorum* Apocynaceae			anthelmintic, adaptogenic, analgesic, aphrodisiac, anticancer, antiinflammation, emetic, asthma, epilepsy, painfulmenstrualperiods, malaria, ringworms ,causes
28	*Tithonia diversifolia* Asteraceae			Malaria, constipation, stamachpains, indigestion, sorethroat, liverpains, treatmentofbruises, liverfunctions, hepatitis, jaundice.
29	*Plumeria rubra* Apocynaceae			Antifertility, anti-inflammatory, antioxidant, hepatitisB,HIV.

Imagery ©2024 Airbus, CNES / Airbus, Maxar Technologies, Map data ©2024   500 m

Fig:1 google map of the campus of St. Ann's college for women

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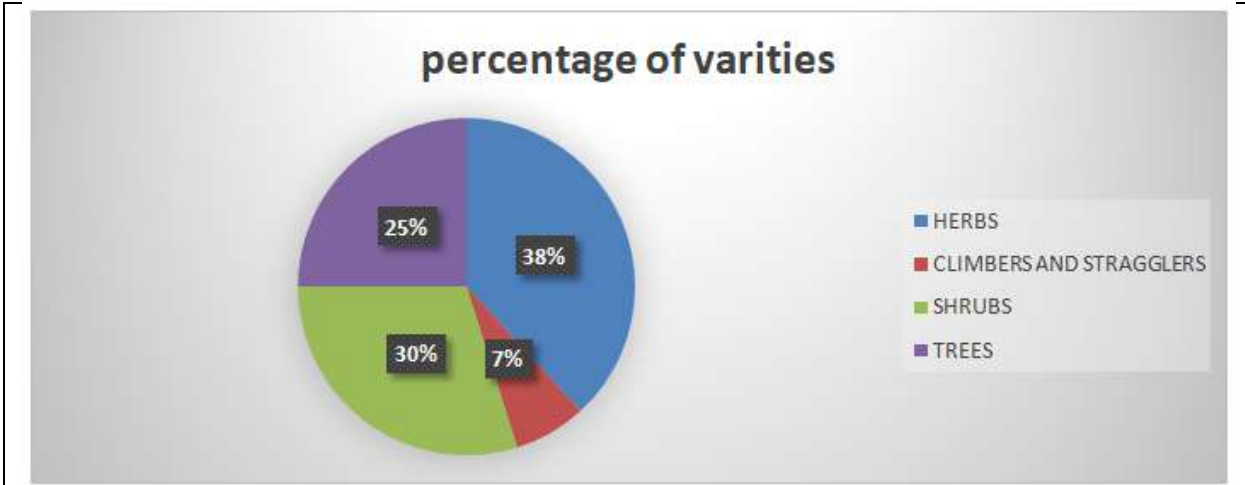
Fig: 2 Representation of varieties of medicinal plants
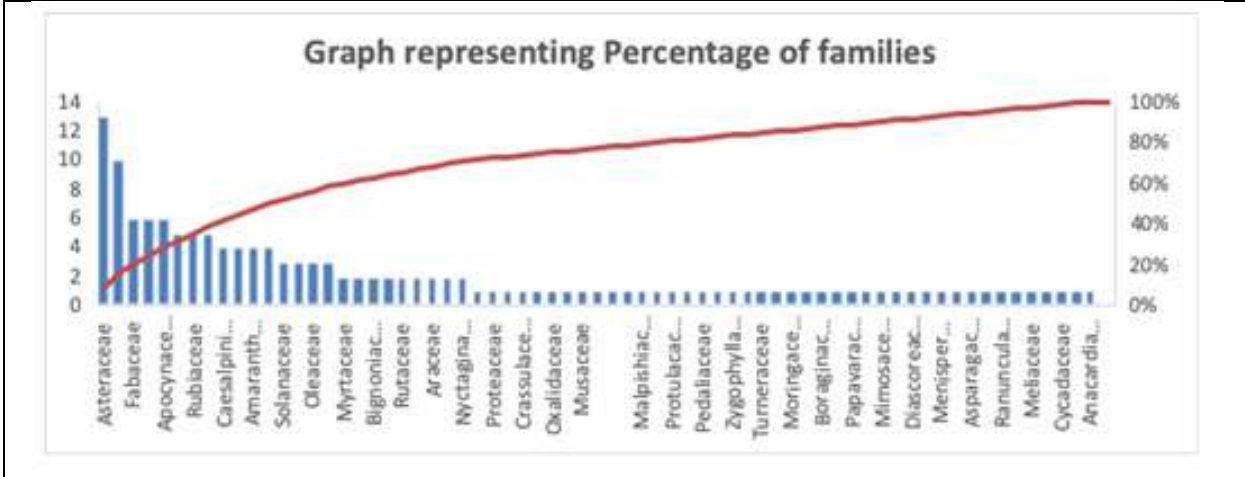
Fig:3 Graph representing percentage of families present in the campus of St. Ann's college

REVIEW ARTICLE

Review of Comparison between Bracketing and Matrixing Sampling Techniques in Stability Testing: Special Emphasis on Statistical Considerations in Both Techniques

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ABSTRACT

Generally, stability studies are performed to comply with ICH guidelines, and in recent days there has been an increase in concern about the statistical approach. Pharmaceutical companies are also trying to adopt this statistical design in their research work. In this paper stability designs and statistical considerations to be followed during the sampling of drugs are discussed apart from this information regarding different sampling techniques like full design and reduced design are also mentioned. Conditions followed during the sampling of drugs for investigation of the expiry date included. In reduced design, there are two main designs i.e., bracketing and matrixing designs what are the parameters to be followed periods for sampling, and whether reduced design results are up to what extent accurate are also mentioned. The conditions that influence the sampling are also mentioned.

Keywords: Bracketing, Matrixing, Full design, Reduced design, Stability testing.

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INTRODUCTION

The goal of stability testing is to determine recommended storage conditions, a retest period for a drug substance, and a shelf life for a drug product, by providing evidence on how the quality of a drug ingredient or drug product varies over time and responds to different environmental conditions, such light, humidity, and temperature. Every drug should be indicated with its shelf life on its label. Testing for stability is an essential step in product development. It does, however, take a lot of time and resources. A new product license often requires a minimum of 12 months of stability data, making it frequently on the vital path of development. Thus stability procedures must be effectively created to reduce the resources needed and guarantee regulatory approval. Reducing the number of stable samples may also result in cost savings in sample production and management, especially since the setup and upkeep of storage facilities are extremely expensive. Samples of stability have to be developed, labelled, and stored. Fortunately, there are ways of lowering the number of stability tests necessary, particularly B&M. When properly implemented, these techniques for lowering the number of product samples that are stability tested shouldn't significantly alter the anticipated shelf life or reduce the quality of the results. Although there are theoretically more presentations or batches evaluated for drug substance than there are for the product, the prospects and rewards are far more constrained. The FDA established detailed guidelines accompanied by suggestions for the Stability study design and analysis for human medications and biologics using statistics in 1987 [1]. As stated in this recommendation, It is crucial to look at the results of several variables, including the batch, strength, kind of packaging, length of storage, and storage environment. This results in a highly extensive and costly study design. The guideline suggests reducing stability testing using designs for matrixing and bracketing as an alternative. Since both designs are more affordable, it goes without saying that pharmaceutical corporations value them highly.

A stability schedule with a matrixing design was characterized as one where just a portion of the total number of samples was evaluated at each designated sample point [1]. Any subset of a full factorial design is how Chow [2] defined the matrixing design. Additionally, Helboe [3] added that a matrixing design only tests a portion of all potential factor combinations at any moment during a sample, but that the factor combinations' subgroups that were looked at different sample periods vary[3]. In general, this design assumes that the stability of the tested sample is indicative ofthe consistency of every sample. Natarajan et al. [4]have studied the influence of medicinal substances on the date of expiry of different matrixing designs regarding sampling time selection while taking reduced testing plans into consideration. By selecting the time-based vectors so that the layout is ideal concerning the greatest details on cost per unit, DeWoody and Raghavarao [5] also examined several ideal matrixing designs in stability experiments. According to FDA rules, all samples are analyzed at the beginning and end of the sampling process only the samples at the extremes of each factor. The extreme samples in this arrangement are thought to symbolize the samples' stability in the intermediate state. Additionally, the patterns of bracketing might be particularly useful if the composition of the strengths is closely connected, or if the container's material or closing type is consistent across the range of sizes. Instead of evaluating each of the three strengths.(20 mg, 30 mg, and 40 mg)of the medication product in three appropriate strengths. we might Test your strengths at both the lowest and greatest levels. (20 mg and 40 mg). In the present paper, we take into account an investigation of stability using a single factor at three levels, depending on whether the FDA allows matrixing or bracketing. We want to determine if a matrixing or bracketing design should be used If there is an annual maximum difference of δ between these values. To respond to this query, we take into account the provided sampling time points from Table 1. As suggested by the FDA, we employed three batches at each level, assuming that there were no slope changes across groups with the same factor levels. The optimal matrixing design and the bracketing design's FDA-recommended time points advised by Dewoody and Raghavarao[5] were also adopted by us. The matrixing design has 45 assays while the bracketing design has 42 assays. The FDA's guidance serves as the basis for the sample intervals used in bracketing design. The selection of time points in matrixing design is primarily concerned with the optimal matrixing design. from DeWoody and Raghavarao[5]

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STABILITY STUDY DESIGN
A stability study's design aims to determine a retest duration or shelf life that will apply to all upcoming batches of the drug substance or product produced under similar conditions, based on testing a small number of batches of the drug substance or product. As a result, tested batches have to meet the drug product's quality standards and be reflective in every way, including formulation, production location, closure and container, manufacturing method, source, and bulk material quality. The stability research needs to be well thought out to estimate the product's shelf life with high precision and accuracy.
Types of stability design include the following

FULL DESIGN AND PARTIAL DESIGN
Full design:
Full designs, sometimes called complete factorial designs, have samples for every combination of all design elements tested as suggested at all times. ICH Q1A(R2)[6]. A minimum of 0, 3, 6, 9, 12, 18, 24, and annually thereafter for long-term testing; a minimum of 0, 3, and 6 months for accelerated testing. As was already indicated, ICH has published several guidelines for the planning and execution of stability studies. The drug material and product must be stored within the long-term guidelines indicated on the label of the container (e.g., 25∘ C ±2∘ C/60% RH ±5% RH or 30∘ C ±2∘ C/65% RH ±5% RH), except when drug substances or drug products are stored in the freezer conditions, they should also be kept in accelerated conditions for 6 months and tested at least once every 3 and 6 months. Additionally, if any "significant change" occurs at any point during the six-month testing period at the accelerated storage condition, the recommendation calls for additional testing at the intermediate storage condition to be conducted and evaluated if long-term studies are conducted at 25∘ C ±2∘ C/60% RH ±5% RH. An example of a stability protocol using a comprehensive design for a medicinal product made in is shown in Table 2, these drug products have three different container sizes, three different container closure systems, and three different strengths. This illustration demonstrates the need for 1188 test samples will be used for accelerated and long-term stability testing. Long-term studies conducted at 25°C ±2°C/60% RH ±5% RH will also need intermediate testing and need 1620 test samples if a "significant change" occurs at any time throughout the six months of testing under accelerated storage conditions.
The long-term condition could be 25∘C ±2∘C/60% RH ±5% RH or 30∘C ±2∘C/65% RH ±5% RH ∗∗If long-term studies are conducted at 25∘C ±2∘C/60% RH ±5% RH and ''significant change'' occurs at any time during 6 months' testing at the accelerated storage condition, then the intermediate testing is needed. Reference is taken from [7] A simple full design is demonstrated in Table 3. This example outlines a procedure for assessing a medicinal product's long-term stability at 25°C and 60% relative humidity. The product comes in three different bottle sizes (10, 50, and 100 ml) and three different strengths (25, 50, and 100 mg). Samples are always assessed for all potential combinations of strength, batch size, and kind of container. In this instance of a full factorial design, the total quantity of samples examined is
N = 3 × 3 × 3 × 8 = 216 . Table 3 shows that comprehensive testing of all factor combinations at every time is required for a full design, and this can be costly. As a result, pharmaceutical businesses want to use the reduced design. Can the reduced design, maintain enough accuracy for the specified shelf life without sacrificing too much data? What types of reduced designs are also applicable? Can it be said to be an effective way to lessen the number of samples tested?

Reduced design
A fractional factorial design, or reduced design, adheres to the ICH Q1D Guideline by evaluating some samples for each factor combination at a time rather than evaluating all of them[6]. A reduced design is any portion of a whole design. The two reduced designs that are most frequently utilized are bracketing and matrixing. Wright [8] first suggested using factorial designs in stability studies in 1989. In his 1991 presentation, Nakagasi [9] utilized the terms matrix and bracket. In articles published in 1992, Nordbrock [10], Helboe [3], and Carstensen [11] discussed several strategies for cutting the number of samples examined from the chemical and financial elements of stability studies. Nordbrock examined several fractional factorial design approaches and compared them based on their capacity to detect a noteworthy discrepancy between slopes. He concluded that power may be used to select the design with the smallest sample size and sufficient performance. Lin [12] examined the applicability of the bracketing and matrixing methodologies to stability studies. She concluded that the complete factorial design is the best option when the

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accuracy of the shelf-life estimation is the most important element, but she also pointed out that matrixing designs could work well for pharmaceutical products that have less variation in strengths and container sizes. Fair weather [13], Ahn [14], Chen [15], and Yoshioka[16] have each suggested various methods for analyzing and categorizing stability data with many design elements concerning complex stability data.

Calculation of the expected expiration dating period via statistical modelling

The following is a representation of the statistical model for the deterioration profile;

$Y_{ij} = \alpha_i + \beta_i X_{ij} + e_{ij}$, i=1,2,3.   j= 1,2, . . ., n_i

where α_i and β_i denote the intercept and slope of the degradation line for level i, Y_{ij} = concentration of the ith level for a drug product at sampling time X_{ij}, and e_{ij} = random errors distributed as independent identically distributed (i.i.d.) N (0, σ^2). Based on the sample time points, the actual values of n_i are 21 for bracketing design and 15 for matrix design.

BRACKETING DESIGN AND MATRIXING DESIGN

When there are multiple designs to choose from, a reduced design may be a better option than a full design. The product under review has several contributing variables. It is important to think carefully before using a reduced design, However, accounting for potential risks associated with the ability to determine a precise and accurate shelf life or the consequences of accepting a shelf life that is shorter than intended. The two reduced designs that are most frequently utilized are bracketing and matrixing. Because there is less stability testing, a bracketing or matrixing design should be able to offer a sufficient degree of precision in shelf-life estimation without losing much information.

Bracketing design

Creating a stability schedule that only takes samples of specific design elements—like strength and packaging size—at their extremes and continually evaluates them, just as in a comprehensive design. The stability of any intermediate levels must be represented in the design. According to how frequently the tested extremes. Bracketing is appropriate when testing a range of strengths if the compositions are the same or closely related (for example, a range of tablets made with different compression weights of identical simple granulation, or a variety of capsules made by filling different plug fill weights of a single fundamental composition into different size capsule shells). Bracketing can be utilized for different container sizes or fills in the same container closing system.

Consider testing the null hypothesis

$H_0: \beta_1 = \beta_3$ against $H_1: \beta_1 \neq \beta_3$

Let $\hat{\beta}_1$ and $\hat{\beta}_3$ be the estimated slopes for levels 1 and 3 of the factors and let $SS_x = \sum_{j=1}^{n_i} (X_{ij} - 2 X_i)^2$, where $X_i = (1/n_i) \sum_{j=1}^{n_i} X_{ij}$. Assume that σ^2 is known. The key region for the test is

$$\left| \frac{\beta_1 - \beta_3}{\sqrt{\frac{2\sigma^2}{SS_x}}} \right| > z_{0.125}$$

Where $z_{0.125}$ = 1.15 is the highest 12.5 percentile of a standard normal distribution. The test's potency when $\beta_1 - \beta_3 = \delta/12$ is

$$Power_B = Power\left\{\beta_1 - \beta_3 = \frac{\delta}{12}\right\}$$

$$= P\left\{reject H_0 / \beta_1 - \beta_3 = \frac{\delta}{12}\right\}$$

$$= 1 - \left\{-1.15 - \frac{\frac{\delta}{12}}{\sqrt{\frac{2\sigma^2}{SS_x}}} < Z < 1.15 + \frac{\frac{\delta}{12}}{\sqrt{\frac{2\sigma^2}{SS_x}}}\right\}$$

$$= 1 - \Phi\left\{1.15 - \frac{2.115\delta}{\sigma}\right\}$$

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Note that δ/12 is the deterioration rate of δ per year to be found in the slopes divided by 12 months.

Matrixing

The creation of a stability schedule that tests a predetermined portion of all potential samples for each factor combination at a given moment in time. For each combination of factors, an additional set of samples is analyzed. The stability of any sample subset under examination, as per the design, is equivalent to the constancy of every single sample at a given moment in time. It is important to note the variations between samples of the same medicinal product, such as those involving various batches, strengths, and sizes of the same container closing system and, under some circumstances, different container closure systems.

Consider testing the null hypothesis

H0: $\beta_1 = \beta_2 = \beta_3$ against H1: not all β_i are equal, for i = 1, 2, 3. Let $\hat{\beta}_1$, $\hat{\beta}_2$, and $\hat{\beta}_3$ be the anticipated slopes for the matrixing design for each of the three levels

Let $\overline{\hat{\beta}} = \sum_{i=1}^{3} \frac{\hat{\beta}_i}{3}$, and let $\chi^2 = \left(\frac{SS_x}{\sigma^2}\right) \sum_{i=1}^{3} \left(\hat{\beta}_i - \overline{\hat{\beta}}\right)^2$

Where SS_x is as defined earlier for the matrixing design. The critical region for the test is

$\chi^2 > \chi^2_{0.25}(2)$,

Where $\chi^2_{0.25}(2) = 2.773$ represents the highest 25th percentile of a central χ^2 distribution including a pair of freedoms.

Under H_1: $\chi^2 \cong \chi^2(2, \Delta)$, $\Delta^2 = \frac{SS_x}{\sigma^2} \sum_{i=1}^{3} \left(\hat{\beta}_i - \overline{\hat{\beta}}\right)^2$

Where $\chi^2(2, \Delta)$ is not centralized χ^2 a two-degree-of-freedom distribution with a non-centrality parameter Δ.

when $\beta_1 - \beta_3 = \delta/12$, Δ^2 is the minimum when $\beta_1 = \overline{\beta} - \frac{\delta}{24}$, $\beta_2 = \overline{\beta}$, $\beta_3 = \overline{\beta} + \frac{\delta}{24}$.

Thus, the minimum Δ^2 is $\Delta^2_{min} = \frac{2SS_x}{(24\sigma)^2} = \frac{3.9875\,\delta^2}{\sigma^2}$

Once the calculations are complete SS_x about the matrixing layout presented in Table 1. Consider that for large Δ,

$$\frac{\sqrt{2\chi^2(2,\Delta)} - \sqrt{2(2 + \Delta^2) - \frac{2+2\Delta^2}{2+\Delta^2}}}{\sqrt{\frac{2+2\Delta^2}{2+\Delta^2}}} = \frac{\sqrt{2\chi^2(2,\Delta)} - \sqrt{2\Delta^2 + 2}}{\sqrt{2}}$$

Z, the typical normal variable, is roughly distributed.[17][see Desu and Raghavarao (6), p. 88.] Consequently, the matrixing design's minimal power is

$Power_M = P\{\chi^2(2,\Delta) > \chi^2_{0.25}(2)\}$

$$= P\left\{Z > \frac{\sqrt{2\chi^2_{0.25}(2) - \sqrt{2\Delta^2 + 2}}}{\sqrt{2}}\right\}$$

$$= 1 - \Phi\left\{\sqrt{2.773} - \sqrt{\frac{3.9875\delta^2}{\sigma^2} + 1}\right\}$$

It should be noted that while H0 appears must be distinct between bracketing and matrixing designs, it is nearly the same for both designs, and there are no differences in the slope for the factor's values.

Expected expiry date

Since the FDA's 1987 guidance states that an expiration date may be achieved for a given slope and that minimum expiry dating should be used when slopes vary, the Expiry date can be calculated using the given formula.

$\beta_1 - \beta_3 = \delta/12$

The expected expiration dating, or E(ED), is determined as follows by combining all the samples when slopes aren't significant.

E(ED)=P * Smallest (ED)+(1-P) * Ave (ED)

where P is the ability to identify notable variations in slopes. The estimations of the theoretical expiration dating under the biggest and average degradation rates, respectively, are Smallest (ED) and Ave (ED). The FDA guidelines establish the potential dates of expiry; In particular, Smallest (ED) and Ave (ED) are the places at which the 95% one-sided lower confidence bound of the mean degradation curve crosses the lower specification limit of 90% if a pharmacological feature is expected to deteriorate over time.

BRACKETING VS MATRIXING
As mentioned before, there are two different ways to create a stability study: matrixing and bracketing. Every design has its presumptions, benefits, and drawbacks. The manufacturing method, stage of development, evaluation of supportive stability data, and additional elements listed in ICH Q1D [6] of the design stability research in question all have a significant impact on whether either study is applicable. The following details on use consideration can be given to a stability study's use of a bracketing or matrixing design. In a bracketing design, samples from a certain batch for a selected extreme of a factor are analyzed at every single time point. Because matrixing research often evaluates samples from a given batch at shorter intervals, In a bracketing examination, assessing the stability pattern is easier.If all of the tested selected strengths or container sizes display the same trend, it may be concluded with a high degree of certainty that the stability of all other strengths or container sizes is mirrored, or bracketed, by the selected extremes. In a matrixing design, the samples to be assessed are selected from all possible factor combinations. This approach could be less sensitive than bracketing to assess the stability pattern because of the shorter time intervals.Therefore, in the following situations, a matrixing design is more appropriate for evaluating a forecast or already available stability information: During production batch stability testing, In terms of annual stability batches, as well later on in the drug's development process, after sufficient supporting evidence is at hand. When conducting stability tests, matrixing has the advantage over bracketing in that all strengths and container sizes are considered. The literature has explored the general application of bracketing and matrixing (e.g., Chambers (1996), Chen (1996), Fairweather and Lin (1999), Helboe (1999), Lin (1994; 1999a, b), Lin and Fairweather (1997), Yoshioka (1999))[15,18–21]. From a statistical and regulatory perspective, the value of bracketing and matrixing depends on the kind of medicinal product, type of submission, type of factor, data variability, and product stability.

In a stability study, certain variables may be bracketed or matriculated, as described in ICH Q1D[6]. This ICH suggestion also covers, in brief, several additional considerations that need to be made when employing these sorts of designs. A bracketing or matrixing design may be preferred over a complete design to minimize the number of samples tested and, therefore, the cost; nevertheless, the ability of these types of reduced designs to precisely estimate the product shelf life should be carefully reviewed. If the preceding data demonstrate consistent product stability, a matrixing design is frequently acceptable. When there are only little patterns observed in the supporting data, matrixing variability. But in cases where the supporting data have a fair amount of variance; hence, the matrixing design should be confirmed by statistics. If a large variety is evident in the corroborating data, applying a matrixing design is not recommended. A statistical justification might be predicated on an evaluation of the proposed matrixing design's precision in the shelf-life estimate or its capacity to detect differences in the rates of degradation across different components. The amount of reduction that can be achieved from a complete design, if a matrixing design is thought to be applicable, depends on how many factor combinations are being assessed. The bigger the degree of reduction that may be taken into consideration, the more factors there are related to a product and the more levels there are in each element. Any simplified design, nevertheless, must be able to accurately anticipate the product's shelf life. Table 4 provides a bracketing design illustration. Similar to the whole design in Table 3, this example is based on a product that is available in three strengths and three container sizes.The 10- and 100-mL containers do represent the two extremes of container sizes, as this illustration should make evident. Furthermore, the extremes of the strengths must be illustrated by the 25 mg & 100 mg strengths. Just like in a

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complete design, the batches for every selected combination should be checked at each time point. A total of samples will be examined.

N = 2 × 2 × 3 × 8 = 96

A matrixing-on-time-points design can be seen in Table 5. The drug product's description is comparable to those from the earlier examples. Two distinct designs each make use of three-time codes. As an example of a full one-third design, the time points for Batch B, which has a strength of 100 mg and a container size of 10 mL, are 0, 9, 24, and 36 months. For this full one-third design, there will be a total of samples examined.

N = 3 × 3 × 3 × 4 = 108.

Table 6 provides an instance of matrixing factors and time points using three-time codes, much like in the preceding example.These tests are conducted on Batch B at 0,6, 9, 18, 24, and 36 months using a 100 mg strength and a 10 mL bottle. For this case, a total of 36 samples will be evaluated.

N = 3 × 3 × 2 × 6 = 10

Power Comparison Between Bracketing and Matrixing Designs

Remember that the lowest power to detect slope changes is Power$_M$.

Power$_M$ >power$_B$, if and only if, is the minimum.

$\sqrt{2.773} - \sqrt{3.9875\delta^2/\sigma^2 + 1} < 1.15 - 2.115/\sigma$

or equivalently,

$0 < \delta/\sigma < (\cong 0.315)$

As it turns out, a matrixing design is more powerful than a bracketing design.

when $\delta/\sigma < 0.315$

Data evaluation

Data on stability from bracketed, matrixed, or both experiments should be handled similarly to data from nonreduced studies. If the visual evaluation of the data shows that there hasn't been a noticeable change in a parameter, then no statistical analysis is required. In case when Statistical evaluation is necessary, data from several batches and testing for the pool ability of presentations should come first. The smallest EP should be utilized rather than being applied to all demonstrations and groups if pooling is not necessary. All presentations are subject to the anticipated EP if combining is acceptable.

Stability protocol

Well-designed stability research is essential to the success of any stability program. The first stage in the program should be to create a stability protocol that explains the purpose of the research, structure, batches and packaging specifics, guidelines, points of time, needs for storage, sampling technique, statistical evaluation method, and other relevant information. The procedure itself must be carefully thought out and adhered to, and data gathering should be comprehensive and done by the process. To prevent the impression of picking a strategy to create the most acceptable conclusion at the time of data analysis, the protocol needs to describe the intended statistical analysis. Any alteration to the design complicates the interpretation of the collected data. Any changes made after the data has been analyzed or without changing the procedure should be clearly stated in the analysis or design plan. The following details have to be included in a stability procedure that is properly thought out:

- Number of Batches
- Containers and closures
- Orientation of storage of containers
- Sampling time points
- Test storage conditions
- Test parameters
- Test methodology
- Acceptance criteria

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THE ESSENTIALS OF DESIGN
Effects of format elements on estimated duration of shelf-life:

There are multiple dosages and packaging choices available for a drug product. For long-term stability studies, the following design characteristics will be incorporated intostability designs: batch, strength, and container size. According to Nordbrock [10] and Chow [2], examining several possibilities is intriguing, including the following ones:

1. The rates of degradation for various container sizes are constant throughout the strengths.
2. The rates of degradation are constant across every container size.
3. The rates of degradation are uniform across all strengths.
4. All batches have the same degradation rates.

Consequently, during long-term testing, it is essential to examine how important effects (such as strength, batch size, and container size) and interaction effects impact the stability of the therapeutic product. When creating a design for stability, one must take into account how much data from various design variables may be pooled. For instance, if the interaction effect is statistically significant for container strength and size, then a distinct shelf life should be predicted depending on the container's dimensions and power. On the contrary, if the rates of degradation for every container size, batch, and strength are identical the combination's effect is not statistically important.The results should thus be combined, and only one shelf life should be calculated for all batch sizes, strengths, and container dimensions that were produced under the same circumstances. A design should be well thought out so that it can identify any potential major effects and interaction effects.

A simplified design is preferable to a comprehensive one since it requires fewer samples to be tested and, thus, less money. Nevertheless, it has the following drawbacks:

1. For some designs, it can be impossible to analyze certain interaction effects. For instance, two-factor effects for a24-1 fractional factorial layout are confused with himself, making it difficult to decide whether to pool the data.
2. If two factors interact, the data cannot be pooled to yield a single shelf life. such as the strength and container size. It is suggested that a distinct shelf life be mentioned for every strength combination and container size. The expected lifespan of the lacking component combinations, however, cannot be estimated.
3. The estimated shelf life might not be as accurate if there are a lot of unavailable component combinations. A design that reduces misleading and/or impact of interaction should be used to improve the accuracy of the expected shelf life. The features of the design should be considered in statistical analysis after design selection.

Concerns with sample quantity and selection

A stability study's overall number of samples evaluated should be sufficient to ascertain the medical product's stability characteristics and offer a fairly accurate estimate of its shelf life. The overall number of test samples required for stability research often depends on the study's goal and design. Limited design alternatives are available for a drug product with only one dosage and package size; samples must be examined every three months in the first year, every six months in the second, and once a year after that. For pharmaceutical items, a range of design types with several design aspects are offered., including complete, bracketing, and matrixing designs. In general, while selecting a design, the anticipated number of batches, variation in information within or between design factors, the expected product shelf life, and the planned variety of design elements for the research should all be considered. The stability data that is now available must also be evaluated, taking into account the variability in both the manufacturing and analytical procedures. The shelf life of a drug product is assessed by analysing a limited number of therapeutic product units. Thus, tested samples should be average in every aspect, as previously suggested.

Other issues

The goal of choosing a suitable stability design is to increase the precision and accuracy of the medication product's specified shelf-life. The design of stability research benefits from background knowledge, such as regulatory requirements, the manufacturing process, suggested specifications, and the findings of developmental studies. The formulation and manufacturing process should be taken into account while selecting a design for a stability study. For instance, a product created from a common granulation that comes in three strengths will have a different research design and statistical analysis than products made from several granulations with various formulas. The

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stability research strategy should be able to minimize variability and prevent bias. As a result, the design should account for differences from various sources. Variances can be caused through particular dose units, vessels within a batch, groups, techniques for analysis, analysts, labs, and batches. production facilities. Furthermore, lacking Values should be avoided, as well as the motivation to document the missing values is necessary. One cannot choose a matrixing design with the presumption that all drug products have the same shelf life. Design elements. If the statistical findings indicate a big difference between batch sizes and package sizes, one cannot depend on a statistical approach or specific batch and container size combinations to provide accurate data on the missing alternatives. Calculating the durability is necessary, given the observed batch and combo combinations, the size of a container, and the smallest shelf ever observed.

CONCLUSION

Generally, stability studies are to be necessarily performed for medical dosage forms so that the max time point up to which it remains (or) retains its therapeutic activity but previously companies used to perform stability studies for whole batches which requires a great amount of time and this method found to be expensive. As an alternative to this full design of stability studies reduced design was introduced which not only helped to lessen the time but was found to be economic by cutting expenses. In reduced design, there are mainly two techniques that are extensively used. These two techniques namely bracketing and matrixing. While sampling one should be careful and should consider different attributes like strength and container size. While considering these reduced design sampling should be done on statistical concerns. A part of this reduced design can have appropriate results that are quite reliable. So instead of a full design one can go with a reduced design in stability considerations.

CONFLICT OF INTEREST
The authors have no conflict of interest.

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Table 4. Sampling time intervals (months) for bracketing and matrixing designs

Factor	Level 1			Level 2			Level 3		
Batch	1	2	3	1	2	3	1	2	3
Bracketing	T_0	T_0	T_0				T_0	T_0	T_0
Matrixing	T_7	T_9	T_5	T_9	T_5	T_7	T_5	T_7	T_9

T_0 (0, 3, 6, 9, 12, 18, 24); T_5 (0, 3, 6, 12, 24); T_7 (0, 3, 12, 18, 24); T_9 (0, 6, 12, 18, 24). Reference is taken from [5]

Table 5. An Example of a Stability Protocol Using a Full Design According to the ICH Q1A(R2) Guidelines

Number of batches	3
Number of strengths	3
Number of container sizes	4
Long term*, intermediate, and accelerated	Long term, 25◦ C ±2 ◦ C/60% RH ±5% RH Intermediate, 30◦ C ±2◦ C/65% RH ±5% RH Accelerated, 40◦ C ±2◦ C/75% RH ±5% RH
Time points (months)	Long-term, 0, 3, 6, 9, 12, 18, 24, 36 Intermediate, 0, 6, 9, 12 Accelerated, 0, 3, 6
Total number of samples tested	1180

Table 6. Example of a Full Stability Study Design

Granulation Batch	Strength	Container Size		
		10 ml	50 ml	100 ml
A	25	T	T	T
	50	T	T	T
	100	T	T	T
B	25	T	T	T
	50	T	T	T

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	100	T	T	T
	25	T	T	T
C	50	T	T	T
	100	T	T	T

T = Sample tested at 0, 3, 6, 9, 12, 18, 24, 36 months Reference is taken from[7]

Table 4. An example of bracketing design

Batch	Strength	Container size		
		10ml	50ml	100ml
A	25	T		T
	50			
	100	T		T
B	25	T		T
	50			
	100	T		T
C	25	T		T
	50			
	100	T		T

Sample tested at 0, 3, 6, 9, 12, 18, 24, and 36 months. Reference taken from[7]

Table 7. Example of a matrixing-on-time-points design

Batch	strength	Container size		
		10ml	50ml	100ml
A	25	T_1	T_2	T_3
	50	T_3	T_1	T_2
	100	T_2	T_3	T_1
B	25	T_2	T_3	T_1
	50	T_1	T_2	T_3
	100	T_3	T_1	T_2
C	25	T_3	T_1	T_2
	50	T_2	T_3	T_1
	100	T_1	T_2	T_3

Reference is taken from[7]

Complete one-third design

Time code	Time points(months)						
T1	0	3			12			36
T2	0		6			18		36
T3	0			9			24	36

Reference is taken from [7]

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Complete two-third design

Time code	Time points(moths)							
T1	0	3		9	12		24	36
T2	0	3	6		12	18		36
T3	0		6	9		18	24	36

Reference is taken from [7]

Table 6. Examples of a matrixing on time points and factors

Batch	Strength	Container size		
		10ml	50ml	100ml
A	25	T1	T2	T3
	50			
	100	T2	T3	T1
B	25	T2	T3	T1
	50			
	100	T3	T1	T2
C	25	T3	T1	T2
	50			
	100	T1	T2	T3

Reference is taken from[7]

Time code	Time points(months)							
T1	0	3		9	12		24	36
T2	0	3	6		12	18		36
T3	0		6	9		18	24	36

Reference is taken from[7]

RESEARCH ARTICLE

A Glance of Renewable Energies in Asian Countries

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ABSTRACT

Fossil fuels like crude oil, coal, and natural gas have been around for millions of years. Their consumption has been increasing due to human needs. Crude oil is easy to extract and transport, while coal is cost-effective and produced in power plants. However, they also release CO2, which contributes to pollution and global warming. Also, emit harmful emissions and harm the environment and human health. They also cause acid rain and water pollution. Global summits aim for sustainable and renewable energy conversion to clean and green energies to combat these issues. The present study focused on sustainable and renewable energies in Asian countries like Bangladesh, India, Pakistan, and Sri Lanka. It compares fossil fuels and renewable sources like solar, wind, and hydropower. Renewable energy is clean and green and benefits natural resources. Renewable energy is cost-effective, pollution-free, and environmentally friendly. The present study overviewed the fossil fuel consumption and Rene energy consumption in Asian studies. This will be helpful as a glance picture for the policy makers and government to take necessary actions and right decisions for making sustainable environments.

Keywords: Renewable energy, Sustainable, Fossil fuel, Energy consumption, CO2 emissions

INTRODUCTION

Energy demand is increasing, diminishing conventional resources that pollute the environment. Non-conventional renewable energy resources (RERs) are limitless, abundant, and pollution-free. Several countries are moving toward RERs due to the diminishing supply of fossil fuels and increasing rate of Green House Gas (GHG) emissions. Renewable energy sources are inexhaustible and contribute to economic and social development goals. Fossil fuels remain the primary source of energy despite their disadvantages. Fossil fuels are the largest contributors to greenhouse gas emissions and climate change. Renewable energy sources have remained low compared to fossil

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fuels. Renewable energy production world bank represents 17-18.5% of global energy production per person for the last 20 years. Non-hydro renewables share in global electricity portfolio was 7.9% in 2016. China, the US, and Germany produced 54.3% of renewable electricity. Japan, India, and Italy produced 14.1% of non-renewable electricity, while remaining countries produced 31.6% of renewable electricity globally. Renewable energy is crucial for sustainable and carbon-neutral energy needs. Increasing its share is critical.

RESEARCH STUDIES

[1]focused on attempts to assess the existing state, future strategies, and policies for hydropower development in India, with a particular focus on SHP. [2] given an overview of the renewable energy status in the Asian countries, and it includes an assessment of the region's renewable potential, current installed renewable energy capacity. In the context of energy scenario, the researchers explored about renewable energy potential and challenges in Asian countries. [3] looked into why Pakistan's hydropower sector has been slow to develop. To investigate the impending reasons, a combined strategy involving NVIVO analysis and Q methodology was used.

RESULTS AND DISCUSSIONS

Renewable Energy in Asian Countries
Asian current description unswerving including Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka as the essential nations. It provides a comprehensive analysis of the fit volume of these types of energy in the region. This report covers the renewable energy market in Asian countries namely, hydro, wind, solar, and others. In 2021, the solar energy market is expected to grow at a significant rate. Asian is a significant contributor to the renewable energy market in the Asia-Pacific region due to the region's rapid emergence and growth. In 2021, India's government's efforts to encourage the expansion of policies and the execution of renewable energy projects were instrumental in the country's increasing 147.1 GW in 2021renewable energy capacity. In addition to government support, various financial instruments such as capital, concessional finance, and generation-based incentives have also been instrumental in India's renewable energy goals.

Need of Renewable Energy in ASIAN Countries
Over the past two decades, the ASIAN has successfully brought about half a billion people into the electricity supply. Unfortunately, many people still live in areas where electricity is not available. The major countries such as India, Pakistan, Bangladesh, and Sri Lanka were considered and highlighted need of renewable energy for electricity requirements of the countries. To meet the growing power consumption in the major countries in the region, the energy supply requirements to increase significantly. Conventional sources of energy are not able to keep up with the region's increasing demand, which is resulting in greater reliance on imported fuel. Renewable energy sources can help meet the region's energy needs.

Renewable Energy Potential in ASIAN Countries
Over the establishment of a regional clean energy development framework, the countries of Asian have been able to increase the renewable energy resources usage. This has also reduced the environmental impact of their energy usage. This strategy can help countries meet their international goals and reduce their greenhouse gas emissions. For instance, Sri Lanka, Afghanistan, and Maldives are expected to develop solar power.In addition, Bhutan and Nepal are also expected to benefit from the region's vast hydro resources. As for larger nations such as Bangladesh, India, and Pakistan, they can potentially increase their renewable energy mix by developing more balanced energy sources. The following table 2 shows the present generation measurements and peak demands of the different countries in the region. For instance, in Nepal and Afghanistan, the installed capacity of power plants is below the peak demand. The technology and country-wise breakdowns of renewable energy installations have been provided below. For instance, Nepal and Bhutan have traditionally been active in hydroelectricity. The other member states of the region, such as

India and Pakistan, have started catching up to their neighbours and are also investing heavily in wind and solar technologies.

CO2 Emission from Energy

Carbon dioxide emission of four countries India, Bangladesh, Sri Lanka, Pakistan from 2011 to 2021 and with comparison to world emission. The graphical representation of the above table mentioned in figure 6 clearly. India CO2 emission is high followed by Pakistan, Bangladesh and Sri Lanka. CO2 emissions from 2011 to 2021 world-wide, peak emissions observed in 2017-18 was displayed in fig 7. Growth rate and share of co2 emissions of 4 countries and world showed in Figure 8

Renewable Energy - Generation by Source (Wind, Solar, Hydro, Others)

Sources of generating renewable energy for India, Sri Lanka, Bangladesh, Pakistan and World were Wind, Solar, Hydro Power and other Renewables along with world data. The illustration showed in figure 9. Out of four countries India stands high in all sources of energy generation. Sources of generating renewable energy for India, Sri Lanka, Bangladesh, Pakistan and World were Wind, Solar, Hydro Power and other Renewables along with world data. The illustration showed in figure 9. Out of four countries India stands high in all sources of energy generation. The study focused on sustainable and renewable energies of major ASIAN countries like Bangladesh, Pakistan, Sri Lanka, India. The paper discusses about the energies like renewable and sustainable energy, non-renewables fossil fuels, CO2 emissions and greenhouse gases and their impact on nations.India's government's policies and financial instruments led to a 147.1 GW increase in renewable energy capacity in 2021. Majority of the renewable energy potential like solar, hydro, wind energy measured in Mega Watts among four ASIAN countries solar power was generated by Bangladesh. Hydro and Wind power. The consumption of electricity percapita in kilowatts is high for India 644 followed by Sri Lanka 636.6 and the population accessing the electricity was differ from 1990 to 2016 for the same. There is a huge difference in 1990 was 8.5% and 2016 was 75.9%To meet the growing power consumption in the major countries in the region, the energy supply requirements to increase significantly. Conventional sources of energy are not able to keep up with the region's increasing demand, which is resulting in greater reliance on imported fuel. Renewable energy sources can help meet the region's energy needs. Further peak demand of renewable energy generation capacity among four countries selected as installed in megawatt was high in India followed by Pakistan. For Installation of renewable energy Sri Lanka generates more in total as per pwc. India has the highest primary energy consumption among four countries (India, Sri Lanka, Bangladesh, Pakistan, and Sri Lanka) with 4.61% compared to the world's 4.4%.The total primary energy consumption in 2021 and its growth rate and share per annum from 2011 to 2021, with the highest consumption in 2019. The utilisation of primary energy across the world was illustrated in figure.8 the measurement expressed in exajoules. The data collected from 2011 to 2021. In India the consumption of energy is maximum in 2021 as 35.43 units followed by 34.15 EJ units in 2019. Among four ASIAN countries the least consumption of energy is Sri Lanka with 0.39EJ unit in 2019 but India is using 35.43 EJ units which is highest of 4 nations. Bangladesh utilizes less (1.65 EJ) energy compared with India (35.43 EJ). The data compared for 11 years from 2011 to 2021. Pakistan is second highest consumption nation of the study i.e., 3.86EJ in 2021 which scores maximum for 10 years of data. Asian's clean energy development framework has led to increased renewable energy usage and reduced environmental impact countries like Sri Lanka, Afghanistan, and Maldives are developing solar power, while Bhutan and Nepal benefit from hydro resources. Larger nations can potentially increase their renewable energy mix by developing balanced energy sources.

CONCLUSION

The fossil fuels consumption is high in the world, so there is significant scope and need of renewable energies. In Asia – Pacific region, Asian is significant contributor to the renewable energy market. The annual energy investment of Asian countries is quite less compared to global level investment comparatively from 2013 it has been increased. The potential of renewable energy, peak demand for production and consumption is high in India. In Carbon dioxide CO2 emission also, India ranked high to control and balance the environment there is a huge need of renewable

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energies in the countries. India is the only country generate renewable energy by source hydro. In conclusion, reducing CO_2 emissions is urgent due to climate change threats. Transitioning to renewable energy sources like solar, wind, and hydropower is essential for a balanced environment. This shift demands concerted efforts from policymakers, industries, and individuals to adopt cleaner technologies. Investing in sustainable infrastructure and promoting energy efficiency will significantly cut emissions, fostering a resilient ecosystem. Additionally, this transformation offers economic benefits through green job creation. Ultimately, embracing renewable energy and reducing CO_2 emissions are critical for a sustainable and prosperous future for our planet.

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Table: 1 Need of Renewable Energy

Country	Population access to electricity (%)		Electricity Consumption Per Capita (kwh)
	1990	**2016**	
Bangladesh	8.5	75.9	278.1
India	43.3	84.5	644
Pakistan	59.9	99.1	457
Sri Lanka	52.9	95.6	636.6
source: bp[5]			

Table: 2 Potential of Renewable Energy

Country	Solar Power (MW)	Hydro Power(MW)	Wind Power (MW)
Bangladesh	5.0 kwh/day/m²		
India	5.0 kwh/day/m²	150,000	102778
Pakistan	5kwh/day/m²	2,000	24000
Sri Lanka	2,900,000	59,000	131,800

source: pwc[4]

Table: 3 Peak demand of Renewable Energy

Country	Generation CapacityInstalled (MW)	Demand in Peak (MW)
India	3,30,860	1,64,000
Sri Lanka	4,084	2,523
Bangladesh	13,846	11,637
Pakistan	25,374	25,713

source: IEA[7]

Table: 4 Installations of Renewable Energy in megawatts

Country	Solar	Wind	Hydro	Biogas	Other	% total
India	21,651	34,145	4,632	9,502	-	33%
Sri Lanka	91.36	131.45	1,729.59	24.10	2,015	49.47%
Bangladesh	17.35	0.90	230	-	-	2.82%
Pakistan	400	551.40	7,340.10	257.91	26,795	31.90%

source: pwc[4]

Table: 5 CO2 Emissions from Energy (Million tonnes)

Year	India	Sri Lanka	Bangladesh	Pakistan	World
2011	1728.4	16.4	56.5	145.2	31904.6
2012	1861.4	18.2	60.4	144.6	32241.1
2013	1934	15.9	62.7	145.3	32710.9
2014	2090.7	19.6	65.4	151.7	32820.2
2015	2146.5	21.6	78	160.3	32837.4
2016	2241.5	24.7	79.2	176.5	33020.6
2017	2320.2	24.4	83.2	188.7	33426.4
2018	2442.6	23.4	89.2	196.9	34148.5
2019	2465.8	25.3	99.1	207.1	34095.8
2020	2281.2	23.8	96.8	206.3	32078.5
2021	2552.8	22.8	100.9	226.4	33884.1

source: bp 2022 [6]

Table 7 - Renewable Energy - Generation by source

YEAR	2021			
Source Countries	Wind (Gw)	Solar (Gw)	Hydro (EJ)	Other Renewables (Gw)
Bangladesh	0.04	0.4	0	0.04
India	68.10	68.3	160.3	35.50
Pakistan	3.40	1.50	0.00	0.70
Sri Lanka	0.70	0.80	0.00	0.10
World	1861.90	1032.50	4273.80	762.80
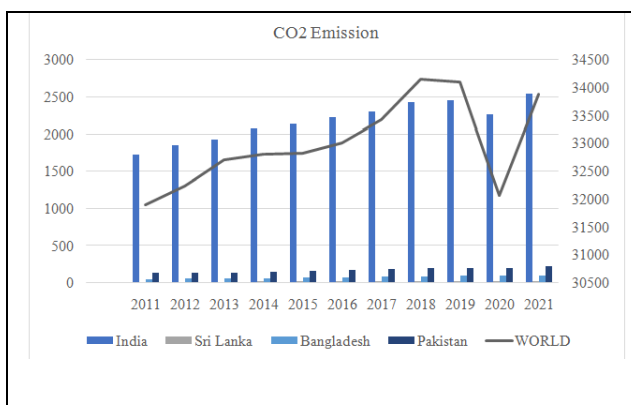
Figure: 1 CO₂ Emissions from 2011-2021 Energy in million tonnes	Figure: 2 Emission of carbon dioxide in world
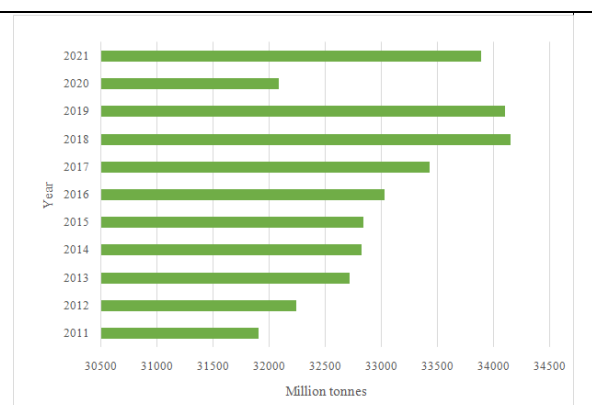
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Figure: 3 CO₂ Emissions from Energy Growth rate & Share	**Figure: 4 Renewable Energy - Generation by source in 2021**

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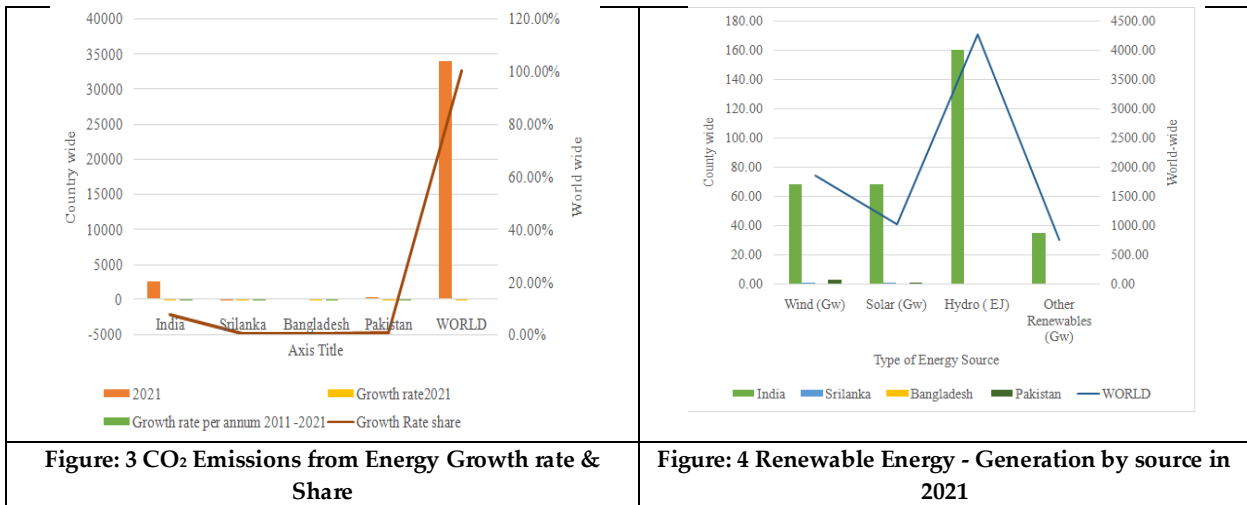
A Series of Cases Highlighting the Effect of Classical Homeopathic Remedies in Addressing Manifestations of Patients with PCOD

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ABSTRACT

Polycystic Ovarian Disease (PCOD) is a prevalent endocrine disorder affecting primarily women of reproductive age. It is characterized by biochemical or clinical evidence of hyperandrogenism, oligo-anovulation and polycystic ovarian morphology. This hormonal dysregulation leads to a range of symptoms, such as irregular menstrual cycles (less than 5-8 cycles per year), acne, hirsutism, hair thinning, obesity, acanthosis nigricans. It is associated with important reproductive morbidity, including infertility, endometrial cancer, metabolic and cardiovascular diseases, insulin resistance in obese and non-obese women. Homeopathy can be thought of as an alternative mode of treatment because its therapeutic approach is based on concept of individualization. As per Hahnemann "It is a man that is sick and needs to be restored to health and not his body or the tissues. Also, the true natural chronic disease arises from the chronic miasm and can only be treated by individualistic homeopathic constitutional medicine". "With this concept of the importance of the endocrine glands in maintaining health, and with the almost infinitesimal amount of some of these glandular secretions, we can hardly fail to see the important relationship the homeopathic remedy may hold to the manifestations of endocrine dysfunction and to the balance of the ductless glands themselves. Though there is a great clamor for information on treatment of endocrine conditions, the endocrinologist's findings are similar to the Hahnemannian philosophy that " The human being is a unit of mind, body and spirit - and these are so correlated as to act freely and without impediment when the vital principle, the spirit-like force, is in equilibrium; yet if this equilibrium of health be thrown out of balance by the dysfunction of one member." Citation : HERBERT A. ROBERTS: The principles and Art of Cure by Homœopathy; Chapter-XXXII- Homœopathic therapeutics in the field of endocrinology.

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INTRODUCTION

The most common cause of secondary amenorrhea is PCOD,occurring in 5-10% of reproductive age women, also known as **Stein-Levanthal Syndrome.** It is a heterogeneous disorder of multifactorial aetiology in woman of reproductive age with the **ovarian expression** of various metabolic disturbances and of clinical features as **menstrual abnormalities**(Amenorrhea, Oligomenorrhea, Irregular bleeding), **Obesity, Hirsutism and Hyperandrogenism.**
The normal ovary is **3x4 cm** in size. In PCOD ovary there is multiple **small size follicles** which gives an appearance of **"Ring of Pearls"**. These follicles are arranged around the **periphery** of the ovary giving it a **Necklace Appearance.**There is presence of **20** or more follicles in either ovary measuring **2-9mm** in diameter or increased ovarian volume (**>10ml**). **According to ESHRE and ASRM conference held in 2018 the number of the follicles is updated from 12 to 20, and even if the one ovary is having this picture means more than 20 follicles is considered as PCOS.** Exact pathophysiology of PCOD is not clearly understood. The major causes for PCOD are hypothalamic pituitary abnormality and insulin resistance. These two factors further lead to androgen excess and chronic anovulation. The dysfunction in the hypothalamic pituitary axis leads to reduced rythmic, pulsatility of the GnRH pulse generator to progesterone suppression. Thus, ovarian steroid negative feedback that tightly regulates the Hypothalamic-Pituitary-Gonadal (HPG) axis is impaired, leading to hyperactive LH secretion. Higher frequency or constant exposure to LH gives rise to anovulation and amenorrhea. Variation in LH pulse frequency influence the ratio of LH and FSH levels. The other key factor that is resposible for the development of PCOD is insulin resistance which originally develops in the form of glucose intolerance. The insulin resistance at certain instances is termed as " the diabetes of bearded women". This insulin resistance manifests itself in different forms such as acanthosis nigricans, cental adiposity (mostly measured as increased hip-to-waist ratio and termed as male pattern obesity). Dyslipidemia is also evident in certain cases which also adds onto the disturbed hormonal levels. These dyslipidemia can also develop hypertension in long run cases. Another feature of hyperandrogenism and insulin resistance is hirsutism. It is defined as the presence of terminal hair in locations at which hair is not commonly found in women. It includes facial hair on the cheek, above the upper lip, on the chin and midline chest hair. The scoring system available for quantifying hirsutism are proposed by ferryman Gallway score. Visual methods are used to determine the density of terminal hairs at eleven different body sites- the lip, chin, chest, upper abdomen, lower abdomen, upper arm, forearm, thigh, lower leg; upper back and lower back- with scores ranging and the total score was calculated from 0-4, A maximum score of 36 is possible; but a score≥8; indicates hirsutism. Increased levels of androgen secretion induces over production of sebum causing desquamation of epithelial cells which lead to acne vulgaris. About 50% of the female suffer from facial acne, even neck, chest and upper back is also involved.

Objectives
1. To gauge the efficacy of homeopathic medicines in PCOD cases.
2. To determine the therapeutic strategy, evaluate the criteria for assessment, and analyze the treatment results of using homeopathic individualistic remedies in PCOD cases.

CASE REPORT

Case 1
A 28-year-old female consulted on 23/09/2022 for the treatment of menstrual irregularities (last 3-4 months menses not appeared), and abnormal hair growth on chin, back, upper lip and chest since 4 years. Menses with unbearable pain in hypogastrium and lumbar region (back). Menses lasts for only one day. Weight gain in last few years; it was 50 kg but now it is 65 kg. She was on gynecologist treatment but did not found quite effective. Menarche at the age of 13 yr,
Past History: recurrent pelvic inflammation, vaginitis, ganglion (operated 6 yr ago)
Family History: Father: High cholesterol, diabetes, Mother: hypertension

Shital C. Shah

Mental Generals

Born and brought up in Ahmedabad, studied B.com, housewife, husband works in a company. Stays with in laws. Normal in nature, not very sensitive, feels if husband can't give her enough time. Feel sad when mother in law scolds her or give advice repeatedly. Had a body image issues due to sudden weight gain. Lived in a joint family, had a strict grandfather who would not allow her to go out and he was very rigid and wanted things in a particular way. Had an incident in 7th std – a servant abused her sexually. That guilty feeling is still there and had a hard time, getting physical touch with her husband. Feels angry and weeps alone when remember the incidence

Physical general

Appetite: normal

Desire: oily food, junk food, onion,

Aversion: nothing specific

Thirst: 2 - 3 lit/day

Bowel: stool- hard, constipated

Urine: 6 -7 times/day

Perspiration: increased on genitals; slightly offensive

Sleep: restless,

Habit- tea/coffee/tobacco/smoking/alcohol-not any

Thermal: Hot

INVESTIGATION

Before treatment

After treatment

Shital C. Shah

First prescription

Thuja 1M single dose and sac lac ,TDS for one month is prescribed and advised for regular exercise for 30–35 min/per day with avoidance of junk/fast food and high-calorie diet.

Basis of prescription

Repertorisation was done of the following symptom:

Mind, delusion, imagination, ugly, is

Mind, anxiety, conscience of, as if guilty of crime

Female genitalia, menses, absent, amenorrhoea

Female, tumor, genitalia, ovary cyst

Skin, white spot, vitiligo

Food and drink, salty food, desire

Case 2

A 17-year-old female consulted on 24/12/2022 for the treatment of menstrual irregularities since menarche, menses every 2-2.5 months with abnormal hair growth on chin, back, upper lip and chest since 3 years. Menses with unbearable pain abdomen. Menses lasts for only one day. Weight gain in last few years; it was 50 kg but now it is 70 kg. She was on gynecologist treatment but did not found quite effective. Menarche at the age of 14 yr.

Past History: Dengue, typhoid.

Family History: Diabetes: mother, father, - grand mother

Mental Generals

Born and brought up in Mumbai, in a rich family, father is a businessman and mother works in a NGO. She always feels alone as her parents are busy in their life. Her mother always neglected me as she used to remain very busy with her meetings and work schedules. She had her first boyfriend at the age of 12yr, but it was just a crush and they broke up within sometime. Had another relationship for much longer than the previous one but they broke up because she needed more time and attention from the guy also the sexuality was higher. She felt that her needs were not fulfilled, so she parted her ways with him too. Recently she moved abroad to study and moved in with her new boyfriend within few months. She has a habit of masturbating quite frequently sometimes more than 5-6 times a day.

Physical general

Appetite: normal

Desire: meat, chocolate

Aversion: bitter gourd, coriander

79587

Thirst: 2 - 3 lit/day
Bowel: stool- hard , constipated
Urine: 6 -7 times/day
Perspiration: increase
Sleep: restless,
Habit- smoking and alcohol
Thermal: Hot

INVESTIGATIONS
Before treatment

After treatment

First prescription : PLATINA 10M single dose and sac lac ,TDS for one month is prescribed and advised for regular exercise for 30–35 min/per day with avoidance of junk/fast food and high-calorie diet.
Basis of prescription
Repertorisation was done of the following symptom:
Food, cold, drinks, water, desire:
Female, tumors, genitalia: ovary
Skin, eruptions: psoriasis
Female genitalia, menses, absent, amenorrhea
Female genitalia, menses, painful, dysmenorrhea
Female genitalia, masturbation, disposition
Female genitalia, menses profuse
Female genitalia, sexual, libido: desire, increased
Generalities, tobacco: desire: smoking
Mind, neglected: ailments from, agg. From being
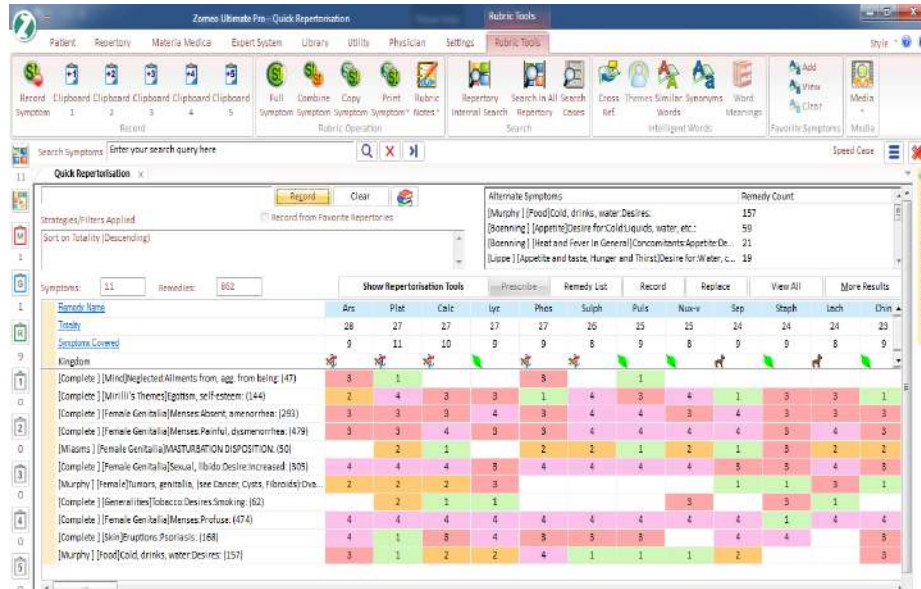
Case 3

A case of 16-year-old girl came with PCOD on 16/9/2022 with complain of irregular menses since menarche. on investigation cysts were found in ovaries and also there was marked hyperandrogenism and a disturbed value of LH and FSH. She had extra hair-growth on chin and face. She had no visible weight gain which was contrary to the classical PCOD symptoms but had a marked biochemical changes.

Past History: recurrent stye.

Family History: Heart disease: Grandfather

Diabetes: grand mother

Mental Generals

Very shy in nature, always help mother in her household activity, father is strict, scolds me on a small matter without any reason, but I never back answer him. Even in a school my class mates tease me but I become quiet, always feel I slap him, but can't. loves to play badminton, and help teacher in extracurricular activity. Wants to go abroad for further studies. Scored 10 out of 30 in social studies. "I studied hard for the examination, but on that day not feeling well. The teacher scolds me badly and called my parents to show the result and complain about me, without knowing any reason, my father started abusing me verbally in school, he never understands me. He loves me and takes good care of me, but the way he scold me that affects me. My mother is mild and very caring in nature."

Physical general

Appetite: 2 times/ day

Desire: junk food +3

Aversion: rice

Thirst: 3-4 L/ day

Bowel: regular

Urine: 5-6 times / day

Perspiration: increased on face

Sleep: sound

Thermal: hot

INVESTIGATIONS
Before treatment

After treatment

First prescription: STAPHYSAGRIA 10M single dose and sac lac ,TDS for one month is prescribed and advised for regular exercise for 30–35 min/per day with avoidance of junk/fast food and high-calorie diet.

Basis of prescription

Repertorisation was done of the following symptom:

Food and drinks: Rice: Aversion

Mind: Insults, offenses: Ailments from, agg.

Mind: Delusions, imagination; Neglected: He is, she is

Mind: Anger Ailments from, agg.: Mental and emotional

Female genitalia: Menses : Absent, amenorrhoea

Female: Tumors, genitalia; Ova

Eyes: sties, styes
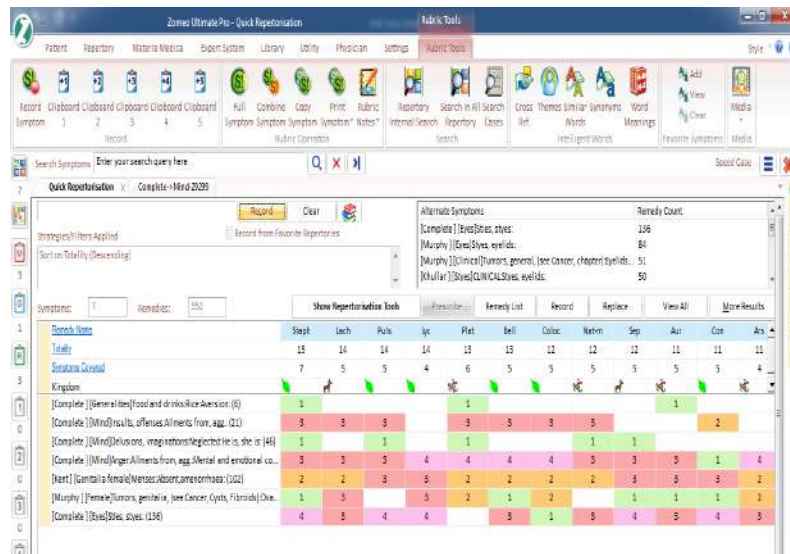
Case 4

Case of a 32-year-old female with irregular menses after the death of her husband with baldness appearing in her hairline. She also had fibroids in the uterus along with multiple cysts in ovaries. She also showed with increased hair growth on the face especially on chin, upper lip and chest.

History: -

Family History: Rheumatism: mother

Mental Generals

Bornand brought up in Ahmedabad. Studied B.com and she is housewife. Husband businessman. Stayed with joint family. She is very emotional and feels hurt when anyone says anything to her. She is taciturn, don't want to talk much. She never explains her feelings to other even she feel sad. Early years of mairrage, mother in law uses censorious words, but she just keep silent. Husband nature was good. He was loving and gives respect and even takes stand for me. But one day when she was at her parents home, and she had a news that he had done suicide, as he had lost everything in his business. Her life was totally changed. She was in depression for few years and had treatment for it. Now she stays with her parents. Her Bhabhi don't like that she stays with them. so fight with her on small matters , and her mother is suffering from initial stage of dementia, so she is controlling herself and not telling others that she had hurt or feel sad. She loved long and driving and risky activities like mountain climbing, diving, driving motorcycle, bungee jumping and parachuting feels attractive to them.

Physical general

Appetite: 3 times/ day

Desire: chocolate^{+2}

Aversion: bitter gourd

Thirst: 2-3L/ day

Bowel: regular

Urine: 5-6 times/ day

Perspiration: more on axilla and chest

Sleep: disturbed

Habit-:

Thermal: chilly

INVESTIGATIONS
Before treatment

After treatment

First prescription: Aurum muriaticumnatronatum 1M single dose and sac lac ,TDS for one month is prescribed and advised for regular exercise for 30–35 min/per day with avoidance of junk/fast food and high-calorie diet.

Basis of prescription
Repertorisation was done of the following symptom:
Mind, grief, sorrow, general: death of loved ones
Mind, sadness: weeping with
Mind, excitement, excitable, ameliorates
Genitalia female, menses: absent, amenorrhoea
Female,tumors, genitalia, :ovaries cyst
Generalities, food and drinks: bread, desires
Generalities, food and drinks: farinaceous desire

Shital C. Shah
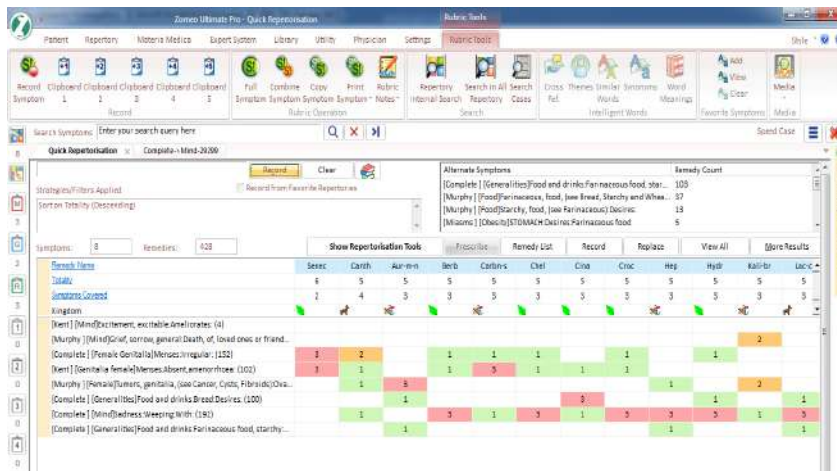
DISCUSSION AND CONCLUSION

In § 5, Dr Hahnemann has mentioned, "the most significant points in the whole history of the chronic disease, to enable him to discover its fundamental cause, which is generally due to a chronic miasm. In these investigations, the ascertainable physical constitution of the patient (especially when the disease is chronic), his moral and intellectual character, his occupation, mode of living and habits, his social and domestic relations, his age, sexual function, etc. are to be taken into consideration."As PCOD is a condition of multisystem involvement, a multidisciplinary approach is pivotal to combat and overcome it. Our dynamic remedies arouse the individuals own immunity which fights the disease as an entity dynamically and re- establishes the health and harmony. Thus, a dynamic homoeopathic similimum clears hormonal imbalance, regularizes natural ovulation, restores menstrual normalcy, handles obesity, and treats as a whole positively. From the analysis of the above results obtained it is obvious that Homoeopathic treatment is effective in Polycystic Ovarian Disease especially where the patient is disturbed emotionally. We should consider mental general and constitution of patient for most similar homoeopathic remedy. Life style modification along with homoeopathic treatment is effective in reducing signs and symptoms of PCOD.

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RESEARCH ARTICLE

An Analytical Study on Financial Literacy among College Students

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ABSTRACT

Financial literacy is important because it is only through being able to understand how money works that we can conquer it. Money may not be the only thing that matters but it does affect everything that matters: education, family, health, etc. Making money is a skill. And like most skills, it can be learned. If we want to become financially free the first steps to this is financial literacy. Become financially literate and start working on our way towards financial freedom. The lack of essential knowledge about financial products and services and their risk-return framework is one typical example of financial illiteracy that is regularly observed. The main objective of this paper is to analyze about the awareness about the financial knowledge among the students , channel of investment and savings. This paper also focuses on which factor plays a predominant role influences the student to invest in pattern of investment. Questionnaire have been framed to collect the data from the under graduate students. It is found that students were aware about the financial literacy and investment.

Keywords: Money, Investment, financial knowledge

INTRODUCTION

The creation, administration, and study of money and investments are collectively referred to as "finance" in this context. It comprises using projected income flows to fund ongoing projects via credit and debit, securities, and investments. Because the concept of financial literacy is complex, it is essential to comprehend its full relevance. Actually, our culture still hasn't fully grasped the need and potential of financial literacy. Financial literacy permeates every social group and economic level. Understanding and effectively utilizing different financial skills, such as

personal financial management, budgeting, and saving, are components of financial literacy. A person who is financially literate has the capacity to appropriately utilise credit, the assurance to manage their money and financial risks, an understanding of the long-term advantages of saving, and a positive outlook on financial planning. These are merely fundamental yet necessary qualities that each and every person and consumer demands. For the improvement of fundamental money management and personal success, the ability to function in a literate society extends specifically to financial competence. These initiatives have benefited from the national strategy for financial inclusion **(NSFI) 2019–2024**. The goal of the plan is to give under banked and underinsured people inexpensive access to formal financial services including banking and insurance. The other two significant goals, which include a comprehensive strategy for empowering end users, are promoting financial literacy and protecting consumers. These initiatives have made it possible to close the gap and include a significant portion of our population in financial services. Women currently own 56 per cent of PMJDY bank accounts. According to the **Economic Survey 2022–23,** India's life insurance penetration rate was 3.2 per cent in 2021, which is somewhat higher than the global average and nearly twice as high as that of emerging markets.

STATEMENT OF THE PROBLEM
The level of financial literacy is cause of concern in all sectors of the economy. The determination of financial literacy of college students in very critical because today's students can be tomorrow's investors. Here is the need of studying financial literacy of college students as there is a tenet that the Indian teenagers lack financial literacy. The development of every economy depends on healthy saving and proper allocation of funds. For that there is a constant need for good financial knowledge among the citizens of the nation. That proper allocation id dependent upon the financial literacy and skills that the individual have. Good financial knowledge will contribute to better savings. The awareness of various investment avenues, the preferences in investing, consideration of the opinion of friends and family members, financial position of family can all affect the financial literacy of a person. These factors may vary from one person to another. Participation of student in various classes should also be taken into consideration. A number of studies have been conducted in India and abroad regarding financial literacy and its importance in the day today life of every individual, lack of financial literacy is not a problem only in emerging or developing economics. Consumers in developed or advanced economics also fail to demonstrate a strong grasp of financial principles in order to understand and negotiate the financial landscape, manage financial risks effectively and avoid financial pitfalls. A study is needed to evaluate the level of understanding about the financial literacy.

REVIEW OF THE LITERATURE

Garg and Singh (gar 2018) Financial literacy among youth though out the world and found low literacy level among youth. The study also revealed that age, gender, income, marital status level of education plays an important role towards youth literacy level and interlink ages was found between knowledge, attitude and behaviour. **Jeyaram and Mustapha(2017)**The Relationship between financial literacy and demographic factor of university students in Malaysia. The results showed that students studying accounting and business administration found to have a better financial literacy than students in other branches. It was also found that there is a relationship between gender and level of financial literacy, as females students found to have lower levels of financial literacy than males. **Mani Goswami (2017)**The primary goal of her research paper, "A Study on Financial Literacy Among College Students in Delhi," is to analyse the degree of financial literacy among college students by evaluating the influence of various demographic factors, including gender, age group, discipline of study, level of study, annual household income, parent's occupation, and source of income to the students. The report also recommended that students be given access to personal finance courses on campus. All disciplines should be required to complete these. These classes ought to give students hands-on experience, encouraging participation and the transmission of knowledge and financial management skills. **Lazar , and Chandrasekar (2016).** A study was done to determine the impact of demographic parameters on financial literacy, including age, years of education completed, and personal income. Other demographic indicators are employed as independent variables, and financial literacy is used as a dependent variable. The survey took into account working women from Pondicherry who were professionals, salaried workers,

daily wage earners, registered business owners, and unregistered business owners. Financial literacy was found to be more strongly influenced by education than by age, and to be unrelated to personal income. **Mahammad Rizwan, Mahammad Sadhik, Kishan Kumar K S (2015).** The purpose of this study, "A Study on Financial Literacy Among the College Students," is to investigate how the Jnana Jyothi Financial Literacy Trust and its literacy initiatives have helped college students gain financial literacy. The study's primary goals are to evaluate the degree of financial literacy among college students, as well as the demand for financial literacy initiatives among present students, on college campuses. All of the respondents agreed that there was a critical need for financial education in both high schools and colleges, it was discovered. This is due to the students' ignorance of the financial services and products offered by banks. As a result, financial education is necessary. Their research also revealed a rise in deposits at the respondents' respondents' savings bank as well as savings. It demonstrates how trust has an impact on encouraging kids to save money. **Muhammad Albeerdy and Behrooz Gharleghi (2015).** "A study on Determinants of the Financial Literacy among College Students in Malaysia'' they tried to investigate the factors influencing the financial literacy among university students in Malaysia. Empirical results show that there is a significant relationship between independent variables of education, and money attitude towards the dependent variable of financial literacy, while there found no relationship between financial socialization agents and financial literacy. Conclusions: This study is important so as to understand how these independent variables affect the literacy rate of young adults. Efforts may be put to strengthen those variables in order increase the literacy rates of those university students. **Bedi, Sobti and Shankar(Bed2015)** a research study examined the relation among demographic characteristics and financial literacy, behaviour and assessment and also analysed the interconnection between the financial literacy and financial behaviour. The findings suggested that financial literacy varies across the level of education and incomes whereas the behaviour differs across "age, marital status, occupation, work experience and level of income of individuals". Lastly study established positive interrelation between financial behaviour and financial literacy.

OBJECTIVES OF THE STUDY:
- To know their financial knowledge towards saving and investment
- To analyze the money management skills possessed by the students.
- To know the financial literacy among the students.

LIMITATIONS OF STUDY
The following are the limitations of the study. The study covers only a sample 110 student respondents among the under graduate students. Due to time constraint the study has limited to a college in Coimbatore city. The result is based on the information collected from a sample of 110 students. So, No generalization is possible.

RESEARCH METHODOLOGY
In order to achieve the objectives of the study and to analyze the data collected, an appropriate methodology was developed. The present study is exploratory as well as descriptive. The collection of data and analysis are planned accordingly. The various aspects of methodology adopted in the present study are discussed below. The research design used in the study is descriptive research design. A descriptive study is undertaken in order to ascertain and be able to describe the characteristics of the variables, the research design reveals the study of facts existing. Primary data have been used by using questionnaire method to collect the response from the respondents. Simple percentage analysis and Chi square analysis have been used to analayse the collected data.

SAMPLE SIZE
Using the random sampling method, the data have been collected from 110 respondents.

SAMPLING METHOD
Convenient sampling method is used to select the respondents.

Hypothesis of the study
Hypothesis: The following Null hypothesis were framed and significant of these were tested with Chi – Square test with 5 percent level of significance.
Ho : There is no significant relationship between age and financial literacy of the respondents.
H1 : There is a significant relationship between age and financial literacy of the respondents.

ANALYSIS AND INTERPRETATION
FINANCIAL KNOWLEDGE TOWARDS SAVINGS AND INVESTMENTS.
Table 1 shows that Eatables gets the first rank with the mean score of 4.36, Stationery gets the second rank with the mean score of 4.345. Clothing, Books and magazines gets the third and fourth position with the mean score of 4.14 and 3.835 respectively. Since most of the student respondents are between 17-19 years they mostly spend their money on eatables, stationery and clothing rather than spending on books and magazines. Table II reveals that 88per cent of the student respondents are having savings bank account. 56 per cent of the student had the habit of keeping hundi at home. 35 per cent of the student have post office saving account. Only 27 per cent of them are availing education loan. This shows that students are aware of saving money by saving bank account or by hundi or by post office saving account and they show less interest in availing loan and insurance policy. Table III reveals that, Safety of principal amount gets the first rank with the mean score value of 3.735. Liquidity get the second rank with the mean score value of 3.085 followed by periodic return with the mean score value of 2.815. This reveals that most of the student respondents prefer saving money in bank thinking that it would keep their principal amount safe, rather than considering about the periodic returns or appreciation in capital value. Table IV shows that, life insurance policy occupies the first rank with the mean value of 3.695. Gold and silver occupies the second rank with the mean value of 3.41. Shares and Securities come in third position with the mean value of 2.78. Real estate and Mutual funds were in fourth and fifth position with a mean values 2.655 and2.595 respectively. This shows that the student respondents prefer to be in safer side by investing their money in low risk investment channels like life insurance policy, gold and silver. So, they avoid investing in high-risk channels such as shares and securities.

AWARENESS OF THE STUDENTS REGARDING THE FINANCIAL PRODUCTS
Table V reveals that the student respondents are having a knowledge about saving with high mean score value of 2.95 and low mean score value of 1. It implies that the students are more aware about savings is a part of our family life. and less aware in differencing the savings and investments. The students have knowledge on interest towards money lenders interest reveals a high mean score value of 2.55, a lesser knowledge of interest on saving towards bank with a mean score value of 2. Respondents believe that health insurance will covers hospitalisation expenses where it shows a higher mean score value of 2, a insurance which reduces financial risk with low mean score value of 2. It is also analysed that the user of e-shopping with credit card were more facilitated with a higher mean score value of 3, a lower usage of ATM card with the less mean score value of 1. From the improper use of credit card we understood that more spending with a high mean score value of 2 and financial trouble with a lower mean score value of 2. The respondents were very much knowledge and aware of educational loan is repayable with a mean score value of 2.5 and less aware of banks that are regulated by RBI with a low mean score value 2. Knowledge about financial literacy in day today life is higher with high mean score value of 2 when compare the knowledge about the slab rates that is with lower mean score value of 2. Table VI portrays that, 50per cent of the students view towards financial literacy, was savings and channels of investment. 26per cent stated that managing debt and financial security, is financial literacy. And 24per cent thinks that protection and accumulation of wealth is financial literacy. This table show that the student respondents had knowledge that saving and investment is financial literacy because most of them preferred to be in safer side by saving their money.

CHI-SQUAREANALYSIS
This analysis is used to determine the inter-relationship between the major and financial literacy.

RELATIONSHIP BETWEEN MAJOR AND FINANCIAL LITERACY

To determine the inter-dependency between the major and financial literacy, the following hypothesis is framed:

H1: There is significant difference between the major and financial literacy.

The above table reveals that the chi-square value was greater than the table value. Hence the hypothesis was accepted. It indicates that, the major and financial literacy depend on each other.

RELATIONSHIP BETWEEN AGE AND FINANCIAL LITERACY

To determine the inter dependency between the age and financial literacy, the following hypothesis was framed:

H2:There is significant difference between the age and financial literacy.

The above table reveal that the chi-square value was greater than the table value. Hence the hypothesis was accepted. Thus, the age and financial literacy depend on each other.

SUGGESTIONS

- It is found that the students respondents were willing to invest in safer modes like gold and silver, deposits in banks. Hence it is suggested to invest in shares and securities to attain hide returns.
- Students should know the importance of money and avoid spending unwantedly.
- It is suggested to the students that, they should be aware of their family budgets which influences their spending attitude.
- Encourage students to engage in part time jobs.
- To create an awareness about investing in other sources such as mutual funds, government bonds which may give higher rate of return.
- Creating awareness among the students about the fraudulent practices from unscrupulous people from southern part of Tamil Nadu.
- It is advised to the students to invest in high-risk investment to gain higher rate of return.

CONCLUSION

The students were willing to be in a safer side when it comes to investment of their principle amount, and they didn't give much importance for the capital appreciation. It is found that the students had the habit of saving either in bank or in post office or atleast by keeping hundi at home which shows that the students are having the knowledge of saving for future by knowing the value of money. We have analyzed that there is a connection between the age and financial literacy of the students. Thus, from the study of financial literacy we came to know that students had good knowledge in the field of finance. There is a long way for the students to know the depth in the field of financial literacy so it is better to teach the students about financial literacy from their early age. The knowledge of financial literacy should be inculcated for the students in their early stage itself preferably from the day of schooling.

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Table – 1: Preference of Spending by Students

S.no	Items	No. of students							Total score	Rank
		R1	R2	R3	R4	R5	R6	R7		
1.	Eatables	61	48	34	28	9	12	16	**872**	I
2.	Stationery	18	45	42	30	30	18	17	**869**	II
3.	Clothing	29	25	31	34	40	23	18	**828**	III
4.	Books and magazines	29	19	28	32	29	32	31	**767**	IV
5.	Entertainment	16	25	36	21	38	41	23	**745**	V
6.	Travel expenses	22	21	25	30	25	30	47	**707**	VI
7.	Cosmetic	20	27	17	20	28	43	45	**682**	VII

Source: Primary Data

Table- 2: Access to Financial Product by Students

s.no	particulars	no. of students (200)	
		number	percentage
1.	Saving bank account	176	88
2.	Availing education loan	54	27
3.	Insurance policy	50	12
4.	Post office saving account	69	35
5.	Keeping hundi at home	112	56

Source: Primary Data

Table – 3: Factors to be Considered while Investing in Future

S.NO	PARTICULARS	NUMBER OF STUDENTS					MEAN SCORE	RANK
		R1	R2	R3	R4	R5		
1.	Safety of the principal amount	76	56	25	25	18	**3.735**	I
2.	Liquidity	41	47	52	54	6	**3.085**	II
3.	Periodic returns	41	44	35	51	29	**2.815**	III
4.	Appreciation in capital value	21	35	36	39	69	**2.62**	IV
5.	Tax concession	22	30	47	52	49	**2.5**	V

Source: Primary Data

Table 4: Channels of Investments Preferred by Student Respondents

S. No	particulars	No. of students					total score	Rank
		R1	R2	R3	R4	R5		
1.	**Investments in:** Life insurance policy	73	44	43	29	11	**3.695**	I
2.	Gold and silver	27	36	42	56	39	**3.41**	II
3.	Shares and securities	27	27	52	38	56	**2.78**	III
4.	Real estate	60	43	40	33	24	**2.655**	IV

5.	Mutual funds	25	36	37	34	71	**2.595**	V

Source: Primary Data

Table- 5: Student's Opinion on Various Factors of Financial Literacy

S. No	Particulars	No. of respondent (mean score value=200)				
		Agree	Disagree	No idea	Total score	Mean score value
1. 2. 3. 4.	**Knowledge about saving** Saving is part of our family life Present saving will enhance our future lifestyle Saving is essential for future financial security No difference between saving and investment	582 474 471 183	4 22 26 94	 4 40 34 90	 590 536 531 367	 2.95 2.68 2.65 1
5. 6. 7.	**Knowledge about interest** Interest is the reward for investment Moneylender charge higher rate of interest Interest on savings account in a bank is calculated on daily	312 357 240	39 28 43	108 106 154	459 491 437	2 2.55 2
8. 9.	**Healing from risk factor:** Insurance will reduce financial risk Health insurance covers hospitalization expenses	303 351	44 40	110 86	457 477	2 2
10 11	**Using of technology:** ATM card facilities quick money transaction e-shopping requires credit card	315 327	19 26	32 270	366 623	1 3
12.	**Improper use of credit card leads to** i) more spending	384	33	78	495	2
	ii) reduce savings	336	37	10	383	1
	iii)leads to financial trouble	285	45	120	450	2
13 14	**Knowledge about bank:** Banks are regulated by RBI Education loan is repayable	306 339	44 29	108 116	458 484	2 2.5
15. 16.	**Others:** Financial literacy is essential for our day to day finance In recent union budget there is no change in tax slab rate applicable to individuals	351 204	40 32	86 200	477 436	2 2

Source: Primary Data

Mean score value	2-3	having good knowledge on related topic
	Between 1-2	having fair knowledge on related topic

Table –6: Student's View on Financial Literacy

S. NO	Particulars	No. of Respondents	
		Number	Percentage
1.	Savings and Channels of investment	100	50
2.	Managing debt financial security	52	26
3.	Protection and accumulation of wealth	98	49

Source: Primary Data

Table:7

Major	Financial Literacy		
	Agree	Disagree	No Idea
Home science	319	182	129
Science	553	250	187
Humanity	307	133	100
Education	82	55	43
Business administration	373	210	137
Community	341	121	78

CHI-SQUARE TABLE

Chi square value	Degree of Freedom	Table Value	Significance
31.534	10	18.307	SIG

Table-8:Age and Financial Literacy

Age	Financial Literacy		
	Agree	Disagree	No Idea
17-19	725	425	398
19-21	418	309	83
21-23	493	192	882
Above 23	199	154	7

CHI-SQUARE TABLE

Chi-square value	Degree of Freedom	Table Value	Significance
55.215	6	12.592	SIG

RESEARCH ARTICLE

A Study of Diabetic Patients in Puducherry after the COVID Lockdown to Measure their Stress and Life Satisfaction

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ABSTRACT

The continents have experienced widespread disorder and tragedy as COVID-19 spreads rapidly. Under such circumstances, the indices measuring life satisfaction may decrease, while the likelihood of experiencing elevated mental stress is expected to increase. This study examines the stress levels and life satisfaction of 240 diabetic patients in our hospital during the COVID-19 pandemic. The average age of participants was 56.28 years, with 44.6% aged 50 or older. Results indicate that 50% of participants experienced moderate to high stress levels, with around 20% facing stress-related difficulties. This suggests a critical need for stress-reducing interventions, as stress may adversely affect blood sugar control in diabetic patients. Implementing stress-management strategies is crucial to prevent future complications associated with diabetes.

Keywords: COVID lockdown; Mental disorder; Daily life satisfaction; Diabetes; Stress.

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INTRODUCTION

The Coronavirus Infectious Disease (COVID) pandemic has caused substantial distress for most of the human population [1]. In response to the COVID epidemic, the governments of several nations have implemented novel strategies to curb the spread of the disease [2, 3]. It has devastated one nation after another, annihilating all that our generation has ever seen [4]. Furthermore, apart from its adverse effects on an individual's physical and psychological well-being, it has led to a worldwide economic decline, joblessness, and international isolation measures [5]. The Indian government implemented the nationwide lockdown in March 2020, which imposed restrictions on the mobility of the nation's 1.3 billion residents, allowing only medical emergencies and crucial services [6]. The confinement zones remain subject to stringent lockdown measures, notwithstanding the progressive easing of restrictions after the conclusion of the lockdown in May 2020 [7]. As a consequence of the COVID epidemic, ordinary persons are experiencing mental health issues due to their exposure to extraordinary circumstances. For those employed in locations far from their residences, the lockdown has resulted in prolonged detachment from their families [8]. Furthermore, the loss of employment has resulted in financial adversity, which might potentially culminate in severe complications [9]. There are several forms of manifestations, including emotional issues like worry and depression, physiological effects like disrupted sleep and appetite, severe mental disorders, and drug misuse [10]. While the lockdown was essential for containing the epidemic, particularly to safeguard vulnerable groups like the elderly, diabetics, and cancer patients, the severe controls are expected to hurt the emotional well-being of the general population [11]. Individuals hailing from various regions of India encountered starvation, fatigue, law enforcement brutality, economic adversity, and joblessness [12]. Furthermore, they ought to have given more significant consideration to receiving appropriate medical care.

Regrettably, there is a lack of statistics about precise demographic information, such as the prevalence of diabetes among individuals. In recent years, researchers have postulated that stressful events may impact the regulation of diabetes and have shown a correlation between stressful events and the management of diabetes mellitus [13]. The hypothalamic-pituitary-adrenal (HPA) axis activates in reaction to psychological stresses related to feelings of defeatism or helplessness [14]. This activation leads to several hormonal imbalances, including elevated cortisol levels and reduced sex steroid levels, which oppose the effects of insulin. Self-care issues might also arise due to responses to external pressures, such as the anxiety and horror caused by COVID and the limitations on movement imposed by a lockdown [15]. It manifests as less physical activity, a worse dietary regimen, and a pervasive sense of melancholy, so impeding the ability to participate in self-care practices [16]. A lot of people in Puducherry have been getting psychological treatment from the government. Addressing the unique requirements of migrant workers, children with special needs, patients with mental disorders, and elderly people living alone is just one more way it has adopted an inclusive approach [17]. The state has provided psychiatric aid to around 1.2 million individuals out of its population of over 3.5 million. Psychiatric First Aid, which involves providing comprehensive assistance to those experiencing distress to promote a sense of calm and enhance their ability to cope, is crucial for preventing psychiatric issues [18]. It is imperative to prioritize the resolution of existing mental health disparities, particularly among the diabetic population, due to the detrimental impact that stress may have on diabetes care [19]. Because mental health services are already in a precarious position nationwide, the massive scope of the epidemic has only made matters worse. The purpose of this study is to examine the effect of COVID lockdown procedures on the psychological distress and subjective well-being of diabetic patients attending an endocrinology outpatient service clinic in Puducherry to obtain treatment.

METHODOLOGY

The study was done after obtaining clearance from the Institutional Ethics Committee of Medical College and Hospital, Puducherry. Patients who were undergoing ongoing follow-up therapy at the institution's Endocrinology Department were the subjects of this cross-sectional study. Amidst the countrywide lockdown, the patients were interviewed by telephone after the interviewer provided a formal self-introduction and obtained their consent to take

part in the research. The Perceived Stress Scale (PSS) and the Satisfaction with Life Scale (SWLS) were used to assess the subjects' stress levels and life satisfaction. The study included all adult individuals who had consistently made at least five visits to the Outpatient Department (OPD) over the previous year. Exclusion was applied to patients who chose not to participate in the survey. Two hundred and forty patients satisfied the criteria above and participated in the clinical study. The higher PSS scores reflect an elevated level of perceived stress, with individual values on the scale ranging from 0 to 40. According to the study, stress levels may be categorized as follows: scores ranging from 0 to 13 indicate mild stress, scores between 14 and 26 indicate moderate stress, and scores between 27 and 40 indicate high levels of perceived stress [12]. Individuals who indicated moderate to high-stress levels were categorized as feeling stress. A brief assessment tool, the Contentment with Existence Scale, was developed to evaluate an individual's overall cognitive happiness with their existence. In addition, a Likert Scale is used, which uses a rating system ranging from 1 to 7. A rating of "1" represents strong disagreement, while a "7" represents strong agreement. The whole outcome is quantified as a score of 35, with higher numbers indicating greater life satisfaction. Individuals who obtained a score of 20 or above were considered content with their lives, whilst those with a score of 20 or below were considered unsatisfied.

Statistical Analysis
The statistical analysis was conducted using SPSS version 29 after data input in Microsoft Excel [20]. The study used descriptive statistics and demographic features to evaluate the proportion of participants who reported high levels of stress and life unhappiness. Using the chi-square test, an investigation was conducted to analyze the correlation between life satisfaction and perceived stress.

RESULTS

The research included 240 participants who had diabetes. The average age of the study's participants was 56.28 ± 15.8 years. The oldest competitor was <=80 years of age, and the youngest was >=18 years old. 4% of the study participants were above 55. The study's participants consisted of more than 75% women. 25% of them have successfully finished their courses and obtained a diploma (Table 1). Based on the Perceived Stress Scale, precisely 50% of the people had moderate to high stress levels. While most individuals had favorable scores on the happiness with life measure, indicating their contentment with their lives, around 15% expressed dissatisfaction. The study found a strong correlation between age **(p = 0.036**) and life satisfaction (p = 0.001) in predicting stress while considering the associated features. Approximately 20% of the participants had difficulty in managing stress. The predominant strategies used to manage stress induced by the COVID lockdown were "Reliance on religious beliefs" and "Assistance from family members."

DISCUSSION

During the first phase of the lockdown, there was a widespread belief that the issue would be resolved swiftly. Nevertheless, with the uncontrolled spread of COVID and the lockdown, a significant number of individuals started encountering heightened levels of stress, melancholy, and sleep disturbances. Individuals may evaluate a stressful event differently based on past information, psychological factors, and social influences. The stress response, sometimes called the "fight-or-flight" response, is a specific series of physiological processes that occur when a perceived threat can harm an individual. When faced with the unprecedented COVID danger, our only recourse is to "respond with determination." Considering its ubiquitous nature, we are unable to evade it. Consequently, individuals may experience a range of stressors, such as anxiety about contracting COVID, inadequate or ambiguous information, monotony and discontentment, a shortage of social interactions, and financial hardships. Consequently, a significant number of individuals are susceptible to developing new mental health conditions, such as health-related anxiety, despair, discontent with Life, acute stress reactions, and emotional fatigue. Thus, it was imperative to assess the level of stress experienced by our community. Our analysis revealed that 50% of our diabetic patients reported stress. Undoubtedly, this proportion is concerning. Puducherry has a prevalence rate of around 20%, with

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over two-thirds of those aged 45 and above either having diabetes or being susceptible to its development. Studies indicate that several factors, including the quality of interactions with medical professionals, the impact of diabetes on daily life and work, and anxiety about the future, have a substantial role in stress-related or exacerbated diabetes. During the lockdown, diabetic patients were deprived of their regular monitoring and support from their reliable healthcare providers. Furthermore, due to the inability to engage in social activities or carry out professional responsibilities, all offices remained shut, perhaps leading to heightened stress levels. Research has shown that social support functions as a protective barrier against stress. Research suggests that stress might impede an individual's ability to self-manage diabetes. During periods of stress, individuals may have difficulties performing essential self-care tasks such as consistently monitoring glucose levels, planning meals, accurately preparing food, and remembering to take insulin or oral medications at the designated times. Hence, it is imperative to acknowledge that our populace is experiencing stress, and it is vital to acquire the ability to manage the negative responses to stress, particularly considering that the underlying factors, such as COVID, will last for an extended duration. Additionally, our research uncovered a significant association between age and stress. 62.2% of those between the ages of 36 and 55 reported experiencing stress. This demographic consists of employed individuals who may have been concerned about fulfilling familial responsibilities, raising their children, facing unemployment, or encountering financial hardships, all of which might have contributed to their elevated stress levels.

The contentment with life, which serves as a measure of well-being, has been associated with indications of mental health. Moreover, it predicts forthcoming behaviors such as suicide attempts. Based on our study, most participants expressed satisfaction with their lives. However, among the subset of individuals constituting 15% who expressed discontent with their lives, it was shown that stress levels were notably elevated, thereby establishing a distinct correlation between stress and unhappiness with life. Stress was found to be prevalent in 80.7% of those who indicated dissatisfaction with their lifestyles. Given the higher prevalence of depression in individuals with diabetes compared to the general population, healthcare providers must also differentiate between stress and depression. To assess for depression, it is necessary to use assessment methods. Research has also shown a significant association between feelings of grief and worry and the media coverage around the COVID outbreak. Media coverage of COVID might potentially have detrimental effects on an individual's emotional well-being. Implementing behavioral changes such as engaging in hobbies, exploring new interests, and limiting exposure to media reports on COVID may effectively reduce stress levels. Furthermore, it is crucial to acknowledge that individuals can effectively cope with this circumstance by cultivating emotional control, relying on their religious beliefs, engaging in regular daily tasks with their children, communicating with others through telephone or other technological means, and cultivating new hobbies or reviving old ones. Our investigation revealed that individuals mostly used family support and religious belief as coping mechanisms for stress. The enduring psychological ramifications of COVID need the continuation of therapy services during the lockdown period and for many months beyond. It is essential to recognize that if stress, depression, and anxiety are not accurately detected and treated, they may intensify into more severe distress. They have the potential to elicit suicidal ideation, emotions of powerlessness, and a sense of despair. During the pandemic, it is necessary to provide ongoing psychological crisis management for those at a higher risk. Under these conditions, helplines serve as vital sources of support. It is crucial to give enough treatment to the many individuals who are experiencing mental health issues because of the pandemic. Additionally, it is critical to cultivate resilience since it is essential for navigating these challenging circumstances.

CONCLUSION

Up to 50% of individuals in Puducherry with diabetes encountered stress. However, almost 85% self-identified as "Satisfied with Life." There was a strong correlation between stress and life satisfaction, and those dissatisfied with their circumstances were more prone to experiencing stress. 20% of the participants exhibited an inability to effectively cope with stress, even though most of them claimed to be doing their utmost effort to manage stress by relying on their religious beliefs and receiving support from their family.

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Table 1:Factors associated with stress.

Variables	Stress		Total	Chi-square	p-value
	Present	**Absent**			
</=35years	32.5%	67.5%	70		
36-55years	62.2%	37.8%	100	6..88	**0.036**
>56years	41.5%	58.5%	70		
Gender					
(n=240)					
Male	54.4%	45.8%	128	0.58	0.336
Female	49.1%	51.1%	112		
PhysicalActivity					
(n=240)					
Present	52.9%	47.1%	178	1.08	0.309
Absent	44.3%	55.9%	62		
Satisfaction With life*					
(n= 225)					
Dissatisfied with Life	80.7%	17.9%	22	10.1	**0.001**
Satisfied with Life	41.7%	58.5%	203		
* The study does not include those individuals who score neutral on the Satisfaction with Life measure.					

RESEARCH ARTICLE

Effects of Urbanization in Bengaluru City using Q-GIS

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ABSTRACT

Bengaluru is the third-most densely populated Indian city in terms of demography, and has adverse effects due to rapid urbanization. This study focuses primarily on determining the adverse effects of urbanisation by focusing on the effects on air, temperature, urban sprawl, and the lakes. The meteorological data was collected and analysed by using software like Google Earth Pro, AutoCAD Map 2000i, and Q-GIS. Within the last two decades, Bengaluru's population has increased by 88.10%, a total of 1955 new high-rise buildings have been built, the lake count has been reduced to 108 from 128 , the built-up area has increased by 87.33% while reducing greenery areas by 47.68%, and the AQI and temperature has also showed the variation as a result of increased urbanization. QGIS software is used to develop the maps representing the current environmental conditions, also a comparison is done with last ten years data

Keywords: Auto CAD Map 2000i, AQI, Google Earth Pro, Q-GIS, Urban Sprawl, Urbanization.

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INTRODUCTION

Bengaluru's Urbanization

Bengaluru City capital of Karnataka, a state situated in southern India which falls under India's fifth-largest metropolitan area. Despite having a long history in manufacturing sector, the last couple of decades have seen it to transform into a global centre for Information Technology and services related with several domestic and international corporations locating offices here. During 1991, the Ministry of Electronics and Information Technology had set up the Software Technology Parks of India (STPI) in Bengaluru. In terms of demography, Bengaluru falls under the third most populated Indian city. Bengaluru's urban assemblage is called as the Bengaluru Metropolitan Region (BMR) and includes Bengaluru's urban & rural districts and Ramanagar district. Bengaluru's Metropolitan Region Development Authority (BMRDA), a regional development authority has jurisdiction over BMR and is functioning as per the provisions of Bengaluru Metropolitan Region Development Authority Act (BMRDA), 1985. The total extent of BMR is 8005 sq. km in terms of area. As of 2011, BMR had the total population count of 11.69 million. Between the years 2001–2011, nearly 38.9% population growth has taken place in the BMR and is primarily attributed to the inrush of IT employees in the city, compared to the prior decade, the population growth rate was 29.3%. Bengaluru is also one of the fastest changing city and growth of industrial and IT corridors are the major reason for this transition[1].However, it has resulted in unplanned growth and management especially in terms of infrastructure and services due to this rapid transition. During 1991-01, the area within the city limits recorded a significant increase by 92.1% and the population by 37.8% [2]. The spatial expansion of the urbanized area has increased to 710 sq. km from 226 sq. km in 1995[3].

Impacts of urbanization

The impacts of Urbanization have majorly considered in three sectors High Rise Building construction & Urban Sprawl (Land), AQI & Temperature (Air) and Lakes (Water).

High Rise Buildings

High-rise buildings are defined as the buildings having floor count more than 13 floors or above and their construction was only possible with the introduction of elevators in the buildings. Buildings with over 40 floors are Skyscrapers and are considered part of the high-rise category. In current scenario, the construction of the high-rise buildings is increasing which alongside arises a risk of eventually reaching a breaking point horizontally.[4]The studies show there's huge social and environmental risks arising due to these mega-structures construction and even having a negative impact on biosphere and human health as well.[5]

Urban Sprawl

The recent emphasis on urban growth and IT industries in Bengaluru is the primary cause of the land use change. There's a rapid land use change in and around city limits, as shown in fig. 1, resulting in geographical expansion and the rapid mushrooming of the population within the city limits. With 90.9 percent of its population residing in the city, Bengaluru is the most urbanised district. With unplanned and rapid urbanization, the city is characterised by high population density, more traffic congestion, a high pollution level, unaffordable housing, the creation of slums, urban crimes, expensive living costs, the degradation of the environment, sanitation issues, and water shortages. The district's area is 2196 sq. km., with 4381 people living in each sq. km[6]. As the cities enlarge, they expand around their outer city limits, but urban sprawl is defined as uncoordinated growth and is specific in nature, it occurs without considering the consequences of the expansion of a community on the environment. Urban sprawl is also identified by titles such as "distributed urbanization' or 'horizontal spreading'[7]. It's observed in both low-income and high-income countries. A variety of reasons are responsible for urban sprawl; among the main causes are lower house taxes, a lack of urban planning, improved infrastructure, lower land rates, rising living standards, increased population growth, and growing consumer preferences. The consequences include impacts on ecology, energy consumption, land consumption, atmospheric pollution, loss of farmland, loss of natural resources, the formation of

urban heat islands, and impacts on wildlife and the ecosystem.

Lakes

Lakes are one of the most essential parts of any ecosystem. In older times, lakes acted as the major water source for daily uses like drinking, washing clothes, etc. Apart from being a source of groundwater, it also serves as a recharge point for underground aquifers[8]. From historical data, in Bengaluru, the lakes are shrinking as a consequence of encroaching construction activities resulting from urbanisation .Lakes are also home to numerous bird, floral, and faunal species[9]. Conservation of the lakes should be done as soon as possible because losing any more time in initiating the process will just lead to skyrocketing the costs in the future to do the same work.

AQI and Temperature

The air quality index (AQI) for a given day is a number used for reporting the air quality: basically, it's the level of cleanliness of the air. It measures the particles and chemicals in the air that affect the health of people [8] The health effects of extreme pollution are severe, ranging from slight irritations to reduced endurance to respiratory problems. The consequence of urbanisation is observed in the form of an increase in the maximum daily temperature and the number of times it has exceeded the maximum limits, especially during the summer season, and results in the formation of urban heat islands and warmer air temperatures near urban centres.Air quality index standards are given in fig:2.

METHODOLOGY

Data Collection

The World Population Review is an independent organisation that turns the complicated demographic data of a country or city, presented in the format of Excel spreadsheets, APIs, etc., into easily understandable articles. Bengaluru's population data count is obtained from the "World Population Review" between the years 2005 and 2022. It is considered as the baseline for the computation of urbanisation and can be applicable as a comparative study for high-rise buildings, urban sprawl, and lakes over time. In India, the air quality and temperature data are monitored and stored by the Central Pollution Control Board (CPCB). The information gathered includes both live and recorded data and the data available can be downloaded in both Word and Excel format. For determining the air quality of Bengaluru, five places are taken into consideration, namely, Bapuji Nagar, Hebbal, Peenya, Silk Board, and the City Railway Station. And the required AQI of the collected data is then calculated using an AQI calculator, which takes into consideration three parameters of air quality. And finally, after overcoming all these steps, the required AQI is obtained. AQI Calculator, is generally used for the purpose of calculating the AQI with inclusion of three or more air pollutant or contaminant parameters.

Google Earth Pro

The required data (high-rise buildings, urban sprawl, and lakes) is first collected by using Google Earth Pro. Software "Google Earth Pro" is a user friendly and free programme that, allows visualization, assessment, overlay, and the creation of geospatial data. It provides options for viewing extremely high resolution satellite imagery, uploading or downloading the geospatial data in its native interoperable file format (KML), and also finding locations. This is a basic software package for students interested in learning about GIS, with basic tools and commands included.

Central Pollution Control Board

The Central Pollution Control Board was constituted under the Water (Prevention and Control of Pollution) Act in September 1974. This organisation is tasked with air quality monitoring and determining the present status and trends of air quality in order to regulate pollution from industries and meet the required air quality standards as per Air Act, 1981 The air quality and temperature data for Bengaluru were collected from this web portal.

Data Processing
Q-GIS
The data collected from Google Earth Pro is then further processed using "Q-GIS Software." QGIS, formerly known as "Quantum-GIS," is an open-source software that facilitates the user's ability to view, edit, and analyse geospatial data, to compose and export geographical maps. Both raster and vector layers are supported by QGIS; vector data is stored in the form of point, line, or polygon features. File formats, including shape files, coverages, dxf, personal geo-databases, Post-GIS, MapInfo, and others, are supported by QGIS as well and can also be used with SAGA GIS and Kosmo. To prepare maps, the Print Layout in QGIS is used, which allows you to add maps, labels, legends, directions, etc.

AutoCAD Map 2000i
AutoCAD Map 2000i is software that basically provides GIS analysis with precision mapping, property alteration tools and data querying, spatial analysis, and allowing access to multiple drawing files simultaneously or multiple-user access to the same drawing file. The data from this software can be exported and imported in just about any file format.

RESULTS AND DISCUSSION

Population
From the data obtained from the World Population Review, the population count in Bengaluru was approximately 6,786,000 in 2005, further, in 2010, it spiked to 8,296,000; thereafter, it reached 10,141,000 in 2015; and finally, in 2021, the count reached 12,765,000. Between 2005 and 2021, a significant population increase of approximately 188% was observed. The population of Bengaluru gradually increased as a result of the constant migration of the rural population and people from other states to Bengaluru as a result of the skyrocketing IT sector. The above graph shows People vs. Year data and is computed on the basis of a 5-year interval. It's crystal clear that the population skyrocketed during 2010–2021.

High Rise Buildings
From the obtained results, we can observe that, the high-rise building count was 185 in 2005, 381 in 2010, 1500 in 2015, and 2140 in the year 2021. Speaking in terms of percentage increase, from 2005 to 2010, it was 204.8%, 2010 to 2015 is 293.70%, and 2015 to 2021 is 42.66%. Here, the highest growth was observed between 2010 and 2015, when the count skyrocketed from 381 to 1500. The growth pattern of the high-rise buildings follows a gradual increase from the city centre to the outskirts of Bengaluru. In 2005, the buildings were in and around the core and on the outskirts, lying in the east of Bangalore (Whitefield).

Urban Sprawl
Spatial changes as the land cover changes from 2004-2020. They represent urban growth pattern in terms of built-up land for being constrained in the core due to lack of space and with rapid spatial expansion of urban areas in the city periphery a decrease in share that covers the agriculture land, land with dense vegetation (tree cover), wetland, and water bodies and simultaneously an increase in built-up land was observed. The percentage of built-up land has been increasing at an alarming rate and the land covering the green portion (trees, vegetation, etc.) has been decreasing as well.

Lakes in Bengaluru
Air Quality Analysis
The annual average Air Quality and Temperature data is obtained from the Central Pollution Control Board spanning from 2018 to 2021. There are majorly five points of interests from where the data is collected namely, Bapuji Nagar, City Railway Station, Hebbal, Peenya and Silk Board. These locations are selected on a criteria basis. Stating, Bapuji Nagar & Hebbal are one of the most densely populated residential areas in Bengaluru, furthermore, the City

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Railway Station becomes a critical location as of it's a junction constituting Bus Stand, Railway Station, Metro Station & Vehicular Traffic, Peenya on other hand is the biggest Industrial Belt of Asia and on the bottom line is the Silk Board that houses India's worst bottleneck vehicular traffic. Finally, every location selected is crucial on its own and falls amongst the most polluted constituencies of Bengaluru.

CONCLUSION

The listed below conclusions can be drawn from the above study conducted: From being 6.78 million in 2005 to 12.76 million in 2021, the population of Bengaluru has almost skyrocketed about 6 million in past gone decades. Due to the growing population and land availability issues the demand and construction of High-Rise buildings increased consequently the count reached to 2140 in 2021 from just being 125 during 2005. As the construction accelerated, there was scarce in the land available to suit the purpose, and consequently resulted in Land-use change. This further had in numerous effects on Lakes, Forests, etc. as they were converted in order to be used for construction. The Urban sprawl data shows an increase of 60.79% in the built-up area, as the area cover reached to 620880 sq.km. in 2020 from just being 331420.9 sq.km in 2005 thereby, consequently reducing green cover by 62.60% from being 405140.2 sq.km in 2005 and reducing to 211961.1 sq.km in 2020. With increasing change in Land-use, the Lakes continued to vanish as they too were converted in order to facilitate urban growth and consequently resulted in reducing the count from 128 in 2005 to 108 in 2020. From the overall studies, we can conclude that, urbanization has impacted almost every key aspect of a vital running ecosystem and being the core reason behind all the ill effects experienced in Bengaluru, varying from change in land use, urban sprawl, air quality deterioration, increase in temperature, decreasing lakes count, level of underground water table, water scarcity to uneven climatic conditions.

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Table 1: Bengaluru lakes count (2005-2020).

Year	2005	2010	2015	2020
Lakes	128	127	125	108

Table: 2 Air quality index standards

Good (0-50)	Minimal Impact	Poor (201-300)	Breathing Discomfort on prolonged exposure
Satisfactory (51-100)	Minor Breathing discomfort to sensitive people	Very Poor (301-400)	Respiratory illness to people on prolonged exposure
Moderate (101-200)	Breathing discomfort to the people with Lung, Heart disease, children and older adults	Severe (>400)	Respiratory effects even on healthy people
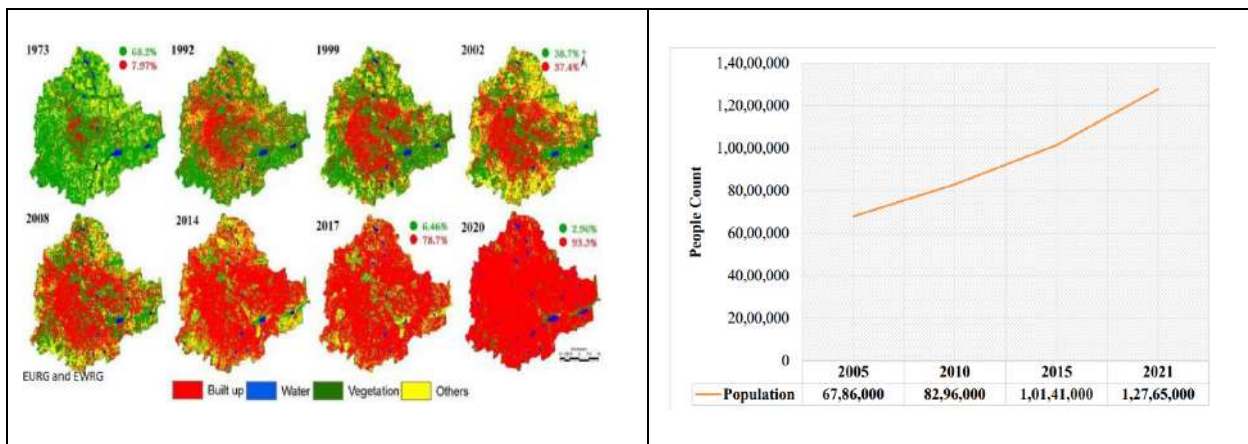
Figure 1: Land-use dynamics of Bengaluru.	**Figure 2:Population Variation**
Figure3: High Rise Buildings2005-2021	**Figure 4: Land Cover pattern**
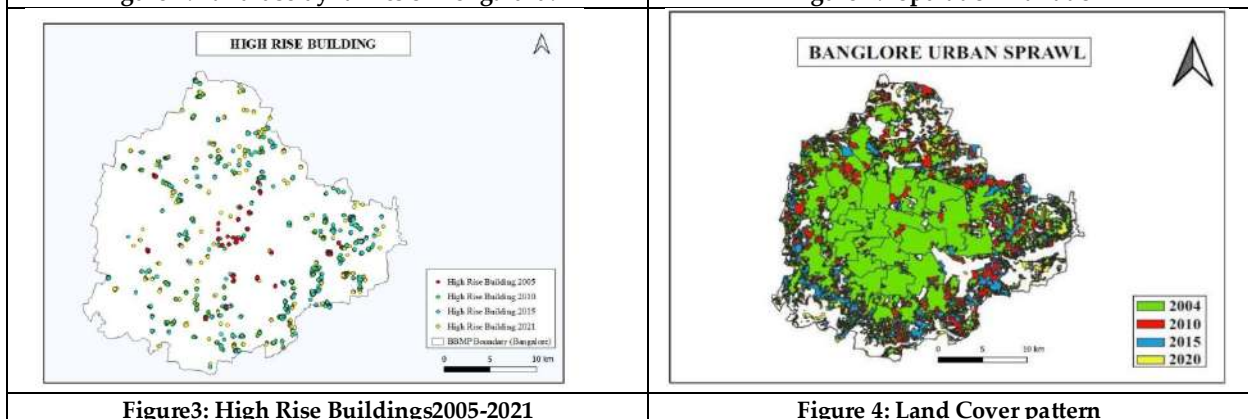
Abhijeet Kumar Gautam and Geena George
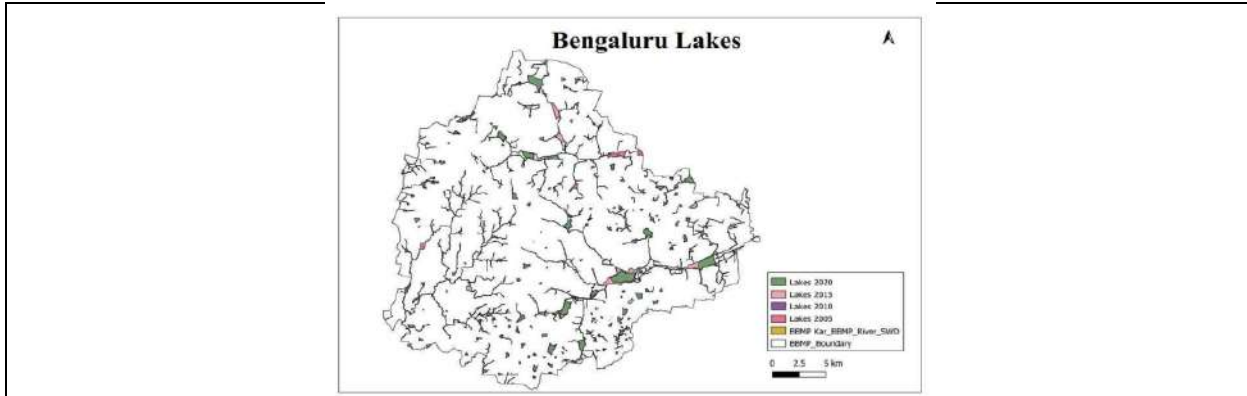
Figure:5 Bengaluru lakes (combined 2005-2020).
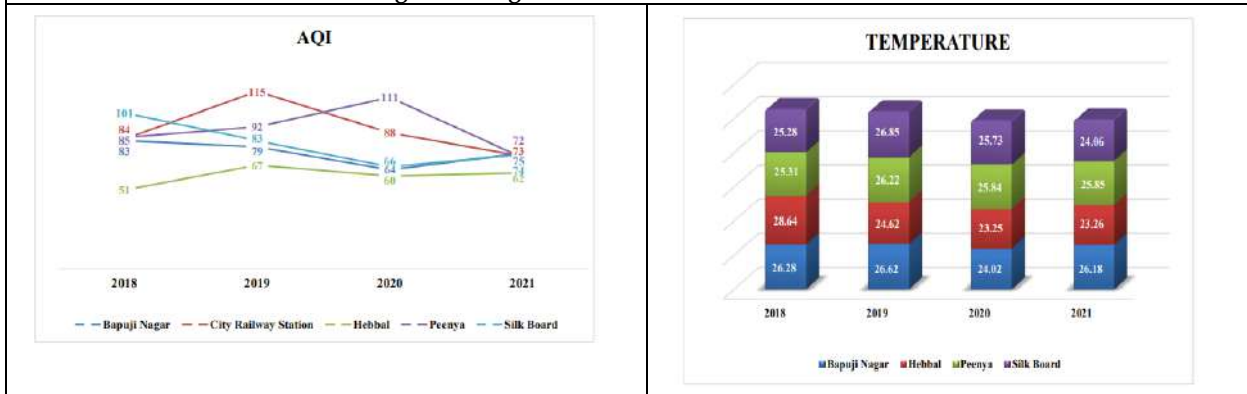
Fig 7: Average AQI & Temperature of major areas of Bengaluru.

RESEARCH ARTICLE

Remote Sensing and GIS Techniques for Identification of Groundwater Potential Zones in Afzalpur Taluk, Karnataka, India

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ABSTRACT

Increasing population and growth of land use for agronomyhasseverely abused the regional groundwater resources. Intensive pumping has resulted in a rapid decline in the level of the water table as well as its quality. For better management practices, establishing sustainable groundwater resources thematic map of the lithology, geomorphology, Land use/ land cover, lineament density, drainage density, soil, slope and rainfall was used to identify the potential zones of the groundwater in the study area. This study adopted a weighted overlay methodology in the software ArcGIS 10.4.1. In the overlay analysis, the weight (for different thematic layers) and rating values (for sub classes) were assigned based on analysis of published literature. The thematic maps of the study area were categorized as four classes for groundwater potential zones and reveal the results such as poor (1%), moderate to poor (16%), moderate (59%), and good (24%).

Keywords: Groundwater, GIS,Lineaments, Potential zones,Remote sensing, Satellite image,Weighted overlay.

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INTRODUCTION

One of the main sources of freshwater is groundwater, for human consumption as well as regional development. Potentiality of ground water depends upon location and additional abstraction wells to accomplish the growing water demand by the help of groundwater potential zones. Geological and hydro-geomorphological characteristics play a significant influence in the occurrence, distribution and movement of groundwater. The methods like geological and geophysical techniques can be used to conduct a comprehensive investigation of groundwater occurrences [1, 2] to observe groundwater potential zones and channels. These methods on the other hand, are dependent on time consuming and extensive ground measurements that are able to only be utilized for large scale mapping. Utilizing data from remote sensing in conjunction with a Geographic Information System is perfectly suiteddue to their high spectral resolutionand data collected from conventional and ground truth data can be simply merged for hydro-geological investigations [3] in remote sensing and GIS platform for identifying possible groundwater zones [4].In this study, satellite imageries are used to prepare various thematic layers such as the geology, geomorphology, soil, slope, lineament density, drainage density, land use, land cover and rainfall. These thematic layers are very useful in identifying the availability of groundwater resources.

The common strategies for determining groundwater possible exist are costly and it takes a long time and they necessitate a vast amount of data [5, 6]. An integrated system remote sensing and GIS research, on the contrary, can provide an effective forum for the study of data in a convergent manner in a relatively short amount of time. Remote sensing can provide a bulk amount of data for present scientific knowledge to better understand the hydrological framework [7]. Apart from its size, remote sensing gives data on locations that are inaccessible and saves time and money. Groundwater quality data has processed and integrated in GIS platform to understand the spatial distribution of thematic featureslike Geology (lithology), geomorphology, lineament density, porosity, slope, drainage density, drainage patterns, rainfall, and land use and land cover are only a few of influencing factors of groundwater occurrence and movement [8, 9, 10].

In the study area people are depended on groundwater for their agriculture practices and domestic uses because during the summer season, Bhima river irrigation canals are discontinued due to low rainfall and lack of water storage. This further add to the scarcity of water as the important available from this source is far less than required, whatever surface resources are obtainable and they either dry up by early monsoon or can only supply local demands for a short time. More number of the villages do not have any secured water supply. Hence, publics are stimulated to search around for alternative sources. Describing potential groundwater zones is therefore a significant undertaking (11, 12, 13). Water shortage can be caused by a number of issues, including uncontrolled groundwater management practices, a lack of rainfall, increased runoff, evaporation, climate change, the rapid rise of urbanization, and an uneven distribution of water resources (14, 15).

Hence, groundwater forms a valuable resource for agriculture also for domestic and drinking purposes in these areas. As a result, the current study was conducted to understand the spatial distribution of groundwater potential zones in Afzalpur taluk, which will suggest the proper management and development of groundwater resources, is essential in the study area.

Study area

Afzalpur Taluk situated in the northern part of Karnataka and western part of Kalaburagi. The research area covers 1050 sq.km. N-Latitudes 17° 03' 30"–17° 22' 40' and E-Longitudes 76°12'45"– 76°42'35".The whole southern boundary of the area is on the banks of River Bhima. Topographically the study area is very gentle slope (3 to 5%) towards southern direction. The entire study area comprises Deccan traps. This area has an arid and semi-arid climate, during the summer the temperature fluctuates from 30 to 46°C, during winter 28 to 35°C, monsoon occurs during June to October and annual rainfall is approximately 677 mm (CGWB 2011).

METHODOLOGY

The geomorphology, soil, slope, rainfall, lineament density, drainage density, and land use land cover maps were prepared using satellite imagery from the Indian Remote Sensing System Linear Imaging Self-scanning Sensor IV (IRS-1D LISS IV) data and Geological Survey of Indiatopo sheet (GSI 2001, 2005)in ArcGIS platform. Using rain gauge station data, rainfall circulation map was prepared and weighted overlay method was applied to combine all thematic layers by giving rank and weightage for every thematic layers. This technique is simple to analyze multi classification of maps based on the relative importance of every thematic layers. Many researchers have describedthe significance of numerous thematic layers that control the groundwater potential in an area. In the certain thematic maps weightage was given based on Saaty's scale [16, 17]for various thematic maps to describe groundwater potential zones. The individual layers and their classes are allocated a weightage and rank ranging from 0.10 to 0.25 and 1 to 4. High weightage and ranks are indicated, high groundwater potential in the study area. The study areas groundwater potential zones were divided into five categories viz, verygood, good, moderate, poor, and very poor. The Cumulative Score Index (CSI) was used to classify the data; the following equation was used to calculate CSI by multiplying the rank and weightage of each thematic layer. CSI= Σ (Geology = rank x weight + Geomorphology = rank x weight + Soil = rank x weight, Lineament density = rank x weight + Drainage density = rank x weight + Rainfall = rank x weight + Land use = rank x weight).

$$CSI= \int^n_{i=1}\int^m_{j=1}W_jX_i \quad (1)$$

Where, W_j= normalized weight of the jth factor, X_i = rank of the ith classes of a thematic layer, 'm' =total number of thematic layers, and 'n' = total number of classes in a thematic layer [18] and [19]. Using Statistical methods, the mean

and standard deviation of CSI was used to calculated the study area as very good (>Mean+ Standard deviation), good (Mean to Mean+ Standard deviation), Moderate (Mean- Standard deviation to Mean) and low (<Mean - Standard deviation).

RESULT AND DISCUSSION

Groundwater availability mainly depends on lithology, geomorphology, soil, slope, lineament density, drainage density, land use, land cover and rainfall. Hence, all the thematic maps pertaining to the study area were prepared using IRS-ID LISS IV satellite data. The salient aspects of these thematic maps are described below.

Lithology
Lithologicallythe area under study comprises dominantly of Deccan traps (Fig. 2). Various flows of Deccan trap overliesBhimagroup of rocks. The Deccan trap comprises numerous flows each of which might have erupted separately. During the interval until the next eruption took place, the weathering of the exposed flows continued, and sediments were deposited. The sedimentary beds were overlain by subsequent flows. These inter-trappings are generally porous and help in recharge of groundwater. The given weightage for this thematic layer while preparing ground water potential zone map is 0.20

Geomorphology
The geomorphological features of this area were prepared using IRS-ID LISS IV satellite data. The geomorphic map shows a gently rolling topography and vast stretches topped by black cotton soil. Broad valleys with intervening flat-topped country are by far the most predominant geomorphic feature in the area. In general, the area exhibits an undulating topography with table lands characteristics of Deccan traps in the north of the study area. The major geomorphological features are alluvial plains, pediments, Pedi plain, plateau highly dissected, plateau moderately dissected, plateau slightly dissected, plateau undissected, plateau weathered, river/stream, upper plateau and water body. And denudation hills are the prominent geomorphologic features (Fig. 3). The most part of the study area

comprises alluvial plains, which are expected to be zones with good groundwater potential. Hence higher weightage of 0.30 was assigned to this layer.

Soil

The study area contains of six types of soils such as fine, clayey, clayey skeletal, fine loamy, loamy, and loamy skeletal (Fig. 4). The soil map represents fine soil occupying most of the study area and covering 67 % of the area, clayey soils covering 21 % along eastern and central borders of the study area. Very fine to clay skeletal soil covered 5 % small portions of the area, fine loamy to loamy type soil covered 0 % (Table-2). The loamy, fine loamy and loamy skeletal soils have a high infiltration rate because it is a mixture of sand and silt and also favorite of maximum plants because it is usually richer in nutrients and humus and will hold water while allowing extra to drain away. It also has good groundwater potential zones. Whereas clayey soils have a low infiltration rate and less groundwater potential availability. Fine, very fine soil is made up of extremely small particles that stick together and obstruct the circulation of water and nutrients. As per result, given high rank and 0.15 weightage was assigned.

Slope

Four categories of slopes (Fig.5) were identified in the study area as nearly level 0-1 %, very gentle slope 1-3 %, gentle slope 3-5 % and moderate slope 5-10 % (Table-2). In the slope map it is observed that, about 56 % of the study area belongs to very gentle slopehaving good groundwater potential zones, 39 % belongs to nearly level slope having very good groundwater potentialdue to slow surface runoff of the rainwater. Gentle slope contains 3% having moderate potential zones due to moderate surface runoff and only 0.6 % of the study area is moderate slope having low potential zones due to high surface runoff for groundwater recharge is difficult and rated as weightage 0.15.

Lineament Density

Lineament density of the study area is categorized into three zones such as Low (0-1,000 km/km²), medium (1,000-1,500 km/km²) and high (>1,500 km/km²) (Table-2). In this study we observed that, most part of the area has low lineament density which indicates that only few areas have high and medium lineament density for groundwater resources (Fig.6) having medium lineament. Hence, it is considered as a moderate groundwater potential zone and given a weightage of 0.10.

Drainage Density

Drainage density is classified in to three classes like, low (<1,000 km/km²), medium (1,100-2,500 km/km²) and high (2,600-3,700 km/km²) (Table-2). Large part of the area falls under medium drainage density; therefore the infiltration of the water will be less in the study area. Since, the entire study area has moderate drainage density hence, this may be considered as good groundwater potential zones (Fig.7) and rated weightageof0.10.

Rainfall

Rainfall is main source of groundwater recharge. The study area comprisesfour rain gauge stations atAfzalpur, Atanoor, Karajagi and Gobbur. The rainfall dispersal map was prepared using the Kriging method in ArcGIS 10.4.1 software. Based on average Rainfall, the study area isdividedinto ten categories (Fig. 8). Highest Rainfall received in Karajagi Rain Gauge station in 2020 (64.21 mm) of the study area, and lowest rainfall received in Afzalpur Rain Gauge station in 2015 (28.95 mm). The study area received the highest mean annual rainfall of 770.55 mm in 2020. Increased rainfall encourages the occurrence of more groundwater. A weightage of 0.10 was given to this layer.

Land Use Land Cover

Land use land cover map (Fig. 9) describes the information about soil moisture, infiltration, surface runoff water cycle of groundwater and surface water. The study area comprises thirteen land use land cover classes such as gullied land, barren land, rabi crop, Rabi + kharif land, kharif land, fallow land, lake/tank, land with scrub, land without scrub, *prosopisjuliflora*, salt affected land, river/stream and town/cities. With respect to groundwater penetration inside the subclasses the lake and river have high weightage due to less runoff, settlement lands (included waste land, barren land, fallow land, gullied land salt affected land) have low weightage due to high

runoff, in agricultural land infiltration will be more, runoff will be less. Most of the study area comprises crop land (7 %) (Table-2). Hence, it is considered to have good groundwater potential and hence it is rated as weightage 0.10.

Groundwater potential zones

By adding all the thematic layers, the groundwater potential zones map were prepared (Fig.10 and fig.11) and four types of groundwater potential zones have been identified in the study area. The results indicated that the green colored area in the map is considered as a good potential zone (Rank-4) due to the alluvial Pedi plain along with the valley which cover about 24 % of the area. 59 % of the area covers a moderate potential zone which is indicated by sky blue in color (Rank 3) due to geologic units of Deccan traps, geomorphologic units of pediments, soil type, medium lineament and drainage density. The remaining 16 % of the area covers moderate to poor potential zone (Rank 2) which is indicated by pink color and it is due to clay patches, denudation hill, land use pattern, settlement areas, and higher drainage density. Poor potential zone (Rank -1) in the study area found is negligible indicated by brick red in color in the study area

CONCLUSION

The detection of groundwater potential zones in the study area by using geographical information system and remote sensing has proved to be powerful method by integration of thematic layers for the information to local authorities and planners about the areas suitable for groundwater exploration to meet the demands of agricultural and domestic uses.The groundwater potential zones were categorized in to four classes in the study area viz., good, moderate, moderate to poor and poor. The areaviz., Jewargi, Gour, Shirwad, Shirwal, Afzalpur, Havnoor, Nandarga, Chowdapur, Dannur was indicates "good" groundwater potential zones. The "moderate" groundwater potential zone wasdetected in the areas viz., Dixanga, Allagi, Hosur. "Moderate to poor" groundwater potential zones were observed in Udachan, Kallur, Chinmallietc and "poor" groundwater potential zones in the study areas were found nil. By this observation, available groundwater resources reveal the results as poor (1%), moderate to poor (16%), moderate (59%), and good (24%) of groundwater potential zones. These results may helpful for the effective planning and sustainable management of the groundwater recourses in the study area.

ACKNOWLEDGMENTS

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Table 1: Area covered under different range of thematic parameters

Parameter	Range	Area covered (Km²)	Percentage (%)
Slope	0-1%	51244.08	39.17779
	1-3%	74232.50	56.75319
	3-5%	4521.95	3.45718
	5-10%	800.28	0.61184
Land Use/ Land Cover			
	Crop Land	9211.38	7.042404
	Barren Land	106.25	0.081232
	Fallow Land	2658.57	2.032564
	Scrub Land	2225.99	1.701843
	Settlement	96.21	0.073556
	Water body	192.59	0.147241
Geomorphology			
	Butte	103.61	0.079213
	Channel island	25.50	0.019496

	Pediment/Pedi plane	11790.12	9.013943
	Plateau highly dissected	62.13	0.0475
	Plateau moderately dissected	16773.70	12.82406
	Plateau slightly dissected	75139.98	57.44704
	Plateau undiscected	4382.06	3.350232
	Plateau weathered	18500.64	14.14436
	River/stream	2636.94	2.016029
	Tank	192.59	0.147242
	Upper plateau	1190.79	0.910399
Lithology			
	Alluvial plane	8473.17	6.478023
	Butte	68.49	0.052362
	Escarpment slope	2727.84	2.085524
	Fracture/Fault line valley	2612.41	1.997279
	Mesa	574.74	0.439409
	Plateau moderately dissected	55922.91	42.75494
	Plateau slightly dissected	1992.97	1.523693
	Plateau undiscected	17579.05	13.43978
	Plateau weathered	28119.20	21.49808
	Valley	12727.91	9.730912
Drainage density			
	0-1,000		
	1,100 - 2,500	1400	
	2,600 - 3,700	1100	
Lineament density			
	0 – 1,000	0 – 1,000	
	1,000 - 1,500	500	
	>1,500	>1,500	
Soil			
	Fine	2787.77	2.131342
	Clayey	28073.90	21.46342
	Clayey skeletal	22.62	0.017294
	Fine	87065.50	66.56444
	Fine loamy	1.90	0.001453

Table 2: Distribution rank and weightage of different factors and CSI values for groundwater potential zones

Factors	Maps Weight (W$_j$)	Different features	Ranks for thematic units (x$_i$)	Rank x weightage of different classes	CSI statistics and groundwater potential
Lithology	0.20	Deccan trap (basalt).	3	0.6	CSI statistics Minimum:1 Maximum:4 Mean: 0.3

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					Standard deviation:0.24
Geomorphology	0.30	Water body, Pedi plane, valley. Plateau dissected. Pediments, ridges, hill.	4 3 1 1	1 0.9 0.3 0.3	Groundwater potential in the study area. Good CSI > = 2.25 Moderate CSI > = 1.40 Moderate to poor CSI > = 1.10 and <1.40 Poor CSI < = 1.10
Slope	0.15	Nearly level slope 0-1° Very gentle slope 1-5° Moderate slope 5-10 and >10°	4 3 2	0.6 0.4 0.3	
Drainage density	0.10	<1000 km². 1,100-2,500 km². 2,600-3,700km²	3 2 1	0.3 0.2 0.1	
Lineament density	0.10	0 – 1,000 1,000 - 1,500 >1,500	1 2 3	0.1 0.2 0.3	
Rainfall	0.10	>670	3	0.3	
Land use/Land cover	0.10	Water body. Agriculture. Waste land, built-up land.	3 2 1	0.3 0.2 0.1	
Soil	0.15	Loamy, fine loamy, loamy skeletal. Fine, very fine. Clay, clay skeletal.	3 2 1	0.45 0.3 0.15	
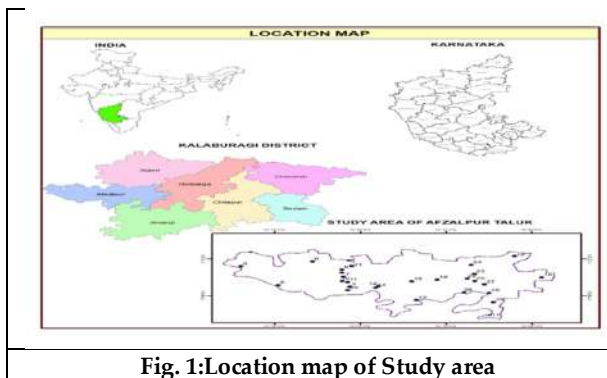
Fig. 1:Location map of Study area	Fig. 2:Lithology map of the stud area
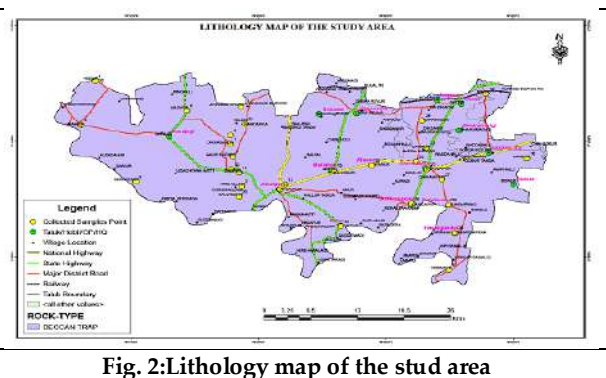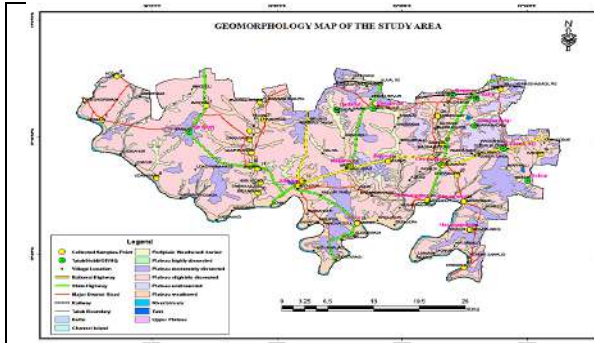
Fig. 3: Geomorphology map of the study area
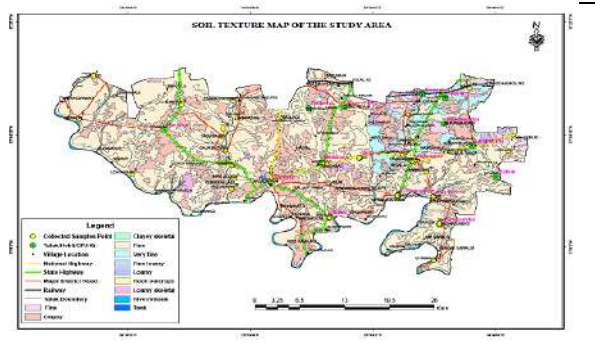
Fig. 4: Soil map of the study area
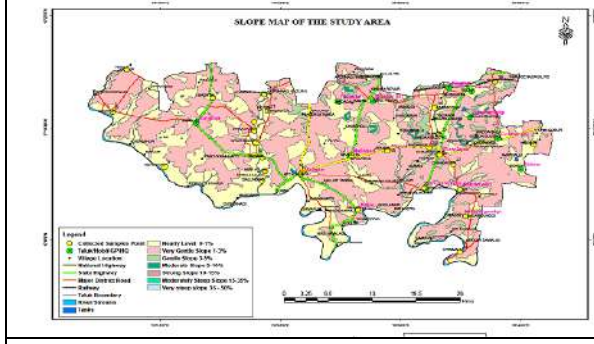
Fig. 5: Slope map of the study area
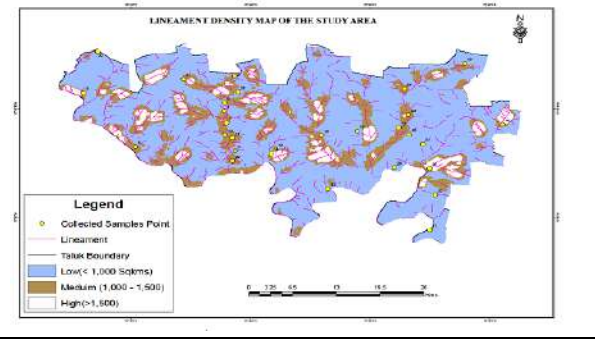
Fig. 6: Lineament density map of the study area
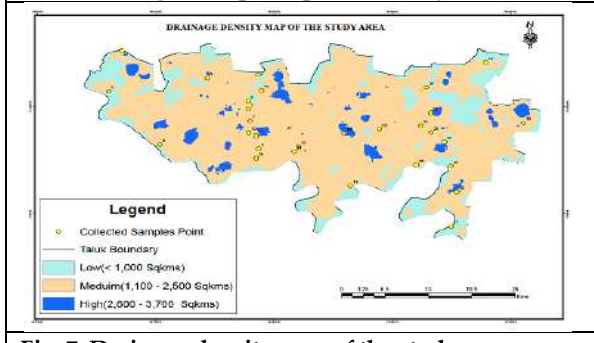
Fig. 7: Drainage density map of the study area
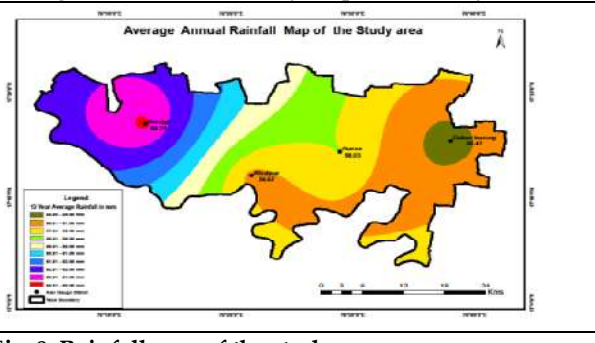
Fig. 8: Rainfall map of the study area
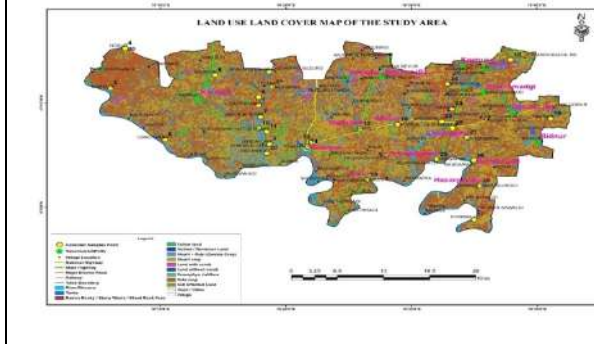
Fig. 9: Land Use Land Cover map of the study area
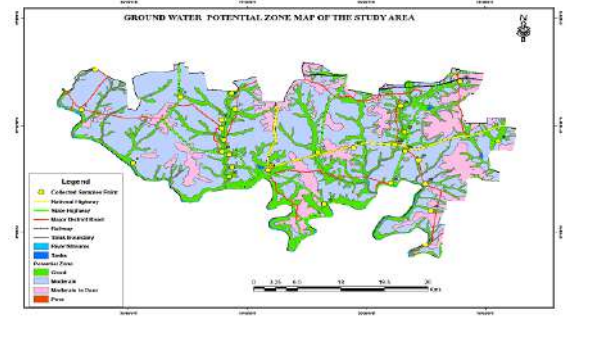
Fig. 10: Groundwater potential zones map of the study area

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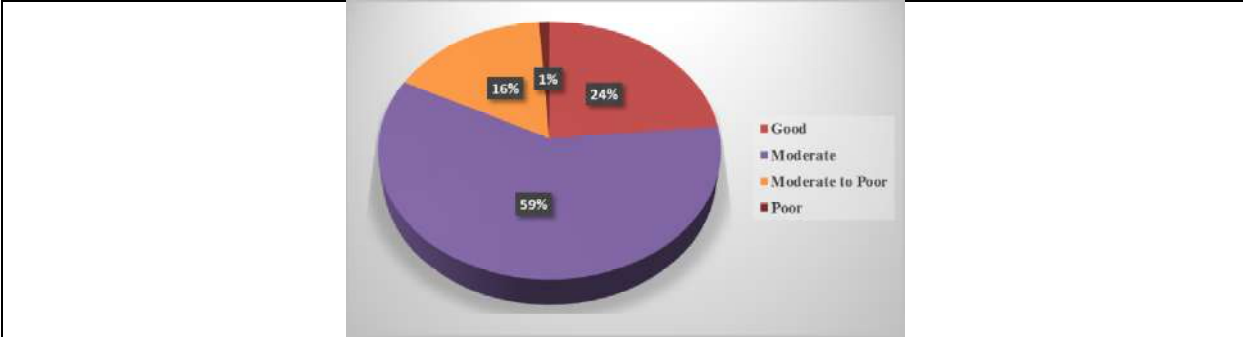
Fig. 11:Percentage of groundwater potential zones in the study area

RESEARCH ARTICLE

Advanced Fuzzy Filter in Image Noise Reduction

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ABSTRACT

In this paper Advanced Fuzzy Filter (AFF) is developed. Objective of AFF is to minimize the Gaussian noise from a fuzzification image and to be obtained a clarity image. The t-test result on experiments using the developed AFF shows that AFF is more effective to reduce the noise comparing with the existing methods mean filter, median filter and modified fuzzy filter.

Keywords: Mean filter, Median filter, MFF, PSNR, AFF

INTRODUCTION

Zadeh's seminal paper on "Fuzzy sets", which investigated fuzzy sets and fuzzy logic, originally published in 1965. In his paper, Zadeh aimed to formulate a theory that could explain for the uncertainty and imprecision of specific forms of sets in human mind. Pattern recognition, communication, and abstraction are all examples of this. Basic principles of image processing and recognition using fuzzy theory is defined by Maria Somodevilla and Frederick E. Petry. Fuzzy filter has wide range of applications concerns with noise control, edge detection, segmentation and image enhancement. In this paper Advanced Fuzzy Filter (AFF) is developed. This AFF is used to minimize the Gaussian noise from a fuzzification image. T-test is applied on the experiments using the developed AFF and it is obtained that AFF is more effective to reduce the noise comparing with the existing methods [2-9] mean filter, median filter and modified fuzzy filter.

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Mean filter

Intensity variation between pixels can be reduced with mean filtering. Mean filtering wants to replace all pixel in a fuzzification image with the average (mean) frequency of its neighboring pixels. Corresponding pixel also replaced by itself. The result is to eliminate pixels with values that are non-typical of their environments. In general, mean filtering I considered a convolutional filter.

Median filter

Spatial filters with sliding windows are called median filters. The center value is modified by computing the median of all the image pixels in the pane.

Modified Fuzzy Filter

We define a modified fuzzy filter as
$$g(I_{u,v}) = \frac{\sum_{u=1}^{n}\sum_{v=1}^{m} I_{u-k,v-l}\chi_{u,v}(I_{u,v})}{\sum_{u=1}^{n}\sum_{v=1}^{m} \chi_{u-k,v-l}(I_{u,v})}$$

where $\chi_{u,v} = W(Membership\ function) * D(Distance\ function)$ is the modified fuzzy basis function and

its value $\chi(I_{u,v}) = \dfrac{\chi_{u-k,v-l}(I_{u,v})}{\sum_{u=1}^{n}\sum_{v=1}^{m} \chi_{u-k,v-l}(I_{i,j})}$.

PSNR

By using Peak Signal to Noise Ratio (PSNR), obtained mean square error (MSE) between the actual image (fuzzification image) and the resultant image. PSNR provide us to analyze a fuzzy filter design's efficiency.

Distance measure in proposed AFF

In RGB dimension, colours are represented by three dimensional space with Red, Green and Blue as the first, second and third elements respectively. A color image CI perform with a 2-D array of vectors where $(u,v) = I_{u,v}$ defines a position in CI called pixel and $CI_{u,v,1} = I_{u,v,1}, CI_{u,v,2} = I_{u,v,2}$ and $CI_{u,v,3} = I_{u,v,3}$ denotes the red, green and blue components respectively of CI. Let D be the Euclidean distance, RG-Red green, RB-Red Blue, N_{RG}- Neighbour Red Green and N_{RB}- Neighbour Red Blue.

Let $RG = (I_{u,v,1}, I_{u,v,2}), N_{RG} = (I_{u+k,v+l,1}, I_{u+k,v+l,2}), RB = (J_{u,v,1}, J_{u,v,2})$ and $N_{RB} = (J_{u+k,v+l,1}, J_{u+k,v+l,2})$. Then

$$D(RG, N_{RG}) = \left(\sqrt{\left(I_{u+k,v+l,1} - I_{u,v,1}\right)^2 + \left(I_{u+k,v+l,2} - I_{u,v,2}\right)^2}\right)$$

$$D(RB, N_{RB}) = \left(\sqrt{\left(J_{u+k,v+l,1} - J_{u,v,1}\right)^2 + \left(J_{u+k,v+l,2} - J_{u,v,2}\right)^2}\right)$$

Weight function of fuzzy noise reduction in proposed AFF

The weight function W for the proposed AFF is defined as the mean of the distinct distance functions D(RG,NRG) and D(RB,NRB).i.e, $Weight\ W = \dfrac{1}{2}(D(RG, N_{RG}) + D(RB, N_{RB}))$

Proposed Advanced Fuzzy Filter

The Advanced fuzzy filter (AFF) is defined based on the distance function D and weight function *W*. AFF is defined

as $h(I_{u,v}) = \left(\dfrac{\sum\limits_{u=1}^{n}\sum\limits_{v=1}^{m} I_{u-k,v-l}\psi_{u,v}(I_{u,v})}{\sum\limits_{u=1}^{n}\sum\limits_{v=1}^{m}\psi_{u-k,v-l}(I_{u,v})} \right)$, where $\psi_{u,v} = W * D$. The Advanced Fuzzy Basis Function is

$\psi(I_{u,v}) = \dfrac{\psi_{u-k,v-l}(I_{u,v})}{\sum\limits_{u=1}^{n}\sum\limits_{v=1}^{m}\psi_{u-k,v-l}(I_{u,v})}$.

Comparison of Modified Fuzzy Filter (MFF) and Advanced Fuzzy Filter (AFF) Result in PSNR of different noise removal methods

	Γ = 5	Γ =10	Γ =20	Γ =30	Γ =40	Γ =50	Γ =60	Γ =70	Γ =80	Γ =90
Noisy	33.10	29.07	23.18	17.88	15.05	13.09	12.04	11.02	10.24	9.58
Mean	29.01	26.03	20.12	14.90	13.02	11.05	10.20	8.79	7.91	7.75
Median	31.05	27.01	21.03	15.28	14.11	12.80	11.01	9.80	8.61	8.87
MFF	34.25	30.09	24.59	18.08	16.90	14.02	13.05	12.02	11.21	10.67
AFF	35.02	31.03	25.08	19.02	17.09	15.02	13.93	13.05	12.25	11.08

T-Test result

The statistical test is conducted on the alternative hypothesis "AFF gives better noise reduction comparing with other three filters" and the following result is obtained.

Case 1 : MFF and AFF. $t = 2.5669$,

The alternative hypothesis is accepted with 95% confidence level.

Case 2 : Median filter and AFF. $t = 14.852$

Case 3 : Mean filter and AFF. $t = 18.13025$

The result shows that AFF is more effective to reduce the Gaussian noise comparing with the existing methods Mean filter, Median filter and Modified Fuzzy Filter.

CONCLUSION

In this paper Advanced Fuzzy Filter (AFF) is developed. By using this AFF, we are able to optimize (Minimize) the Gaussian or white noise from an image. Using R-Software, T-test is applied used to reduce the Gaussian noise from an image signal. Using software R, T-test is applied on the experiments and it is obtained that AFF is more effective to reduce the noise comparing with the existing methods Mean filter, Median filter and Modified Fuzzy Filter.

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Fig. 1.PSNR=34.25 AFF with X=3(7 by 7 window)and Y=2(5 by 5 window)	Fig. 2. PSNR=35.02 MFF with X=3(7 by 7 window) and Y=2(5 by 5 window)
Fig. 3. PSNR=30.09 MFF with X=3(7 by 7 window) and Y=2(5 by 5 window)	Fig. 4. PSNR=31.03 AFF with X=3(7 by 7 window)and Y=2(5 by 5 window)

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Fig. 5.   PSNR=24.59
MFF with X=3(7 by 7 window) and Y=2(5 by 5 window)

Fig.6.   PSNR=25.08
AFF with X=3(7 by 7 window)and Y=2(5 by 5 window)

Fig.7. PSNR=18.08
MFF with X=3(7 by 7 window) and Y=2(5 by 5 window)

Fig. 8. PSNR=19.02
AFF with X=3(7 by 7 window)and Y=2(5 by 5 window)

RESEARCH ARTICLE

Novel Approach for Synthesis of Flyash Geopolymer Sand: Characterization and Feasibility Investigation

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ABSTRACT

In recent years, the application of flyash in geopolymer concrete has acquired significant focus because of its environmental benefits and possible uses in construction materials. The synthesis process involves the utilization of fly ash, an abundant industrial waste, as the primary material, thereby addressing both environmental concerns and the necessity of using sustainable building material. The synthesized fly ash geopolymer sand was subjected to comprehensive characterization studies, including physical, chemical, and mechanical properties. The characterization results gives information about the structural composition, microstructure, performance characteristics of geopolymer sand. The utilization of fly ash geopolymer sand not only reduces the environmental impact associated with fly ash disposal but also offers significant advantages in terms of strength, durability, and resource conservation. Overall, this research contributes to advancing the field of sustainable construction materials by offering a viable solution for the utilization of fly ash waste in geopolymer sand synthesis.

Keywords: Class F Flyash, Flyash Geopolymer Sand (FGPS), Conventional Fine Aggregate, Geopolymerization.

INTRODUCTION

The need for environmentally friendly building materials has been fueled by research efforts to identify substitutes that maintain performance requirements while minimizing environmental effect. Because of their remarkable qualities and sustainable nature, geopolymers have emerged as viable alternatives in this endeavor. Fly ash stands out among the variety of raw materials that are needed to make geopolymers because of its availability and potential

for value-adding. The novel method for creating fly ash geopolymer sand is presented in this research, along with an analysis of its viability and suitability for real-world building applications. Fundamentally, geopolymers are inorganic polymers that are created by alkali-activating aluminosilicate substances such as slag, fly ash, or metakaolin. In this technique, Si-O and Al-O bonds are dissolved, and then polycondensation processes with alkaline activators are used to generate a three-dimensional network structure. As an appealing substitute for conventional cement-based materials, the resultant material has outstanding mechanical strength, durability, and resistance to chemical assault. (Davidovits, J. 2014). Because of possible contamination and disposal problems, fly ash is a bi-product obtained from burning coal as a fuel in power plants, poses serious environmental risks. Fly ash, however, may be transformed into a useful building material by creating geopolymers, solving waste management issues and lowering dependency on the mining of natural sand. (Hardjito, D., et al. 2004).

A number of processing procedures, including material selection, formulation, mixing, curing, and grinding, are involved in the creation of fly ash geopolymer sand. Important factors influencing the final product's characteristics are fly ash's chemical makeup, the kind and quantity of alkaline activators used, the curing environment, and the grinding methods used. By adjusting these variables, geopolymer sand may be made to match the needs of certain applications, including workability, strength, and particle size distribution. Understanding fly ash geopolymer sand's microstructure, mechanical characteristics, and long-term performance requires characterization. The morphology, phase composition, and chemical bonding of the material may be understood by the use of experimental methods including Fourier-transform infrared spectroscopy (FTIR), X-ray diffraction (XRD) and scanning electron microscopy (SEM), Mechanical testing assesses the material's performance under various stress scenarios by measuring its compressive strength, abrasion resistance along with flexural strength. (Palomo, A. 2007). Assessments of environmental effect, commercial potential, and techno-economics are all included in a feasibility inquiry. Large-scale manufacturing and commercialization of fly ash geopolymer sand are feasible depending on a number of factors, including market demand, energy consumption, production costs, availability of raw materials, and greenhouse gas emissions. In order to evaluate the fly ash geopolymer sand's sustainability and economic feasibility, these properties are quantified and contrasted with regular sand and other alternative materials. (Provis, J. L. 2014). In summary, the production of flyash geopolymer sand offers a viable path toward the production of sustainable building materials. This work attempts to expand knowledge of fly ash geopolymer sand and its possible uses in the building sector by means of creative methods and thorough characterization.

MATERIALS AND PROCEDURES

The experimental procedure involved the usage of flyash which was sourced from thermal power plant situated in Raichur District of Karnataka, India. The physical and chemical properties of flyash is shown in Table 1, conforming to Class F specifications according to ASTM standards (2008). Notable concentrations of SiO_2 (57%), CaO (0.97%) and Al_2O_3 (26%) characterize its composition. Approximately 72% of fly ash material exhibit size lesser than 45μm. The synthesis of Fly Ash Geopolymer Sand (FGPS) employed laboratory-grade silica gel with particle sizes ranging from 0.12 to 0.25 mm, alongside sodium hydroxide as activators. For comparative analysis, Conventional Fine aggregate from Bangalore, locally sourced, was utilized.

Preparation of alkaline activator
To mitigate mineral interference, potable water is employed in the production of sodium hydroxide (NaOH) solution. NaOH pellets are dissolved in distilled water to create solutions of varying molarities: 8M, 10M, 12M, and 14M. These solutions are then left to cool overnight at room temperature following exothermic reaction that occurs upon mixing NaOH with potable water, during which heat is liberated.

Formulation of Flyash geopolymer Sand (FGPS)
Slurry was formed by blending 1 kg of fly ash with 172 ml of sodium silicate and 114ml of 8 M solution of NaOH, maintaining a solids-to-solution ratio of 3.5:1. The ratio of Na_2SO_4 to NaOH was maintained at 1.5:1. The resulting

slurry underwent initial curing in an oven at 100°C for 20 minutes, followed by a 10-minute cooling period. Subsequently, the sample was passed through a 4 mm IS sieve to separate the fine aggregate. These fine aggregates, identified as Fly Ash Geopolymer Sand (FGPS) particles, were further cured for two hours at 100°C in a temperature-controlled oven with an accuracy of ±2°C to facilitate complete geopolymer reactions.

Tests on FGPS and Conventional Aggregate

The pH values of FGPS and conventional aggregate were determined according to (IS) 2720. After mixing the specimens with potable water for one hour, the solid-to-water ratio (measured on a mass basis) was determined by centrifuging the suspensions. The suspensions were then centrifuged to determining Electrical conductivity(EC) of supernatant solutions after mixing the sample by potable water (solid:water=1:2) about an hour. The EC values obtained for FGPS and conventional aggregate specimens were then used to compute the Total Dissolved Solids (TDS) from the equation, 1 mg/L equals 7.28 µS/cm (Todd 1980). Specific gravities of FGPS along with conventional aggregate sample were found out using the IS 2720 (BIS 1980) method, while their particle size distributions were determined using the IS 2720 (BIS 1985) approach. Additionally, X-ray diffraction (XRD) patterns of fly ash, FGPS, and silica gel specimens were obtained using an X-ray diffractometer.

Mortar Specimen Preparation and Testing

According to IS 2250 (BIS 1981) guidelines, a mortar mixture was formulated by combining one part ordinary Portland cement with three parts conventional aggregate. The resulting Conventional Aggregate Mortar (CAM) specimens were prepared using water: cement of 0.45, kept as suitable for achieving workable consistency. However, observations were made that a higher water: cement ratio of 0.9 was necessary for a feasible blend of FGPS with cement. Both wet mixtures were compacted through static compaction until reaching 86.65cm^3 as a fixed volumne. During the Compaction process, FGPS- Cement blend achieved 1.94 Kg/m^3 which is a lower dry density compared to the Conventional Aggregate-cement mixture, which reached a dry density of 2.08 Kg/m3. Three compacted specimens were fabricated for each type of cement mixture (FGPS and Conventional Aggregate), resulting in a total of six compressed specimens. These specimens underwent a 24-hour curing period at room temperature in a laboratory, followed by immersion in tap water for 28 days. Later the immersion period, compression strength was measured at a strain rate of 1.2 mm/min. Triplicate assessments of both CA-M and FGPS-M specimens revealed that their respective strengths displayed variations from the mean of under 5%. Subsequently, pH and TDS levels were quantified in the failed CA-M and FGPS-M specimens using the outlined methods.

DISCUSSION AND FINDINGS

Graph 1 shows the particle size distribution of both FGPS along with Conventional fine Aggregate specimens. FGPS demonstrates fractions of fine aggregate ranging from 0.425 to 0.075mm, Mid Range (2 to 0.425 mm), and coarse (4.75 to 2 mm), constituting 7.59%, 81.38%, and 11.03%, accordingly In contrast, conventional aggregate primarily comprises mid range (64.49%) and fine (34.13%) particles, with a minor content of sand (1.38%). FGPS particles are categorized as poorly graded Fine Aggregate per IS 1498 (BIS 1970), evidenced by their coefficient of curvature (Cc) and uniformity coefficient (Cu) values of 1.55 and 3.25, accordingly, attributable to their higher water absorption property. Specific gravity measurements reveal values of 2.30 for FGPS and 2.62 for Conventional fine Aggregate, while fly ash exhibits a specific gravity of 2.15. The higher specific gravity of FGPS particles is attributed to the close packing of SiO─AlO units. FGPS particles exhibit a pH of 11.58, indicating strong alkalinity, expected to minimally impact mechanical properties when blended with cement for mortar or concrete production, as per IS 1498:1970. Both FGPS and Conventional Aggregate are classified as badly graded soil based on their Cu and Cc values. SEM patterns of fly ash and FGPS particles reveal distinctive features, with flyash showing wide lump inbetween 2θ values of 6 to 15 degrees, shows the presence of glassy materials. Peaks corresponding to mullite and quartz further characterize the fly ash pattern. Fly ash, especially Class F, exhibits pozzolanic qualities and can react with cementing agents or chemical activators like sodium silicate to form cementitious compounds or geopolymers, respectively. XRD analysis of the FGPS specimen indicates pronounced clarity in the shiny phase inbetween 6.n and 16 degrees, suggesting

heightened structural organization due to geopolymerization events. Graph 3 depicts the failure show of both conventional aggregate particles and FGPS, along with stress-strain curves from compression experiments conducted on CA- M and FGPS-M sample. Comparable 12.23 and 21.81MPa for 28-day compressive strengths were attained by CA-M and FGPS-M specimens, respectively. The initial tangent moduli (ITMs) of CA-M and FGPS-M specimens were also similar, measuring 0.5 and 0.495 GPa, respectively. The lower specific gravity observed may stem from various factors such as a high concentration of hollow cenospheres or alterations in the chemical composition, particularly in the iron content.

CONCLUSION

FGPS were synthesized through the geopolymerization process of blending fly ash and amorphous silica for four hours at 120°C in an 8 M NaOH solution. These FGPS particles primarily comprised medium-sized sand particles (2 to 0.425 mm). The grain size distribution properties, characterized by the coefficient of curvature and homogeneity coefficient, categorized as Sand Particles. The dissolution and subsequent poly-condensation of reaction Specimens gives the compact arranging of SiO_2AlO_2 units within the FGPS particles, resulting in a specific gravity of 2.30, comparable to conventional aggregate at 2.62. Upon dissolving in a high medium of alkaline, FGPS particles attained a markedly alkaline pH of 11.58, akin to the pH range observed in cement hydration processes, indicating their suitability for use in mortar and concrete production. Furthermore, the total dissolved solids (TDS) value of 478 mg/L for FGPS particles suggests their classification as suitable soil material. In direct shear tests, FGPS particles demonstrated a comparable high friction angle of 35.5 degrees despite their spherical grains. Similar specific gravity values and grain size distributions were found when FGPS and conventional aggregate were compared. Comparing FGPS particles to conventional aggregate, however, revealed that the former had a greater friction angle and much higher pH (8.0) and TDS (31.5 mg/L).

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Table 8: The Physio-Chemical Characteristics of Flyash (Class F)

Chemical properties:		Physical properties:	
pH	8.4	Specific gravity	2.15
EC (µS/cm)	225	BET surface area(m²/g)	1.2
TDS (mg/L)	144	Particle size distribution(%)	
SiO_2 (%)	57	Sand fraction(4.75mmto0.075mm)	24%
Al_2O_3 (%)	26	Silt fraction(0.075mmto0.002mm)	74%
CaO (%)	0.97	Clay fraction(<0.002mm)	2.00%
TiO_2 (%)	1.54		
K_2O (%)	1.825		
MgO (%)	0.487		
Loss on ignition (%)	2.32		
Fe_2O_3 (%)	8.71		

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Table 9: Comparing FGPS with Conventional Aggregate's Physical and Chemical Properties

Physical properties	FGPS	Conventional Aggregate
Coarse sand fraction (4.75 to 2 mm)	81.4	64.5
Specific gravity	2.3	2.62
Medium sand fraction (2 to 0.425 mm)	11	34.2
Friction angle (degrees)	35.5	28.9
Particle size distribution (%)	7.6	1.4
Chemical properties	**FGPS**	**Conventional Aggregate**
pH	11.58	8
TDS (mg/L)	478	31.5
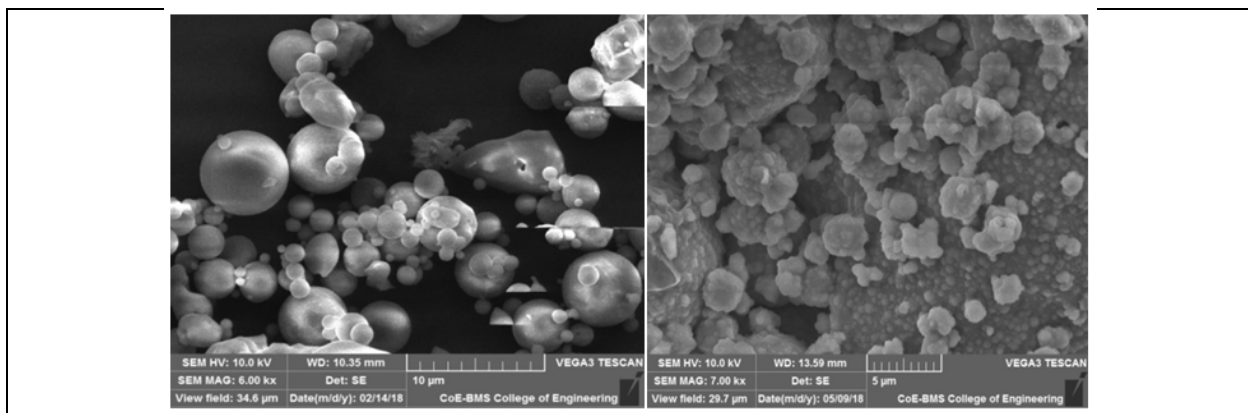
Figure 1: SEM of Flyash and FGPS
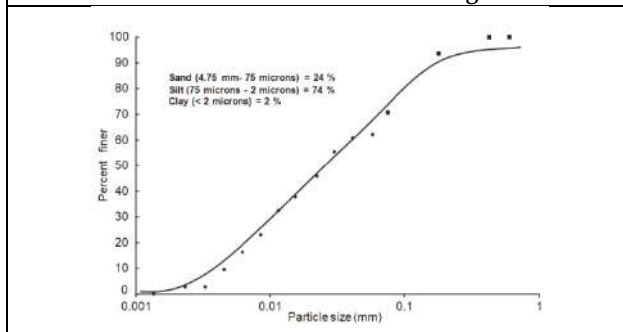
Graph 2: Grain size analysis of FGPS
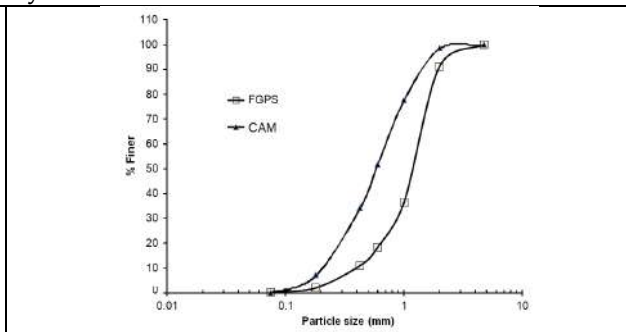
Graph 3: Particle Size Distribution
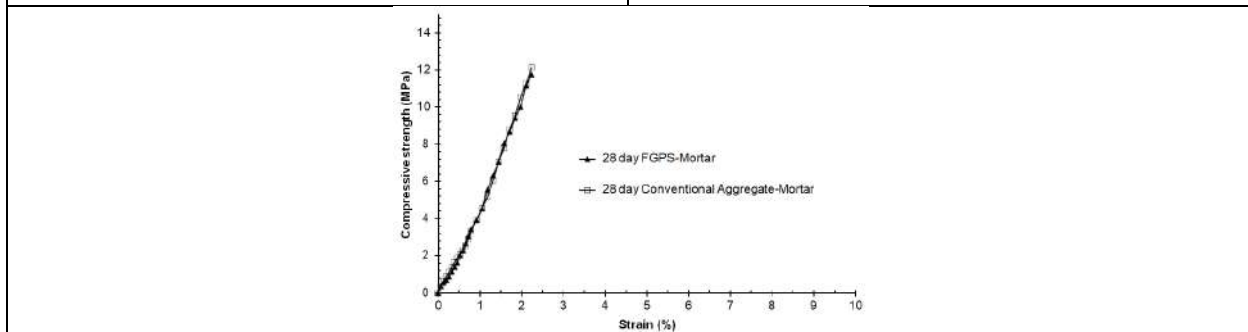
Graph 3: Stress Strain Curves from Compression test on CA and FGPS

RESEARCH ARTICLE

Understanding the Role of Intestinal Microbiota and Vitamins in Parkinson's Disease

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ABSTRACT

Although motor symptoms are part of the normal Parkinson's disease (PD) symptoms a variety of nonmotor symptoms, such as digestive problems, typically manifest before the motor symptoms. Through neurological, endocrine, and immune system pathways implicated in the microbiota–gut–brain axis, a variety of microbes that reside in the gastrointestinal tract can have a significant impact on the physiopathology of the central nervous system. Furthermore, a wealth of data points to be considered to correlate PD and the gut microbiome. The most recent research on microbial alterations in PD and its clinical significance is summed up in this review. Gastrointestinal symptoms may arise before motor symptoms in PD, a prevalent neurodegenerative condition. PD patients' gut microbiomes exhibit distinctive alterations that could be utilized as early disease indicators. Although the exact pathogenic pathways are unknown, changes in the makeup of the gut microbiota may have an impact on the development or manifestation of motor or non-motor symptoms. It has been proposed that the gut microbiota and its metabolites control neuro inflammation, barrier function, and neurotransmitter activity, which may play a role in the etiology of PD. The brain, gut, and microbiota axis may serve as a channel for the transfer of α-synuclein. Bidirectional communication exists between the enteric nervous system and the central nervous system. We discuss new findings about changes to the gut microbiota associated with PD. There is a wealth of research linking vitamin deficiencies and PD. One potential neuroprotective treatment approach is dietary supplementation of vitamins possessing antioxidant, anti-inflammatory, anti-apoptotic, and free radical scavenging qualities. The research that assessed the

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function of vitamins (A, B, C, D) in PD are compiled in this review. It may offer a framework for developing treatment plans to combat the illness and will direct future research into the possible therapeutic role of vitamins in disease pathogenesis.

Keywords: Parkinson's disease, gut microbiota, vitamins, neurodegeneration, neuroprotection

INTRODUCTION

Parkinson's disease (PD), the most prevalent movement illness worldwide, affects 1-2 people out of every 1,000. Many non-motor symptoms, such as sensory abnormalities, orthostatic hypotension, constipation, fatigue, depression, pain, and anhedonia, can even occur before the motor signs extend throughout the clinical spectrum in addition to the primary symptoms of motion (akinesia, tremor, rigidity, and postural instability [1],[2]. Based on epidemiological research, there is a lower chance of developing Parkinson's disease (PD) in those who drink green tea, coffee, and blueberries and don't consume dairy products [3]. The primary pathogenic alterations of PD include harm to dopaminergic neurons in the central nervous system's substantia nigra and development of Lewy body (LB), also known as Lewy pathology (LP). The etiology of PD is multifaceted and has been linked to oxidative stress, mitochondrial malfunction, and neuroinflammation [4].

GUT MICROBIOTA AND PARKINSON'S DISEASE
With over 100 million neurons, the Enteric Nervous System (ENS), also referred to as the "second brain," is a complex neural network. The distribution of enteric neurons is irregular in both plexuses. The ENS, which runs the length of the gastrointestinal tract, is made up of extrinsic innervation from the sympathetic and parasympathetic nervous systems and intrinsic innervation from the gastrointestinal wall. The ENS regulates GIT function, especially secretion and motility, independently of the central nervous system(CNS). At the autonomic nervous system level, however, the ENS and CNS form the so-called gut-brain axis (GBA) due to their bidirectional connectivity. Through bacterial metabolites or parts of the bacterial wall, the gut microbiome continuously interacts with the ENS, affecting neuronal transmission in the ENS [5]. The intestinal epithelium forms a barrier that prevents the passage of harmful content and at the same time allows the absorption and secretion of nutrients. By directing the expression of tight junction proteins including occludin, claudins, and zonula occludens-1 (ZO-1), the makeup of the intestinal microbiota influences the appropriate function of this barrier. Furthermore, lower L-DOPA absorption is linked to *Helicobacter pylori* infection, regardless of whether this is because of elevated stomach acid secretion or an inflammatory response that *Helicobacter pylori* causes in the guts of PD patients. The L-DOPA responsive motor issues improved in patients when *Helicobacter pylori* was eradicated [5]. Gut microbiota is intimately connected to the occurrence, development and progression of PD in its early stage. By adjusting the gut microbiota, it may be possible to monitor a person's health through an in-depth understanding of the microbiota-gut-brain axis in PD[6]. The relationship between neurological illnesses and the gut bacteria has been getting a lot of attention nowadays. Through metabolites, hormones, the immune system, and afferent nerves, among other channels, the gut microbiota connects with the CNS and ENS [2]. A variety of microorganisms, including bacteria, yeasts, and viruses, make up the gut microbiota. Firmicutes, Bacteroidetes, Actinobacteria, Proteobacteria, Fusobacteria, and Verrucomicrobia are the primary phyla of the human gut microbiota.In healthy people, the gut microbiota and host have a mutually beneficial relationship that can be broken by infections, viruses, fungus, and other parasites[2]. Recent research has shown that the Verrucomicrobiaceae family—which includes the genus Akkermansia—and Lactobacillaceae family are more abundant and decreased Prevotellaceae and Lachnospraceae families, which includes the genus Roseburia. The commensal mucin-degrading intestinal bacterium Prevotellaceae contributes to the creation of intestinal mucus and influences the regular fermentation of fiber to produce short-chain fatty acids (SCFAs). The host may consequently suffer increased intestinal permeability as a result of decreased intestinal mucus levels and the synthesis of microbe-derived SCFAs, which raises the possibility of local inflammation throughout the intestinal canal. Remarkably, it has been proposed that prevotellaceae may protect against the neurodegenerative process of PD by secreting ghrelin and

synthesizing mucin. Remarkably, the rise in Lactobacillaceae and fall in Prevotellaceae is connected to the decline in the gastrointestinal hormone ghrelin, which can preserve and safeguard the substantia nigra and striatum's normal dopamine function by altering the production of reactive oxygen species and mitochondrial respiration. Furthermore, a clinical investigation found that patients with PD had lower total and active levels of plasma ghrelin, suggesting that measuring this level could be a target for both illness diagnosis and treatment [2],[7]. Raised Enterobacteriaceae concentration in PD patients, which is correlated with the degree of postural instability and trouble with gait. Moreover, since the Lactobacillaceae family is known to have anti-inflammatory properties, the development of inflammatory processes is primarily linked to the markedly decreased levels of this family in PD patients. Given their capacity to lower levels of short-chain fatty acids (SCFAs), it is fascinating that certain bacterial families—like Prevotellaceae, Lactobacillaceae, and Lachnospiraceae—have decreased in PD patients [7] or ghrelin [8]. Due to the neuroprotective properties of both SCFA and ghrelin, it is possible that the lower levels of these two hormones in PD patients indicate both the severity of the disease and one of its key contributing components [9]. Pathological α-syn has been suggested in several recent investigations to have prion-like behavior. The ability of prions to interact with and change healthy proteins (PrPC) into their diseased version (PrPSC) and their transmissibility are the two factors that determine their classification [10],[11]. To summarize, individuals suffering with PD exhibit notable changes in their gut microbiota quantity and features. These changes could potentially serve as biomarkers or targets for therapeutic interventions. The precise mechanisms have not been fully understood, nevertheless, because of variations in research methodologies, living situations, and individuals, as well as the timing and kinds of altered gut microbiota.

Transmission of α-synuclein pathology
The food, the gut microbiome (GM), and its metabolites are among the many environmental elements that have drawn a great deal of scientific interest. In the 1980s, reports of Lewy pathology in the ENS began to surface, providing evidence of a malfunctioning gut-brain axis in PD. From that point on, both top-down and bottom-up models have been attempted to simulate the transfer of **α** -synuclein disease from the gut to the brain.

Bottom-up transmission of a-synuclein pathology:[12]
Braak [18] suggests that an invading pathogen that reaches the body through the stomach and nasal cavities causes sporadic PD. When α-synuclein in enteric or olfactory neurons is in contact with the invader, it causes α-synuclein aggregation. The olfactory bulb and vagus nerve allow the aggregated α-synuclein to enter the CNS, from which it finally travels to the SNpc. Furthermore, according to Braak's Parkinson disease staging, the pathology caused by α-synuclein first appears in the brainstem and olfactory bulb regions, then progresses to the cortical regions[13]. Regarding the many mechanisms that could lead to the start of α-synuclein pathology in the ENS in PD, Braak's idea is supported by multiple lines of evidence. LB illness is seen in the ENS and GI tract in humans, in rodent vasoactive intestinal polypeptide (VIP) and cholinergic neurons, and in neurons that produce VIP [14]. PD patients with ENS dysfunction (60–80%) might develop chronic constipation and other non-motor symptoms well before the onset of motor symptoms[15],[16]. PD patients are more likely than non-patients to experience ENS dysfunction, which may hasten the genesis of the disease by ten years before clinical symptoms appear [17]. The vagus nerve serves as a pathway for the transmission of α-synuclein pathology from the ENS to the CNS, according to postmortem investigations carried out on humans [18]. It is interesting to note that longitudinal human cohort studies from northern Europe have linked truncal vagotomy, as compared to controls, to a lower chance of developing PD. Asynucleinopathy may be transmitted from below up, as evidenced by the presence of α-synuclein aggregates in the ENS of α-synuclein transgenic mice, even before any known pathogenicity in the CNS.

Top-down transmission of α-synuclein pathology:[12].
It is crucial to look into whether the degeneration of dopaminergic neurons and the aggregation of α -synuclein in the brain can affect GI tract activity because of the bidirectional communication between the gut and the brain. The main nerve supply to the gastrointestinal system is the myenteric plexus, which controls GI motility via inhibiting neurotransmitters such as VIP and nitric oxide and excitatory neurotransmitters such as acetylcholine[9]. It might therefore act as a conduit for the transmission of aggregated α-synuclein from the brain to the intestines. Impairment

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seen in the CNS that causes alterations to the GI tract or the brain-gut communication may be a manifestation of GI dysfunction linked to PD. The 6-Hydroxydopamine (6-OHDA) model of PD has been employed to rigorously analyze this hypothesis. In this model, injection of the neurotoxin in the substantia nigra or medial forebrain bundle (MFB) causes dopaminergic neuron deletion in the SNpc [19]. Observed intestinal irritation in rats given a unilateral 6-OHDA injection at two MFB locations. Increases in pro-inflammatory cytokine levels, oxidative stress, and colonic excitatory tachykininergic motility were linked to the intestinal inflammation. Similarly, in rats, bilateral injections of 6-ODHA at SNpc resulted in a decrease in acetylcholine levels, which typically increases gut motility, and an increase in the levels of inflammatory and colonic markers [20]. Because the human microbiome can be easily affected by external stimuli, the delicate balance between the microbiome and the development of psychopathologies is particularly noteworthy, such as diet, [21]exposure to antimicrobials [22]or disrupted sleep patterns [23].

VITAMINS

Vitamin A and Carotenoid:[24].

When free radicals cause damage to cells, including neurons, vitamin A functions as an antioxidant in the form of retinoic acid. It is thought that oxidative stress plays a role in the neurodegeneration observed in PD antioxidants have the potential to lessen this harm. Fish, meat, dairy products, and vegetables are rich sources of vitamin A, also known as retinol, which is a significant antioxidant in the diet. Vitamin A influences the expression of genes involved in brain development, neural tube patterning, and neuronal differentiation during the development of the CNS[25]. In vitro, it was previously shown that beta-carotene and vitamin A minimize the generation of alpha-synuclein fibrils and destabilize the ones that have already formed in a dose-dependent way. Retinoic acid (RA), which interacts with nuclear receptors to modify gene transcription, has a special precursor in vitamin A. Within the CNS, vitamin A and carotenoids serve a function in a complicated signal transmit that regulates neural tube patterning and neuronal differentiation in addition to gene expression throughout several organs, including the brain. Retinoic acid receptors have been shown to be crucial for the survival, adaptation, and equilibrium functioning of the dopaminergic system, and these further strengthens the role of retinoid signal transduction in regulating dopaminergic neurotransmission. The mesotelencephalic dopamine system has a substantial amount of retinoic acid-synthesizing enzymes. By encouraging cell survival and lowering inflammation, some research indicates that vitamin A and its derivatives may have neuroprotective effects. Neurons may benefit from this protection against PD-related degenerative processes. Due to its interactions with retinoic acid receptors (RARs) and retinoid X receptors (RXRs), vitamin A affects gene expression and cellular differentiation. A dysregulation of gene expression has been linked to PD and other neurodegenerative illnesses. Vitamin A may have an impact on pathways related to PD through its role in gene regulation. Keeping the immune system strong requires vitamin A. PD has been shown to progress due to immune system dysfunction and inflammation. Making sure you have enough vitamin A may help your immune system work better and control inflammatory reactions, which may change how your illness develops.

Vitamin B

A common cause of neurological damage and disability worldwide is a deficit in the B vitamin. More people with PD than in the general population have B vitamin deficiencies. Shortfalls in B1 are associated with increased homocysteine levels, whereas deficiencies in B12, B6, and folate are linked to neuroinflammation and dementia. Because homocysteine is a byproduct of the essential amino acid methionine cycle, there is research to support the crucial role of B vitamins in PD. In neurodegenerative diseases, such as PD, homocysteine exhibits a variety of neurotoxic pathogenetic effects. When compared to age-matched healthy individuals, those with PD had higher homocysteine levels. Through neurotoxic effects, elevated homocysteine levels may expedite the death of dopaminergic cells in PD, while decreased homocysteine in plasma may lower the likelihood of developing PD. B vitamins are needed as cofactors in the conversion of homocysteine to methionine. Elevated B vitamin consumption, thus, lowers plasma homocysteine levels and may offer protection against PD. The human substantia nigra has significant concentrations of vitamin B1. It has been shown that intrastriatal vitamin B1 administration increases dopamine release, and that striatal dopamine concentrations decrease in the presence of vitamin B1 deficiency [26]. High dosages of vitamin B1 reduce motor symptoms in PD patients who are not getting any other anti-Parkinson therapy, from 31.3% to 77.3% on the Unified Parkinson's Disease Rating Scale (UPDRS), according to clinical research

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on PD patients [27]. There is evidence that taking supplements of vitamin B3 can help with a number of PD symptoms. Strong dietary supplements of nicotinamide, an active form of vitamin B3, have been demonstrated to alleviate motor impairments associated with PD and regulate aberrant mitochondrial activity in a Drosophila PD model. In the SNpc area of the brain, it has also been demonstrated that nicotinamide administration can stop DA depletion and dopaminergic cell death. Supplementing with vitamin B3 has also been shown in clinical studies to reduce neuroinflammation in PD patients by altering macrophage polarization from M1 (proinflammatory) to M2 (counter-inflammatory). Scientifically, vitamin B3 mediates the release of nicotinamide through poly-ADP ribosylation and encourages the manufacture of the traditional enzyme cofactor nicotinamide adenine dinucleotide (NAD). This results in an anti-inflammatory reaction that mitigates the neuroinflammation-induced dopaminergicneurodegeneration. According to these results, vitamin B3 intake may lessen neuroinflammation and oxidative stress, hence preventing the death of dopaminergicneurons [25],[28]. In small amounts, nicotinamide has antioxidant and neuroprotective properties; but, in large amounts, it causes toxicity, particularly dopaminergic toxicity. PD is linked to excessive nicotinamide use, and PD patients have higher levels of 1-methylnicotinamide (MNA), which can be produced excessively nicotinamide-induced overproduction. These findings were published by ZHAO [31] from several research. Griffin [36] discovered in an in vitro experiment that low-dose nicotinamide (10 mM) significantly influences the induction of neuronal differentiation from embryonic stem cells; but, larger doses (>20 mM) of nicotinamide cause cytotoxicity and cell death[28],[29]. Neurological function is one of the many physiological processes in the body that depend on vitamin B, specifically on B6 (pyridoxine), B9 (folate), and B12 (cobalamin). It has been demonstrated that vitamin B6 in particular has neuroprotective properties.

It aids in the manufacture of dopamine and other neurotransmitters. Due to its role in the synthesis of dopamine and its antioxidant properties unrelated to homocysteine metabolism, vitamin B6 may reduce the risk. In an open-label pilot research assessing the effects of 100 mg intramuscular vitamin B1 given twice weekly, 50 people with PD showed a sustained improvement in their motor and non-motor symptoms over the course of the 3-to 27-month follow-up period [30]. Status epilepticus and early-onset epilepsy are brought on by a vitamin B6 deficit in people with PD. Insufficient consumption of vitamin B6 in the diet is associated with a higher chance of PD, according to Japanese case-control research that included 249 PD patients and 368 healthy controls. Based on a population-based cohort study conducted in Rotterdam on 5289 participants over the age of 55, increased dietary consumption of vitamin B6 was linked to a considerably lower risk of PD. These findings are consistent with previous research [25].Research indicates that vitamin B12 deficiency in patients with PD is linked to neuropathy, impaired cognition and gait, and a fast decline in their ability to walk [31],[32]. Higher baseline levels of vitamin B12 at the time of PD diagnosis were linked to a lower risk of dementia, according to a population-based cohort research. Studies show that shortage in vitamin B12 can slow down the synthesis of S-adenosylmethionine, which can worsen apoptosis and result in Parkinsonian phenotypes in rats. Vitamin B12 enters the cell through the CD320 receptor-mediated transport mechanism, which prevents the degeneration of DA-ergic neurons and decreases oxidative stress, eases movement disorders, and restores mitochondrial function. Vitamin B12 also deconstructed pre-existing fibrils and prevented α-synuclein fibrillation, which decreased cytotoxicity. These data indicate that vitamin B12 is a nutritional source with promise for use in the treatment of PD. It may be explored as a potential functional food ingredient[25].

Vitamin C
It possesses anti-inflammatory, antiviral, anti-microbial, and antioxidant qualities. For PD patients, vitamin C can improve the absorption of levodopa, which can assist control "delayed on" or "poor on" responses [28]. Because it is essential for the sympathetic neurons to produce norepinephrine, ascorbic acid is also a promising target for treating orthostatic hypotension in PD [33]. Vitamin C deficiency and neurological diseases, including atypical Parkinsonism, have a close connection [34]. In addition, vitamin C supplementation has been demonstrated in the DJ-1 mutant fly model of PD to decrease protein oxidation, suppress H_2O_2 generation, and increase anti-oxidant enzymatic activity. The activation of microglia and astrocytes is linked to the inhibition of neuroinflammatory responses by vitamin C, which also modulates the TLR/NF-B/NLRP3/IL-1 pathway, thereby ameliorating PD-associated neuroinflammation, according to a study on MPTP-induced mice model of Parkinson's disease. According to a different in vivo study,

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vitamin C prevents oxidative damage caused by MPP+, which in turn stops the loss of DAergic neurons in PD. Apoptotic signaling-mediated cell death is inhibited by vitamin C, which also prevents LB development in PD [25]. For two hours, the human neuroblastoma cell line SK-N-SH was incubated with ascorbic acid (100-500 mM), and Seitz [34] observed a dose-dependent overproduction of DOPA. Furthermore, after incubation with ascorbic acid (200 mM) for five days, the tyrosine hydroxylase gene expression increased thrice. Ascorbic acid may be useful in treating PD in its early stages, according to the experts' conjectures [35].

Vitamin D:[26]
Reduced verbal fluency, increased postural instability, motor severity, and poor memory have all been linked to vitamin D insufficiency. Vitamin D deficiency is substantially linked to a number of non-motor symptoms in PD patients in addition to the motor symptoms [25]. One crucial neurosteroid needed for proper brain development and operation is vitamin D. It has been proposed that vitamin D is linked to a number of neurological conditions, including multiple sclerosis, stroke, and neurodegenerative illnesses. Numerous brain regions have vitamin D receptors as well as the enzyme 1-alpha-hydroxylase, which is responsible for activating vitamin D. Research conducted on animals indicates that vitamin D could serve as a neurotrophic agent, boost antioxidant concentrations, and guard against excitotoxicity. It appears that the risk and severity of PD are negatively correlated with serum vitamin D concentrations. According to a meta study by Liang [28]PD patients had lower mean levels of 25-hydroxyvitamin D [25(OH)D] than healthy controls (weighted mean difference (MD), -16.9, 95% confidence interval (CI)], -33.5 to -0.2), PD risk was higher in patients with vitamin D insufficiency (25(OH)D level <75 nmol/l). PD risk was doubled in patients with vitamin D insufficiency (25(OH)D level <50 nmol/l). A higher risk of PD is linked to low vitamin D levels (36),(37). Compared to healthy controls, PD patients were shown to have decreased levels of 25(OH)D (38). The results of a randomized, placebo-controlled, double-blind experiment involving 114 PD patients provide evidence about the effectiveness of vitamin D in treating the disease. Specifically, individuals with the FokI TT or CT genotype may have a brief period of PD stabilization while taking 1200 IU of vitamin D3 daily (39).

In a variety of PD animal models, vitamin D3 has been reported to ameliorate behavioral abnormalities, lower oxidative stress, and lessen DA depletion and neuronal death. Tyrosine hydroxylase and the dopamine transporter are both overexpressed as a result of it, according to the molecular process. It suppresses the production of ROS that is mediated by inducible nitric oxide synthase (iNOS), MAO-B, and NADPH oxidase (NOX). In addition, vitamin D therapy causes PD neuroprotection by decreasing pro-inflammatory reactions and triggering anti-inflammatory ones. Mechanistically, vitamin D3 promotes the activation of M2 microglia for an anti-inflammatory response while inhibiting the pro-inflammatory activities of neuroinflammatory TNF-, TLR-4, iNOS, CD11b, MAO-B, IL-I, p47phox, and M1 microglia. In addition, vitamin D3 therapy increases brain-derived neurotrophic factor (BDNF) and glial-derived neurotrophic factor (GDNF) levels in PD animal models, which helps keep neurons alive. GDNF forms a complex with the proto-oncogene tyrosine-protein kinase receptor Ret after binding to the GDNF family receptor alpha 1. The neuronal survival-granting intracellular signaling is activated by this complex. GDNF is a potent antioxidant that promotes the synthesis of glutathione (GSH), SOD, and CAT in the striatum and helps dopaminergicneuron regeneration [25].

DAIRY PRODUCTS
The idea that consuming a lot of milk and perhaps other dairy products overall is linked to a higher risk of PD has received support from several researchers. A Hawaiian study discovered that consuming more than two glasses of milk a day was linked to a reduction in neuronal density in the SN at postmortem [40]. Using data from the American Cancer Society's Cancer Prevention Study II Nutrition Cohort, Honglei [41] prospectively examined the relationship between dairy consumption and PD risk in 57,689 men and 73,175 women." The follow-up period (1992–2001) revealed the identification of 138 women and 250 men with PD. PD risk was strongly correlated with dairy consumption. The likelihood of developing PD was positively correlated with dairy consumption [41]. A significant research of American men and women found that eating three or more servings of low-fat dairy products per day was linked to an increased chance of receiving a PD diagnosis [42]. There may be several mechanisms responsible to explain the association between PD progression and dairy consumption: (1) Dairy intake lowers uric acid [43]. Uric

acid quenches peroxynitrite in the CNS, and low uric acid levels are associated with greater PD incidence and faster PD progression. (2) Diary consumption is associated with insulin resistance. There is a growing body of evidence that PD and other neurodegenerative diseases are a form of "type III diabetes" (3) Lactose intolerance, occurring when the enzyme, lactase, that digests the milk sugar decreases with age, is especially common in individuals of African, Asian, Hispanic, and Native American decent. Consuming dairy in the absence of sufficient lactase may contribute to intestinal inflammation and intestinal permeability. (4) Presence of a neurotoxic component or contaminant, for example, pesticides, may be present in dairy. (5) Introduction of bovine microbiota, facilitating seeding of methanogenic organisms, leads to the development of methane-dominant small intestinal bacterial overgrowth (SIBO) and other forms of abnormal intestinal flora [3],[44]. A recent meta-analysis reported a combined risk of 1.4 for highest vs. lowest levels of dairy food intake, with a stronger association for men than for women [45].

COENZYME Q10 (UBIQUINONE)
PD has been shown to frequently result from mitochondrial malfunction, which is thought to contribute to the etiology of the illness. Coenzyme Q10, which is an antioxidant as well as an electron acceptor for complexes I and II of the mitochondrial electron transport chain (ETC), is an essential part of the chain [46]. When taken in daily doses ranging from 300 to 1,200 mg, coenzyme Q10 can reduce inflammation, motor neuron symptoms, finger dexterity, and visual color acuity [47]. Significantly less CoQ10 was found in the brain's cortex, according to research by Hargreaves [48], which suggest that the etiology of PD may be influenced by signs of a brain CoQ10 deficiency [48]. It was proposed by Hyung-Woo [49] that intrastriatal delivery of a modest dose of Coenzyme Q10 on a continuous basis could effectively prevent the degeneration of dopaminergic neurons. Although the dose of intrastriatal Coenzyme Q10 was 17,000 times lower than that of oral Coenzyme Q10, rats exposed to intrastriatal Coenzyme Q10 also showed less inflammation, more dopaminergic neurons, and higher expression of neurogenetic and angiogenetic factors. These effects were more pronounced than those of Coenzyme Q10 administered orally. Consequently, one efficient method of preventing neurodegeneration in PD may involve the continuous intrastriatal delivery of Coenzyme Q10, particularly in conjunction with implantable devices for convection-enhanced delivery or deep brain stimulation [49].

CONCLUSION

Research on the gut microbiota has made great strides because to high-throughput sequencing techniques. Although there is a lot of circumstantial evidence suggesting the microbiota may play a role in PD, definitive proof is still missing. Determining the exact biochemical pathways through which the microbiome contributes to the etiology of PD is a very challenging task.Notably, recent advancements in tissue culture technologies—most notably, the creation of organoids from human intestinal tissue and their incorporation into more complex organ-on-a-chip systems—offer excellent model systems for researching host-microbe interactions that have a high degree of clinical relevance [50]. Eating a nutritious, well-balanced diet can either reduce or eliminate the risk of PD. The start of PD has been linked to a number of vitamin deficiencies, including deficiencies in vitamins A, B, C, D. Consequently, consuming enough of these vitamins might be viewed as a vital prophylactic against PD. Numerous vitamin supplements can alleviate motor impairments and the clinicopathological changes associated with PD in the general population, as well as lower the prevalence of the disease. This has been shown in previous pre-clinical and clinical investigations. Vitamins may be helpful in treating PD due to their antioxidative properties and biological influence on different gene expressions linked to the disease. Therefore, more research on the neuroprotective vitamins and their active metabolites against PD is needed in the future to confirm vitamins as potent therapeutics against PD.

DECLARATION OF COMPETING INTEREST
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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RESEARCH ARTICLE

Protective Effect of *Ficus glomerata* on Antioxidant Status against Hydrogen Peroxide Induced Oxidative Damage in Erythrocytes (RBC)

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ABSTRACT

Oxidative stress is initiated by free radicals which seek stability through electron pairing with biological macromolecules such as proteins, lipids, and DNA in healthy human cells, therein causing protein and DNA damage along with lipid peroxidation. To prevent damage caused by free radicals, tissues possess an antioxidant defense system that includes enzymatic antioxidants, such as superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx) dietary non-enzymatic antioxidants such as reduced glutathione (GSH), vitamin C and vitamin E. In the present study was investigated the effect of different doses of *Ficus glomerata* on hydrogen peroxide induced oxidative stress in rat erythrocytes. The qualitative analysis of methanolic extract of *Ficus glomerata* leaves showed that tannin, phlobatannins, saponin, flavonoids, steroids, terpenoids, triterpenoids, carbohydrate, polyphenol, protein and glycoside while quantitative revealed total phenol (234 mg/gm) and flavonoids (142mg/gm). The increased content of MDA in group I as compared with other groups, indicates that the increase in oxidative stress and lipid peroxidation while treatment with *Ficus glomerata* decreased MDA content, based on dose dependent manner. The decreased activity of serum enzymatic antioxidant such as SOD, glutathione peroxidase (GPx) and catalase in erythrocyte were observed group I as compared with other groups. This may be indicating the increased free radical in aging attack on enzymes and inactivate them. Treatment with *Ficus glomerata* increased GPx and CAT activity, based on dose dependent manner. The decreased

level of erythrocyte GSH, vitamin C and vitamin E in group I compared with other groups, demonstrating the increased free radicals accumulation. Treatment with *Ficus glomerata* increased vitamin C and vitamin E content, based on dose dependent manner. The results obtained from the present study indicate that hydrogen peroxide enhance lipid peroxidation in the erythrocyte and influence the antioxidant enzymes of erythrocytes. The above results suggested that increased risk of oxidative stress related diseases such as cardiovascular diseases, diabetes, cancer, arthritis etc.

Keywords: Oxidative stress, Antioxidant activity, Phytochemicals, *Ficus glomerata*

INTRODUCTION

Stress is associated with increase in oxidant production and oxidative damage *via* imbalances of hormones, neurotransmitters, oxidants and other stress mediators, as well as the interactions of these stress-related substances, which result from stress-associated changes in metabolic rate/catabolic processes. The stress theory of aging suggests that aging is a result of the cumulative effects of stress experienced during an organism's lifespan. The increased accumulation of oxidative damage to biomolecules critically contributes to aging acceleration and age-related diseases, such as neurodegenerative diseases (Liu and Mori, 1999). Normal metabolism is associated with unavoidable mild oxidative stress resulting in biomolecular damage that cannot be totally repaired or removed by cellular degradative systems, including lysosomes, proteasomes, and cytosolic and mitochondrial proteases. Consequently, irreversibly damaged and functionally defective structures accumulate within long-lived post-mitotic cells, such as cardiac myocytes and neurons, leading to progressive loss of adaptability and increased probability of death and characterizing a process called aging, or senescence. Intralysosomal 'garbage' is represented by lipofuscin (age pigment)., an autophagocytosed materials, while extra-lysosomal 'garbage' involves oxidatively modified cytosolic proteins, altered biomembranes, defective mitochondria and other organelles. In aged post-mitotic cells, heavily lipofuscin-loaded lysosomes perform poorly, resulting in the enhanced accumulation of defective mitochondria, which in turn produce more reactive oxygen species causing additional damage (the mitochondrial–lysosomal axis theory) (Terman and Brunk, 2006b).

The oxidative stress theory of aging has become increasingly accepted, playing a role in the aging process. The intensity of oxidative stress is determined not only by the free radicals production but also by antioxidant (enzymatic and non-enzymatic). Defense (Beltowski *et al.,* 2000). Potential anti-aging strategies may involve the overall reduction of oxidative stress by the use of antioxidant and intralysosomal iron chelators hampering Fenton-type chemistry as well as the stimulation of cellular degradative systems (Terman and Brunk, 2006b). The exposure of aerobic organism to oxidative stress is an unavoidable consequence of their high capacity to produce energy from respiratory activity. Thus, to protect their own structures, organisms have developed several defense mechanisms with antioxidant activity. Because oxidative stress is considered to have a critical role in changes associated with senescence, it is conceivable that antioxidants are important antiaging agents (Mecocci, 2000). A broad class of protective agents termed antioxidants, which prevents oxidative damage by reacting with free radicals before any other molecules can become a target neutralizes the harmful effect of reactive oxygen species. The enzymatic antioxidant such as SOD, CAT, GPx etc., and non-enzymatic antioxidants are vitamin C, vitamin E ceruloplasmin, albumin and reduced glutathione play an important role in the protection of cells against free radical mediated damage (Halliwell, 1994). The balance between ROS production and antioxidant defense leads to 'oxidative stress'. Any compound, natural or synthetic with antioxidant properties might contribute towards the partial or total alleviation of this type of damage. Phytochemicals are biologically active, naturally occurring chemical compounds found in plants, which provide health benefits for humans further than those attributed to macronutrients and micronutrients (Hasler and Blumberg, 1999). They protect plants from disease and damage and contribute to the plant's colour, aroma and flavor. In general, the plant chemicals that protect plant cells from environmental hazards such as pollution, stress, drought, UV exposure and pathogenic attack are called as phytochemicals (Mathai, 2000).

Recently, it is clearly known that they have roles in the protection of human health, when their dietary intake is significant. More than 4,000 phytochemicals have been cataloged and are classified by protective function, physical characteristics and chemical characteristics (Meagher and Thomson, 1999). Medicinal plants are of great importance to the health of individuals and communities. The medicinal value of these plants lies in some chemical substances that produce a definite physiological action on the human body. Many of these indigenous medicinal plants are used as spices and food. Medicinal herb is considered to be a chemical factory as it contains a multitude of chemical compounds like alkaloids, glycosides, saponins, resins, oleoresins, sesquiterpene, locations and oils (essential and fixed) (Rajalkshmi *et al.*, 2013). Higher plants produce both primary and secondary chemical metabolites, the former being vitally important in normal development and reproduction of plants. On the other hand, secondary metabolites are known to play important roles in plant survival as defense mechanisms against adverse biotic and a biotic conditions. Plant chemicals to protect itself but recent research demonstrate that many phytochemicals can protect humans against diseases including cancer, cardiovascular and inflammatory diseases. Hence, the present study was investigate the antioxidant activity of *Ficus glomerata* on hydrogen peroxide induced oxidative stress in rat erythrocytes. *Ficus glomerata*. Roxb. is a popular medicinal plant in India, which has long been used in Ayurveda for the treatment of diabetes, liver disorders, respiratory, urinary diseases and inflammatory conditions.

MATERIALS AND METHODS

Plant materials and Preparation of extract
The leaf of *Ficus glomerata* was collected from Thamarankottai, Thanjavur district. The collected leaves were cut into small pieces and shade dried at room temperature and makes a fine powder using pestle and mortar. The powder materials of leaves were macerated with 70% methanol at room temperature for 24 hours. After 24 hours, the supernatant was transferred into china dish. The supernatant was completely removed by keeping the china dish over a boiling water bath at 45°C. A semi solid extract was obtained after complete elimination of alcohol. The obtained residue was kept in the refrigerator for further use.

Phytochemical screening
Chemical tests were carried out on the alcoholic extract and on the powdered specimens using standard procedures to qualitative identify the constituents as described by Sofowara (1993), Trease and Evans (1989) and Harborne (1973, 1984). Total phenols estimated by the method of Edeoga *et al.,* (2005). Flavonoid determine by the method of Bohm and Kocipai-Abyazan (1994).

Preparation of erythrocytes suspensions (Wu *et al.*, 1997)
Fresh blood samples from healthy volunteers (10–15ml) were collected and centrifuged at 3000 rpm for 15 minutes, plasma and pufy coats were removed. Red cells were washed with PBS (pH 7.00) for three times and erythrocytes were lysed with ice-cold distilled water. The antioxidant activities in erythrocytes were evaluated by the method of Sasikumar *et al.* (2015).

Experimental design
Erythrocyte suspensions obtained from healthy donor were divided into five groups.
Group I- H_2O_2 Control: [Erythrocyte suspension (750µl), 10mM H_2O_2 (50µl), PBS (950µl) and D.H_2O (250µl)]. **Group II Normal:** [Erythrocyte suspension (750µl), PBS (1000µl) and D.H_2O (250µl)]. **Group III-** *Ficus glomerata* **(100 µg/ml):** [Erythrocyte suspension (750µl), 10mM H_2O_2 (50µl), *Ficus glomerata* extract (500µl) and PBS (950µl)]. **Group IV-** *Ficus glomerata* **(250 µg/ml):** [Erythrocyte suspension (750µl), 10mM H_2O_2 (50µl), *Ficus glomerata* extract (500µl) and PBS (950µl)]. **Group V-** *Ficus glomerata* **(500 µg/ml):** [Erythrocyte suspension (750µl), 10mM H_2O_2 (50µl), *Ficus glomerata* extract (500µl) and PBS (950µl)].   These experimental groups were incubated at 37°C for 1 hour. Following the incubation, enzymic and non-enzymic antioxidant activity were determined.

BIOCHEMICAL ESTIMATION

Estimation of Malondialdehyde

Malondialdehyde was estimated by the thiobarbituric acid assay method of Beuge and Aust (1978). Reduced glutathione was estimated by method of Moron *et al* (1979). The level of ascorbic acid was estimated by the method of Omaye *et al* (1979). α-tocopherol was estimated by the method of Baker *et al* (1980). The activity of catalase was assayed by the method of Beers and Sizer (1952). The activity of mitochondrial glutathione peroxidase was assayed by the method of Rotruck *et al* (1973).

Statistical Analysis

Values are expressed as Mean ± SD for triplicates. Data were analyzed by one-way ANOVA followed by post-hoc Tukey HSD test, using SPSS ver. 20. Statistically significant variation was derived by comparing Group I versus Group II, Group III, Group IV and Group V. *$P<0.05$ statistically significant and NS= Non significant ($P>0.05$) compared with Group I (Negative control).

RESULTS AND DISCUSSION

Plants that having curing properties are known as medicinal plants or herbs. Herbs have been used in treating human diseases for thousands of years by tribal communities and ancient civilizations. They may be used directly as such, or in other extracted forms for their natural chemical constituents. They may also be used as constituents in different forms of medicines. Medicinal plants are not only a major source for the traditional medicine & herbal industry but also provide livelihood and health security to a large segment of Indian population. According to the World Health Organization (WHO), approximately 80% of the world's population currently uses herbal medicines in healing different ailments. Among the estimated 400,000 plant species, only 6% have been studied for biological activity, and about 15% have been investigated phytochemically (Pushpa Latha *et al.*, 2010). This shows a need for planned activity guided phyto-pharmacological evaluation of herbal drugs. This article is aimed to provide an overview of research work done on this plant which is helpful for further investigations and forms an important aspect of drug studies. The qualitative analysis of methanolic of extract of *Ficus glomerata* leaves showed that tannin, phlobatannins, saponin, flavonoids, steroids, terpenoids, triterpenoids, carbohydrate, polyphenol, protein and glycoside were present (Table 1). Quantitative analysis revealed that the plant has phenols, alkaloids, saponin and tannin. Rich amount of total phenol (234.28 mg/gm) and flavonoids (142.28mg/gm) was presented. This is because of the pharmacological activity of this plant is used to trace the particular compound.

Erythrocytes, the unique carriers of oxygen are highly susceptible to oxidative stress conditions. The rich polyunsaturated membrane lipids and iron, a potent catalyst for free radical reactions makes erythrocyte a good substrate for oxidative damages. Membrane oxidations do affect the intrinsic membrane properties as well, by altering membrane fluidity, ion transport and loss of enzymic activities of the cell (Chiu *et al.*, 1989). As cell membrane is an important target for radical damage, and blood can reflect the liability of the whole animal to oxidative condition, erythrocytes have been used extensively for determining the effect of aging in studies concerning the possible involvement of free radicals. The erythrocyte cell membrane has a total negative electric charge, which determines the correct course of many processes like transport of metabolic substrates and products through ionic pumps, carriers and membrane channels, for the transfer of information (Nalecz, 1989) and mainly to prevent aggregation of erythrocytes from each other (Jovtchev *et al.*, 2000). The aggregability of erythrocytes is mainly determined by glycocalyx on their membrane, in particular by the amount of the sialic acid residues bearing negative surface charge. Oxidative stress or other damaging effects to surface sialosaccharide may itself play role in aggregation of erythrocytes, increasing the adhesiveness to endothelial cells contributing for the development of various pathologies including diabetes mellitus, atherothrombotic complications (Wautier *et al.*, 1981) and sequestration of circulating erythrocytes by macrophages (Beppu *et al.*, 1995).

The vital function that blood cells perform, together with the susceptibility of this highly proliferative tissue to intoxication by xenobiotics, makes the hematopoetic system unique as the target organ. The various blood cells are produced at a turnover rate of about 1 to 3 million per second in a healthy human adult and this value could be altered in certain physiological or pathological states including hemolytic anemia or suppressive inflammation (Guyton, 1991). Erythrocytes are highly vulnerable to free radical induced LPO reactions due to rich content of polyunsaturated fatty acids (PUFAs)., presence of transition metals and continuous exposure to high concentration of molecular oxygen (Chiu *et al.*, 1982). Under normal conditions, the continuous production of free radicals is compensated by the powerful action of protective enzymes like superoxide dismutase, catalase and glutathione peroxidase that are believed as major antioxidant enzymes present in the human body that protect against the oxygen toxicity. As a result, a lipid peroxidation (LPO) process occurs. Therefore, antioxidant enzyme activities and lipid peroxidation levels are accepted as important parameters in the evaluation of oxidative stress in aerobic organisms (Abraham *et al.*, 2005). The present study was carried out to investigate the influences of hydrogen peroxide on the antioxidant status and lipid peroxidation (LPO) in erythrocytes. Table 2 represents the levels of MDA in experimental group. Group I hydrogen peroxide treated RBC showed a significant increased in the level of MDA when compared to Group II rats. Group III to V hydrogen peroxide exposed RBC treated with different doses (100, 250 and 500µg/ml) of *Ficus glomerata* significantly decreased in the level of MDA when compared to group I.

Among the various doses, 500mg/kg possess significant activity than other doses. Values are expressed as Mean ± SD for triplicates. Statistically significant variation was derived by comparing Group I versus Group II, Group III, Group IV and Group V. *$P<0.05$ statistically significant and NS= Non significant ($P>0.05$) compared with Group I (Negative control). Malondialdehyde (MDA) is the major aldehyde resulting from the peroxidation of biological membrane polyunsaturated fatty acid. MDA, a secondary product of lipid peroxidation is used as an indicator of tissue damage by series of chain reactions (Ray and Husain, 2002). The study of lipid peroxidation is attracting much attention in recent years due to its role in diseases process membrane lipids are particularly susceptible to lipid peroxidation due to the presence of polyunsaturated fatty acids. It has been implicated in the pathogenesis of a number of diseases and clinical conditions. These include atherosclerosis, cancer etc., Experimental and clinical evidence suggests that aldehyde products of lipid peroxidation can also act as bioactive molecule in physiological and pathological conditions. It is now generally accepted that lipid peroxidation and its product play an important role in liver, kidney, heart and brain toxicity (Lakshmi *et al.*, 2005). MDA is one of the indicators of oxidative stress. In the present study, the increased content of MDA in group I as compared with other groups, indicates that the increase in oxidative stress and lipid peroxidation. Treatment with *Ficus glomerata* decreased MDA content.

The decrease was observed dose dependent manner. Among the various doses, 500mg/kg possess significant activity than other doses. Table 3 represents the activity of SOD, Catalase and Glutathione peroxidase (GPx) in experimental group. Group I hydrogen peroxide treated RBC showed a significant decreased in the activity of SOD and Catalase when compared to Group II rats. Group III to V hydrogen peroxide exposed RBC treated with different doses (100, 250 and 500µg/ml) of *Ficus glomerata* significantly decreased in the activity of SOD and Catalase when compared to group I. Among the various doses, 500mg/kg possess significant activity than other doses. Group I hydrogen peroxide treated RBC showed a significant decreased in the activity of Glutathione peroxidase when compared to Group II rats. Group III to V hydrogen peroxide exposed RBC treated with different doses (100, 250 and 500µg/ml) of *Ficus glomerata* significantly increased in the activity of Glutathione peroxidase when compared to group I. Among the various doses, 500mg/kg possess significant activity than other doses. Values are expressed as Mean ± SD for triplicates. Statistically significant variation was derived by comparing Group I versus Group II, Group III, Group IV and Group V. *$P<0.05$ statistically significant and NS= Non significant ($P>0.05$) compared with Group I (Negative control). Glutathione is an important antioxidant that functions directly in elimination of toxic peroxides and aldehydes and indirectly in maintaining vitamins C and E in its reduced and functional forms. Vitamin C deficiency results in decreased plasma GSH and vitamin E supplementation increases plasma GSH. Both vitamin C and E concentrations in plasma decrease with age (Samiec *et al.*, 1998)., suggesting that GSH may also decrease in plasma with age diminished GSH status has been linked with normal aging as well as with neurodegenerative disease (Benzi and Moretti, 1997). The finding of our study showed decrease level of erythrocyte glutathione in group I as compared

with other groups. This may be due to increased utilization for detoxification of free radicals generated by hydrogen peroxide. Treatment with *Ficus glomerata* increased GSH content. The increase was observed dose dependent manner. Among the various doses, 500mg/kg possess significant activity than other doses. Ascorbate plays an important role with the lipophilic antioxidant α-tocopherol in protecting the membrane from oxidative stress. Recycling of ascorbic acid requires GSH, which reduces dehydroascorbate to ascorbate (Winkler, 1992). Ascorbate in turn is essential for the recycling of tocopherol radical to tocopherol (Packer *et al.*, 1997). The observed decline in glutathione level may contribute to the decrease in ascorbate as well tocopherol concentration in aged subject. Both vitamin C and E concentrations is decrease with age reported by Samiec *et al*. (1998). A variety of antioxidant defense systems is present in erythrocytes including α-tocopherol to detoxify pro-oxidants and scavenge free radicals to protect itself against oxidative damage. α-Tocopherol serves as a potent scavenger of peroxyl radicals to protect PUFA present in erythrocyte membranes against peroxidation (Mukai *et al.*, 1993). The significant decrease in erythrocyte α-tocopherol levels in aging subjects may be due to the scavenging of peroxyl and sanguinary induced production of ROS, as evidenced by increased peroxidation of erythrocyte. α-Tocopherol and ascorbate are well known non-enzymatic antioxidants, which play an important role by oxido-reductive mechanism in protecting biological membranes against toxicant induced oxidative damage by trapping ROS (McCay, 1985). In the present study, we also observed the decreased level of erythrocyte vitamin C and vitamin E in group I as compared with other groups, demonstrating the increased free radicals accumulation. Treatment with *Ficus glomerata* increased vitamin C and vitamin E content. The increase was observed dose dependent manner. Among the various doses, 500mg/kg possess significant activity than other doses.

CONCLUSION

The results obtained from the present study indicate that hydrogen peroxide enhance lipid peroxidation in the erythrocyte and influence the antioxidant enzymes of erythrocytes. The above results suggested that increased risk of oxidative stress related diseases such as cardiovascular diseases, diabetes, cancer, arthritis etc. Treatment with *Ficus glomerata* increased antioxidant activity. The increase was observed in dose dependent manner. Among the various doses, 500mg/kg possess significant activity than other doses. Antioxidant supplementation may be benefited to the free radical mediated diseases including diabetic, cancer, cardiovascular diseases etc.

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Table 1: Phytochemical screening of *Ficus glomerata*

S. No	Phytochemical	Results
1	Tannin	+
2	Phlobatannins	+
3	Saponin	+
4	Flavonoids	+
5	Steroids	+
6	Terepenoids	+
7	Triterpenoids	+
8	Alkaloids	+
9	Carbohydrate	+
10	Protein	+
11	Anthroquinone	+
12	Polyphenol	+
13	Glycoside	+

(+) Presence   (-) Absence

Table 2: Effect of *Ficus glomerata* **on MDA in experimental rats**

Parameters	Group I	Group II	Group III	Group IV	Group V
MDA (μ mole/g Hb).	13.48±1.13	7.42±0.94*	9.69±0.94*	8.93±0.97*	8.17±1.20*

Table 3: Effect of *Ficus glomerata* **on SOD, Catalase and Glutathione peroxidase (GPx) activity in experimental group.**

Parameters	Group I	Group II	Group III	Group IV	Group V
SOD (U/g Hb)	1.69±0.22	3.20±1.59*	3.49±0.15*	3.86±0.33*	4.65±0.33v
Catalase (U/g Hb).	2.99±0.02	5.89±0.02*	4.06±0.01*	4.46±0.01*	6.29±1.14*
GPx (U/g Hb).	2.29±0.03	3.19±00.12*	2.85±0.03*	2.97±0.01*	3.18±0.03*

Table 4: Effect of *Ficus glomerata* **on Vitamin C, E and GSH in experimental rats**

Parameters	Group I	Group II	Group III	Group IV	Group V
Vit-C (μg/g Hb).	2.76±0.25	5.83±0.15*	4.16±0.20*	5.86±0.32*	6.76±0.25*
Vit-E (μg/g Hb).	2.72±0.02	4.55±0.05*	3.4±0.5*	4.34±0.03*	4.55±0.06*
GSH (mg/g Hb).	5.57±0.03	6.31±0.01*	6.14±0.19*	6.65±0.33*	6.86±0.33*

Herbal Allies in Indian Maxillofacial Surgery : A Journey into Evidence-based Practice

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ABSTRACT

"Oral and maxillofacial surgery encompasses the treatment of diseases affecting the head, neck, and face, particularly focusing on the oral cavity. This includes a wide spectrum of procedures ranging from routine teeth extraction to more complex interventions such as facial bone fracture reduction, oncological surgeries, and access osteotomies. Typically, both pre-operative and post-operative courses involve the administration of antibiotics and analgesics, albeit sometimes resulting in adverse reactions in patients. In India, alongside modern medicine, we have the AYUSH system, which offers treatments for various pathologies affecting the head, neck, and oral cavity, utilizing herbal remedies and therapies without the accompanying complications of conventional medication. The AYUSH system comprises Siddha, Ayurveda, Unani, and Sowrigba (Himalayan herbal medicine), all of which are rooted in herbal practices. Recognized by the World Health Organization (WHO) as a form of herbal medicine, AYUSH has gained significance, especially in the wake of the COVID-19 crisis, where herbal remedies have proven to be lifesavers. Herbal remedies, being a staple in Indian culture for centuries, are easily accessible and

affordable. They have been employed in treating both communicable and non-communicable diseases and can serve as effective alternatives for infection control and pain management in the field of oral and maxillofacial surgery (OMFS). This review highlights the potential of various AYUSH drugs, known for their minimal adverse effects, to contribute to the well-being of OMFS patients."

Keywords: AYUSH, Siddha, Ayurveda, Unani, maxillofacial surgery

INTRODUCTION

Diseases of the oral cavity primarily affect the teeth and surrounding tissues, spanning from common dental caries to pre-malignant lesions, conditions, and oral squamous cell carcinomas. Herbal remedies have been utilized for centuries in treating oral cavity diseases, boasting high success rates due to their interactions with specific receptors within the body. In light of the need for alternative treatments that are safe, effective, affordable, and devoid of side effects, the search for alternative herbal products persists. It is increasingly evident that plant extracts offer advantages over synthetic chemicals [1]. Traditionally, there were 18 Siddhars (Agasthiyar, Korakkar, Punnakkeesar, Pulasthiyar, Poonaikannar, Idaikkadar, Bogar, Pulikaiisar, Karuvurar, Konkanavar, Kalangi, Sattainathar, Azhuganni, Agappai, Pumbatti, Theraiyar, and Kudhambai) credited with the development of Ayush medicine, with Agasthiyar being particularly esteemed. Regarded as the originator of Siddha medicine, Agasthiyar holds a position akin to that of Hippocrates in modern Western medicine. The Siddha medicine system predominantly incorporates the use of metals, minerals, and chemical products, with the utilization of metals dating back to the period of Vagbhata (6th Century AD). While the exact dates of alchemy texts remain uncertain, they likely originated between the 9th and 18th Centuries AD, with the period between the 10th and 14th Centuries witnessing notable flourishing [2].

MATERIALS AND METHOD

This review checklist was followed in conducting the systematic review of the literature for the present study. To create a database of herbal product use in oral health literature from January 2000 to January 2020, a thorough search method was devised to find both published and unpublished citations. An automatic search of bibliographic databases, such as PubMed, Embase, Scopus, and the Web of Science database, was included in the search. These searches made use of proximity, phrases, truncation, and index terms from either the EMtree thesaurus or MeSH headings. Subject heading terms and keywords for oral disorders and herbal goods (e.g., "herbal medicine," "herbal extract," "herbal supplements," "plant extract," or "natural drug") were included in the search concepts.

Inclusion criteria and study selection
In order to determine if herbal products are beneficial in treating oral diseases, preliminary research encompassing cross-over studies, clinical trials, randomized controlled trials, and in vitro investigations was incorporated into this review. Editorials, commentaries, letters, review papers, and observational studies (such as case controls, cohorts, and cross-sectional studies) were not included.

Data extraction
Data were separately gathered from all included articles by two review authors, SS and GS. The study team created basic forms by extracting the characteristics of the included studies. The bibliographical data (title, authors, publication dates, and affiliations), patient data (age, gender, and oral disease subgroup), and methodological data (herbal product name, intervention group, control group, outcome assessment, and follow-ups) were some of these features.

Evaluation of the evidence's quality
Utilizing the Cochrane Handbook for Systematic Reviews of Interventions, the standard of the randomized trials included is evaluated. The Cochrane handbook lists five criteria—random sequence generation, allocation concealment, blinding, inadequate outcome data, and selective reporting—as a means of evaluating the quality of randomized controlled trials. The Health Gains Notation framework was utilized to evaluate the efficacy of the interventions.

Disease and Cause Concept in Siddha Medicine:
According to Siddha medicine principles, diseases occur when there is a disruption in the usual balance of the three components: Vatha, Pitha, and Kapha. Various factors such as environment, climate conditions, diet, physical activities, and stress contribute to this imbalance. In a healthy state, the ratio of these three components is typically 4:2:1.With the advent of modern medicine, there has been a decline in the use of traditional herbal medicine. However, the emergence of new diseases and the adverse effects associated with modern medicine have led to a resurgence of interest in Ayush treatments, which are known for their lack of adverse effects. Ayush medicine is not limited to a specific department but can be integrated into various specialties. As previously mentioned, Ayush is increasingly being utilized in oral and maxillofacial surgery (OMFS). Ayush medicine offers an alternative to modern medicine in various forms, including antibiotics, analgesics, antacids, antivirals, wound healing enhancers, anesthetics, and hemostatic agents. During the COVID-19 pandemic, many countries, including India, explored the use of indigenous medicines. In India, KabasuraKudineer was used to treat COVID-19, resulting in reduced mortality rates compared to conventional medicine. This serves as evidence that Ayush drugs can be comparable to modern medicine drugs [2].

Natural Remedies for Oral and Maxillofacial Surgery Conditions:
According to the WHO, 70-80% of people worldwide depend on native herbal medicine as their first line of treatment due to its high safety margin and availability [3]. Consequently, there is a crucial need for the development of evidence-based herbal medicine in modern dental practice. This article discusses the various diseases seen in oral and maxillofacial surgery and herbal-based treatments for these conditions based on existing Indian literature."

Ginger: The botanical name of Ginger is Zingiberofficinale
According to Indian literature, ginger has anticancer properties [4]. Zerumbone is a sesquiterpenoid and cyclic ketone extracted from the essential oil of ginger rhizomes. NurSyafinazZainal et al. demonstrated in their study that zerumbone, extracted from ginger, exhibits anticancer activity by inhibiting the activation of CXCR4-RhoA and PI3K-mTOR signaling pathways, thereby reducing the cell viability of ORAL SQUAMOUS CELL CARCINOMAcells. From this study, we conclude that zerumbone is a promising phytoagent for the development of new therapeutics for ORAL SQUAMOUS CELL CARCINOMAtreatment [5]."

Garlic: The botanical name of Garlic is Allium sativum .
According to Indian literature, garlic has anticancer and antifungal properties [4]. In epidemiological studies, the usage of garlic and garlic-based extracts has been associated with a lower risk of cancer. VoinPetrovic et al., in their study, examined the molecular and cellular activities of garlic extract and found that it enhanced the activities of chemotherapeutics, as well as MAPK and PI3K inhibitors. Furthermore, garlic extract affected hundreds of proteins involved in cellular signaling, including changes in vital cell signaling cascades regulating proliferation, apoptosis, and the cellular redox balance [6]. Polymicrobial biofilms are notorious for damaging intraoral tissues. Streptococcus sanguinis and Streptococcus mitis, which are commensals of the oral cavity, have been observed to coexist alongside C. albicans in resistant infections. There is an urgent need for alternate therapy choices. In their study, Ayesha Fahim et al., assessed the efficacy of garlic and bakuchiol combination against candida virulent genes and their subsequently secreted proteins. They found that ALS3 and SAP5 were significantly downregulated in the garlic and bakuchiol-treated polymicrobial biofilm. Therefore, garlic can be used against Candida albicans [7].

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Turmeric: The botanical name of turmeric is Curcuma longa .
According to Indian literature, turmeric has anticancer and antifungal properties [4]. It belongs to the family of ginger and is a native plant of the Indian subcontinent. Phytochemical components of turmeric include diarylheptanoids, a class comprising numerous curcuminoids such as curcumin, demethoxycurcumin, and bisdemethoxycurcumin. Curcumin has been shown to possess anti-infectious, antioxidant, anti-inflammatory, and anticarcinogenic effects. The low bioavailability of curcumin has been overcome by numerous analogues and nanoformulations, including nanoparticles, liposome complexes, micelles, and phospholipid complexes. Curcumin's anticancer effects are mediated by its action on multiple molecular targets, including activator protein 1, protein kinase B (Akt), nuclear factor κ-light-chain-enhancer of activated B cells, mitogen-activated protein kinase, epidermal growth factor receptor (EGFR) expression, and EGFR downstream signaling pathways. These targets play essential roles in oral cancer development, hence curcumin is a promising adjuvant therapy approach [8]. FatemehForouzanfar et al. conducted a study on turmeric and its antibacterial effect over periodontal disease and found it to be equally or more effective when compared to chlorhexidine [9]

Tulasi: The botanical name of tulasi is Ocimum sanctum.
According to Indian literature, tulasi has anticancer properties [4]. The plant and its oil contain diverse phytochemicals, including tannins, flavonoids, eugenol, caryophyllenes, carvacrol, linalool, camphor, and cinnamyl acetate. Oral Submucous Fibrosis (OSMF) is defined as an insidious chronic condition of unknown etiology affecting the oral mucosa, characterized by dense collagen tissue deposition within the submucosa, occasionally extending to the pharynx and esophagus [10]. The condition is marked by trismus, a burning sensation, loss of tongue movement, loss of gustatory sensibility, and blanching and stiffness of the oral mucosa. The majority of these cases affect Indian people [11]. OSMF can be treated with tulasi, which is easily available and most recognized by Indians as the first line of medicine for sore throat and fever. AditSrivastava et al., in their study, used tulasi and turmeric for the treatment of OSMF and concluded that these herbs reduced the burning sensation and improved mouth opening [12]

Aloe vera: The botanical name of aloe vera is Aloe barbadensismiller .
According to Indian literature, aloe vera has antifungal properties [4]. Candida infection causes two types of infections: superficial infections such as oral and vaginal lesions, and systemic manifestations. Karina Nabila, in their study, determined the effectiveness of the antifungal nature of aloe vera by mixing aloe vera extract with 70% ethanol and dissolving it in DMSO into multiple concentrations (6.25%, 12.5%, 25%, and 50%). Candida albicans was cultured in Sabouraud dextrose agar for 72 hours, and the disc diffusion method was used to evaluate the inhibitory effect of each concentration compared to fluconazole. Zones of inhibition at 72 hours were measured and documented, then analyzed to obtain the mean inhibition zone (MIZ). Results: After 72 hours, all concentrations of Aloe vera ethanol extract showed inhibitory effects against C. albicans, with mean inhibition zones for each concentration. Aloe vera ethanol extract possesses concentration-dependent activity against Candida albicans that is comparable to standard antifungal agents. [13]

Large Caltrop: The botanical name of large caltrop is Pelladium murex.
According to Indian literature, Pelladium murex has lithiatic properties [4]. There is literature supporting the nephrolithiatic property of Pelladium murex. Petroleum ether, chloroform, ethanol, and aqueous extracts of the plant were prepared and evaluated for their anti-nephrolithiasis activity. Albino rats were treated with the prepared extracts. Thus, it may be concluded that P. murex possesses significant anti-nephrolithiatic activity. Moreover, it possesses antioxidant and anti-ulcer activity [14]. Hence, research should be conducted towards the lithiatic property of Pelladium murex in silolithiasis of the salivary gland.

Neem: The botanical name of neem is Azadirachtaindica .
According to Indian literature, neem has antibacterial, antiviral, antioxidant, and anticancer activities [4]. In primitive villages of India, people affected with chickenpox are treated with neem leaves for the blisters that appear on the body surface, and it has been shown to reduce blister formation [4]. Neem plays a role as a free radical scavenger due to its rich source of antioxidants. Azadirachtin and nimbolide showed concentration-dependent antiradical

scavenging activity and reductive potential in the following order: nimbolide>azadirachtin>ascorbate [16]. Neem ingredients show an effective role in the management of cancer through the regulation of cell signaling pathways. Neem modulates the activity of various tumor suppressor genes (e.g., p53, pTEN), angiogenesis (VEGF), transcription factors (e.g., NF-κB), and apoptosis (e.g., bcl2, bax) [15].

Neem also plays a role as an anti-inflammatory agent by regulating proinflammatory enzyme activities, including cyclooxygenase (COX) and lipoxygenase (LOX) enzymes [15].

Role of Neem in Oral Cancer

Nimbolide, extracted from neem, has demonstrated autophagy and apoptosis effects in hamster oral cancer study models. The exact mechanism of action is that nimbolide negatively regulates the PI3K/Aktsignaling pathway, resulting in an increase in p-GSK-3βTyr216, the active form of GSK-3β that inhibits autophagy. Downregulation of HOTAIR, a competing endogenous RNA that sponges miR-126, may be a major contributor to the inactivation of PI3K/Akt/GSK3 signaling by nimbolide. Analysis of key markers of apoptosis and autophagy, as well as p-AktSer473 during the sequential progression of hamster and human oral squamous cell carcinoma, revealed a gradual evolution to a pro-autophagic and antiapoptotic phenotype that could confer a survival advantage to tumors. From the above study, it was proven that nimbolide augments apoptosis by overcoming the shielding effects of cytoprotective autophagy through modulation of the phosphorylation status of Akt and GSK-3β as well as the ncRNAs miR-126 and HOTAIR. Therefore, neem may be the future oral anticancer drug.

DISCUSSION

The use of Siddha medicine, a form of herbal medicine, has persisted in treating certain non-curable and emerging diseases such as Covid-19. In India, the government has approved native herbal medicine as the first line of treatment and home remedial measure.[18]AnuragSrivastava conducted a double-blinded randomized control study to assess the efficacy of NilavembuKudineer and KabasuraKudineer alongside allopathic treatment in managing mild to moderate symptomatic patients with Covid-19. The study demonstrated that both NilavembuKudineer and KabasuraKudineer significantly reduced hospital stay time, viral load of SARS-CoV-2, and the time taken for patients to transition from symptomatic to asymptomatic. These findings indicate that traditional herbal medicine can be effective in treating novel infectious diseases. There is a global need for promising drugs that are effective and devoid of drug-induced complications. Similarly, in the field of Maxillofacial surgery, which is a sub-specialty of surgery, there is a desire for medicinal interventions that are highly effective without causing complications. Traditional therapies have been shown to be readily available, free of side effects, and effective in this regard. The concept of patient safety is paramount in healthcare as every stage of the healthcare delivery process carries the risk of error. This means that issues with practices, goods, processes, or systems of healthcare delivery may arise, potentially leading to unfavorable outcomes for patients, such as negative drug reactions.

The World Health Organization (WHO) defines a negative drug reaction as "a response to a drug that is noxious and unintended and occurs at doses normally used in man for the prophylaxis, diagnosis or therapy of disease, or for modification of physiological function." This underscores the importance of ensuring that medications are administered safely and effectively to minimize the risk of adverse reactions and enhance patient well-being.[19] There have been no reported side effects or complications associated with Siddha drugs used for the treatment of maxillofacial diseases. However, after tooth extraction, effective pain management is crucial for reducing patient discomfort, minimizing the risk of infection, and promoting faster healing. Due to safety concerns related to commonly prescribed medications like NSAIDs, there is a need for reliable and safe alternatives for pain relief. The use of natural products for pain management in dentistry has gained traction due to advancements in alternative medicine. Swapnil U Shinde conducted a study utilizing analdent, which is an AYUSH analgesic, for the treatment of post-extraction pain. The study demonstrated that analdent was nearly as effective as aceclofenac in reducing pain following tooth extraction, but with fewer adverse effects. These findings suggest the potential for developing modern drugs based on traditional herbal medicine, offering effective pain relief with improved safety profiles.[20] A

panel of ORAL SQUAMOUS CELL CARCINOMA(oral squamous cell carcinoma) cell lines was utilized to investigate the cytotoxic, anti-proliferative, anti-migratory, and anti-invasive properties of zerumbone. Through Western blotting analysis, the impact of zerumbone on the PI3K-mTOR and CXCR4-RhoA pathways, two crucial signaling pathways implicated in the spread and carcinogenesis oforal squamous cell carcinoma, was examined. These pathways are attractive targets for oral squamous cell carcinomatherapy due to their activation. Zingiberzerumbet (L.) Roscoe, also known as tropical ginger, produces rhizomes containing zerumbone, a bioactive monocyclic sesquiterpene with promising anticancer effects. Zerumbone has demonstrated the ability to affect several molecular targets involved in carcinogenesis. The study presented evidence suggesting that zerumbone may inhibit the activation of the CXCR4-RhoA and PI3K-mTOR signaling pathways, thereby reducing the survival capacity of oral squamous cell carcinoma cells. This indicates that zerumbone could be a promising phytoagent for the development of new therapeutics for oral squamous cell carcinoma treatment. Furthermore, ginger plays a significant role in iron metabolism and the absorption of oral iron supplements. The bioactive polyphenols present in ginger act as prebiotics for the gut microbiota, promoting gut health and reducing the undesirable side effects of iron tablets. Additionally, ginger has been shown to increase erythropoiesis, the production of red blood cells.

Therefore, ginger may have the potential to mitigate the negative effects and restore iron balance in cases of iron excess.[21]Further research is indeed necessary to delve deeper into the potential applications of ginger polyphenols. While existing studies have highlighted their beneficial effects on gut health, iron metabolism, and erythropoiesis, there may be additional therapeutic properties yet to be discovered. Regarding garlic, VoinPetrovic's research has shown that garlic extract reduces the proliferation of cancer cells by inducing increased endoplasmic reticulum (ER) stress. This finding underscores the potential anticancer properties of garlic and its potential role in cancer therapy.
Additionally, garlic has been the subject of research for its osteogenic capacity. The natural therapeutic effects of garlic compounds make them valuable additions to medicinal formulations used in bone scaffolds for targeted treatment aimed at stimulating tissue creation and promoting bone healing. When ginger and garlic extracts are incorporated into 3D-printed (3DP) bone tissue engineering scaffolds, they enhance osseointegration and promote osteogenesis, thereby facilitating bone tissue in-growth. This suggests that naturally obtained compounds from ginger and garlic could play a significant role in enhancing bone regeneration and improving outcomes in bone defect applications, particularly in low load-bearing bone and dental scenarios where 3DP scaffold biomedical devices are utilized.[22] Oral cancer poses a significant threat to public health due to its high morbidity and mortality rates, with squamous cell carcinoma being the most prevalent type in the head and neck region. Typically originating from the epithelium, oral cancer treatment options primarily include chemotherapy, surgery, and radiotherapy, either alone or in combination. While chemotherapy has demonstrated efficacy, it is often accompanied by serious side effects and the potential for tumor resistance and recurrence.To address these challenges and improve the effectiveness and safety of oral cancer treatment, there is a pressing need for the development of anticancer medications that are highly precise and have minimal adverse effects. Curcumin, a plant polyphenol extracted from the rhizome of the turmeric plant Curcuma longa, has emerged as a promising adjuvant therapy option.

Extensive research has demonstrated that curcumin possesses anti-inflammatory, anti-infectious, antioxidant, and anticarcinogenicproperties.Despiteits potential benefits, curcumin's therapeutic efficacy has been hindered by its low bioavailability. However, various analogues and nanoformulations of curcumin, including micelles, nanoparticles, liposome complexes, and phospholipid complexes, have been developed to overcome this limitation. These formulations enhance curcumin's bioavailability and improve its therapeutic potential.Studies have elucidated that curcumin's anticancer effects are mediated through its action on multiple molecular targets involved in the pathophysiology of oral cancer. These targets include nuclear factor κ-light-chain-enhancer of activated B cells, protein kinase B (Akt), activator protein 1, mitogen-activated protein kinase, expression of the epidermal growth factor receptor (EGFR), and downstream signaling pathways of EGFR. By modulating these targets, curcumin exhibits promising anticancer activity and holds potential as an effective adjuvant therapy for oral cancer.curcumin represents a valuable adjunct to conventional oral cancer treatment modalities due to its multifaceted pharmacological properties and favorable safety profile. Continued research and development of curcumin-based therapies, particularly in the form of optimized nanoformulations, hold promise for improving patient outcomes in

oral cancer management.[8] Clinical trials investigating the effectiveness of curcumin in treating various human diseases, including oral disorders, have been conducted extensively. One notable study focused on oral leukoplakia, a potentially malignant lesion of the oral cavity for which effective treatments are limited. Conducted by Kuriakose et al., this phase IIB clinical trial employed curcumin in a randomized, double-blinded, placebo-controlled manner among participants with oral leukoplakia. The results of the study demonstrated significant improvements in both histological and clinical responses with curcumin therapy. Particularly noteworthy was the sustained clinical response observed following treatment with curcumin at a dose of 3.6 g over a 6-month period. Importantly, the therapy was well-tolerated by the participants, indicating its safety profile in the management of oral leukoplakia.[23] Furthermore, recent studies have shown promising results regarding the use of topical curcumin in the treatment of oral mucositis, a common complication of cancer therapy characterized by inflammation and ulceration of the oral mucosa. These studies suggest that curcumin's anti-inflammatory and wound-healing properties make it an effective agent for managing oral mucositis and alleviating associated symptoms.[24] Overall, the findings from these clinical trials highlight the potential of curcumin as a therapeutic agent for various oral disorders, including oral leukoplakia and oral mucositis. Further research and clinical trials are warranted to fully elucidate curcumin's therapeutic benefits and optimize its use in clinical practice. The development of drug delivery systems at the nanoscale has been pioneered by nanotechnology. Because of the surface, small size, quantum size, and quantum tunnel effects of nanoparticles, hydrophobic compounds like curcumin can have enhanced bioavailability.[25] Several novel strategies have been developed to design curcumin nanoparticles as targeted drug-delivery systems, and these have been studied in various disease states, including cancer.[8]

Tulsi, referred to as "The Incomparable One," "Mother Medicine of Nature," and "The Queen of Herbs" in Ayurveda, is highly regarded as a "elixir of life" that is unmatched in its therapeutic and spiritual qualities.[26]According to these studies, tulsi possesses a special combination of properties, such as antimicrobial (including antibacterial, antiviral, and antifungal properties), antiprotozoal, antimalarial, anthelmintic), mosquito-repellent, anti-diarrheal, anti-oxidant, anti-cataract, anti-inflammatory, chemopreventive, radioprotective, hepato-protective, neuro-protective, cardio-protective, anti-diabetic, anti-hypercholesterolemia, anti-hypertensive, anti-carcinogenic, analgesic, antipyretic, anti-allergic, immunomodulatory, central nervous system depressant, anti-thyroid, anti-fertility, anti-ulcer, anti-emetic, anti-spasmodic, anti-arthritic, adaptogenic, anti-stress, anti-cataract, anti-leukodermal, and anticoagulant properties. [27-30] Tulsi also lessens DNA damage and causes precancerous and cancerous cells to undergo apoptosis, which helps to prevent malignancies brought on by hazardous substances. promoting survival and slowing the growth of experimental malignancies.[31,32] Contemporary scientific investigations on tulsi attest to the wisdom of the plant's numerous psychological and physiological advantages. intrinsic to AYUSH system of medicine , which honortulsi as a plant that can be consumed, worshipped, turned into tea, and used in daily life for both medical and spiritual purposes. With the objective to determine how well aloe vera and tulsi will they react to oral submucous fibrosis, Radha P. Dalai conducted a study , and found differences in the mouth opening and lessening of the burning sensation on the visual analog scale (VAS) were statistically analyzed.[33]

Nisha Singh conducted a study to compare the efficacy of Aloe vera with antioxidant when given along with physiotherapy in the management of OSMF and found significant Improvement in all the parameters was seen with the individuals receiving Aloe vera gel in comparison to antioxidants.[34]. When combined with appropriate habit limitation, aloe vera, a calming, easy-to-use, and safe kind of treatment, can be thought of as an effective regimen in the management of OSMF. Traditionally, neem leaves, blossoms, seeds, fruits, roots, and bark have all been used to cure fever, infections, inflammation, skin conditions, and dental issues. The therapeutic benefits of neem leaf in particular have been documented. Immunomodulatory, anti-inflammatory, antihyperglycemic, antiulcer, antimalarial, antifungal, antibacterial, antiviral, antioxidant, antimutagenic, and anticarcinogenic qualities have all been shown for neem leaf and its compounds.[35] After neem's anticancer qualities were assessed, it was shown that the plant's active ingredients have clear preventive and therapeutic potential against oral cancer.[36] Furthermore, research led by Shashank M. Patil revealed that neem functions as a natural contraceptive.[37] As of now, more than 400 substances have been identified from various neem components. These include significant bioactive secondary metabolites like gedunin, azadirachtin, nimbidin, nimbin, and nimbolide.[38] Nimbolide exhibited effectiveness

against H. pylori, with minimum inhibitory concentrations (MICs) and minimum bactericidal concentrations (MBCs) ranging from 1.25-5 µg/mL and 2.5-10 µg/mL, respectively, across the nine tested strains. Furthermore, both neem oil extract and nimbolide demonstrated efficacy against H. pylori biofilms.[39,40]

CONCLUSION

traditional herbal medicine offers a rich repository of therapeutic compounds with diverse pharmacological activities, making them valuable assets in addressing contemporary healthcare challenges. Further research and development efforts are warranted to harness the full potential of herbal compounds for improving patient outcomes and advancing medical treatments.

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Table:1

sl.no	Diseases in OMFS	Modern Medicine	Herbal Medicine	PROPERTY	Part Used
1.	Leukoplakia	Lycopene-betacarotine	Ginger	Antiulcerogenic, Anticarcinogenic	Root
			Turmeric		Root pulp
			Garlic		
2.	Submucous Fibrosis	Lycopene-betacarotine	Tulasi	Antiulcerogenic, Anticarcinogenic	Leaf
			Turmeric		Root tuber
5.	Candidiasis	Ointment clotrimazole	Turmeric	Antifungal	Root tuber
			Aleovera		Leaf
			Garlic		
6.	Halitosis	Oral prophylaxis	Clove	Anti-Halitosis	Leaf
		Chlorhexidine mouthwash	Cardamom		Flower
					Fruit
7.	Dental Pain	Aceclofenac, Ibuprofen, Paracetamol	Chukku		Root
			Clove		Flower
			Boswelliya serrate		Resin
			Cinnamon verum		Bark
			Alpina galangal		Root
8.	Sialolithiasis	Scopolamine/Extra corporal lithotripsy	Pedalium murex	Lithiasis	Full Plant
9.	Oral squamous cell carcinoma	Surgery/Chemotherapy	Neem	Antiulcerogenic, Anticarcinogenic	Leaf

RESEARCH ARTICLE

Statistical Analysis and Characterisation of Diabetes Mellitus Data

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ABSTRACT

Diabetes is a standout amongst the most well-known non-transmittable diseases in the world. It is assessed to be the seventh leading cause for death. It is predicted that the diabetes rate in adults worldwide will become 642 million in 2040. Diabetes and obesity are associated with non-modifiable and modifiable risk factors. Non-alcoholic fatty liver disease (NAFLD) and type 2 diabetes (T2DM) are common conditions that regularly co-exist and can act synergistically to drive adverse outcomes. The presence of both NASH and T2DM increases the likelihood of the development of complications of diabetes as well as augmenting the risk of more severe NASH, including cirrhosis, hepatocellular carcinoma and death. Also cardiovascular disease is the most prevalent and detrimental complication of diabetes mellitus. Type 2 diabetes (T2D) is the result of interaction between environmental factors and a strong hereditary component. In this paper, summarised and critically evaluated the available data, with the aim of helping to inform the reader as to the most pertinent issues when managing patients with co-existent NASH, CVD, HEREDITY and T2DM and fit appropriate statistical distribution to the collected real data.

Keywords: Type 2 DM, NASH, CVD, Heredity, NAFLD, and Pascal Distribution.

INTRODUCTION

Type 2 diabetes (T2DM) is a complex metabolic disorder that has become a major public health problem worldwide in the past three decades. About one in 11 adults worldwide now have diabetes mellitus, of which 90% have T2DM. T2DM can cause injury not only to the pancreas and insulin system but also the liver, cardiac, kidneys, gut, muscle, fat cells and even the brain. Diabetes can affect many different organ systems in the body and, over time, can lead to serious complications, such as non-alcoholic fatty liver disease. The correlation between NASH and type 2 diabetes mellitus (T2DM) is complicated and bidirectional. NASH increases the risk of incident diabetes and is common in T2DM patients. Insulin resistance and type 2 diabetes mellitus are generally accompanied by low HDL cholesterol and high plasma triglycerides, which are major cardiovascular risk factors. This review describes abnormalities in HDL metabolism and reverse cholesterol transport, i.e. the transport of cholesterol from peripheral cells back to the liver for metabolism and biliary excretion, in insulin resistance and type 2 diabetes mellitus. Cardiovascular disease remains the leading cause of death in women. Both obesity and diabetes mellitus are important independent risk factors for the development of cardiovascular disease. Obesity is the leading risk factor for type 2 diabetes. Central obesity as well as obesity in general is associated with physiological changes that may cause the development of diseases like high blood pressure, heart disease, high blood cholesterol and type 2diabetes. Cholesterol is a waxy substance that's made by the body and found in some animal-based foods. Blood cholesterol levels describe a group of fats also known as lipoproteins (lipids) which include HDL-C, "good" cholesterol and LDL-C or "bad "cholesterol. Cholesterol is important to overall health, but when LDL-C levels are too high, it can contribute to narrowed or blocked arteries. Unfortunately, people with diabetes are more prone to having high cholesterol, which contributes to cardiovascular disease (CVD).In individuals who have diabetes, there are higher incidences of liver function test abnormalities than individuals who do not have diabetes. The most common liver function tests (LFTs) include the Serum Glutamic Pyruvate Transaminase (SGPT) activity, to measure the concentration of intracellular hepatic enzyme that has leaked into the blood and serves as a marker of hepatocytic injury. In this study we analyse the risk factors which affects type 2 diabetes mellitus and developing a predictive model with the aim to identify important risk factors for the development of NAFLD in patients with T2DM and try to fit appropriate statistical distributions to the collected real data.

REVIEW OF RELATED LITERATURE

AlaAmourah et al.,(2022) conducted study on Exploiting the Pascal Distribution Series and Gegenbauer Polynomials to Construct and Study a New Subclass of Analytic Bi-Univalent Functions to construct a new subclass of analytic bi-univalent functions defined on symmetric domain by means of the Pascal distribution series and Gegenbauer polynomials. Annabel Acs et al., (2018) studied Prevalence of cardiovascular disease in type 2 diabetes: a systematic literature review of scientific evidence from across the world in 2007–2017 and concluded that globally, overall CVD affects approximately 32.2% of all persons with T2DM. CVD was a major cause of mortality among people with T2DM, accounting for approximately half of all deaths over the study period. Coronary artery disease and stroke were the major contributors. Abraham TM et al., (2015) conducted a study on Trends in diabetes incidence: the Framingham Heart Study and established the result as the risk of new-onset diabetes continued to be higher in the 2000s compared with the 1970s. In the past decade, diabetes incidence remained steady despite the on-going trend of rising adiposity. Sarwar N et al ., (2010) explained in the study Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies as Diabetes confers about a two-fold excess risk for a wide range of vascular diseases, independently from other conventional risk factors. In people without diabetes, fasting blood glucose concentration is modestly and non-linearly associated with risk of vascular disease. Fox CS, et al., (2008) proposed a study on Lifetime risk of cardiovascular disease among individuals with and without diabetes stratified by obesity status in the Framingham heart study and explained as the lifetime risk of CVD among individuals with diabetes is high, and this relationship is further accentuated with increasing adiposity. Van Hateren KJ et al., (2009) conducted a study on The lipid profile and mortality risk in elderly type 2 diabetic patients and stated as the lipid profile was not predictive in the overall group of elderly patients,

higher lipids were related to increased cardiovascular mortality in patients with diabetes of long duration. Muhammad AmmaarAslam et al., (2 019) proposed a study on prevalence of cardiovascular disease in type 2 diabetes- systematic literature review and concluded that CVD is one of the major cause of death in T2DM with coronary artery disease having the high prevalence. MarsoSPet al., (2016) studied Liraglutide and cardiovas- cular outcomes in type 2 diabetes and concluded that the rate of the first occurrence of death from cardiovascular causes, nonfatal myocardial infarction, or nonfatal stroke among patients with type 2 diabetes mellitus was lower with liraglutide than with placebo. Mills EPet al.,(2018) examined in the study Treating nonalcoholic fatty liver disease in patients with type 2 diabetes mellitus and reviewed that all reviewed treatment options are safe for management of NAFLD in patients with T2DM but long-term histological improvements are minimal. TZDs are efficacious for resolution of NASH and improvements in fibrosis but long-term use is required to maintain the results. Alessandro Mantovaniet.al., (2018) [16] studied "Non-Alcoholic Fatty Liver Disease and Risk of Incident Type 2 Diabetes: A Meta-analysis" and found that NAFLD is significantly associated with a twofold increased risk of incident diabetes. However, the observational design of the eligible studies does not allow for proving causality. Bhatt KN et.al., (2017) [17] conducted study 0n "Prevalence of Nonalcoholic Fatty Liver Disease in Type 2 Diabetes Mellitus and its Relation with Insulin Resistance in South Gujarat Region." The study revealed a high incidence of NAFLD in Type 2 diabetes patients stressing the need for early screening. Carrie R. Wong, et. Al., (2018) [18] conducted study on "The Association between Non-alcoholic Fatty Liver Disease and Cardiovascular Disease Outcomes" and concluded that the causal relationship of CVD and NAFLD remains under investigation, but the strong bidirectional association between CVD and NAFLD warrants clinical intervention in patients with NAFLD to modify metabolic risk factors, including T2DM, dyslipidemia, hypertension, and obesity. Claudio Tana et.al., (2019) [19] conducted study on "Cardiovascular Risk in Non-Alcoholic Fatty Liver Disease: Mechanisms and Therapeutic Implications" to conclude that all cardio-metabolic risk factors should be carefully and routinely screened among patients with NAFLD, and that disease management should be focused on both specific lifestyle modifications and aggressive risk factors modification, which would not only reduce the risk of liver disease progression, but may also provide benefits by reducing the risk of developing cardiac complications. Dharmalingam M, Yamasandhi P G (2018) [20] conducted a study on "Alcoholic Fatty Liver Disease and Type 2 Diabetes Mellitus" and concluded that T2DM and NAFLD have a common association. The increasing prevalence makes it a public health problem.

Targher G et. al., (2007) [21] conducted study on "Non-alcoholic Fatty Liver Disease is Independently Associated with an Increased Incidence of Cardiovascular Events in Type 2 Diabetic Patients." The findings suggest that NAFLD is associated with an increased incidence of CVD in type 2 diabetic patients, independent of traditional CVD risk factors and metabolic syndrome components. Dyson JK, et.al., (2014) [22] studied "Non-alcoholic Fatty Liver Disease: A Practical Approach to Treatment" concluded that lifestyle interventions aimed at weight loss and increased activity are essential for all patients with NAFLD and if sustained are effective in the treatment of NAFLD. Hagstromet.al., (2019) [23] studied "Cardiovascular Risk Factors in Non-alcoholic Fatty Liver Disease." The study concluded that patients with NAFLD are at an increased risk for CVD compared to matched controls, but histological parameters do not seem to independently predict this risk. Carrie et.al.,(2018) conducted a study on "The Association between Non-alcoholic Fatty Liver Disease and Cardiovascular Disease Outcomes and found that the causal relationship of CVD and NAFLD remains under investigation, but the strong bidirectional association between CVD and NAFLD warrants clinical intervention in patients with NAFLD to modify metabolic risk factors, including T2DM, dyslipidemia, hypertension, and obesity. Jonathan M. Hazlehurst, et.al., (2016) studied "Non-alcoholic Fatty Liver Disease and Diabetes and concluded Turkish Journal of Physiotherapy and Rehabilitation; that diabetes and NAFLD are reciprocal risk factors and when they occur together, an increasing body of data demonstrates that diabetes is more difficult to manage and that NAFLD is more likely to progress. Mathews et.al.,(2018) conducted a study on "Non-alcoholic Steatohepatitis, Obesity, and Cardiac Dysfunction." It summarises obesity as a major factor in the development of Nonalcoholic Fatty Liver Disease (NAFLD) and its progression to steatohepatitis. Patients with NAFLD have a significant increase in cardiovascular disease risk. For biopsy-proven NASH, Vitamin E and Pioglitazone are the recommended medical treatments in addition to lifestyle modification. NasrinAmiriet.al., (2017) conducted the study, "Type 2 Diabetes Mellitus and Non-Alcoholic Fatty Liver Disease: A Systematic Review and Meta-analysis." The findings indicated that the overall prevalence of NAFLD among type 2

diabetes mellitus patients is significantly higher. It can be concluded that type 2 diabetes mellitus patients should be managed to prevent NAFLD. Prasanth et.al., (2017) conducted a study on "Prevalence of NAFLD in Patients with Type 2 Diabetes Mellitus" and concluded that prevalence of NAFLD and NASH in our cohort of type 2 DM patients is high and increases with multiple components of metabolic syndrome. NASH and advanced fibrosis can occur in diabetic patients without any symptoms, signs or routine laboratory test abnormalities. Rashmee and Gagan (2017) studied "Non-alcoholic Fatty Liver Disease and Cardiovascular Risk and concluded that Non-alcoholic Fatty Liver Disease (NAFLD) is often associated with insulin resistance and is strongly associated with type 2 diabetes mellitus and obesity. NAFLD is now recognized as a risk factor for poor cardiovascular outcomes including mortality and morbidity from major vascular events. As a whole, NAFLD patients may benefit from more careful surveillance and early treatment interventions Shunquan Wu et.al., (2016) conducted a study "Association of Non-alcoholic Fatty Liver Disease with Major Adverse Cardiovascular Events: A Systematic Review and Meta-analysis." The main results of meta-analysis were NAFLD was not associated with overall mortality and CVD mortality. NAFLD was associated with an increased prevalence and/or incidence of other adverse cardiovascular events, including CVD, CAD, hypertension, and atherosclerosis; (3) NASH was not associated with overall mortality and CVD mortality but was associated with an increased incidence of CVD. Targher, et.al., (2005) conducted study on "Nonalcoholic Fatty Liver Disease and Risk of Future Cardiovascular Events Among Type 2 Diabetic Patients" and suggested that the metabolic syndrome predicts incidents of cardiovascular disease (CVD), so it is possible to hypothesize that NAFLD patients might portend a greater CVD risk and that NAFLD itself might confer a CVD risk above that associated with individual metabolic syndrome risk factors. Wenjie Dai et.al.,(2017) studied "Prevalence of Nonalcoholic Fatty Liver Disease in Patients with Type2 Diabetes Mellitus" and concluded that the high pooled prevalence of NAFLD in T2DM patients found in this study significantly underscores the need for early assessment of NAFLD and the importance of strengthening the management of NAFLD in T2DMpatients.

METHODOLOGY AND DATA ANALYSIS

The proposed study aims to summarize the evidence of the association with NASH and CVD with risk factors such as age, height, weight, waist circumference, blood sugar, cholesterol level, sgot, sgpt, TG, heredity, bmi, systolic pressure, diastolic pressure in childbearing diabetic women. 603 subjects were randomly selected from various hospitals in the two districts, Palakkad and Malappuram - at Kerala to make a real data analysis. Baseline information for this study was obtained via a questionnaire on general information, physical examination (height, weight, and blood pressure), laboratory tests (triglycerides, total cholesterol, blood glucose, aspartate aminotransferase (AST) or serum glutamic-oxaloacetic transaminase (SGOT) and alanine aminotransferase (ALT) or Serum glutamic pyruvic transaminase (SGPT)), Body mass index (BMI) and waist circumference (WC). Prevalence of T2DM patients is high and increases with multiple components of metabolic syndrome (Metabolic syndrome is a cluster of conditions that occurs together, increasing risk of heart disease, stroke and type2 diabetes. These conditions include increased blood pressure, high blood sugar, excess body fat around the waist, and abnormal cholesterol or triglyceride levels).

RESIDUAL STATISTICS
The residual is the vertical distance (or deviation) from the observation to the predicted regression line. Predicted values are points that fall on the predicted line for a given point on the x-axis.
The summary statistics of these variables are given in table.

ASSOCIATION OF BLOOD SUGAR, BMI AND WAIST CIRCUMFERENCE
Body mass index has a strong relationship to diabetes and insulin resistance. Overweight and obesity are defined by an excess accumulation of adipose tissue to an extent that impairs both physical and psychosocial health and well-being. The influence of obesity on type 2 diabetes risk is determined not only by the degree of obesity but also by where fat accumulates. Increased upper body fat including visceral adiposity, as reflected in increased abdominal girth or waist-to-hip ratio, is associated with the metabolic syndrome, type 2 diabetes, and cardiovascular disease.

Excess body weight has a well-established link with decreased insulin sensitivity which in turn is a correlate of cardiovascular risk factors and a defining characteristic of type 2 diabetes. An excessive BMI and visceral obesity are the most common and well-documented risk factors for NAFLD, also contributing to metabolic syndrome and other complications. In diabetes, individuals with excessive fat storage have been noted to have higher insulin levels and are said to have insulin resistance, which is described as the cause of T2DM. The entire spectrum of obesity, ranging from overweight to obese and severely obese, is associated with NAFLD. The correlations among the variables were positive; blood sugar and BMI have medium correlation. ANOVA indicates the model is also good for the data since $p < 0.05$. The graph of each data set shows that there is linear relationship. Linear Regression Model: 1
Blood sugar (PP) = 7.968517 bmi-0.7330wc+ constant

ASSOCIATION OF BLOOD SUGAR, SYSTOLIC AND DIASTOLIC PRESSURE
Hypertension and type 2diabetes are common comorbidities. Hypertension is twice as frequent in patients with diabetes compared with those who do not have diabetes. Moreover, patients with hypertension often exhibit insulin resistance and are at greater risk of diabetes developing than are normotensive individuals. The major cause of morbidity and mortality in diabetes is cardiovascular disease, which is exacerbated by hypertension. Accordingly, diabetes and hypertension are closely interlinked because of similar risk factors, such as endothelial dysfunction, vascular inflammation, arterial remodelling, atherosclerosis, dyslipidemia, and obesity. There is also substantial overlap in the cardiovascular complications of diabetes and hypertension related primarily to microvascular and macro vascular disease. Diabetes is associated with both macrovascular (involving large arteries such as conduit vessels) and microvascular (involving small arteries and capillaries) disease. Hypertension is an important risk factor for diabetes-associated vascular complications, because hypertension itself is characterized by vascular dysfunction and injury. Figure 2: Vascular processes whereby diabetes and hypertension predispose to cardiovascular disease. Common risk factors promote diabetes and hypertension, which are associated with atherosclerosis, vascular inflammation, endothelial dysfunction, and structural remodelling, which lead to macrovascular and microvascular disease. Vascular damage and endothelial dysfunction is amplified when diabetes and hypertension coexist. In this study also the correlation between blood sugar, systolic and diastolic pressure is positive and the linear regression model is Blood sugar (pp) = 0.099405 SP+1.037123 DP+ constant

ASSOCIATION BETWEEN BLOOD SUGAR, NASH AND CVD
Non-alcoholic fatty liver disease (NAFLD) and type 2 diabetes mellitus are common conditions that regularly co-exist and can act synergistically to drive adverse outcomes. There are many ways to image NAFLD and NASH, including abdominal ultrasound, CT scan, and magnetic resonance imaging (MRI) or MR spectroscopy. More recently, elastography performed with ultrasound or MR has gained traction in diagnosing different stages of NAFLD and NASH. Cardiovascular disease is the most prevalent and detrimental complication of diabetes mellitus. The incidence of cardiovascular mortality in diabetic subjects without a clinical history of previous cardiac events is as high as the incidence in nondiabetic subjects with a history of myocardial infarction. This inordinate increase in the risk of coronary events in diabetic patients is attributed to multiple factors, including glycation and oxidation of proteins and increased prevalence of classic risk factors of coronary disease, such as hypertension, obesity, and dyslipidemia.Chronic hyperglycemia leads to many long-term complications in the eyes, kidneys, nerves, heart, and blood vessels. Individuals with pre-diabetes, undiagnosed type 2 diabetes, and long-lasting type 2 diabetes are at high risk of all complications of macrovascular disease, coronary heart disease (CHD), stroke, and peripheral vascular disease. More than 70% of patients with type 2 diabetes die of cardiovascular causes. Therefore, the epidemic of type 2 diabetes will be followed by an epidemic of diabetes-related cardiovascular disease (CVD). Out of 603 children bearing diabetic women 373 (62%) had fatty liver or more risk for NASH. Majority of person's level of SGPT and SGOT are in normal range. Only countable number of persons was in the above risk level. While considering the cholesterol and triglyceride level of fatty liver diabetic patients nearly 50% persons higher cholesterol level. Graph of cholesterol level of fatty liver Diabetic patients is given below.

ASSOCIATION BETWEEN HEREDITY AND BLOOD SUGAR

Type 2 diabetes (T2D) is the result of interaction between environmental factors and a strong hereditary component. Hereditary factors clearly play a role in the development of diabetes; the actual genetic variants involved in this inherited risk were completely unknown prior to the advent of modern genetic technologies. The study reveals that the risk of developing type 2 DM increases with the   number of affected family members through parents or through influence of genetic factors. There is 62% of child bearing diabetic women have influenced by hereditary factors while the remaining were not influenced.

1. Dependent Variable: BLOODSUGAR(PP)
2. Predictors: (Constant), BMI
3. Predictors: (Constant), BMI, DIASTOLIC PRESSURE
4. Predictors: (Constant), BMI, DIASTOLIC PRESSURE, TG
5. Predictors: (Constant), BMI, DIASTOLIC PRESSURE, TG, CHOLESTROL
6. Predictors:(Constant),BMI,DIASTOLICPRESSURE,TG,CHOLESTROL,AGE

The model is perfectly significant for the predictor variables BMI, Diastolic pressure, TG, Cholestrol, and Age corresponding to the dependent variable Blood sugar(PP).

FITTING BEST PROBABILITY DISTRIBUTIONS TO THE DATA

In statistics and probability, distributions of random variables play a basic role and are used extensively to describe and model a lot of real life phenomena; they describe the distribution of the probabilities over the random variable values Some distributions are used in practice and have been given special names to clarify the importance of these distributions and the random experiments behind them. Appropriate distributions were derived using statistical tools; the collected data were fitted to four distributions named as Pascal Distribution, Poisson Distributions for two different means, discrete uniform Distribution. Using goodness of fit, Pascal Distribution is the best fitted distribution for the collected data. Comparison of fitted distributions were given below From the table it is clear that the p value is highest for Pascal Distribution. From the distributions considered, the best fitted distribution for the collected data is Pascal Distribution.

CDF OF PASCAL DISTRIBUTION FOR THE COLLECTED DATA

The best fitted distribution follows the Pascal Distribution. So CDF is also drawn for the best fitted distribution for the collected data.

CONCLUSION

The study supports the finding that diabetes development and obesity were positively and significantly associated. When it comes to type 2 diabetes mellitus patients who are childbearing, BMI and WC are more strongly linked to diabetes than other risk factors. The degree of connection with diabetes risk was drastically raised when BMI and WC were used. This shows that when determining the risk for diabetes, waist circumference should also be examined in addition to BMI. Therefore, preventing central obesity and being overweight at the same time has significant public health consequences for the prevention of diabetes. Also, it might be advisable to maintain blood pressure between 130-139/80-85 mm Hg, supported by other therapeutic and lifestyle interventions to improve cardiovascular outcomes in patients with diabetes. Patients with T2DM and NASH should be considered at high risk of CVD and could benefit from more intensive CV prevention. Additional long-term follow-up is needed to demonstrate that the treatment of NASH effectively reduces the risk of CVD. Type 2diabetes has a stronger link to family history and genetics play a very strong role in the development of type 2 diabetes. Here 62% of childbearing diabetic women have been influenced by hereditary factors. In fitting a distribution to a collected set of biological data, say, it is also important for the mathematical model underlying the theoretical distribution to have a reasonable biological meaning. The fitted Pascal Distribution offers interesting possibilities in this direction. This study is an exposure to medical science to predict different aspects of blood sugar in relation to its components.

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Table: 1 Residuals Statistics[a]

Minimum		Maximum	Mean	Std. Deviation	N
Predicted Value	155.66	272.96	211.64	20.250	543
Residual	-76.149	95.823	.124	35.167	543
Std. Predicted Value	-2.885	3.090	-.034	1.032	543
Std. Residual	-2.144	2.698	.003	.990	543

a. Dependent Variable: BLOODSUGAR (PP)

Table 2: Summary Statistics

Clinical characteristics	Min/Max	Mean	Median	Mode	Skewness	Kurtosis
Age	20/48	30.8±5	31	28	0.163827	-0.40751
Height	140/176	157±7.3	155	152	0.456	-0.789
Weight	48/99	68.97±8.8	68	65	0.525	0.206
Blood sugar(pp)	122/312	209.9±39.6	203	210	0.505	-0.05
BMI	22.5/35.5	27.7±2.3	27.4	27.4	0.397	0.647
WC	27/44	37.13±3.1	37	35	-0.584	1.184
SGOT	11.4/48.6	18.95±5.09	18.4	18.6	1.34	3.35
SGPT	17/59	36.15±8.64	36.8	28.6	0.1007	-0.238
Cholesterol	115/321	217.29±42.5	214	265	0.1634	-0.466
TG	92/356	218.19±66.9	227.9	269	-0.1598	-0.7345
SP	110/160	130±15	130	120	0.393	-0.666
DP	70/100	84±8	85	90	-0.414	-0.814

Table: 3 Adult Body Mass Index (BMI)

BMI	Considered
Below 18.5	Underweight
18.5 to 24.9	Healthy weight
25.0 to 29.9	Overweight
30 or higher	Obesity
40 or higher	Class 3 Obesity

Table: 4 correlations between PP, WC, BMI

	BLOOD SUGAR(PP)	WAIST CIRCUMFERENCE	BMI
BLOODSUGAR(PP)	1		
WAIST CIRCUMFERENCE	0.100653	1	
BMI	0.551416	0.297895	1

Table: 5 Regression coefficients

	Coefficients
Intercept	3.941855
BMI	7.859242
WAIST CIRC	-0.73303

Table: 6 MODELLING ANOVA[a]

Model		Sum of Model Squares	df	Mean Square	F	Sig.
1	Regression	97837.689	1	97837.689	67.275	.000[b]
	Residual	775141.649	533	1454.300		

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	Total	872979.338	534			
2	Regression	147951.725	2	73975.862	54.281	.000^c
	Residual	725027.613	532	1362.834		
	Total	872979.338	534			
3	Regression	185942.793	3	61980.931	47.904	.000^d
	Residual	687036.545	531	1293.854		
	Total	872979.338	534			
4	Regression	198884.178	4	49721.044	39.093	.000^e
	Residual	674095.161	530	1271.878		
	Total	872979.338	534			
5	Regression	205780.634	5	41156.127	32.631	.000^f
	Residual	667198.705	529	1261.245		
	Total	872979.338	534			

Table 7: comparison of fitted distributions

Name of Distribution	Chi Square Statistic	P Value
Poisson distribution (207.788)	45.3088	0.58378
Poisson distribution (167.095)	50.0706	0.550116
Pascal Distribution	45.8394	0.998625
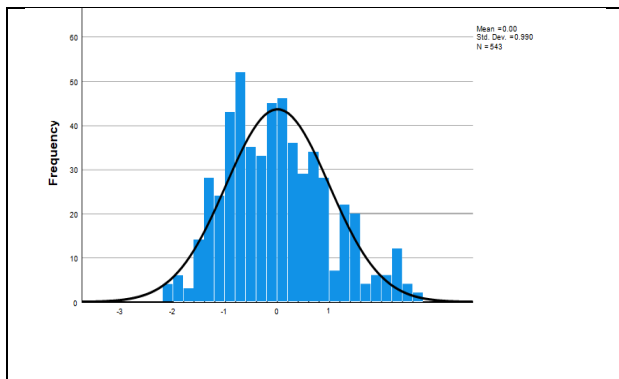
Figure: 1 Histogram - Dependent variable BLOOD SUGAR (PP)
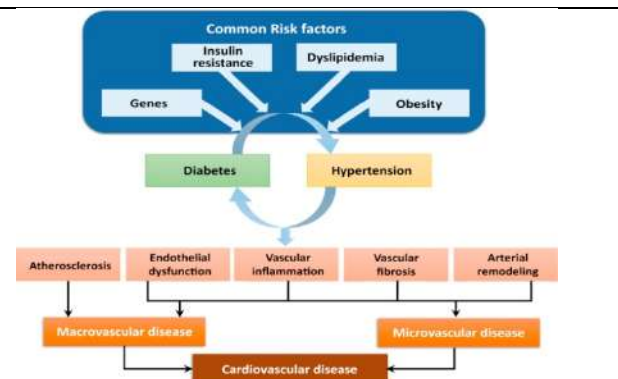
Figure 2: Common Risk factors of CVD
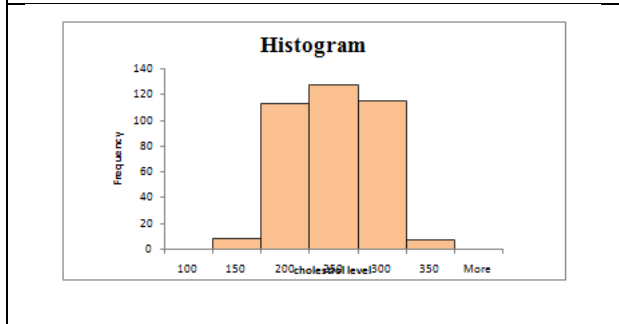
Figure: 3 Histogram of cholesterol level
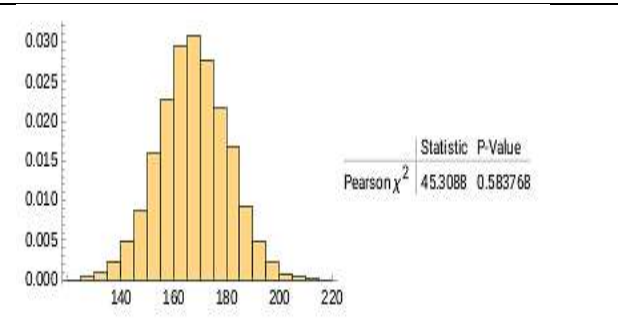
Figure 4: Fitted distribution of Poisson distribution (207.788)

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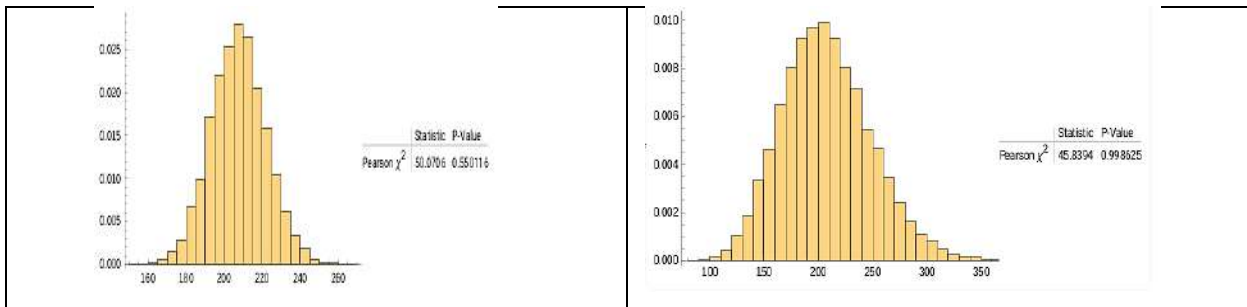
Figure 5:Poisson distribution (167.095)

Figure 6:Pascal Distribution
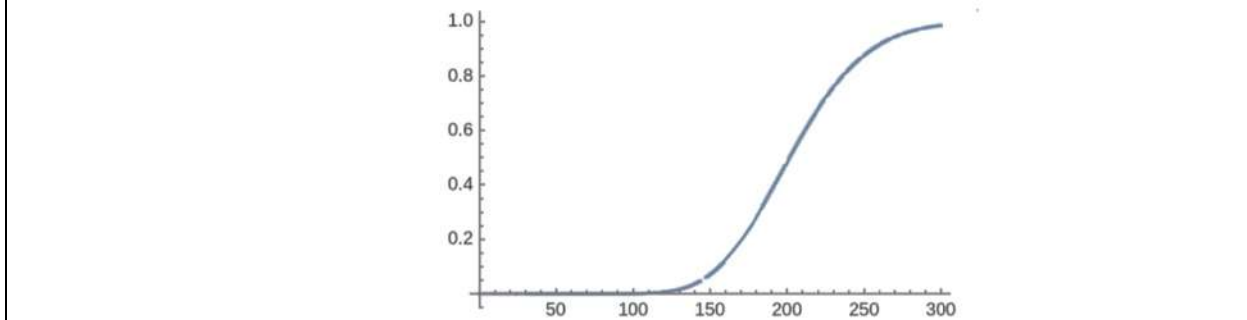
Figure 7:Pascal Distribution - CDF

RESEARCH ARTICLE

Standardisation of Biopriming Treatment of *Vigna unguiculata* to Improve Seed Germination Parameters

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ABSTRACT

Cowpeas (*Vigna unguiculata*), an important legume is a versatile crop, also commonly known as southern pea, black eye pea, crowder pea, lubia, niebe, coupe or Frijole. The establishment of this crop is poor due to poor germination. Seed priming technique helps to overcome this difficulty. There is only less research have been carried out to enhance seed germination in cowpea by seed biopriming technique. This research paper focuses on standardising seed biopriming technique in cowpea VBN 3 using *Trichodemaviridi*, Phospobacteria, Sea weed extract at three different concentrations viz., 10%, 20%, 30% and hydro priming all in 3 hrs and 6 hrs soaking conditions. The untreated seeds serve as control. The result from the present study revealed that the germination parameters viz., germination value, germination index, imbibition, co-efficient of variation of germination, seed length, root length, seedling length, vigour index were at its maximum for the seeds primed with *T.viridi* and sea weed extract concentration of 10 % whereas Phospobacteria at 20 %. Biopriming of seeds at lower concentration improves the seed germination thereby increasing the yield.

Keywords: *T.viridi* and sea weed extract concentration of 10 % whereas Phospobacteria at 20 %.

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INTRODUCTION

Seed germination is a critical parameter for the successful development of sustainable agricultural practices [1]. Germination and seedling establishment are critical stages in the plant life cycle. The ability of crop to germinate under stress affect the crop establishment. However, if the stress effect can be alleviated at the germination stage, chances for attaining a good crop establishment would be high [2] Seed biopriming is an emerging technique to enhance seed germination under stress conditions [3]. It is a controlled hydration process that involves exposing seeds to low water potentials that restrict germination, but permits pregerminative physiological and biochemical changes [4]. It is the method of soaking of seeds in a solution of any priming agent followed by drying of seeds that initiates germination related processes without radical emergence [5].[6] reported that, seed priming is an effective seed in vigouration method to increase the rate and uniformity of emergence and crop establishment. Biopriming, a sub-category of seed priming, involves inoculation of seed with beneficial microorganisms. biopriming enhances nutrient and water uptake, boosts seedling vigour as well as induces systemic resistance to biotic and abiotic stresses [7], [8].In this method the seeds are primed in a solution containing bio-control agents like *T.harzianum*, *T.viride*, *Pseudomonas flourescens* etc. It has biological and physiological (seed priming) aspects of disease control. Except improvement in germination percent, uniformity of emergence and decrease the time to emergence like other priming methods, it also controls disease in plant [9]. Cowpeas (*Vigna unguiculata*), an important legume is a versatile crop, also commonly known as southern pea, black eye pea, crowder pea, lubia, niebe, coupe or Frijole. Cowpea grain contains, on an average, 23–25 % protein and 50–67 % carbohydrate. As in case of most legumes, amino acid profile of cowpea complements cereal grains. Presence of significant amounts of protein, calories and some water-soluble vitamins, makes cowpea a promising food ingredient [10].The establishment of this crop is poor due to poor germination. This results in the low yield and reduces per capita availability of the crop.Seed priming technique helps to overcome this difficulty. There is only less research have been carried out to enhance seed germination in cowpea by seed biopriming technique. This research paper focuses on standardising seed biopriming technique in cowpea VBN 3 using *T. viridi*, Phospobacteria, Sea weed extract at three different concentrations viz., 10%, 20%, 30% and hydro priming all in 3 hrs and 6 hrs soaking conditions. The untreated seeds serve as control.

MATERIALS AND METHODS

The study was conducted using genetically pure seeds of cowpea cv. VBN 3 obtained from Krishi Vigyan Kendra, Sandhiyur, Tamilnadu. The experiment was conducted at the Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar (11°24 N latitude and 79°44 'E longitude with an altitude of +5.79 m above mean sea level) with four replications in a Factorial Completely Randomized Block Design (FCRD) in three sets. The bulk seeds were first dried to below 9% moisture content, cleaned, and then graded with suitable sieves. The concentrations of the priming agents as factor 1 and factor 2 being the duration of soaking hours. Their treatment details are given in Table 1. Seeds were treated with their respective solutions for a specified duration. Following treatment, the seeds were extracted from the solutions, rinsed with water two to three times, air-dried in shade until they regained their original moisture content, and evaluated for various seed quality parameters,such as germination index, root length, shoot length, dry weight, seedling length (cm) [11], mean germination rate and time[12], imbibition rate [13], water content, speed of germination, germination percentage, peak value [14], germination value [14], days to 50 % germination,germination percentage and vigor index were recorded with hydroprimed seeds and control in each set. Germination test was carried out using glassplate and petri-plate method (ISTA, 1985) and calculated as Germination (%) = No. of normal seedlings germinated × 100/ Total no. of seeds placed for germination. Speed of germination was calculated according to the equation of [15]: MGT = $\sum(n \times d) / N$, where n = number of seeds germinated on each day, d = number of days from the beginning of the test, and N = total number of seeds germinated at the termination of the experiment . Root length and shoot length test was carried out by glassplate method. Vigor Index was also calculated by [16] as Vigor index-I = Germination (%) × Seedling length (cm). Vigor index -II= Germination (%) × Seedling dry weight (g). Data from the experiment underwent analysis using the 'F' test for significance, as outlined by [17]. In cases where necessary, percentage values were converted to

angular (arc-sine) values before analysis. Critical differences (CD) were determined at a 5 percent probability level. Non-significant results from the 'F' test were denoted by the abbreviation NS.

RESULTS AND DISCUSSION

Significant differences were observed in all the seed and seedling quality parameters in Cowpea VBN 3 due to the priming agents and duration of priming. The interaction effect between priming treatments and durations was also significant for germination characters, seedling length, dry matter production and vigour index. Between the soaking durations of 3 and 6 hours, three hours of soaking recorded the maximum physiological and morphological parameters of seed and seedling quality parameters compared to control. In the present study the seeds of VBN3 were hydroprimed and bioprimed using *T.viridi* Phospobacteria and seaweed extract at three different concentrations viz., 10%, 20% and 30%   along with hydropriming. Among all the treatments values for all the germination parameters were higher in the seeds soaked for three hours than for six hours. Water content and imbibition rate was higher in the seeds primed with priming agents *T.viridi and seaweed extract* at 10 percentage and phospobacteria at 20 %. Germination begins with the rapid imbibition of water by quiescent dry seeds to activate metabolic processes[18]. In unprimed seeds water content and imbibition rate is zero. Seed germination and seedling growth are two critical phases of the plant life cycle [19].Seed priming methods influenced the seed germination process by increasing the speed and reliability of germination. Increased germination, uniformity of germination, and sometimes greater total germination rate are widely reported in the primed seeds[20]. Many treatments for pre-hydration or priming have been used to improve the seed germination rate and synchronization of seeds [21]. The present study showed that, compared with the control group, the rate of hydration increased dramatically after seed primed by reagents. This implies that seed priming may improve seed germination of seeds by speeding up imbibition, which could contribute to facilitate emergence phage of seed after raining [22]. Similar results were also reported that priming improved germination of sunflower cultivars by accelerating imbibitions[23].The main effect of seed priming on germination and primary seedling establishment indicated by increased germination and other related indicators like mean germination time and vigor, root and shoot length, germination rate [24].

The seeds primed using biopriming agents *T.viridi*and seaweed extractat 10 percentage and phospobacteria at 20 % for 3 hours had nearly 90 percent germination which is the maximum than any other treatments. Hydroprimed seeds had 80 % germination and in control 75 percentage germination was achieved. [24]revealed that seed germination and seed quality of chickpea improved when seeds primed with *Tviridae*.[25] stated that the increment in germination percent ranged from 32.40 to 60.70 per cent in barnyard millet when seeds are treated with bioagent (Trichodermspp). Germination per cent ranged from 50 to 92 per cent in pearl millet was reported by[26] whereas[27] reported 79.15 percent germination in paddy seeds when seeds are treated with bio agents. All other germination parameters viz., peak value, germination value,time to 50 percent germination was higher for the seeds primed with bio priming agents *T.viridi*and seaweed extractat 10 percentage and phospobacteria at 20 % for 3 hours than all the other treatments. The stimulatory effect of seaweed extracts on seed germination has been widely recognized [28]; [29]. Seaweed extracts are predominantly high in phytohormones, which tend to play a major role in seed germination [30],[31]. Seaweed extracts enhanced plant growth attributes at low concentrations. The *germination index* (GI) [32] is defined as a weighted sum of the daily numbers of germinated seeds. Higher GI value denotes a higher percentage and a higher rate of germination. In the present study Germination index was higher for the seeds primed with bio priming agents *T.viridi* and seaweed extractat 10 percentage and phospobacteria at 20 % for 3 hours. The *coefficient of velocity of germination* (CVG) [33] gives an indication of the rapidity of germination. Its value increases when the number of germinated seeds increases and the time required for germination decreases. The seeds had maximum shoot length of 16.6 cm, root length of 12.2 cm, seedling length 28.8 cm, germination index 6.75 when primed with *T. viridi* at 10 % for three hours. The seeds primed with phospobacteria at 20 % for three hours had maximum shoot length of 16.8 cm, root length of 11.95 cm, seedling length 28.75 cm, germination index 6.15. The seeds primed with seaweed extract at 10 % for three hours had maximum shoot length of 16.4 cm, root length of 14.2 cm, seedling length 30.55 cm, germination index 6.04. The increase in shoot length with primed seeds might be due to

the fact that, priming induced nuclear replication in root tips of seeds [34] in bell pepper. The higher seedling length in bioprimed seeds might be attributed to enlarged embryos, higher rate of metabolic activities and respiration, better utilization and mobilization of metabolites to growing points and higher activity of enzymes. The unprimed seeds have the least values for the above germination parameters. Seed Vigor testing measures the percentage of viable seed in a sample and also reflects the ability of those seeds to produce normal seedlings optimum or adverse growing conditions. Priming often induces physiological and biochemical seed modifications during seed treatments[35] and increased amylase production enhances metabolic tasks, resulting in higher seed vigor[36]. Seed viability is the ability of the seed to germinate under optimal conditions, whereas vigour is its ability to emerge uniformly even under adverse environmental conditions in the field. These terms are often used interchangeably and incorrectly. In the current study the seeds primed with *T.viridi* and seaweed extract at 10 %, phospo bacteria at 20% had maximum seed vigour. Seed vigor is reflected by the rapid and uniform emergence of seedlings, field establishment, and plant performance [37],[38]. High seed vigor enhances the ability to obtain optimal plant densities and high crop yields [39]. In *Cucumis sativis* seed bio-priming agents *T.harzianum* (NBAII -THlO) and *P. fluorescens* enhanced the efficiency of biocontrol agents and increased the PGPR activity of beneficial microorganisms [40].Seeds primed with *T. viride* and *P. fluorescens* significantly improved seedling emergence of 96 and 98% respectively in chickpea [16]. From the above study it can be concluded that biopriming of seeds at lower concentration improves the seed germination thereby increasing the yield rather than by hydropriming.

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Table: 1. Priming agents, their concentrations, and duration of priming in Cowpea cv. VBN 3.

Priming agent			Concentration (%) (Factor 1)	Duration of soaking (h) (Factor 2)
Set 1	Hydropriming	Hydro	-	3 and 6
	T.viridi	Tv$_1$	10%	
		Tv$_2$	20%	
		Tv$_3$	30%	
Control	-	-	-	
Set 2	Hydropriming	Hydro	-	3 and 6
	Phospobacteria	Pb$_1$	10%	
		Pb$_2$	20%	
		Pb$_3$	30%	
Control		-	-	
Set 3	Hydropriming	Hydro	-	3 and 6
	Seaweed extract	Sw$_1$	10%	
		Sw$_2$	20%	
		Sw$_3$	30%	
Control	-	-	-	

Table 2. Standardization of bio priming using *T.viridi*on water content Imbibition Rate, , Germination (%) and Mean germination time and mean germination rateof *Vigna ungiculata*

Priming agent	Water content	Imbition Rate	Germination %	Mean Germination Time	Mean Germination Rate
	Soaking duration in h (d)	Soaking duration in h (d)	Soaking hrs	Soaking hrs	Soaking hrs

	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean
Hydro	12.8	12.68	12.74	1.138	1.099	1.12	80	79	80	4.1	4.05	4.08	0.21	0.215	0.213
TV 10%	**15.19**	**13.68**	**14.44**	**1.32**	**1.21**	**1.27**	**90**	**87**	**89**	**4.76**	**4.36**	**4.56**	**0.289**	**0.231**	**0.26**
TV 20%	12.76	13.5	13.13	1.018	0.854	0.94	83	85	84	4.18	4.1	4.14	0.253	0.244	0.248
TV 30%	13.47	12.96	13.22	1.065	0.982	1.02	86	80	83	4.48	4.22	4.35	0.226	0.232	0.229
C	0	0	0	0	0	0	75	75	75	3.78	3.78	3.78	0.19	0.19	0.19
Mean	10.84	10.56	10.7	0.91	0.83	0.87	83	81	82	4.26	4.1	4.18	0.234	0.222	0.228
	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T
Sem	0.0868	0.137	0.194	0.005	0.009	0.013	0.486	0.769	1.088	0.0257	0.04	0.057	0.001	0.002	0.003
Sed	0.12	0.19	0.269	0.008	0.013	0.018	0.688	1.087	1.538	0.036	0.057	0.081	0.002	0.003	0.004
Cd (P = 0.05)	0.258	0.408	0.577	0.017	0.028	0.039	1.445	2.285	3.232	0.076	0.121	0.171	0.004	0.006	0.009

Table 3. Standardization of bio priming using *T. viridi*on mean daily germination, peak value, cv, CVG and Germination indexof *Vigna ungiculata*

Priming agent	Mean Daily Germination %			Peak Value			(CV$_t$)			(CVG)			Germination Index		
	Soaking hrs			Soaking hrs			Soaking hrs			Soaking hrs			Soaking hrs		
	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean
Hydro	10.1	10.17	10.13	12.1	12.21	12.16	34.17	32.12	33.15	22.14	21.03	21.59	5.25	5.32	5.29
TV 10%	**11.72**	**10.24**	**10.98**	**14.95**	**13.08**	**14.01**	**40.46**	**36.86**	**38.66**	**25.85**	**23.07**	**24.46**	**6.75**	**5.76**	**6.26**
TV 20%	10.33	10.54	10.44	13.23	13.45	13.34	36.12	37.45	36.79	24.28	24.39	24.33	5.98	6.04	6.01
TV 30%	10.5	10.67	10.58	12.65	12.78	12.72	35.49	35.95	35.72	22.58	23.2	22.89	5.43	5.68	5.56
C	9.33	9.33	9.33	9.2	9.2	9.2	29.85	29.85	29.85	20.12	20.12	20.12	4.05	4.05	4.05
Mean	10.4	10.19	10.29	12.43	12.14	12.28	35.22	34.45	34.83	22.99	22.36	22.68	5.49	5.37	5.43
	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T
Sem	0.061	0.097	0.137	0.078	0.123	0.174	0.213	0.337	0.477	0.138	0.219	0.31	0.037	0.059	0.084
Sed	0.087	0.137	0.195	0.11	0.174	0.247	0.302	0.477	0.675	0.196	0.31	0.439	0.053	0.084	0.119

Cd (P = 0.05)	0.183	0.289	0.409	0.232	0.367	0.519	0.635	1.004	1.42	0.412	0.652	0.923	0.112	0.177	0.25

Table 4. Standardization of bio priming using *T.viridi*on, shoot length, root length, seedling length, vigour index I and vigour index IIof *Vigna ungiculata*

Priming agent	Shoot Length (cm)			Root Length (cm)			Seedling Length (cm)			Vigour Index I			Vigour Index II		
	Soaking hrs			Soaking hrs			Soaking hrs			Soaking duration in h (d)			Soaking duration in h (d)		
	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean
Hydro	10.1	10.8	10.5	9.5	8.3	8.9	19.6	19.1	19.35	1568	1517	1543	51.2	42.9	47.05
TV 10%	**16.6**	**14**	**15.3**	**12.2**	**11.4**	**11.8**	**28.8**	**25.4**	**27.1**	**2592**	**2210**	**2401**	**85.5**	**71.34**	**78.42**
TV 20%	12.4	11.4	11.9	10.4	9.7	10.05	22.8	21.1	21.95	1892	1794	1843	59.76	45.9	52.83
TV 30%	11.4	12.6	12	10.3	9.8	10.05	21.7	22.4	22.05	1866	1792	1829	74.82	51.2	63.01
C	9.6	9.6	9.6	6.7	6.7	6.7	16.3	16.3	16.3	1223	1223	1223	18	18	18
Mean	12	11.7	11.9	9.82	9.18	9.5	21.84	20.86	21.35	1828	1707	1768	57.86	45.87	51.86
	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T
Sem	0.0758	0.1119	0.1699	0.062	0.099	0.14	0.138	0.218	0.309	11.554	18.268	25.835	0.393	0.621	0.879
Sed	0.107	0.1699	0.2399	0.088	0.14	0.198	0.195	0.309	0.437	16.339	25.834	36.536	0.555	0.879	1.243
Cd (P = 0.05)	0.225	0.356	0.504	0.186	0.294	0.416	0.41	0.649	0.918	34.339	54.279	76.762	1.168	1.846	2.612

Table 5. Standardization of bio priming using Phospobacteriaon water content, imbibition rate, germination %, Mean germination time and Mean germination Rate of *Vigna ungiculata*

Priming agent	Water content			Imbition Rate			Germination %			Mean Germination Time			Mean Germination Rate		
	Soaking duration in h (d)			Soaking duration in h (d)			Soaking hrs			Soaking hrs			Soaking hrs		
	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean
Hydro	13.33	11.69	12.51	0.98	0.95	0.97	80	81	81	3.91	3.78	3.84	0.215	0.205	0.21
Pb 10%	12.51	12.61	12.56	1.05	1.02	1.04	85	83	84	4.1	4.14	4.12	0.25	0.245	0.25
Pb 20%	**15.72**	**13.23**	**14.48**	**1.21**	**1.11**	**1.16**	**93**	**86**	**90**	**4.78**	**4.25**	**4.52**	**0.295**	**0.243**	**0.27**
Pb 30%	12.74	14.24	13.49	1.02	1.04	1.03	87	84	86	4.2	4.3	4.25	0.241	0.237	0.24

C	0	0	0	0	0	0	76	76	76	3.15	3.15	3.15	0.18	0.18	0.18
Mean	10.86	10.35	10.61	0.85	0.82	0.84	84	82	83	4.03	3.92	3.98	0.24	0.22	0.23
	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T
Sem	0.094	0.149	0.211	0.007	0.011	0.016	0.499	0.79	1.117	0.026	0.042	0.059	0.001	0.002	0.003
Sed	0.131	0.207	0.293	0.01	0.015	0.022	0.706	1.117	1.58	0.037	0.059	0.084	0.002	0.003	0.005
Cd (P = 0.05)	0.281	0.444	0.628	0.021	0.034	0.048	1.485	2.348	3.321	0.079	0.125	0.177	0.004	0.007	0.01

Table 6. Standardization of bio priming using phospobacteriaon mean daily germination, peak value, cv, CVG and Germination index of *Vigna ungiculata*

Priming agent	Mean Daily Germination %			Peak Value			(CV_t)			(CVG)			Germination Index		
	Soaking hrs			Soaking hrs			Soaking hrs			Soaking hrs			Soaking hrs		
	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean
Hydro	10.1	10.17	10.13	12.65	12.21	12.43	32.36	31.24	31.8	22.78	21.87	22.33	6.22	5.71	5.97
Pb 10 %	10.67	9.86	10.26	13.6	14.78	14.19	36.14	34.12	35.13	24.48	23.41	23.95	6	6.3	6.15
Pb 20 %	**11.5**	**10.98**	**11.24**	**15.78**	**14.8**	**15.29**	**39.26**	**35.36**	**37.31**	**26.85**	**24.3**	**25.58**	**6.39**	**5.92**	**6.15**
Pb 30 %	10.25	9.52	9.89	14.78	13.37	14.07	34.57	32.85	33.71	23.07	22.06	22.57	6.06	5.79	5.92
C	8.1	8.1	8.1	10.24	10.24	10.24	28.45	28.45	28.45	20.12	20.12	20.12	5.12	5.12	5.12
Mean	10.12	9.73	9.92	13.41	13.08	13.24	34.16	32.4	33.28	23.46	22.35	22.91	5.96	5.77	5.86
	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T
Sem	0.0631	0.099	0.141	0.08906	0.14081	0.19913	0.21432	0.33886	0.47922	0.14536	0.22983	0.32503	0.03569	0.05643	0.0798
Sed	0.089	0.141	0.199	0.12594	0.19913	0.28161	0.30308	0.47921	0.6777	0.20556	0.32502	0.45964	0.05047	0.07979	0.11285
Cd (P = 0.05)	0.187	0.296	0.419	0.2646	0.41837	0.59166	0.63676	1.00681	1.42384	0.43188	0.68286	0.96571	0.10603	0.16765	0.23709

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Table 7. Standardization of bio priming using phospobacteriaon shoot length, root length, seedling length, vigour index I and vigour index II of *Vigna ungiculata*

Priming agent	Shoot Length (cm)			Root Length (cm)			Seedling Length (cm)			Vigour Index I			Vigour Index II		
	Soaking hrs			Soaking hrs			Soaking hrs			Soaking duration in h (d)			Soaking duration in h (d)		
	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean
Hydro	13.6	12.5	13.05	9.8	8.6	9.2	23.4	21.1	22.25	1872	1716	1794	47	44	46
Pb 10 %	16.2	14.9	15.55	10.8	10.2	10.5	27	25.1	26.05	2304	2083	2194	68	57	63
Pb 20 %	**17.2**	**16.4**	**16.8**	**12.5**	**11.4**	**11.95**	**29.7**	**27.8**	**28.75**	**2762**	**2391**	**2576**	**81**	**53**	**67**
Pb 30 %	14.1	15.7	14.9	10.3	9.8	10.05	24.4	25.5	24.95	2131	2153	2142	68	45	56
C	10.1	10.1	10.1	6.7	6.7	6.7	16.8	16.8	16.8	1238	1238	1238	26	26	26
Mean	14.24	13.92	14.08	10.02	9.34	9.68	24.26	23.26	23.76	2061	1916	1989	58	45	52
	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T
Sem	0.09655	0.15265	0.21589	0.06735	0.10648	0.15059	0.16371	0.25884	0.36606	14.5405	22.9906	32.5136	0.41655	0.65862	0.93142
Sed	0.13653	0.21588	0.30553	0.09524	0.15059	0.21296	0.23151	0.36605	0.51767	20.5626	32.5124	45.9794	0.58906	0.93139	1.31718
Cd (P = 0.05)	0.28686	0.45356	0.64143	0.20001	0.31638	0.44743	0.4864	0.76906	1.08762	43.2021	68.3085	96.6028	1.23762	1.95685	2.7674

Table 8. Standardization of bio priming using seaweed extracton water content, imbibition rate, germination %, Mean germination time and Mean germination Rate of *Vigna ungiculata*

Priming agent	Water content			Imbition Rate			Germination %			Mean Germination Time			Mean Germination Rate		
	Soaking duration in h (d)			Soaking duration in h (d)			Soaking hrs			Soaking hrs			Soaking hrs		
	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean
Hydro	9.35	10.41	9.88	0.842	0.74	0.791	80	79	80	4.05	4	4.025	0.22	0.24	0.23
SW 10 %	**15.64**	**12.41**	**14.03**	**1.176**	**0.981**	**1.078**	**93**	**85**	**89**	**5.4**	**4.65**	**5.025**	**0.28**	**0.22**	**0.25**
SW 20 %	9.09	10.85	9.97	0.94	0.863	0.902	84	83	83	4.27	4.54	4.405	0.23	0.25	0.24
SW 30 %	12.91	11.49	12.2	1.037	1.022	1.03	83	82	83	4.34	4.18	4.26	0.24	0.21	0.225

C	0	0	0	0	0	0	77	77	77	3.45	3.45	3.45	0.18	0.18	0.18
Mean	9.4	9.03	9.22	0.799	0.721	0.76	84	81	82	4.302	4.164	4.23	0.23	0.22	0.225
	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T
Sem	0.074	0.117	0.165	0.006	0.01	0.014	0.411	0.65	0.919	0.025	0.04	0.057	0.001	0.002	0.003
Sed	0.102	0.162	0.229	0.008	0.014	0.02	0.581	0.919	1.3	0.036	0.057	0.081	0.001	0.003	0.004
Cd (P = 0.05)	0.22	0.348	0.493	0.019	0.03	0.042	1.221	1.931	2.732	0.076	0.121	0.171	0.004	0.006	0.008

Table 9. Standardization of bio priming using seaweed extract on mean daily germination, peak value, cv, CVG and Germination index of *Vigna ungiculata*

Priming agent	Mean Daily Germination %			Peak Value			(CV_t)			(CVG)			Germination Index		
	Soaking hrs			Soaking hrs			Soaking hrs			Soaking hrs			Soaking hrs		
	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean	3	6	Mean
Hydro	10.5	10.17	10.3	13.56	12.93	13.25	32.28	33.45	32.87	22.46	21.03	21.75	5.22	5.45	5.34
SW 10 %	**11.64**	**10.67**	**11.15**	**14.8**	**13.87**	**14.33**	**40.19**	**35.31**	**37.75**	**26.72**	**23.85**	**25.28**	**6.3**	**5.79**	**6.04**
SW 20 %	11	10.83	10.92	14.22	13.2	13.71	35.49	34.74	35.12	22.99	24.56	23.78	5.7	5.51	5.6
SW 30 %	10.33	10.5	10.42	12.92	12.87	12.89	38.36	36.45	37.41	23.45	22.36	22.91	5.54	5.3	5.42
C	8.25	8.25	8.25	11.52	11.52	11.52	28.25	28.25	28.25	18.72	18.72	18.72	4.89	4.89	4.89
Mean	10.34	10.08	10.21	13.4	12.88	13.14	34.91	33.64	34.28	22.87	22.1	22.49	5.53	5.39	5.46
	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T
Sem	0.063	0.101	0.143	0.08	0.127	0.18	0.215	0.341	0.482	0.134	0.212	0.3	0.033	0.052	0.074
Sed	0.09	0.143	0.202	0.114	0.18	0.255	0.305	0.482	0.682	0.189	0.3	0.424	0.046	0.074	0.104
Cd (P = 0.05)	0.19	0.3	0.425	0.239	0.379	0.536	0.64	1.013	1.432	0.398	0.63	0.891	0.098	0.155	0.219

Table 10. Standardization of bio priming using seaweed extract shoot length, root length, seedling length, vigour index I and vigour index II of *Vigna ungiculata*

Priming agent	Shoot Length (cm)			Root Length (cm)			Seedling Length (cm)			Vigour Index I			Vigour Index II		
	Soaking hrs			Soaking hrs			Soaking hrs			Soaking duration in h (d)			Soaking duration in h (d)		
	3	6	Mea	3	6	Mea	3	6	Mea	3	6	Mea	3	6	Mea

			n			n			n			n			n
Hydro	13.2	13.4	13.3	10.3	9.8	10.1	23.5	23.2	23.35	1880	1843	1862	58	42	50
SW 10 %	**17.4**	**15.4**	**16.4**	**14.7**	**13.6**	**14.2**	**32.1**	**29**	**30.55**	**3000**	**2472**	**2736**	**83**	**57**	**70**
SW 20 %	16.3	14	15.2	14.2	12.8	13.5	30.5	26.8	28.65	2569	2212	2391	32	37	35
SW 30 %	16.6	16	16.3	11.8	10.3	11.1	28.4	26.3	27.35	2371	2150	2260	73	52	62
C	10.1	10.1	10.1	6.7	6.7	6.7	16.8	16.8	16.8	1294	1294	1294	26	26	26
Mean	14.7	13.8	14.3	11.5	10.6	11.1	26.26	24.42	25.34	2223	1994	2108	54	43	49
	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T	D	T	D*T
Sem	0.097	0.153	0.217	0.075	0.119	0.168	0.16	0.254	0.359	14.204	22.459	31.762	0.323	0.511	0.723
Sed	0.137	0.217	0.307	0.106	0.1685	0.238	0.2272	0.359	0.508	20.087	31.761	44.916	0.457	0.723	1.023
Cd (P = 0.05)	0.289	0.457	0.646	0.223	0.354	0.5	0.477	0.754	1.067	42.203	66.729	94.37	0.961	1.52	2.15

Table 11. Standardization of bio priming using T.viridi , Phospobacteria and seaweed extract on germination value of *Vigna ungiculata*

Priming agent	Germination Value			Priming agent	Germination Value			Priming agent	Germination Value		
	Soaking hrs				Soaking hrs				Soaking hrs		
	3	6	Mean		3	6	Mean		3	6	Mean
Hydro	130.23	129.48	129.86	Hydro	145.16	131.33	138.25	Hydro	143.67	131.33	137.5
TV 10%	**156.78**	**141.54**	**149.16**	Pb 10 %	154.78	168.14	161.46	**SW 10 %**	**156.33**	**147.47**	**151.9**
TV 20%	141.87	136.98	139.42	**Pb 20 %**	**174.6**	**162.4**	**168.5**	SW 20 %	154.53	143.13	148.83
TV 30%	138.3	143.37	140.83	Pb 30 %	165.61	159.61	162.61	SW 30 %	135.32	134.85	135.08
C	110.15	110.15	110.15	C	112.38	112.38	112.38	C	112.38	112.38	112.38
Mean	135.47	132.3	133.88	Mean	150.51	146.77	148.64	Mean	140.45	133.83	137.14
Sem	0.757	1.198	1.694	Sem	1.00883	1.5951	2.25581	Sem	0.866	1.37	1.937
Sed	1.071	1.694	2.395	Sed	1.42665	2.25573	3.19009	Sed	1.225	1.937	2.74
Cd (P = 0.05)	2.251	3.559	5.033	Cd (P = 0.05)	2.99739	4.73929	6.70237	Cd (P = 0.05)	2.574	4.0712	5.757

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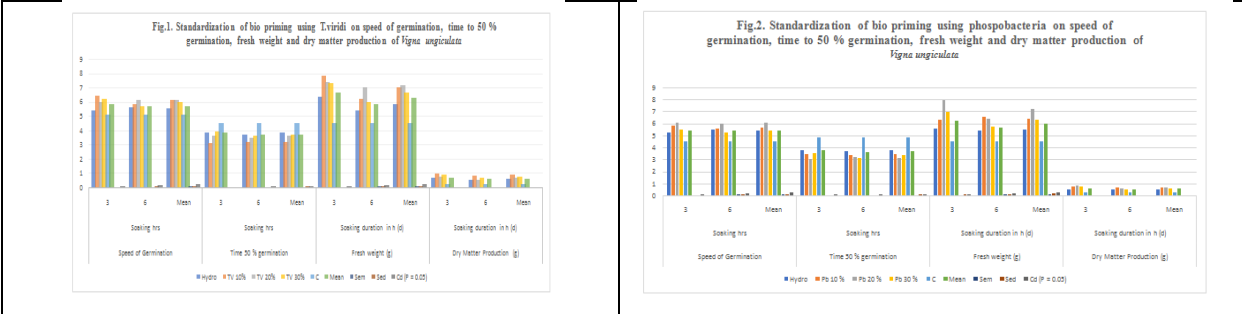
Fig.1. Standardization of bio priming using T.viridi on speed of germination, time to 50 % germination, fresh weight and dry matter production of *Vigna ungiculata*

Fig.2. Standardization of bio priming using phospobacteria on speed of germination, time to 50 % germination, fresh weight and dry matter production of *Vigna ungiculata*
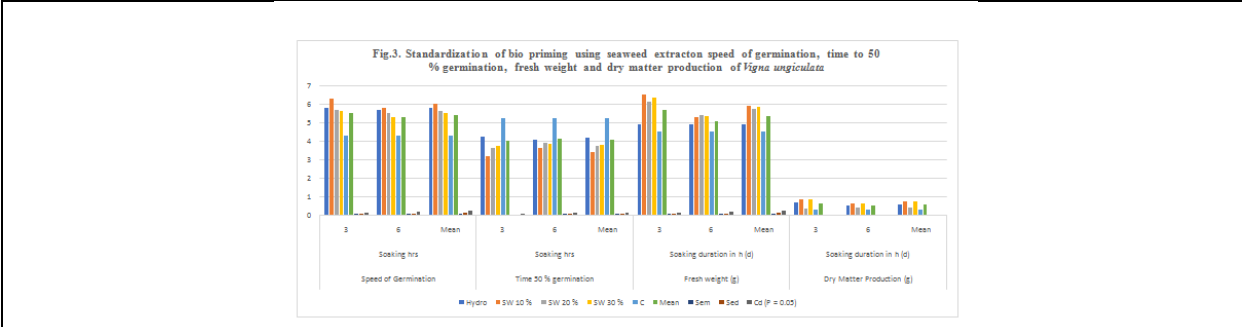
Fig.3. Standardization of bio priming using seaweed extract on speed of germination, time to 50 % germination, fresh weight and dry matter production of *Vigna ungiculata*

RESEARCH ARTICLE

A Comprehensive Comparison of Fuzzy VIKOR, TOPSIS with Entropy and CRITIC Weight Techniques

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ABSTRACT

This study compares different methods for assessing air quality, specifically focusing on the use of fuzzy VIKOR, TOPSIS with Entropy, and the CRITIC weight method. The goal is to assess and contrast the effectiveness of different approaches in calculating the air quality index based on a certain set of pollutant characteristics. The process includes gathering air quality 2020 data from the Tamil Nadu Pollution Control Board. The comparative analysis involves evaluating the efficiency, precision, and computational speed of fuzzy VIKOR, TOPSIS with Entropy, and the CRITIC weight method in measuring air quality. The initial findings show that each methodology has unique performance traits: fuzzy VIKOR is adept at handling fuzzy and imprecise data; TOPSIS with Entropy excels at managing uncertainty and decision-making with complex criteria; and the Critic Weight Method provides a structured way to include expert opinions and domain knowledge in the assessment process. This comparative study intends to analyze the strengths and limits of several air quality assessment approaches to assist in making informed decisions for environmental management and policy formation.

Keywords: Air quality evaluation, fuzzy VIKOR, TOPSIS, Entropy, CRITIC weight method, MATLAB, environmental supervision.

INTRODUCTION

Decision-making processes in today's environment sometimes include navigating between multiple conflicting objectives and criteria. Multi-factor Decision Making (MCDM) provides a structured approach to tackle challenges by considering multiple factors simultaneously. Multi-Criteria Decision Making (MCDM) offers a systematic method for evaluating choices and determining the best course of action across several domains like business, engineering, public policy, and personal decision-making. MCDM recognizes that decisions usually encompass many factors. They include several components such as cost, time, quality, risk, and sustainability, each with its own unique significance and trade-offs. Traditional decision-making methods that focus on a single criterion or rely on intuition may overlook crucial aspects and lead to suboptimal outcomes. Multiple Criteria Decision Making (MCDM) strategies aim to address this complexity by integrating various criteria, preferences, and uncertainties into a cohesive decision-making process. Multi-criteria efficiency entails determining the most suitable and feasible solution according to defined criteria. Practical issues often involve many incompatible and conflicting requirements, making it unattainable to discover a solution that accomplishes all criteria at the same time. The alternative comprises a collection of possibilities that are either equal or a compromise based on the decision-maker's preferences. [1] Several Multiple Attribute Decision Making (MADM) methods have been introduced in recent decades, including Simple Additive Weighting (SAW), the Analytic Hierarchy Process (AHP), VIekriterijumsko KOmpromisno Rangiranje (VIKOR), Technique for the Order of Preference by Similarity to an Ideal Solution (TOPSIS), Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE), Elimination and Choice Translating Reality (ELECTRE), and Grey System Theory. These strategies try to identify answers for a collection of actions that are based on contradictory criteria. Standard Multiple Attribute Decision Making (MADM) procedures are ineffective in dealing with real-world challenges that contain imprecise and ambiguous information.

The VIKOR method is a potent tool used in multi-criteria decision analysis (MCDA). M. Zeleny's VIKOR is well-known for its capacity to handle choice issues involving multiple alternatives and conflicting criteria. The VIKOR technique excels at balancing conflicting objectives and determining a compromise solution that best meets all requirements. By combining elements of optimism and pessimism, VIKOR provides decision-makers with a holistic view, helping them traverse decision-making challenges with enhanced clarity and certainty. The VIKOR approach is commonly utilized for Multiple Attribute Decision MADM because of its ability to address conflicts across attributes and reach a compromise answer[2]. VIKOR offers the advantage of maximizing communal benefit and minimizing individual regret, increasing the likelihood of the compromise option being approved by decision-makers. The conventional VIKOR approach is limited to addressing MADM problems using attribute values represented as real numbers. Researchers have expanded the spectrum of applicability of the VIKOR technique. X.Han and X.Chen introduced a new VIKOR method using DNs[3]. L.Wang et al. developed a VIKOR method for picture fuzzy environments [4].Z.Tian et al.employed the VIKOR approach to ascertain the risk priority of failure modes [5]. The TOPSIS method is a widely acknowledged and often used technique in the field of MCDM. TOPSIS, created by Hwang and Yoon in the early 1980s, provides a structured method for assessing and ordering options by measuring their closeness to the best solution and their distance from the worst solution. The TOPSIS technique evaluates alternatives by comparing their proximity to the best potential outcome and distance from the worst possible consequence, aiming to identify the most suitable answer. TOPSIS offers decision-makers a comprehensive view by considering both the positive and negative elements of each alternative, helping them make clear and precise decisions amidst complications. We utilize the TOPSIS method to determine fuzzy states for all objects. Most studies focused on enhancing and advancing the TOPSIS approach for promotional purposes. Shen et al. [6] expanded the TOPSIS approach in intuitionistic fuzzy environments using a novel distance metric. Wu et al. [7] investigated the use of an interval-type-2 fuzzy TOPSIS model in social networks. Furthermore, certain researchers have significantly contributed to the fundamental concept of the TOPSIS technique. The fundamental concept of the TOPSIS approach is that the object performs better when it is closer to the positive ideal solution and farther from the negative ideal solution. Some researchers have conducted studies based on this premise. Opricovic et al. [8] conducted a

comparison between the TOPSIS approach and the VIKOR method. They highlighted that the correlation coefficient calculation in the original TOPSIS method did not account for the preference between the two distances. Doukas et al. [9] introduced a novel correlation coefficient formula that considers the preference between two distances. Kuo [10] demonstrated the validity and efficacy of the original correlation coefficient formula and developed a new correlation coefficient formula. Kuo developed a ranking situation for any two items based on positive and negative ideal distances in [10]. Overall, the decision-making approaches mentioned are enhancements and expansions of the TOPSIS method. Some techniques are adaptations of the TOPSIS approach for different simulation environments, while others are enhancements to the original TOPSIS method in real-valued information systems. This work aims to utilize TWD concepts to develop a new TOPSIS approach for real-valued information systems. Qingyong Wang, Hong-Ning, and Hao Wang have studied the influence of air pollution on urban economic development using TOPSIS[17]. Chen et al. (2018) identified coal-fired power stations and manufacturing emissions as the primary contributors to pollution through the utilization of the VIKOR approach[18]. Supriya Raheja and colleagues determined the most heavily polluted city in India in terms of many pollutants using CODAS[19]. Rashmi Bhardwaj and Shanky Garg analyze the detrimental effects of air pollution on human health, utilizing TOPSIS and DMCTM to determine and assess the factors of air pollution and its impact on health[20]. Mohsen, Tayebi and colleagues suggested creating a hybrid Decision Support System (DSS) by combining AHP, DAMATEL, and MULTIMOORA techniques, applied to three situations in Iran: a petrochemical plant, a gas refinery, and an oil refinery[21]. According to many evaluation techniques like WSM, VIKOR, TOPSIS, and ELECTRE [22], Hsing-Chen Lee and Chin-Ter Chang contend that hydropower is the best renewable energy source in Taiwan because of its cutting-edge technology and affordability. The method includes using entropic weights from Shannon's information theory to choose the material, along with critic approaches [23] and the Peng method for ranking preference functions that make use of composition enrichment technology [24].

METHODOLOGY

ENTROPY Method

An unbiased weighting, Entropy, method introduced by Shannon [26] in 1948, the technique employed involves the allocation of weights to choice criteria, taking into account their respective levels of relevance and variability.It measures the degree of uncertainty associated with each criterion and assigns higher weights to those with lower Entropy values, indicating greater consistency.

i) Calculate the projection value of each criteria is given by,

$$P_{kj} = \frac{f_{kj}}{\sum_{k=1}^{m} f_{kj}}, \text{k} = 1, 2, \ldots, \text{n}.$$

ii) Calculate the Entropy values are computed by using the following expression,

$$E_j = -c \sum_{k=1}^{m} P_{kj} \log (P_{kj}), \text{k} = 1, 2, \ldots, \text{m and j} = 1, 2, \ldots, \text{n}.$$

Where c = $(\log(m))^{-1}$ is a constant.

iii) Determine the degree of divergence d_j for each criteria

$$d_j = 1 - E_j, \text{j} = 1, 2, \ldots, \text{n}.$$

iv) Calculate the weight for each criteria are obtained as

$$W_j = \frac{d_j}{\sum_{j=1}^{n} d_\beta}, \text{j} = 1, 2, \ldots, \text{n}.$$

CRITIC Method

i) Normalize the decision matrix

$$\bar{X}_{ij} = \frac{X_{ij} - X_j^{-ve}}{X_j^{+ve} - X_j^{-ve}}$$

ii) Calculate the Standard deviation σ_j for each criteria

iii) The aim is to figure out the symmetric matrix of $n \times n$, where r_{jk} represents the linear correlation coefficient between the vectors $X_j \& X_k$

iv) Determine the scale of the conflict created by criterion j with respect to the

decision- making scenario established by the other criteria $\sum_{k=1}^{m} 1 - r_{jk}$

v) Analyzing the information's quality based on each criterion,

$$c_j = \sigma_j * \sum_{k=1}^{m}(1 - r_{jk})$$

vi) Determining the objectives weights $W_j = \frac{c_j}{\sum_{k=1}^{m} c_j}$

The VIKOR method

i) To find the optimal values of f_j^* and the minimum values of f_j^- for all criterion functions, j=1,2,...,n. When the jth function represents a benefit, the function f_j^* is defined as the $f_j^* = max_k f_{kj}$, indicating the desirable level. Conversely, the function f_j^- is defined as the $f_j^- = min_k f_{kj}$, indicating the lowest level.

ii) Compute the value S_k and R_k,k=1,2,...,m by the relations .

$$S_k = \sum_{j=1}^{m} wj \frac{|f_j^* - f_{kj}|}{|f_j^* - f_j^-|},$$

$$R_k = max\{\frac{|f_j^* - f_{kj}|}{|f_j^* - f_j^-|}\} \text{ k=1,2,...m, j=1,2,...,n.}$$

iii) Obtain the values Q_k, k=1,2,...,m by the relation

$$Q_k = \mho \frac{(S_k - S^*)}{(S^- - S^*)} + (1-\mho)\frac{(R_k - R^*)}{(R^- - R^*)} \text{ , k=1,2,...,m (alternatives).}$$

The variable $\mho$ is represented as the weight assigned to the strategy of "the majority of criteria" or "the maximum group utility," with a value of 0.5.

iv)Arrange the possibilities in descending order based on the values S, R, and Q. The outcome consists of ranking lists.

v) Suggest the alternative (μ') as a compromise option, which is ranked as the best according to the minimal measure Q, provided that the following two conditions are met.

C_1 : "Acceptable advantage "

Q(μ'')-Q(μ')≥ DQ

Where μ'' is the alternative with second position in the ranking list by Q^- ,DQ =$\frac{1}{(J-1)}$ and J is the number of alternatives .

C_2 : "Acceptable stability in decision making"

If any of the conditions are not met, a predetermined set of compromise solutions is suggested, which includes:

- The alternatives μ' and μ'' if only condition C_2 is unsatisfied, or
- The alternatives $\mu', \mu'', ..., \mu^{(n)}$ if condition C_1 is unsatisfied; and $(\mu^{(n)})$ is determined by the relation Q($\mu^{(n)} - Q(\mu')$)< DQ for maximum n
- The optimal options, denoted by Q, are those with the lowest value of Q. The "advantage rate" determines the primary outcome, which is the compilation of various options and the compromise solution.

The TOPSIS method

i) $r_{kj}(x) = \frac{x_{kj}}{\sqrt{\sum_{k=1}^{m} x_{kj}^2}}$, k=1,2,...,m; j=1,2,...,n

ii) For benefit criteria (large is better) , $r_{kj} = \frac{(x_{kj} - x_j^-)}{(x_j^* - x_j^-)}$

where $x_j^* = max_k x_{kj}$ and $x_j^- = min_k x_{kj}$

Then to calculate weighted normalized rating by $V_{kj}(x) = W_j r_{kj}(x)$, k=1,2,...,m; j=1,2,...,n.

Next the positive ideal point (PIS) and the negative ideal point (NIS) are derived as,

PIS =A^+ ={(max $V_{kj}(x)$)}

NIS=A^- ={($min_k V_{kj}(x)$)}

To proceed, it is necessary to compute the distance between the PIS and the NIS for each choice. The Euclidean distance, denoted as, can be utilized to quantify the separation values.

$A_k^* = \sqrt{\sum_{j=1}^{m}[\alpha_{kj}(x) - \alpha_j^+(x)]^2}$, k= 1, 2,...,m. ;j=1,2,...,n.

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$$A_k^- = \sqrt{\sum_{j=1}^{m}[\alpha_{kj}(x) - \alpha_j^-(x)]^2}$$, k= 1 , 2,...,m;j=1,2,...,n.

The commonalities to the PIS can be derived as

$$C_k^* = \frac{D_k^*}{(D_k^* + D_k^-)}$$, k=1, 2,...,m

Ultimately, the optimal ordering can be derived based on the resemblances to the PIS(C_k^*) in a descending manner, with the aim of selecting the most favourable options.

STUDY AREA

This study attempts to evaluate air quality and determine the most polluted location during January, February, and March in the cities of Bangalore, Chennai, Mumbai, Delhi, and Kolkata. This study   different cities as potential alternatives for controlling metropolitan pollution. The air quality assessment using the MCDM method examines the characteristics of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter (PM_{10} and $PM_{2.5}$) as pollutants in the air. The pollutant concentration data for January, February, and March 2020 was acquired from the Tamil Nadu Pollution Control Board [27] and the graph is drawn using MATLAB are displayed in Figure 1. This study proposes that includes the Entropy weighting techniques and Criteria importance through inter criteria correlation to assign relative importance to each attributes. The VIKOR and TOPSIS approach is used to classify the alternatives to identify the most polluted state in India. The flowchart for the Entropy-CRITIC-VIKOR-TOPSIS approach is shown in fig.2

Numerical Example

Our health is directly influenced by the quality of our environment and the nourishment we consume. Air pollution is the introduction of gases, dust particles, fumes, or odour into the atmosphere in a manner that is hazardous to humans, animals, and plants. The presence of air pollution poses a threat to the well-being of both people and other living organisms on Earth. The emission of smog and acid rain results in the development of cancer and respiratory illnesses, the depletion of the ozone layer, and the exacerbation of global warming. The government has established and is continuously refining recommendations for air quality and regulations to limit emissions in order to manage air pollution. Individually, we can lessen our impact on pollution by utilizing public transit. This study attempts to evaluate air quality and pinpoint the most polluted region during January, February, and March in the cities of Bangalore, Chennai, Mumbai, Delhi, and Kolkata. The study assesses cities as potential alternatives for controlling metropolitan pollution. The air quality assessment using the MCDM method examines the characteristics of sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter (PM_{10} and $PM_{2.5}$) as pollutants in the air. The pollutant concentration data for January, February, and March 2020 was acquired from the Tamil Nadu Pollution Control Board and then displayed [25]. Here the pollutants are taken as criteria and the states are taken as alternatives. The normalized decision matrix was created based on the obtained data and is illustrated in Table 1. The decision matrix is employed for the purpose of ascertaining the Entropy weights associated with the criteria., which are illustrated in Table 2. The CRITIC technique involves computing the normalized decision matrix, followed by determining the correlation matrix, calculating the amount of information c_j, and determining the criteria weights W_j as given in Table 3.

Comparing the Entropy – VIKOR and CRITIC – VIKOR

In this part, the decision matrix is used to identify the optimal and suboptimal values for each criterion. The values of optimal collective utility (S_k) and the limited personal remose of the opponents (R_k) are then determined. The value of Q_k can be computed and is displayed in Table 4. The options are arranged in ascending order by ranking the variables S_k , R_k , and Q_k. Consequently, three ranking lists are created based on the precise values of S, R, and Q, which are then used to provide a compromise option for the alternatives.

Comparing the Entropy – TOPSIS and CRITIC – TOPSIS

The decision matrix, which includes values for criteria against each choice, is initially normalized. The multiplication of the normalized decision matrix is performed using the Entropy and CRITIC weights derived from the techniques

employed for criteria weighting. The subsequent step involves the determination of the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS). It is necessary to compute the Euclidean distances between the points PIS and NIS. The ranks will be established using two sets, namely Entropy - TOPSIS and CRITIC-TOPSIS. Table 5 presents the results.

Comparison of Entropy –VIKOR-TOPSIS with CRITIC –VIKOR-TOPSIS methods
From the Table 4, the Entropy-VIKOR and CRITIC-VIKOR result indicates that Delhi is ranked as one of the five states in India, Chennai is ranked as two, Kolkata is ranked as three, Bangalore is ranked as four in Entropy method and five in CRITIC weight method, Mumbai is ranked as five in Entropy method and four in CRITIC method in 2020 respectively. And also from the Table 5 the Entropy- TOPSIS and CRITIC- TOPSIS result indicates that Delhi is ranked as one of the five states in India, Chennai is ranked as two, Kolkata is ranked as three, Bangalore is ranked as four in Entropy method and five in CRITIC weight method, Mumbai is ranked as five in Entropy method and four in CRITIC method in 2020 respectively. Figure 3 are drawn using MATLAB and represents the comparison of the ranks obtained by the VIKOR and TOPSIS method to assess their performance and effectiveness in ranking various states. The result for the year 2020 shows that the Entropy-VIKOR and Entropy-TOPSIS gives the same result when compare to the CRITIC-VIKOR and CRITIC-TOPSIS. Also the result shows that Entropy weight method gives the efficient result when compare to the CRITIC weight method.

RESULTS AND DISCUSSIONS

The VIKOR framework presents a well-balanced solution that effectively addresses the objectives of maximizing collective benefit and minimizing individual regret. TOPSIS focuses on the closeness of alternatives to the optimum answer, which is advantageous when there is a distinct reference point. The selection of VIKOR or TOPSIS relies on the unique attributes of the air quality evaluation issue and the preferences of the decision-maker. The entropy method offers a straightforward method for ascertaining weights by considering the diversity of criteria values. CRITIC examines inter-criteria correlations to offer a more detailed insight into the importance of criteria. Entropy is easier to apply, but CRITIC may provide more precise weights, particularly when criteria are interrelated. Examining the results of air quality analysis using VIKOR and TOPSIS methods along with entropy and CRITIC weights shows how important it is to use both methods. VIKOR and TOPSIS have unique benefits, and the selection between entropy and CRITIC relies on the decision problem's complexity and the data at hand. By combining these methodologies, a thorough assessment of air quality may be conducted, aiding in making well-informed decisions for environmental management and policy formulation. Fuzzification of numerical data can be accomplished by using the centroid technique along with the normalized decision matrix in Table 1. The target weight can be calculated using the Entropy and CRITIC method, as shown in Table 2 and Table 3. Algorithms are used on the dataset to analyze the regions and determine the most polluted state in India.

CONCLUSION

In conclusion, the comparison of air quality analysis utilizing fuzzy VIKOR and fuzzy TOPSIS approaches with weight Entropy and CRITIC methods provides useful insights for environmental management decision-making. Both fuzzy VIKOR and fuzzy TOPSIS are adept at managing the uncertainty and ambiguity present in air quality data, rendering them appropriate for such investigations. The addition of weight Entropy and CRITIC techniques promotes the robustness and accuracy of the decision-making process by dealing with the subjective nature of criteria weighting and identifying the best options. By comparing different methods, it is clear that using a combination of approaches can offer a thorough insight into air quality problems and help in choosing the best solutions. Integrating weight Entropy and CRITIC techniques enhances the objectivity and reliability of decision-making, enabling stakeholders to make well-informed choices to enhance air quality and reduce environmental risks efficiently. The comparative study emphasizes the significance of utilizing advanced decision-making approaches in

air quality analysis. It underscores the relevance of a rigorous approach that takes into account both the technical parts of methodology and the subjective elements of decision criteria. This comprehensive method facilitates the implementation of more efficient environmental management tactics and aids in the sustainable growth of global communities.

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Table:1 Normalized fuzzy decision matrix for VIKOR

	G_1	G_2	G_3	G_4	G_4
ξ_1	0.2134	0.23	0.4406	0.5673	0.3773
ξ_2	0.1966	0.2362	0.321	0.5266	0.6656
ξ_3	0.4879	0.4157	0.573	0.3891	0.6854
ξ_4	1	1	1	1	0.9476
ξ_5	0.7732	0.6101	0.3796	0.759	1

Table:2 Calculating the normalized weight using Entropy method

	G_1	G_2	G_3	G_4	G_4
E_α	0.7913	0.9025	0.9437	0.9676	0.969
d_j	0.2087	0.0975	0.0563	0.0324	0.031
W_j	0.49	0.2289	0.1321	0.076	0.0727

Table:3 Calculating the normalized weight using CRITIC method

	G_1	G_2	G_3	G_4	G_4
SD	2.101	1.7427	1.6335	2.1222	2.8734
r_{jk}	0.6221	0.5236	1.3814	1.0118	1.3125
c_j	1.307	0.9124	2.2565	2.1472	3.7713
W_j	0.1257	0.0877	0.217	0.2065	0.3628

Table: 4 Rank obtained using Entropy – VIKOR and CRITIC – VIKOR methods

	Entropy VIKOR				CRITIC VIKOR			
	S_k	R_k	Q_k	Ranking	S_k	R_k	Q_k	Ranking
ξ_1	0.9202	0.4797	0.9709	4	0.8595	0.3628	1	5
ξ_2	0.9766	0.49	1.0107	5	0.796	0.217	0.7423	4
ξ_3	0.6865	0.3123	0.6737	3	0.6518	0.2065	0.6397	3
ξ_4	0.0061	0.0061	0	1	0.0305	0.0305	0	1
ξ_5	0.3938	0.1383	0.3392	2	0.3221	0.1551	0.3632	2

Table:5 Rank obtained using Entropy – TOPSIS and CRITIC – TOPSIS

	Entropy – TOPSIS				CRITC – TOPSIS			
	A_k^*	A_k^-	C_k^*	Rank	A_k^*	A_k^-	C_k^*	Rank
ξ_1	0.3168	0.0159	0.0479	4	0.1920	0.0310	0.1392	5
ξ_2	0.3232	0.0140	0.0416	5	0.1714	0.0636	0.2707	4
ξ_3	0.2156	0.1118	0.3414	3	0.1408	0.0823	0.3688	3
ξ_4	0.0022	0.3248	0.9932	1	0.0110	0.0823	0.8815	1
ξ_5	0.1232	0.2173	0.6381	2	0.1115	0.1526	0.5777	2

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(a)$PM_{2.5}$

b)PM_{10}

(c)NO_2

d)CO
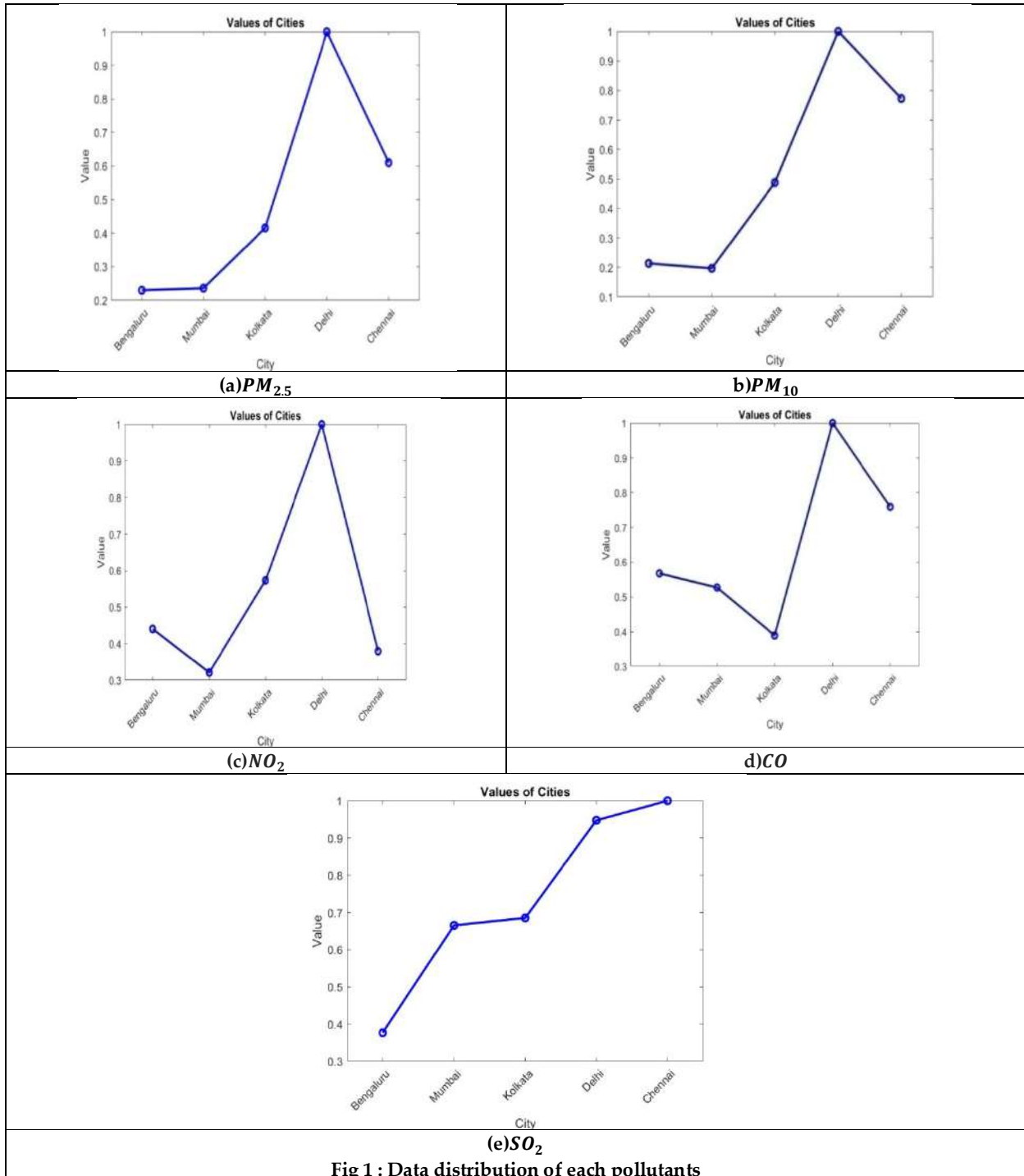
(e)SO_2
Fig 1 : Data distribution of each pollutants
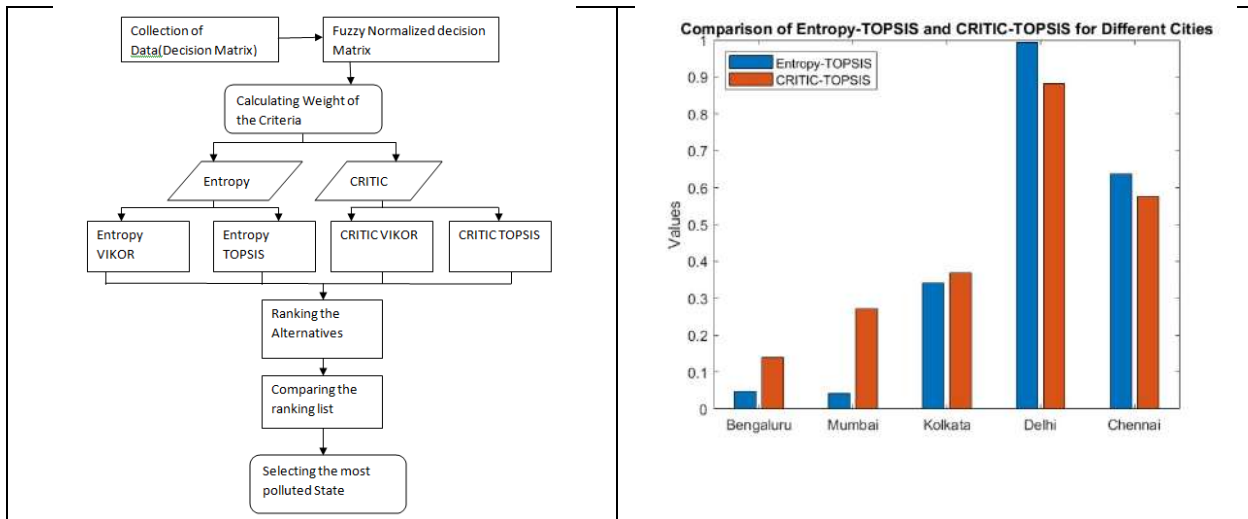
Fig 2: Frame work of the article.	**Fig. 3 Comparative ranks of VIKOR and TOPSIS in the year 2020 (a)Comparison of E-VIKOR &C-VIKOR**
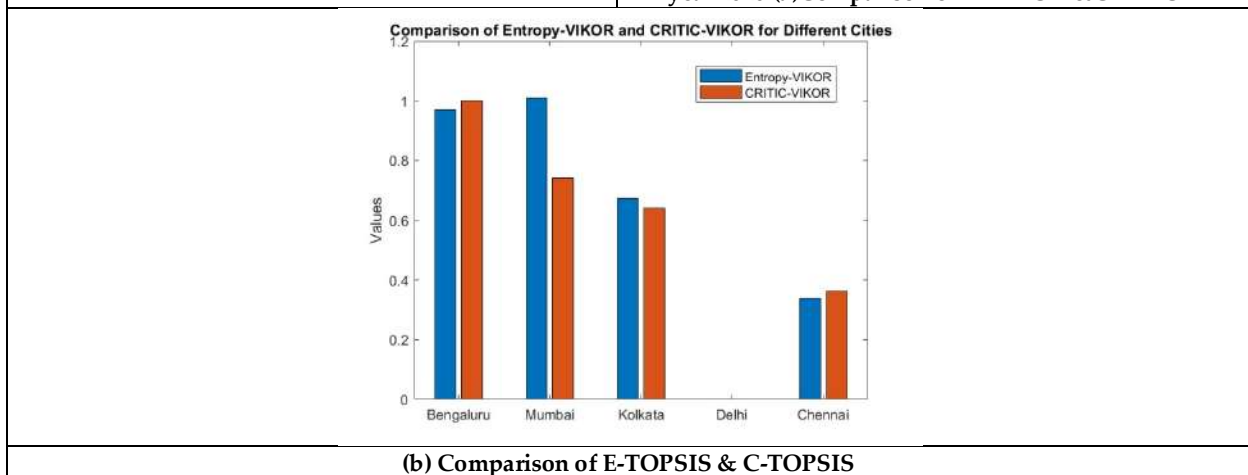
(b) Comparison of E-TOPSIS & C-TOPSIS

RESEARCH ARTICLE

PreNet: Integrating ImageNet Pre-trained Features for Enhanced Classification of Breast Cancer

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ABSTRACT

Abstract. Among women, breast cancer stands out as the prevailing type of cancer, with invasive ductal carcinoma (IDC) emerging as its most prevalent form. The precise identification and categorization of breast cancer subtypes represent crucial clinical responsibilities. Employing automated methods in this context not only saves time but also diminishes the likelihood of errors. Machine learning algorithms can be trained on extensive datasets, enabling them to recognize subtle patterns and features that might be challenging for human eyes. This enhances the accuracy and precision of breast cancer detection, potentially leading to earlier identification of tumors. This article outlines a comprehensive methodology aimed at detecting breast cancer in histopathology images, utilizing the concepts of preprocessing and hybrid CNN architecture. The data preprocessing is essential for ensuring the quality, reliability, and suitability of data for analysis or model training. Data preprocessing phase in this study applies Normalization, Resizing and Random sampling techniques to prepare the data for Modeling phase. Hybrid CNN architecture in this study involves integration ImageNet with custom-designed CNN layers or module tailored to specific tasks or datasets. The confusion matrix, used as a visualization tool, helps to understand how well the model is performing by showing the distribution of predicted and true class labels. It breaks down the model's predictions into categories such as true positives, true negatives, false positives, and false negatives. Python libraries like matplotlib and seaborn have been used for visual interpretation of model's predictions by generating heatmaps. This holistic approach strives to enhance

breast cancer detection by harnessing state-of-the-art techniques in pre-processing and leveraging deep learning-based methods for feature extraction and detection. The goal is to enhance diagnostic accuracy and interpretability, thereby contributing to advancements in the field of breast cancer detection.

Keywords: Breast cancer detection, Histopathology images, hybrid CNN, Normalization, Random Sampling, Confusion matrix, Seaborn, ImageNet, PreNet

INTRODUCTION

Cancer is a complex category of illnesses marked by the unregulated proliferation and dissemination of abnormal cells within the body. These aberrant cells have the capacity to create tumors, infiltrate adjacent tissues, and spread to distant parts of the body through a process known as metastasis. With more than 100 distinct types, each presenting unique features, risk factors, and therapeutic strategies, cancer exhibits considerable heterogeneity across its various manifestations [1]. Breast cancer stands as one of the prevalent forms of cancer and ranks as the second leading cause of death in women, following lung cancer. According to a surveillance study conducted by the American Cancer Society, approximately one in every eight women is affected by breast cancer during their lifetime [2]. As per International Agency for Research on Cancer (IARC) there are about 8.2 million deaths and are expected to increase by 27 million in 2030. The majority of breast cancers initiate in the milk-producing glands known as lobules or in the ducts, which are the tubes connecting these glands to the nipple. Early stage detection of breast cancer can reduce the death rate. The best combination of advanced technology, latest clinical research and efficient healthcare professional can make early stage detection feasible [3]. Breast cancer diagnosis typically involves a combination of imaging tests, clinical examinations, and biopsy procedures. There are numerous diagnostic methods available like Histology, Mammography, Clinical Breast Exam (CBE), Breast Ultrasound, MRI (Magnetic Resonance Imaging), Biopsy, Genetic Testing and Ductogram [4]. Now a days among all histology is considered a gold standard. Histology involves the microscopic examination of tissue samples and there by provides a definitive diagnosis of whether cancer is present and its specific type. More over Histopathology images also provide detailed information about the characteristics of a tumor, including its size, grade, and subtype. Thereby guiding healthcare professionals for further treatment plans. The procedure of histology entails applying specific dyes to the tissue samples, enhancing the visibility of cellular structures and abnormalities. Analyzing these stained tissues under a microscope enables the pathologist to discern irregular cell growth, detect the presence of tumors, and identify the distinctive characteristics of the cancer cells [5] [3]. This study has used dataset of Histopathology images taken from Kaggle for classification of breast cancer. The PreNet, which integrates ImageNet with customized CNN layers to create the hybrid CNN architecture, fed with the preprocessed data has been presented for this study. The Hybrid model approach allows leveraging the strengths of both pre-trained models and user defined architectures to achieve better performance, improved accuracy and facilitates enhanced interpretability. The structure of the paper is outlined as follows: section 2 explains literature review comprising recent publications. Section 3 is about proposed methodology. Section 4 includes the results obtained from the proposed method and compare with the other methods, and Section 5 concludes the article.

LITERATURE REVIEW

In 2016, Spanhol, et al., [5], have proposed CNN which has adapted AlexNet for classifying Breast cancer histopathological images. The BreaKHis database, consists of 7,909 microscopic biopsy images of benign and malignant breast tumors and collected at P&D lab, Brazil during Jan-Dec,2014, has been used as input for classification. It is observed that CNN based classification achieves better accuracy with compared to traditional machine learning algorithms trained on same dataset.

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In 2018, V Gupta and A Bhavsar[6] conducted a study with the objective of delving deeper into the capabilities of fine-tuned pre-trained Convolutional Neural Network (CNN) models for the classification of breast cancer histopathology images. Their research introduced a sequential model that strategically amalgamates features from various layers, resulting in an enhanced performance in the classification of breast cancer histopathology images. In their study the outcomes reveal that the integration of multilayer deep feature fusion within the sequential framework of the proposed approach outperforms the performance of the baseline network.

In 2020, TG Debelee, et al., [7], have proposed a comprehensive review of articles published between 2004 and 2018 was undertaken to achieve the objectives like, Examine the Utilization of Imaging Modalities, Compare Breast Cancer Imaging Modalities, Identify Frequently Cited and Publicly Accessible Breast Cancer Databases, Evaluate Implementation of Deep Learning (DL) in Medical Image Analysis and Assess Application of DL in Histopathology-Based Breast Cancer Image Analysis. The findings of this comprehensive review contribute to the current understanding of breast cancer diagnostic methodologies, emphasizing the role of imaging modalities, database accessibility, and the evolving landscape of Deep Learning in medical image analysis, particularly within the context of breast cancer research.

In 2021, Demir [8] proposed an innovative and resilient approach for automated breast cancer diagnosis from histopathology images. The method leverages a convolutional-long short-term memory (CNN-LSTM) learning model, a pre-processing technique utilizing a marker-controlled watershed segmentation algorithm, and an optimized support vector machine (SVM) classifier. Unlike existing approaches where CNN-LSTM models are trained separately for classification tasks, the suggested method integrates them into a unified framework. The marker-controlled watershed segmentation algorithm (MWSA) is employed to delineate inherent small regions. However, a drawback of this approach is its dependence on powerful hardware, making it less practical for applications with large datasets, as it demands high-performance computing resources.

In 2021, Aswathy and Jagannath [9]proposed an automated method for breast cancer classification that relies on integrated features and employs a Support Vector Machine (SVM) classifier. The study suggests identifying the classifier that aligns most effectively with the task of breast cancer detection using histopathological images. An integrated feature extraction module was introduced to extract and combine three sets of biologically significant and clinical traits. The study included a statistical analysis to underscore the significance of different classifier performances. It's important to note that the proposed method did not integrate a real-time approach for breast cancer diagnosis, potentially limiting its application in dynamic, time-sensitive scenarios.

In 2022, D Muduli, et al., [10], have proposed A novel deep convolutional neural network (CNN) model for the automated classification of breast cancer using two distinct types of images: mammograms and ultrasounds. Their investigation revealed that Convolutional Neural Network (CNN) models exhibit unique attributes like automated feature extraction, high-level feature learning, and proficiency in transfer learning. When compared to alternative Computer-Aided Detection (CAD) models, those based on CNNs demonstrate superior accuracy in the detection of features, showcasing the efficacy of CNNs in enhancing detection performance.

In 2022, N Ranjan, et al., [3]introduced a methodology that involves the adaptation of Convolutional Neural Networks (CNNs) for the categorization of histopathology images. They developed classifiers that employ a hierarchical structure, utilizing multiple CNNs. The accuracy of this proposed CNN-based hierarchical classifier was examined using the BACH challenge dataset. To address the challenges posed by inter-class similarity and intra-class variability in histopathology images, a pre-trained CNN was modified for effective categorization. It's noteworthy that the evaluation of histopathological categorization was limited to a specific subset in this study.

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Problem Statement

Breast cancer remains one of the most commonly diagnosed cancers globally, with millions of new cases reported each year. The incidence rates vary across regions, and lifestyle factors, genetics, and access to healthcare play significant roles [11]. Early detection through screening programs, including mammography, clinical breast exams, and self-examinations, continues to be a key focus. As a result of advancements in research, treatments and enhanced supportive care, a growing number of individuals diagnosed with breast cancer are now enjoying extended life expectancy and an improved quality of life [12]. The landscape of breast cancer continues to evolve with ongoing research and clinical trials, actively investigating novel treatment options, identifying biomarkers, and exploring potential interventions. The surge in popularity of deep learning in medical image analysis can be attributed to its intrinsic capability to autonomously acquire hierarchical features from intricate data, specifically within the domain of medical images. The worldwide scenario of breast cancer displays fluctuations, marked by continuous advancements in early detection methods, treatment approaches, and overall prognoses. It is imperative to recognize that the status of breast cancer is dynamic, susceptible to alterations over time. Consequently, staying informed and obtaining the most up-to-date information from reliable health sources or organizations through recent research is paramount [13]. As described in literature review a lot of research has been conducted on breast cancer detection by considering various attributes like different modalities, varieties of databases, various MLTs and it continues [14]. Nevertheless, several limitations are acknowledged across various studies, encompassing the requirement for robust hardware, challenges related to dataset generalization, and shortcomings in both segmentation and feature extraction and classification methodologies. Moreover, the utilization of histopathological images has been firmly established as the gold standard in research dedicated to breast cancer detection [15]. These aspects highlight areas that necessitate further exploration and enhancement of automated breast cancer diagnostic techniques.

PROPOSED METHODOLOGY

In recent years, image data classification using deep learning has propelled computer vision applications to unprecedented heights, empowering machines to discern and categorize visual information with remarkable precision. At the forefront of this transformative journey are Convolutional Neural Networks (CNNs), wielding their efficacy in diverse image classification tasks. The key facets of image data classification using deep learning are 1) Data Pre-processing through data augmentation techniques, such as rotation, flipping, and scaling to increase the diversity of the dataset, leading to improved model generalization, 2) Convolutional Neural Networks (CNNs) which are the backbone of image classification in deep learning. They are designed to automatically and adaptively learn spatial hierarchies of features from input images. The convolutional layers capture local patterns, and pooling layers help in down sampling and extracting essential information. 3) Model Architecture, is the architecture of a deep learning model for image classification typically consists of convolutional layers for feature extraction, activation functions (e.g., ReLU) for introducing non-linearity, pooling layers for spatial reduction, and fully connected layers for global patterns. 4) Transfer learning which involves leveraging pre-trained models on large datasets, such as ImageNet, and fine-tuning them for specific image classification tasks. 5) Loss Functions like categorical cross-entropy for multi-class classification and binary cross-entropy for binary classification are used for effective training. 6) Optimization Algorithms like Adam, SGD (Stochastic Gradient Descent), and RMSprop are employed to update the model parameters during training. These algorithms play a crucial role in converging the model to a solution efficiently. 7) Regularization Techniques such as dropout layers and batch normalization are used to prevent overfitting, ensuring that the model generalizes well to new, unseen data, Hyper parameter Tuning, Evaluation Metrics. 8) Hyper parameter Tuning: Adjusting hyper parameters, such as learning rate, batch size, and the number of layers, is essential for optimizing the model's performance on the specific image classification task [16] [17] [18].

The proposed methodology for breast cancer detection combines various techniques to improve accuracy and interpretability in histopathology images as shown in Fig:1. The process involves Random sampling, ReinhardColour Normalization for consistent color representation, Data Augmentation through elastic transformations, and median filtering for noise reduction during pre-processing. Adaptive thresholding is employed for segmentation to identify regions of interest. Feature extraction comprises texture features and color histograms, and a Variance Thresholding

technique is utilized for feature selection. The detection model, named PreNet, integrates a combination of ImageNet and a customized Convolutional Neural Network (CNN) architecture. This holistic yet succinct approach is designed to elevate the precision of breast cancer detection in histopathology images while facilitating a more understandable interpretation of the results.

Pre-processing

In the initial pre-processing phase of the breast cancer detection methodology, random sampling is utilized to randomly select a subset of images from an extensive dataset of histopathology images. Furthermore, Reinhard Colour Normalization is applied to ensure consistent color representation across all histopathology images, providing a standardized foundation for subsequent analyses. To address the variability in tissue structures, elastic transformations are employed, simulating deformations that augment the dataset. This augmentation strategy contributes to the model's resilience by exposing it to a broader range of variations in tissue morphology. In addition to these techniques, noise reduction is a crucial aspect of pre-processing. Median filtering is employed for this purpose, effectively diminishing noise in the histopathology images. This approach preserves structural information while enhancing the overall quality of the images, creating a more reliable foundation for subsequent stages of the breast cancer detection process[5] [18] [19].

Random Sampling

Random sampling in preprocessing is a technique where a subset of data points is chosen randomly from a larger dataset. Widely applied in machine learning and data analysis, this method is employed to create smaller, representative samples that encapsulate the essential characteristics of the overall dataset. The primary objectives of random sampling include reducing computational burden, expediting training processes, and, in certain cases, enhancing the generalization performance of a model. In the specific context of breast cancer detection or medical image analysis, random sampling is implemented to select a random subset of images from an extensive collection of histopathology images. This chosen subset serves various purposes, such as training a machine learning model, validating its performance, or conducting exploratory data analysis. The fundamental principle behind random sampling is to guarantee that the chosen subset is a representative sample of the entire dataset. This mitigates biases that might arise if only specific portions of the data were used, contributing to the creation of a diverse set of examples. Ultimately, this approach enhances the model's robustness and its ability to generalize effectively to unseen data in the domain of breast cancer detection or medical image analysis[5]. Mathematically, if you represent your dataset as $D = \{x_1, x_2, ..., x_N\}$, where x_i is an individual data point, and you randomly select indices $i_1, i_2, ..., i_n$, then your randomly sampled subset S would be $S = \{x_{i_1}, x_{i_2}, ..., x_{i_n}\}$.

Color Normalization through Reinhard's Method

Reinhard's Color Normalization is aTechnique for Consistent Histopathology Image Representation. Reinhard Color Normalization is implemented to standardize color variations, ensuring a uniform representation across histopathology images [20]. In this approach, the background color (and brightness) of the reference image is replaced with that of the color-normalized image. The mean and standard deviations of each color channel in both images are aligned through a linear transformation in the l $\alpha\beta$ color space. Additionally, an alternative global color normalization technique is chosen, involving the projection of the target image's mean color onto the source image. This technique guarantees the preservation of fluctuations in intensity from the source image. The resultant modified image closely mirrors the intended image, providing a processed picture with contrast matching the target image's contrast while preserving the structural characteristics of the original image. Despite these advantages, it's worth noting that stains in the l$\alpha\beta$ color space may not be evenly spaced.

Data Augmentation

By applying data augmentation to the original images, one can create new images with variations in appearance while retaining the same underlying concepts. This process helps enhance the model's robustness to various real-world conditions such as different lighting conditions, viewpoints, occlusions, and other environmental factors [7]. By exposing the model to a broader range of image variations during training, data augmentation can improve its

ability to generalize well and perform effectively when applied to unseen data in real-world scenarios. Elastic deformation is an effective augmentation method originally developed for image enhancement purposes. This technique involves generating a random displacement field, where the intensity is controlled by the elasticity coefficient σ and a scaling factor α. By applying this displacement field to the image, elastic deformation introduces realistic deformations that simulate the behavior of elastic materials. The following is a mathematical description of this deformation

$$I^{'}\big(x + \Delta x(x,y), y + \Delta y(x,y)\big) = I(x,y) \qquad (1)$$
$$\Delta x = G(\sigma) * \big(a \times Unif([-1,1,n,m])\big) \qquad (2)$$
$$\Delta y = G(\sigma) * \big(a \times Unif([-1,1,n,m])\big) \qquad (3)$$

In this method, Δx and Δy represent horizontal and vertical displacement grids of size n × m, respectively. $I^{\wedge'}$ and I denote the deformed and original images, respectively. The displacement values x and y are generated by convolving a Gaussian filter with a standard deviation of σ, applied to the product of a uniformly drawn value in the range [−1, 1] and α. This approach is particularly effective for capturing images of elastic objects, such as breast tissue, which may naturally undergo distortion due to factors like patient movement, breathing, or pressure from imaging devices. By simulating these deformations, the method can enhance the robustness of models trained on such images and improve their performance in real-world scenarios.

Noise Reduction through Median Filtering
Removing noise from input images is a fundamental step in image processing, crucial for improving the accuracy and reliability of subsequent analyses or visualizations. It's essential to apply noise reduction techniques while preserving the edges and details of the original image to achieve optimal results [16]. One widely used method for this purpose is median filtering. Median filtering is a common low-pass filtering technique used to remove noise while preserving image sharpness and clarity. Unlike traditional averaging filters, which calculate the output pixel value by averaging the intensities of neighboring pixels, median filtering replaces each pixel's value with the median value of the intensities within its local neighborhood. The size of the pixel neighborhood, also known as the filter size or kernel size, determines the extent of the median filtering effect. Larger filter sizes encompass more neighboring pixels, resulting in greater noise reduction but potentially causing blurring or loss of detail. Conversely, smaller filter sizes may preserve finer details but might not effectively suppress noise. One notable advantage of median filtering is its effectiveness in removing impulsive noise, such as salt-and-pepper noise, which can appear as random bright or dark pixels in the image. By replacing each pixel's value with the median value of its neighborhood, the median filter effectively eliminates these outliers without significantly affecting the underlying image structure. In practice, median filtering is applied as a preprocessing step to input images before further analysis or visualization. By replacing each pixel's value with the median value of its neighborhood, median filtering helps improve the image quality by reducing noise while maintaining important image features.

$$y_{(m,n)} = median\big(x_{i,j} : (i,j) \in \tau\big) \qquad (4)$$

Where τ represents the nearby neighbors in (m,n).

Segmentation through adaptive thresholding

Segmentation through adaptive thresholding is a technique used in image processing and computer vision to separate objects or regions of interest from the background in an image. Traditional thresholding methods use a fixed threshold value to binarise an image, where pixel values above the threshold are considered part of the object, and those below are considered part of the background. However, this approach may not be suitable for images with varying illumination conditions or uneven backgrounds. Adaptive thresholding addresses this limitation by dynamically adjusting the threshold value for each pixel based on its local neighborhood. This allows for more robust

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segmentation, particularly in images with non-uniform lighting or varying contrast.Here's how segmentation through adaptive thresholding typically works: 1) Local Thresholding: Instead of using a single global threshold for the entire image, adaptive thresholding divides the image into smaller regions or windows. For each pixel in the image, a threshold value is computed based on the intensity distribution within its local neighborhood. 2) Threshold Calculation: The threshold value for each pixel is computed based on statistics such as the mean or median intensity of its local neighborhood. This calculation can also take into account factors like standard deviation to adaptively adjust the threshold based on the local image characteristics. 3) Binarization: Once the threshold values are computed for all pixels, each pixel's intensity is compared to its corresponding threshold. Pixels with intensities above the threshold are classified as foreground (object), while those below are classified as background. 4) Output Image: The result of adaptive thresholding is a binary image, where foreground pixels represent the segmented objects or regions of interest, and background pixels represent the surrounding areas. Segmentation through adaptive thresholding is particularly useful in applications such as document processing, medical image analysis, and object detection, where accurate delineation of objects against complex backgrounds is critical [9]. By adapting the threshold locally, this technique can effectively handle variations in illumination and contrast, leading to more accurate segmentation results.

Feature Extraction

Feature extraction in image analysis is a pivotal process that entails condensing raw image data into a condensed and informative feature set. These features are meticulously crafted to accentuate particular patterns, structures, or attributes within the image, thus facilitating various tasks such as classification, object detection, or image retrieval. This study considered texture features and color histograms for the same. Texture features in image processing encompass attributes that delineate the visual patterns, structures, or surface properties exhibited by textures within an image. Texture analysis plays a pivotal role in tasks like image classification, segmentation, and recognition, as discerning the nuanced texture details can offer invaluable insights [21]. An array of techniques and methodologies are utilized to extract texture features from images. Some texture feature extraction techniques considered in this study are LGPT (Local Gradient Pattern), GLDS (Gray Level Difference Statistics), and LTP (Local Ternary Pattern). LGPT (Local Gradient Pattern): LGPT is a texture descriptor that captures information about the local gradients in an image. It considers the magnitudes and orientations of gradients to represent texture patterns. LGPT is particularly useful for tasks where gradient information plays a significant role, such as edge detection or texture discrimination. GLDS (Gray Level Difference Statistics): GLDS is a set of statistical measures calculated based on the differences between neighboring pixel intensities in an image. It provides a way to quantify the variations in gray levels. GLDS can be employed for texture analysis, particularly in scenarios where the distribution of intensity differences is informative about the texture properties. LTP (Local Ternary Pattern): LTP is a texture descriptor that encodes information about local variations in pixel intensities. It categorizes each pixel based on whether its intensity is greater, equal to, or less than the average intensity of its neighbors. LTP is commonly used for texture classification tasks, especially when distinguishing between different types of textures based on local intensity patterns.

These techniques are part of the broader field of local texture analysis, where the focus is on capturing information within local neighborhoods of pixels in an image. Such techniques are beneficial for tasks like image classification, object recognition, and segmentation, where understanding the local texture patterns is crucial.

Feature Selection

Feature selection methods aim to choose a subset of relevant features from a larger set, improving the efficiency and effectiveness of machine learning models. This study considered Variance thresholding as a feature selection technique. Variance thresholding is a feature selection technique that involves removing features with low variance. The idea behind variance thresholding is that features with little variation in their values across samples may not provide much information for predictive modeling. Therefore, by setting a threshold on the variance, you can eliminate features with insufficient variability [22].

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Here's how variance thresholding for feature selection typically works: 1) Calculate Variance: For each feature in the dataset, calculate its variance across all samples. Variance measures the spread or variability of values within a feature. Features with low variance have values that are close to each other, indicating little variation. 2) Set Threshold: Determine a threshold value for variance below which features will be considered low-variance and thus candidates for removal. This threshold can be chosen empirically based on domain knowledge or through experimentation. 3) Filter Features: Remove features from the dataset that have variance below the threshold. These low-variance features are deemed less informative and are unlikely to contribute significantly to the predictive power of a model. 4) Retain Informative Features: Keep the remaining features in the dataset, which have variance above the threshold. These features are expected to exhibit greater variability across samples and are more likely to contain useful information for building predictive models.

PreNet based detection

A comprehensive deep learning-based detection model integrating ImageNet, with customized CNN for capturing diverse features and temporal dependencies. ImageNet has played a crucial role in the advancement of image classification and object recognition [23]. Many deep learning models, especially convolutional neural networks (CNNs), have been pre-trained on ImageNet. These pre-trained models serve as powerful feature extractors and can be fine-tuned for specific tasks, allowing developers to leverage the knowledge gained from ImageNet for a variety of computer vision applications. The sequential model which constructs the PreNet for this study has incorporated the concept of ImageNet along with customized CNN. The architecture of customized CNN is named as BIA-CNN (Breast Image Analysis- CNN) which is show in Figure: 2 [24] [25] [26]. CNNs consist of multiple layers arranged in a hierarchical manner. The typical layers include: Convolutional Layers, Pooling Layers, Fully Connected Layers (also known as Dense Layers). Below is the explanation of each layer of CNN in details.

Input Layer

The input layer represents the raw input data, typically images in the case of computer vision tasks. Let's denote the input image as X, where X is a 3D array representing the image with dimensions (height, width, channels). For example, an RGB image would have 3 channels (Red, Green, Blue), hence   X can be represented as $X \in R\_{(H \times W \times C)}$, where H is the height, W is the width, and C is the number of channels.

Convolutional Layers

The core building blocks of CNNs are convolutional layers. These layers apply convolution operations to input data. Convolution involves passing a filter (also called a kernel) over the input data to extract features. The filter slides over the input, performing element-wise multiplication and summing up the results. This operation helps in capturing features like edges, textures, and patterns from the input images. Let's denote the output of the previous layer (input image or feature maps from a previous layer) as $A^{(l-1)}$. Convolution operation involves applying a filter $W^{(l)}$ (also called a kernel) to the input feature maps $A^{(l-1)}$. The output feature map $Z^{(l)}$ is obtained by convolving the filter over the input feature map using element-wise multiplication and summing up the results along with the bias term $b^{(l)}$ and applying an activation function f.

Mathematically,

$$Z_{i,j,k}^{(l)} = f\left(\sum_{c=1}^{C^{(l-1)}} \sum_{p=0}^{F-1} \sum_{q=0}^{F-1} W_{p,q,c,k}^{(l)} \cdot A_{i+p,j+q,c}^{(l-1)} + b_k^{(l)}\right) \qquad (5)$$

F is the filter size (both width and height), $C^{(l-1)}$ is the number of channels in the previous layer, i and j iterate over the spatial dimensions of the output feature map, and k iterates over the channels of the current layer.

Activation Function: After computing the convolution operation, an activation function is applied element-wise to the output feature map. The most commonly used activation function is the Rectified Linear Unit (ReLU), defined as:

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$f(x)=\max(0,x)$ (6)

ReLU introduces non-linearity into the network and helps in capturing complex patterns in the data.

Pooling Layer: Pooling layers are interspersed between convolutional layers to reduce the spatial dimensions of the feature maps. Max pooling is a common pooling operation, where the maximum value within a certain region (e.g., 2x2 or 3x3) is retained. Let's denote the output of the previous layer as $A^{(l-1)}$, and the pooled feature map as $P^{(l)}$.

Mathematically (for max pooling):

$P^{(l)}_{i,j,k} = \max_{m,n} A^{(l-1)}_{2i+m,2j+n,k}$ (7)

(2i,2j) are the starting coordinates of each pooling region, and (m,n) iterate over the region.

Fully Connected Layer: After several convolutional and pooling layers, fully connected layers are used for making final predictions. The output of the last pooling layer is flattened into a vector and fed into the fully connected layer. Let's denote the flattened output as $F^{(l)}$ and the output of the fully connected layer as $O^{(l)}$.

Mathematically,

$O^{(l)} = f(W^{(l)} \cdot F^{(l-1)} + b^{(l)})$ (8)

$W^{(l)}$ is the weight matrix, $b^{(l)}$ is the bias vector, and f is the activation function (e.g., ReLU or softmax).

Dataset Description
As this is an eye catching application of AI, the varieties of datasets have been utilized in various study. The dataset used for this study is taken from kaggle database, which is widely utilized in study now a days. The dataset is comprised of 277,524 histopathology patches derived from 162 whole mount slide images of Breast Cancer specimens, captured at a magnification of 40x. Each patch is a 50 x 50 pixel image and is annotated based on the presence or absence of Invasive Ductal Carcinoma (IDC). Among these patches, 198,738 are categorized as IDC negative (Class 0), indicating the absence of IDC, while 78,786 patches are labeled as IDC positive (Class 1), signifying the presence of IDC. The patches are named using the convention u_xX_yY_classC.png, where: 'u' represents the patient ID. 'X' and 'Y' denote the x and y-coordinates of the patch's cropping location. 'C' indicates the class, where 0 corresponds to non-IDC and 1 corresponds to IDC. This nomenclature allows for easy identification and organization of the patches within the dataset.

This dataset is particularly valuable for tasks such as automatic grading and the development of machine learning models for the detection of IDC in breast cancer histopathology images. Pathologists typically concentrate on IDC regions for aggressiveness grading, underscoring the clinical relevance and significance of this dataset in advancing research and diagnostic capabilities in the field of breast cancer pathology [10].

RESULT AND DISCUSSION

In this section, the outcomes of the proposed model are juxtaposed with existing approaches. The input images are sourced from the Breast Histopathology Images dataset [27]. The implementation is conducted utilizing the Python programming platform. The dataset is partitioned such that thirty percent of the data is allocated for testing and validation, while the remaining seventy percent is earmarked for training. The model undergoes training exclusively on one subset, and its generalizability is subsequently assessed by evaluating its performance on the other subset. This division ensures a robust evaluation of the model's effectiveness and adaptability to unseen data.

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In terms of performance evaluation, this study employs widely recognized metrics such as Accuracy (Acc), Sensitivity (Sn), Specificity (Sp), and Area Under the Curve (AUC) [28]. Accuracy (Acc) quantifies the percentage of samples accurately classified out of the total samples. Sensitivity (Sn) corresponds to the true positive rate, measuring the percentage of correctly classified abnormal samples. Specificity (Sp) represents the true negative rate, indicating the percentage of correctly classified normal samples. Area Under the Curve (AUC) is a prevalent metric used for model evaluation, particularly in scenarios where distinguishing between optimal and suboptimal models is crucial. The formulas for Accuracy (Acc), Sensitivity (Sn), and Specificity (Sp) are provided below [29]:

$$Acc = (TP + TN) /(TP + TN + FP + FN) \qquad (9)$$
$$Sn = (TP)/(TP + FN) \qquad (10)$$
$$Sp = (TN)/(TN + FP) \qquad (11)$$

Where TP: true positive, TN: true negative, FP: false positive, FN: false negative.

A Comparative Analysis: Evaluating the Proposed Breast Cancer Detection Model against Literature-Reviewed Approaches

This section depicts comparative analysis of proposed model and models considered in the studies presented in literature survey of this research study. The proposed PreNet model is contrasted with other currently employed models in considered articles, such as AlexNet CNN [30], DenseNet based sequential CNN model [6], Varieties of DCNN [7], a convolutional-long short-term memory (CNN-LSTM) learning model [8], Integrated feature extraction along with SVM classifier [31], Deep CNN [10], CNN-based hierarchical classifier [3]. Table 1 reflects the comparative analysis.

Here in the Table 1 it appears the description of a machine learning experiment comparing various techniques for a data classification task. The description includes information about evaluated metrics like accuracy, specificity and sensitivity to showcase the performance of different machine learning techniques [7] [32].

Among the various techniques assessed, the 'Proposed' method stands out with remarkable performance, consistently outperforming alternative approaches like AlexNet CNN, DenseNet based CNN, Varieties of DCNN, CNN-LSTM, SVM, Deep CNN and CNN-based hierarchical classifier across nearly all metrics [31] [33] [34]. Noteworthy is the 'Proposed' technique's outstanding accuracy at 96.13%, underscoring its proficiency in overall classification and precise identification of positive instances.

Accuracy
In the realm of machine learning algorithms, accuracy stands as a foundational metric for evaluating a model's performance in classification tasks. It quantifies the ratio of correctly predicted instances to the total number of instances within the dataset. The accuracy score offers a broad perspective on the model's capability to accurately assign instances to their respective classes. The following chart depicts comparison of proposed and reviewed methods with respect to Accuracy.

Specificity
Specificity refers to the extent to which a test accurately identifies individuals without a particular condition or disease. In medical diagnostics, specificity measures the ability of a test to correctly identify those who do not have a certain disease or condition among individuals who do not have the disease. It is essentially the proportion of true negative results among all individuals who do not have the disease. In the context of breast image analysis, specificity remains a crucial measure but is often applied to the performance of diagnostic tests or imaging techniques rather than traditional medical tests. Specifically, it assesses the ability of a breast imaging method to correctly identify images without evidence of a particular condition, such as breast cancer. The following chart depicts comparison of proposed and reviewed methods with respect to Specificity.

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Sensitivity

Sensitivity, in the context of medical testing or diagnostic imaging, refers to the ability of a test or imaging method to correctly identify individuals who have a particular condition or disease. It is also known as the true positive rate or the recall. Sensitivity is a measure of how well a test can identify all the actual positive cases, minimizing false negatives. The following chart depicts comparison of proposed and reviewed methods with respect to Sensitivity.

A Comparative Analysis: Evaluating the Proposed Breast Cancer Detection Model with respect to different batch sizes

The comparative analysis of a proposed breast cancer detection model with respect to different batch sizes can be explained and understood through the lens of optimization and training dynamics in machine learning. Several theories and concepts in machine learning and deep learning can contribute to explaining the observed behavior [35] [36]. The choice of batch size is closely tied to the optimization algorithm being used. The batch size can affect the generalization capability of the model. Small batch sizes might introduce more noise into the training process, potentially leading to overfitting, while large batch sizes may result in a less noisy but less accurate gradient estimation. The study may investigate how different batch sizes impact the model's ability to generalize to unseen data. Larger batch sizes can lead to more efficient parallelization and GPU utilization, but they may come with trade-offs in terms of model performance. In brief, the choice of batch size is a critical hyper parameter that can significantly influence the training dynamics and performance of a deep learning model. Analyzing the proposed breast cancer detection model with respect to different batch sizes involves considering the interplay of optimization algorithms, learning rates, generalization, computational efficiency, and statistical efficiency. The following is the graphical presentations of outputs with respect to various batch sizes along with 60 epochs.

Graphical representation of proposed model's outputs with 60 epochs and 25 batch size.

From the figures 6 to 16, It can be noted that the choice of batch size has a noticeable impact on the performance metrics of the model. Specifically, when the batch size is set to 25, the model achieves a loss of 0.1798 and an accuracy of 0.9584. Increasing the batch size to 35 results in improved performance, with a lower loss of 0.1761 and a higher accuracy of 0.9613. However, using a batch size of 50 leads to a slightly higher loss of 0.1835 and a lower accuracy of 0.9579. Upon closer examination, it is evident that the combination of a batch size of 35 and an epoch value of 60 yields the optimal results. This configuration produces the highest accuracy of 0.9613 with a relatively low loss of 0.1761. Therefore, it can be concluded that, for this specific model and dataset, a batch size of 35 and 60 epochs provide the best balance between accuracy and loss.

CONCLUSION

In conclusion, this study presents a comprehensive and integrated methodology for breast cancer detection in histopathology images, incorporating various stages such as pre-processing, segmentation, feature extraction, and deep learning-based detection. The pre-processing phase employs techniques like random sampling, Reinhard Colour Normalization, data augmentation through elastic transformations, and median filtering, aiming at consistent color representation, focused region analysis, dataset augmentation, and noise reduction. The segmentation process utilizes adaptive thresholding for region identification. Feature extraction encompasses a diverse set of features, including deep learning-based, texture, color, and shape features, with the Variance Thresholding Algorithm aiding in effective feature selection.The PreNet detection model, a fusion of ImageNet architecture and a customized CNN, is a key component of this methodology. The overall objective is to advance breast cancer detection by leveraging state-of-the-art techniques, ultimately contributing to heightened diagnostic accuracy and interpretability in histopathology analysis. This holistic approach underscores the potential impact of combining advanced image processing and deep learning methods to improve the efficiency and effectiveness of breast cancer diagnosis.

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Table 1: Comparison of performance metrics for reviewed models with proposed model

Technique	Accuracy	Specificity	Sensitivity
Proposed	0.9613	0.9701	0.9859
AlexNet CNN [5]	0.90	0.9144	0.9112
DenseNet based CNN [6]	0.9471	0.9489	0.9403
Varieties of DCNN[7]	0.90	0.96	0.86
CNN-LSTM[8]	0.94	0.9434	0.92941
SVM [31]	0.92105	0.94286	0.86047
Deep CNN [10] (mammogram dataset)	0.9068	0.9272	0.8821
CNN-based hierarchical classifier [3]	0.95775	0.94231	0.95833

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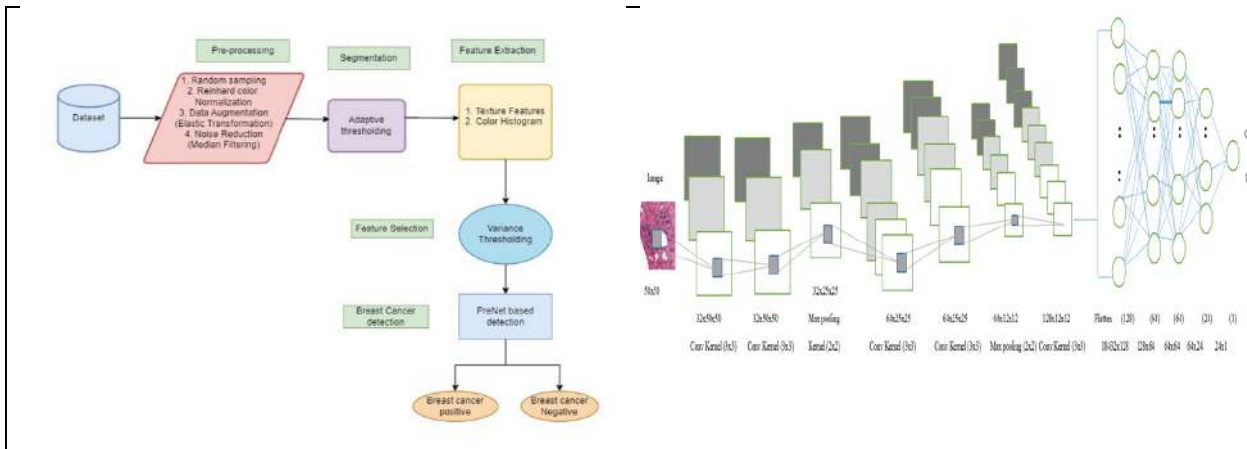
Figure 1: Block Diagram of the proposed PreNet Model	**Figure 2: BIA-CNN (Breast Image Analysis- CNN) [Customized CNN]**
Figure 3: Accuracy Comparison of proposed method with existing methods	**Figure 4: Specificity Comparison of proposed method with existing methods**
Figure 5: Sensitivity Comparison of proposed method with existing methods	**Figure 6: Proposed Model's Accuracy graph for batch size 25**
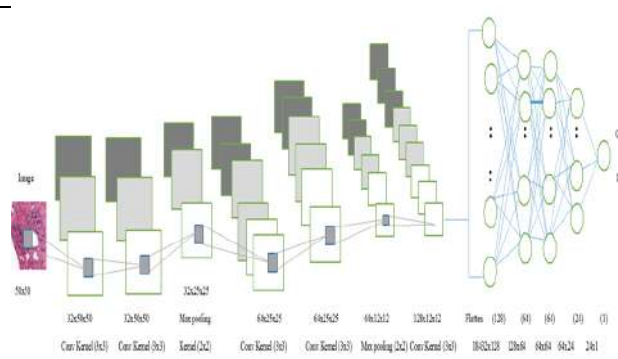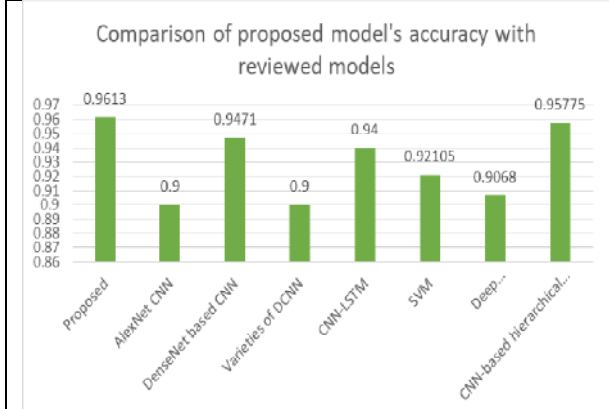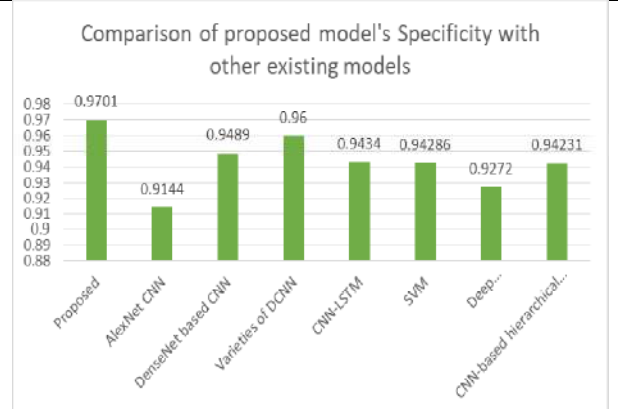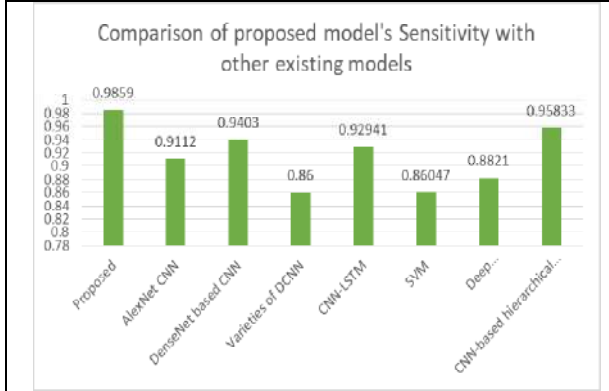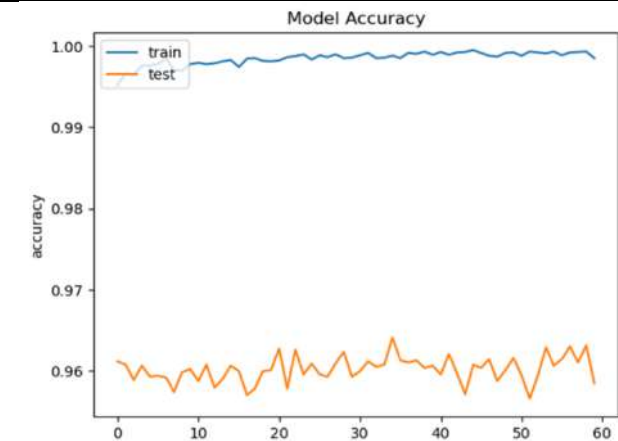
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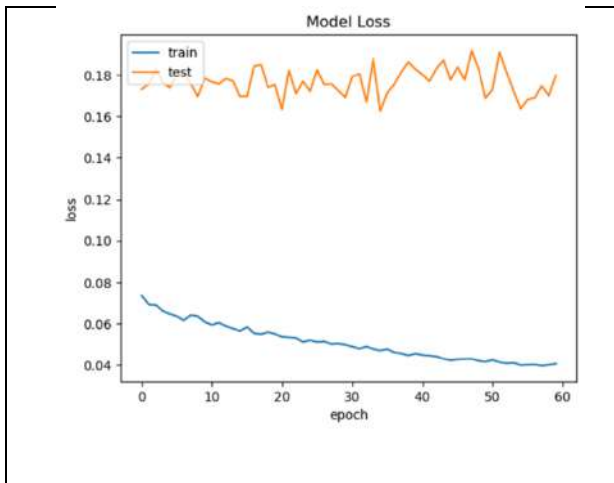
Figure 7: Proposed Model's loss graph for batch size 25	**Figure 8: Confusion Matrix for batch size 25**
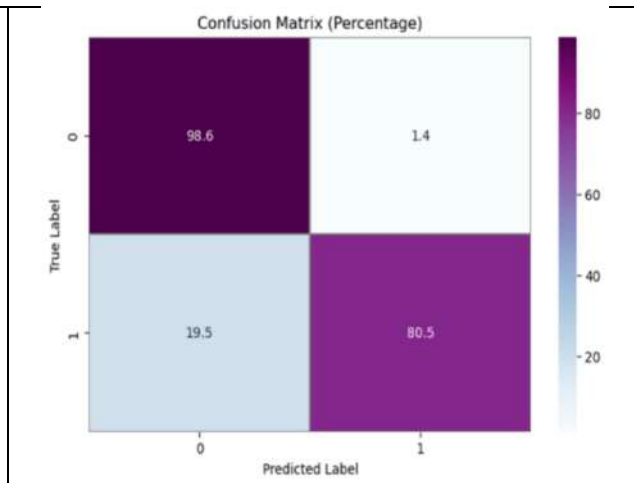
Graphical representation of proposed model's outputs with 60 epochs and 35 batch size.
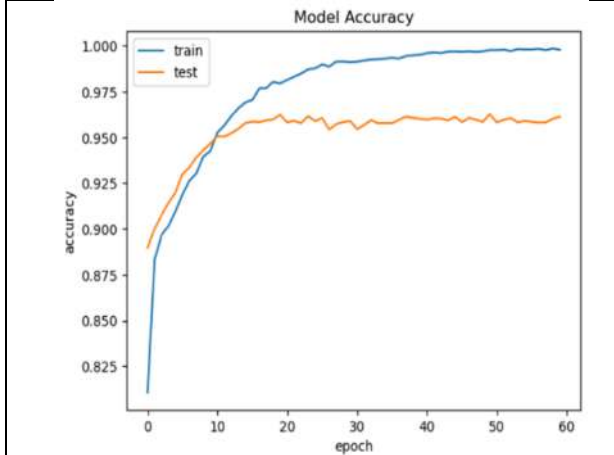
Figure 9: Proposed Model's Accuracy graph for batch size 35	**Figure 10: Proposed Model's loss graph for batch size 35**
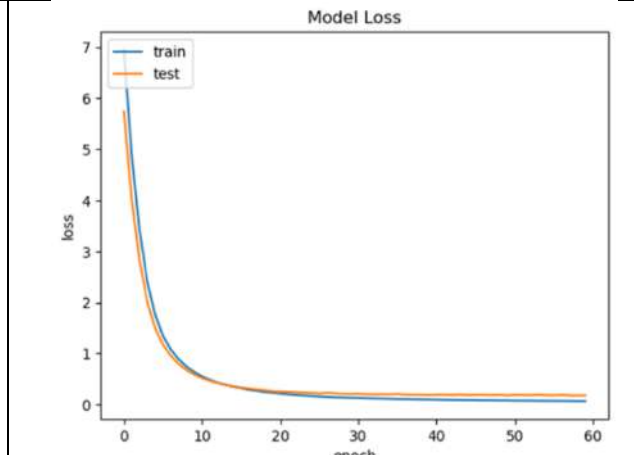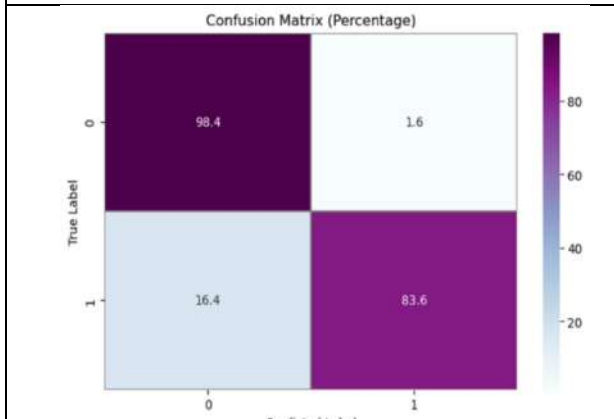
Figure 11: Confusion Matrix for batch size 35	**Figure 12: Proposed Model's Accuracy graph for batch size 50**
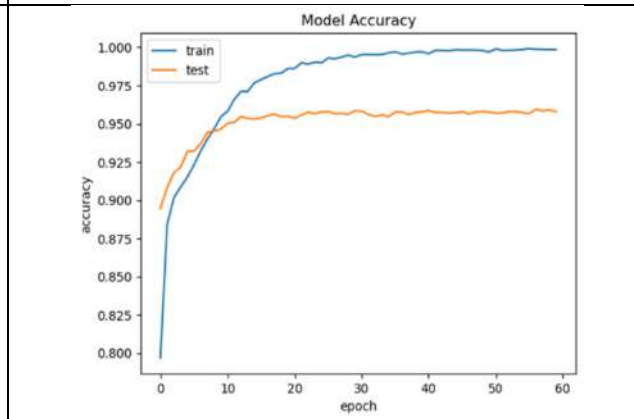
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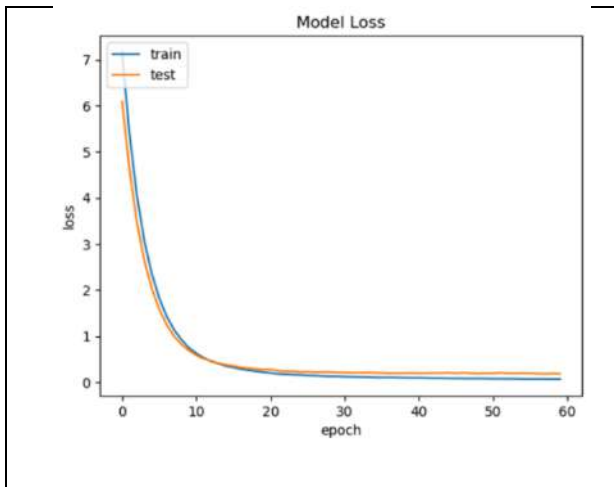
Figure 13: Proposed Model's loss graph for batch size 50	Figure 14: Confusion Matrix for batch size 50
Figure 15: Graphical presentation of Proposed model's Loss with respect to Batch size	**Figure 16: Graphical presentation of Proposed model's Accuracy with respect to Batch size**
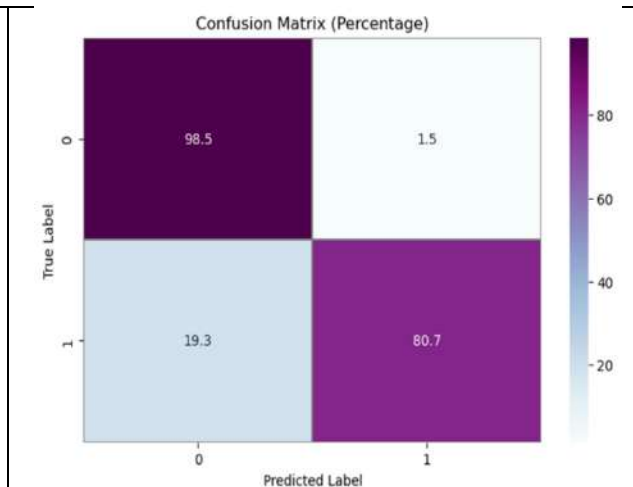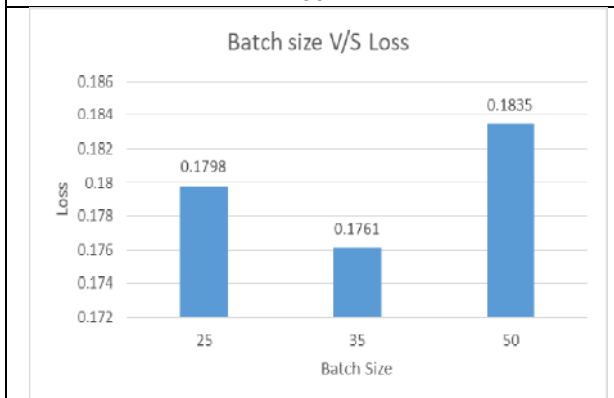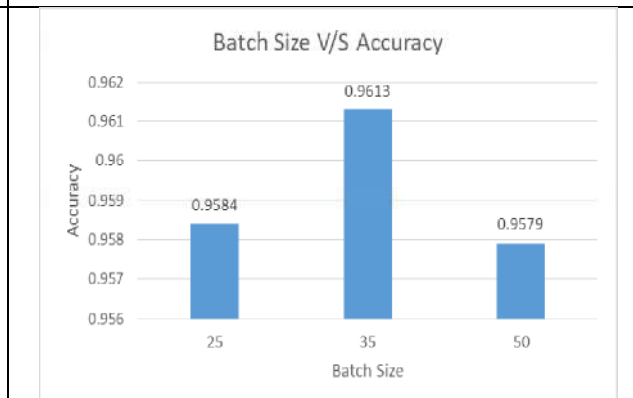
RESEARCH ARTICLE

Characterization of k–Centrosymmetric 2× 2 Neutrosophic Fuzzy Matrices

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ABSTRACT

A method for finding the generalized inverse of Centrosymmetric and k– Centrosymmetric Neutrosophic Fuzzy Matrices is provided in this paper. We discussed various g-inverse associated with a regular Neutrosophic Fuzzy Matrices and obtain characterization of set of all inverses by using Centrosymmetric and k–Centrosymmetric Neutrosophic Fuzzy Matrices. We proved sum, product and scalar multiplication oftwo Centrosymmetric Neutrosophic Fuzzy Matrices is again a Centrosymmetric Neutrosophic Fuzzy Matrices and also focusing on the fundamental principles and theorems of Centrosymmetric and k- Centrosymmetric Neutrosophic Fuzzy Matrices, as well as examples.

Keywords: Centrosymmetric NFM,k- Centrosymmetric NFM, Generalized inverse.

INTRODUCTION

Zadeh [1] first introduced fuzzy sets (FSs) in 1965. These are traditionally defined by their membership value or grade of membership. Assigning membership values to a fuzzy set can sometimes be challenging. Atanassov [2] introduced intuitionistic FSs to solve the problem of assigning non-membership values. Smarandache [3] introduced the concept of neutrosophic sets (NSs) to handle indeterminate information and deal with problems that involve imprecision, uncertainty, and inconsistency. Fuzzy matrices are used to solve certain kinds of issues. Many researchers have since completed numerous works. Only membership values are addressed by fuzzy matrices. These matrices cannot handle values that are not membership. The generalized inverse (g -inverse) deals withmatrix inverse generalization for both singular and non-square matrices Kim and Roush [8] have discussed Generalized fuzzy matrices. Pradhan and Pal [10] have studied The Generalized Inverse of Atanassov's IFM. Pradhan and Pal [11] have studied Some results on Generalized Inverse of IFM. The generalized inverse of matrices is applicable in many field, likely power, robotics, image processing and signal processing. Ann Lec [1] has introduced Secondary symmetric and skew symmetric secondary orthogonal matrices. Cantoni and Butler [2] have studied Eigenvalues and eigenvectors of symmetric centrosymmetric matrices. James Weaver [7] has discussed Centrosymmetric matrices their basic properties eigenvalues and eigenvectors. Punithavall [12] has studied Symmetric-Centro Symmetric Fuzzy Matrices. Elumalai and Rajesh kannan [3] have focused on k - Symmetric Circulant, s - Symmetric Circulant and s – k Symmetric Circulant Matrices. Elumalai and Arthi [4] have studied Properties of k - CentroSymmetric and k – Skew CentroSymmetric Matrices. Gunasekaran Mohana [5] have studied k-symmetric Double stochastic, s-symmetric Double stochastic , s-k-symmetric Double stochastic Matrices. Hazewinkel and Michiel [6] have focused on Symmetric matrix. Meenakshi [9] has studied Fuzzy Matrix: Theory and Applications. Anandhkumar [13,14] has studied Pseudo Similarity of NFM, On various Inverse of NFM and Reverse Sharp And Left-T Right-T Partial Ordering On NFM .Aim of this paper is to describe generalized inverse of Centrosymmetric, k– Centrosymmetric Neutrosophic Fuzzy Matrices and to discuss some basic principles and theorems of Centrosymmetric and k-Centrosymmetric matrices, as well as examples .

RESEARCH GAP

Punithavalli presented the concept of Centrosymmetric and K–Centrosymmetric Fuzzy Matrices. Here, we have applied the concept ofCentrosymmetric and K–Centrosymmetric 2×2 Neutrosophic FuzzyMatrices .We have examined some of the results and extended both concepts to NFMs. We discussed various g-inverse associated with a regular matrices and obtain characterization of set of all inverses by usingCentrosymmetric and K–Centrosymmetric NFM.

Preliminaries and notations

P^T is the Transpose of P if P is a Centrosymmetric NFM. Let k denote a fixed distinct transposition product in $S_n$and Krepresent the permutationNFM. Clearly K meets characteristics like K^T =K and K^2=I.

DEFINITIONS AND THEOREMS

Definition:1.1 Centrosymmetric NFM(CSNFM):A Square NFM which is symmetric about the centre of its array of elements is called CS,thus P= [p_{ij}]CS if p_{ij} = $p_{n-i+1,n-j+1}$.If K denotes the n×n IFM with <1,1,0> on the counterdiagonal and <0,0,1> everywhere else (i.e. $K_{i,n+1-i} = <1,1,0>;\quad K_{i,j} = <0,0,1>$ if $j \neq n+1-i$),then Pis CSNFM iff PK = KP.

Example:1 Let us consider the IFM

$$P = \begin{bmatrix} <0.7,0.2,0.4> & <0.4,0.2,0.3> \\ <0.4,0.2,0.3> & <0.7,0.2,0.4> \end{bmatrix} \text{and } K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$$

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Then $PK = \begin{bmatrix} <0.4,0.8,0.3> & <0.7,0.8,0.4> \\ <0.7,0.8,0.4> & <0.4,0.8,0.3> \end{bmatrix}, KA = \begin{bmatrix} <0.4,0.8,0.3> & <0.7,0.8,0.4> \\ <0.7,0.8,0.4> & <0.4,0.8,0.3> \end{bmatrix}.$

Definition: 1.2 If P Centrosymmetric Neutrosophic Fuzzy matrices (NFM) $P \in (NFM)_n$ is called k-Centosymmetric NFM if P = KP^{T}K

Definition 1.3 Suppose p and q are two NFM elements $p = <p_{ij\alpha}, p_{ij\beta}, p_{ij\gamma}>, q = <q_{ij\alpha}, q_{ij\beta}, q_{ij\gamma}>,$ are component wise addition and multiplication are described as,

$p + q = <\max \left\{ p_{ij\alpha}, q_{ij\alpha} \right\}, \max \left\{ p_{ij\beta}, q_{ij\beta} \right\}, \min \left\{ p_{ij\gamma}, q_{ij\gamma} \right\}>$

and $p.q = <\min \left\{ p_{ij\alpha}, q_{ij\alpha} \right\}, \min \left\{ 1 - p_{ij\beta}, 1 - q_{ij\beta} \right\}, \max \left\{ p_{ij\gamma}, q_{ij\gamma} \right\}>$

Definition1.4 (Transpose) The transpose P^T of an NFM $P = \left[p_{ij} \right]_{m \times n}$ is defined as $P^T = \left[p_{ji} \right]_{n \times m}$ where

$p_{ji} = <p_{ji\alpha}, p_{ji\beta}, p_{ji\gamma}>.$

Definition 1.5 (IFPM) If each row and each column contains accurately one <1,1,0> and all other entries are <0,0,1> in a square NFM, it is known as Neutrosophic Fuzzy permutation matrix .

Definition 1.6 A basis D of an Neutrosophic fuzzy vector space W is standard basis iff whenever $d_i = \sum_{j=1}^{n} a_{ij} d_j$ for

$d_i, d_j \in D$ and $a_{ij} \in [0,1]$ then $a_{ij} d_i = d_i$

Generalized Inverse
This section shows the g-inverse of an NFM. We also described a method for finding the g-inverse of a Centrosymmetric and k– Centrosymmetric NFMs.

Definition:2.1 For NFM P∈(NFM)ₘₓₙand another NFM K ∈(NFM)ₙₓₘ satisfies the given equation
1.   PKP = P   (g-inverse)
2.   KPK = K (2-inverse)
3.   (PK)^T =PK, (Least square g- inverse of P or P{1,3} inverses)
4.   (KP)^T =KP, (P{1,4} inverses).

Theorem:1 Let P be a Centrosymmetric NFM with a standard basis of non-zero rows. If P satisfies the equation PKP = P with the maximum and minimum process for some NFPMK, then K is a generalized inverse of P.

Proof: A standard basis is formed by the non-zero rows of an NFM P.
If KP = Z, Therefore the rows of Z and the rows of P rearranged.
Then Z is an idempotent NFM,
i.e., Z= Z², with the similar row space as P and non-zero rows forming a standard basis as well. Therefore the standard basis is unique,
$\Rightarrow$P = ZK, where K is permutation matrix.
Therefore,
PK^T P= ZKK^{T}ZK
= ZZK   (KK^T=I)
=ZK
=P
PKP=P (K^T=K)

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Therefore ,K is 2-inverse.

Example:2 Consider the NFM, $P = \begin{bmatrix} <0.6,0.2,0.4> & <0.8,0.2,0.3> \\ <0.8,0.2,0.3> & <0.6,0.2,0.4> \end{bmatrix}$, $K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$

$$KP = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}\begin{bmatrix} <0.6,0.2,0.4> & <0.8,0.2,0.3> \\ <0.8,0.2,0.3> & <0.6,0.2,0.4> \end{bmatrix} = \begin{bmatrix} <0.8,0.8,0.3> & <0.6,0.8,0.4> \\ <0.6,0.8,0.4> & <0.8,0.8,0.3> \end{bmatrix}$$

$$PKP = \begin{bmatrix} <0.6,0.2,0.4> & <0.8,0.2,0.3> \\ <0.8,0.2,0.3> & <0.6,0.2,0.4> \end{bmatrix}\begin{bmatrix} <0.8,0.8,0.3> & <0.6,0.8,0.4> \\ <0.6,0.8,0.4> & <0.8,0.8,0.3> \end{bmatrix}$$

$$PKP = \begin{bmatrix} <0.6,0.2,0.4> & <0.8,0.2,0.3> \\ <0.8,0.2,0.3> & <0.6,0.2,0.4> \end{bmatrix}$$

Theorem:2 For Centrosymmetric NFM $Q \in F_n$, if Q^+ exists $\Leftrightarrow (KQ)^+$ exists.

Proof : For Centrosymmetric NFM $Q \in F_n$, if Q^+ exits then $Q^+ = Q^T$

$\Rightarrow Q^T$ is a generalized inverse of Q , then $QQ^TQ = Q \Rightarrow Q^TQQ^T = Q^T$

Therefore , Q^T is a {2} inverse of Q.
Since both QQ^T and Q^TQ are symmetric.

Hence $Q^+ = Q^T$

Q^+ exists $\Leftrightarrow QQ^TQ = Q$

Q^+ exists $\Leftrightarrow KQQ^TQ = KQ$

Q^+ exists $\Leftrightarrow (KQ)(KQ)^T(KQ) = KQ$ where $K^2 = I$

Q^+ exists $\Leftrightarrow (KQ) \in (KQ)\{1\}$

$\Leftrightarrow (KQ)^+$ exists

Example:3 Consider the IFM , $Q = \begin{bmatrix} <0.8,0.2,0.4> & <0.6,0.3,0.4> \\ <0.6,0.3,0.4> & <0.8,0.2,0.4> \end{bmatrix}$, $K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$

Theorem:3 If $P \in (NFM)_n$ is k-Centrosymmetric NFM, then K is a least square g- inverse of P.

Proof : It is enough to show
1.   PKP = P
2. $(PK)^T = PK$
By theorem (1) ,(i) is easily verified
Let $P \in (NFM)_n$ is K-centrosymmetric NFM

$P = KP^TK$
$PK = KP^TK.K$
$PK = KP^TK^2$ $(K^2 = I)$
$PK = KP^TI = KP^T$
$(PK)^T = K^TP^T = KP^T$ $(K^T = K)$
$(PK)^T = KP^T$
Therefore, $(PK)^T = PK$

Example:4 Let us consider the NFM, $P = \begin{bmatrix} <0.8,0.1,0.4> & <0.6,0.3,0.4> \\ <0.6,0.3,0.4> & <0.8,0.1,0.4> \end{bmatrix}$

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$$,K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$$

$$PK = \begin{bmatrix} <0.8,0.1,0.4> & <0.6,0.3,0.4> \\ <0.6,0.3,0.4> & <0.8,0.1,0.4> \end{bmatrix}\begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix} = \begin{bmatrix} <0.6,0.9,0.4> & <0.8,0.7,0.4> \\ <0.8,0.7,0.4> & <0.6,0.9,0.4> \end{bmatrix}$$

$$(PK)^T = \begin{bmatrix} <0.6,0.9,0.4> & <0.8,0.7,0.4> \\ <0.8,0.7,0.4> & <0.6,0.9,0.4> \end{bmatrix}$$

Theorem:4 If $P \in (NFM)_n$ is k-Centrosymmetric NFM, then K is a {1,4} generalized inverse of P.

Proof : It is enough to show

1.   PKP = P
2. $(KP)^T = KP$

By theorem (1) ,(i) is easily verified

Let $P \in (NFM)_n$ is K-Centrosymmetric matrix

P=KP^{T}K

K = K.KP^{T}K

KP = K^2 P^{T}K (K^2=I)

KP = IP^{T}K=P^{T}K

$(KP)^T$ = P^{T}K^T=P^{T}K   (K^T=K)

$(KP)^T$=P^{T}K

Therefore,$(KP)^T$=KP

Example:5 Consider the IFM, $P = \begin{bmatrix} <0.5,0.1,0.2> & <0.4,0.1,0.7> \\ <0.4,0.1,0.7> & <0.5,0.1,0.2> \end{bmatrix}, K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$

Centrosymmetric Neutrosophic Fuzzy Matrix

This part, depicts the Centrosymmetric of an NFM.

Lemma: 1 If P and Q are Centrosymmetric NFM over a field F, then P + Q, PQ, and cP are Centrosymmetric NFM for all c in F.

Proof: By using definition:1

Example:6 Consider   the   NFM $P = \begin{bmatrix} <0.6,0.2,0.4> & <0.8,0.2,0.3> \\ <0.8,0.2,0.3> & <0.6,0.2,0.4> \end{bmatrix}$

$$,Q = \begin{bmatrix} <0.8,0.8,0.3> & <0.6,0.8,0.4> \\ <0.6,0.8,0.4> & <0.8,0.8,0.3> \end{bmatrix}$$

$$P+Q = \begin{bmatrix} <0.6,0.2,0.4> & <0.8,0.2,0.3> \\ <0.8,0.2,0.3> & <0.6,0.2,0.4> \end{bmatrix} + \begin{bmatrix} <0.8,0.8,0.3> & <0.6,0.8,0.4> \\ <0.6,0.8,0.4> & <0.8,0.8,0.3> \end{bmatrix}$$

$$= \begin{bmatrix} <0.8,0.8,0.3> & <0.8,0.8,0.3> \\ <0.8,0.8,0.3> & <0.8,0.8,0.3> \end{bmatrix}$$

Therefore ,P+Q is centrosymmentric

$$PQ = \begin{bmatrix} <0.6,0.2,0.4> & <0.8,0.2,0.3> \\ <0.8,0.2,0.3> & <0.6,0.2,0.4> \end{bmatrix}\begin{bmatrix} <0.8,0.8,0.3> & <0.6,0.8,0.4> \\ <0.6,0.8,0.4> & <0.8,0.8,0.3> \end{bmatrix}$$

$$PQ = \begin{bmatrix} <0.6, 0.2, 0.4> & <0.8, 0.2, 0.3> \\ <0.8, 0.2, 0.3> & <0.6, 0.2, 0.4> \end{bmatrix}$$

Therefore, PQ is centrosymmentric

$$cA = <0,0,1> \begin{bmatrix} <0.7, 0.2, 0.3> & <0.4, 0.6, 0.5> \\ <0.4, 0.6, 0.5> & <0.7, 0.2, 0.3> \end{bmatrix} = \begin{bmatrix} <0, 0.8, 1> & <0, 0.4, 1> \\ <0, 0.4, 1> & <0, 0.8, 1> \end{bmatrix}$$

Therefore ,cP is centrosymmentric

K-Centrosymmetric Neutrosophic Fuzzy Matrix
This part, depicts the K- Centrosymmetric matrices of an NFM.

Theorem: 5 Let $P \in (NFM)_n$ is k-Centrosymmetric NFM then $P^T = KPK$.

Proof: Let $P \in (NFM)_n$ is k-Centrosymmetric NFM

K PK = KP^TK where $P = P^T$
= P^TKK where $KP^T = P^TK$
= $P^TK^2 = P^T$

Example:7 Consider the IFM $P = \begin{bmatrix} <0.7, 0.2, 0.4> & <0.4, 0.2, 0.5> \\ <0.4, 0.2, 0.5> & <0.7, 0.2, 0.4> \end{bmatrix}$, $K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$

$$AK = \begin{bmatrix} <0.7, 0.2, 0.4> & <0.4, 0.2, 0.5> \\ <0.4, 0.2, 0.5> & <0.7, 0.2, 0.4> \end{bmatrix}\begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix} = \begin{bmatrix} <0.4, 0.8, 0.5> & <0.7, 0.8, 0.4> \\ <0.7, 0.8, 0.4> & <0.4, 0.8, 0.5> \end{bmatrix}$$

$$KAK = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}\begin{bmatrix} <0.4, 0.8, 0.5> & <0.7, 0.8, 0.4> \\ <0.7, 0.8, 0.4> & <0.4, 0.8, 0.5> \end{bmatrix} = \begin{bmatrix} <0.7, 0.2, 0.4> & <0.4, 0.2, 0.5> \\ <0.4, 0.2, 0.5> & <0.7, 0.2, 0.4> \end{bmatrix}$$

$$KAK = A^T$$

Theorem: 6 If P,Q are both k-Centro symmetric NFM , then PQ is as well.

Proof : P and Q are both k-Centro symmetric NFM if P = KP^TK and Q = KQ^TK.
We know that, P^T and Q^T are also k-Centro symmetric NFM then P^T = K PK & Q^T = KQK.
To prove PQ is k-Centro symmetric NFM
It's enough to show, PQ= K(PQ)^{T}K
Now K(PQ)^{T}K   = KQ^TP^TK
= K[(KQK)(KPK)]K   where , P^T = KPK and Q^T = KQK
= K^2 QK^{2}P K^2Properties of K- Centro Symmetric NFM,
=QP   Where K^2= I
=PQ Where, PQ=QP

Example:8 Consider the NFM, $P = \begin{bmatrix} <0.8, 0.2, 0.4> & <0.6, 0.4, 0.2> \\ <0.6, 0.4, 0.2> & <0.8, 0.2, 0.4> \end{bmatrix}$, $K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$ and

$$B = \begin{bmatrix} <0.6, 0.4, 0.5> & <0.7, 0.3, 0.6> \\ <0.7, 0.3, 0.6> & <0.6, 0.4, 0.5> \end{bmatrix}$$

$$PQ = \begin{bmatrix} <0.8, 0.2, 0.4> & <0.6, 0.4, 0.2> \\ <0.6, 0.4, 0.2> & <0.8, 0.2, 0.4> \end{bmatrix}\begin{bmatrix} <0.6, 0.4, 0.5> & <0.7, 0.3, 0.6> \\ <0.7, 0.3, 0.6> & <0.6, 0.4, 0.5> \end{bmatrix}$$

$$= \begin{bmatrix} <0.6,0.6,0.5> & <0.7,0.7,0.6> \\ <0.7,0.7,0.6> & <0.6,0.6,0.5> \end{bmatrix}$$

$$(PQ)^T = \begin{bmatrix} <0.6,0.6,0.5> & <0.7,0.7,0.6> \\ <0.7,0.7,0.6> & <0.6,0.6,0.5> \end{bmatrix}$$

$$(PQ)^T K = \begin{bmatrix} <0.6,0.6,0.5> & <0.7,0.7,0.6> \\ <0.7,0.7,0.6> & <0.6,0.6,0.5> \end{bmatrix} \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$$

$$= \begin{bmatrix} <0.7,0.4,0.6> & <0.6,0.3,0.5> \\ <0.6,0.3,0.5> & <0.7,0.4,0.6> \end{bmatrix}$$

$$K(PQ)^T K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix} \begin{bmatrix} <0.7,0.4,0.6> & <0.6,0.3,0.5> \\ <0.6,0.3,0.5> & <0.7,0.4,0.6> \end{bmatrix}$$

$$= \begin{bmatrix} <0.6,0.6,0.5> & <0.7,0.7,0.6> \\ <0.7,0.7,0.6> & <0.6,0.6,0.5> \end{bmatrix}$$

$$K(PQ)^T K = PQ$$

Theorem: 7 If $P \in (NFM)$ is k-Centrosymmetric NFM then PP^T is likewise k-Centrosymmetric NFM.

Proof : Let $P \in (NFM)_n$ is said to be k-Centrosymmetric NFM, then P= KP^{T}K

If P^T also k-centrosymmetric NFM then P^T = KPK
To prove that, PP^T = K(PP^T)^{T}K
 K(PP^T)^{T}K   = K[(P^T)^T P^T]K
                         =K[(PP^T)]K
=(PP^T)K.K
 =(PP^T)K^2 Where ,K^2 = I
=PP^T

Example:9 Consider the NFM, $P = \begin{bmatrix} <0.4,0.2,0.3> & <0.2,0.4,0.5> \\ <0.2,0.4,0.5> & <0.4,0.2,0.3> \end{bmatrix}, K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$

$$PP^T = \begin{bmatrix} <0.4,0.2,0.3> & <0.2,0.4,0.5> \\ <0.2,0.4,0.5> & <0.4,0.2,0.3> \end{bmatrix} \begin{bmatrix} <0.4,0.2,0.3> & <0.2,0.4,0.5> \\ <0.2,0.4,0.5> & <0.4,0.2,0.3> \end{bmatrix}$$

$$= \begin{bmatrix} <0.4,0.4,0.3> & <0.2,0.6,0.5> \\ <0.2,0.6,0.5> & <0.4,0.4,0.3> \end{bmatrix}$$

$$(PP^T)^T = \begin{bmatrix} <0.4,0.4,0.3> & <0.2,0.6,0.5> \\ <0.2,0.6,0.5> & <0.4,0.4,0.3> \end{bmatrix}$$

$$(PP^T)^T K = \begin{bmatrix} <0.4,0.4,0.3> & <0.2,0.6,0.5> \\ <0.2,0.6,0.5> & <0.4,0.4,0.3> \end{bmatrix} \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$$

$$= \begin{bmatrix} <0.2,0.6,0.5> & <0.4,0.4,0.3> \\ <0.4,0.4,0.3> & <0.2,0.6,0.5> \end{bmatrix}$$

$$K\left(PP^{\mathrm{T}}\right)^{\mathrm{T}} \mathrm{K} = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix} \begin{bmatrix} <0.2,0.6,0.5> & <0.4,0.4,0.3> \\ <0.4,0.4,0.3> & <0.2,0.6,0.5> \end{bmatrix}$$

$$K\left(PP^{\mathrm{T}}\right)^{\mathrm{T}} \mathrm{K} = \begin{bmatrix} <0.4,0.4,0.3> & <0.2,0.6,0.5> \\ <0.2,0.6,0.5> & <0.4,0.4,0.3> \end{bmatrix}$$

$$\mathrm{K}\left(PP^{\mathrm{T}}\right)^{\mathrm{T}} \mathrm{K} = PP^{\mathrm{T}}$$

Note: If $P \in (NFM)_n$ is k-Centrosymmetric NFM then P^2 is also k-centrosymmetric NFM.

Theorem:8 If $P \in (NFM)_n$ is k-centrosymmetric NFM then $P + P^{\mathrm{T}}$ is also k-centrosymmetric NFM.

Proof : Let $P \in (NFM)_n$ is said to be k-Centrosymmetric NFM, then P= K P^{T}K

If P^{T} also k-centrosymmetric NFM, then $P^{\mathrm{T}} = KPK$
To prove that , $P + P^{\mathrm{T}} = K(P + P^{\mathrm{T}})^{\mathrm{T}}K$
$K(P + P^{\mathrm{T}})^{\mathrm{T}}K = K(P^{\mathrm{T}} + (P^{\mathrm{T}})^{\mathrm{T}})K$
$= K(P^{\mathrm{T}} + P)K$
$= (P^{\mathrm{T}} + P)K.K$
   $= (P^{\mathrm{T}} + P)K^2$ Where , $K^2 = I$
 $= (P^{\mathrm{T}} + P) = (P + P^{\mathrm{T}})$

Note: If $P \in (NFM)$ is k-centrosymmetric NFM then $A - A^{\mathrm{T}}$ is likewise k-centrosymmetric NFM.

Example:10 Consider the NFM, $P = \begin{bmatrix} <0.8,0.2,0.6> & <0.2,0.4,0.7> \\ <0.2,0.4,0.7> & <0.8,0.2,0.6> \end{bmatrix}, K = \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$

Theorem:9 If P and Q are k-Centrosymmetric NFM then P+Q is also k-Cetrosymmetric NFM.

Proof : If both P and Q are k-centrosymmetric NFM if P= $KP^{\mathrm{T}}K$ & Q= $KQ^{\mathrm{T}}K$
Since P^{T} and Q^{T} are also k-Centro symmetric NFM then $P^{\mathrm{T}} = KPK$ and $Q^{\mathrm{T}} = KQK$.
To show that P+Q is k-centrosymmetric NFM matrix
To prove that , P+Q= $K(P+Q)^{\mathrm{T}}K$
Now $K(P+Q)^{\mathrm{T}}K = K(P^{\mathrm{T}} + Q^{\mathrm{T}})K$
$= KP^{\mathrm{T}}K + KQ^{\mathrm{T}}K = P+Q$

Example:11   Consider   the NFM,   P $= \begin{bmatrix} <0.7,0.2,0.3> & <0.6,0.2,0.4> \\ <0.6,0.2,0.4> & <0.7,0.2,0.3> \end{bmatrix}$

$, B = \begin{bmatrix} <0.4,0.2,0.6> & <0.5,0.3,0.4> \\ <0.5,0.3,0.4> & <0.4,0.2,0.6> \end{bmatrix}$

$A + B = \begin{bmatrix} <0.7,0.2,0.3> & <0.6,0.2,0.4> \\ <0.6,0.2,0.4> & <0.7,0.2,0.3> \end{bmatrix} + \begin{bmatrix} <0.4,0.2,0.6> & <0.5,0.3,0.4> \\ <0.5,0.3,0.4> & <0.4,0.2,0.6> \end{bmatrix}$

$= \begin{bmatrix} <0.7,0.2,0.3> & <0.6,0.3,0.4> \\ <0.6,0.3,0.4> & <0.7,0.2,0.3> \end{bmatrix}$

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$$(A+B)^T K = \begin{bmatrix} <0.7,0.2,0.3> & <0.6,0.3,0.4> \\ <0.6,0.3,0.4> & <0.7,0.2,0.3> \end{bmatrix} \begin{bmatrix} <0,0,1> & <1,1,0> \\ <1,1,0> & <0,0,1> \end{bmatrix}$$

$$(A+B)^T K = \begin{bmatrix} <0.6,0.3,0.4> & <0.7,0.2,0.3> \\ <0.7,0.2,0.3> & <0.6,0.3,0.4> \end{bmatrix}$$

$$K(A+B)^T K = \begin{bmatrix} <0.7,0.2,0.3> & <0.6,0.3,0.4> \\ <0.6,0.3,0.4> & <0.7,0.2,0.3> \end{bmatrix}$$

$$K(P+Q)^T K = P+Q$$

Note: If P and Q are k-Centrosymmetric NFM then P-Q is also k-Cetrosymmetric NFM.

Theorem:10 If P is k-Centrosymmetric NFM and K is the NFPM , k=(1 2) then KP is also k-cento symmentric NFM.

Proof: An NFM $P \in (NFM)_n$ is said to be k-Centrosymmetric NFM if $P = KP^T K$

Since P^T is also k-Centrosymmetric NFM if $P^T = KPK$
To show that KP is k-Centrosymmetric NFM
It's enough to show , $KP = K(KP)^T K$

$$K(KP)^T K = K(P^T K^T) K$$
$$= KP^T \qquad (K^T K = I)$$
$$= KP$$

CONCLUSION

We introduced the concept of Centrosymmetric and k– Centrosymmetric NFMs. We also described a method for finding the g-inverse of a Centrosymmetric and k– Centrosymmetric NFM, which emphasis the fundamental principles and theorems of Centrosymmetric and k– Centrosymmetric NNFMs, as well as examples.

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RESEARCH ARTICLE

Interval Valued Secondary k- Column Symmetric Neutrosophic Fuzzy Matrices

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ABSTRACT

The characterization of interval valued secondary k- column symmetric Neutrosophic fuzzy matrices have been examined in this study with an example. It is discussed how interval valued s-k column symmetric , s- column symmetric, interval valued k- column symmetric, and interval valued column symmetric matrices relate to one another. We establish the necessary and sufficient criteria for IV s-k column symmetric Neutrosophic fuzzy matrices. The existence of several generalized inverses of a matrix in interval valued Neutrosophic fuzzy matrices. It is also established what are the equivalent criteria for various g-inverses of an interval valued $s-\kappa$ column symmetric fuzzy matrix to be an interval valued $s-\kappa$ column symmetric. The generalized inverses of an interval valued $s-\kappa$ column symmetric P corresponding to the sets P$\{1, 2\}$, P$\{1, 2, 3\}$ and P$\{1, 2, 4\}$ are characterized.

Keywords: Interval valued Neutrosophic Fuzzy matrix,Interval valued column symmetric Neutrosophic fuzzymatrix, s-k-column symmetric Interval valued Neutrosophic fuzzymatrix.

INTRODUCTION

Matrices are crucial in many fields of research in science and engineering. The traditional matrix theory is unable to address problems involving numerous kinds of uncertainties. Zadeh [1] has studied fuzzy set . The traditional fuzzy

sets are characterized by the membership value or the grade of membership value. Some- times it may be very difficult to assign the membership value for fuzzy sets. An intuitionistic fuzzy set introduced by Atanassov [2] is appropriate for such a situation. The intuitionistic fuzzy sets can only handle incomplete information considering both the truth membership (and simply membership) and falsity-membership (or nonmembership) values. It does not handle the indeterminate and inconsistent information which exists in belief system. Smarandache [3] introduced the concept of neutrosophic set which is a mathematical tool for handling problems involving imprecise, indeterminacy and inconsistent data. Fuzzy matrices are used to solve certain kinds of issues. Many researchers have since completed numerous works. Only membership values are addressed by fuzzy matrices. These matrices cannot handle values that are not membership. Khan, Shyamal, and Pal [4] have studied intuitionistic fuzzy matrices (IFMs) for the first time. Atanassov [5,6] has discussed IFS and Operations over IV IFS. Hashimoto [7] has studied Canonical form of a transitive matrix. Kim and Roush [8] have studied generalized fuzzy matrices. Lee [9] has studied Secondary Skew Symmetric, Secondary Orthogonal Matrices. Hilland Waters [10] have analyzed Onk-Realandk-Hermitian matrices. Meenakshi [11] has studied Fuzzy Matrix: Theory and Applications. Meenakshi andJayaShree [12] have studied Onk-kernelsymmetricmatrices. Meenakshi and Krishanmoorthy [13] have characterized On Secondary k-Hermitian matrices. Meenakshi and JayaShree [14] have studied On K -rangesymmetricmatrices. Jaya shree [15] has studied Secondary κ-Kernel Symmetric Fuzzy Matrices. Shyamal and Pal [16] Interval valued Fuzzy matrices. Meenakshi and Kalliraja [17] have studied Regular Interval valued Fuzzy matrices. But, practically it is difficult to measure the membership or non-membership value as a point. Anandhkumar [18,19] has studied Pseudo Similarity of Neutrosophic Fuzzy matrices and On various Inverse of Neutrosophic Fuzzy Matrices. Anandhkumar [20] has studied Kernal and k-kernal Intuitionistic Fuzzy matrices. Punithavalli and Anandhkumar [21] have studied Reverse Sharp and Left-T And Right- T Partial Ordering on Intuitionistic Fuzzy matrices. Pal and SusantaKha [22] have studied IV Intuitionistic Fuzzy Matrices. Vidhya and Irene Hepzibah [23] have discussed on Interval Valued Neutrosophic Fuzzy Matrices. So, we consider the membership value as an interval and also in the case of non-membership values, it is not selected as a point, it can be considered as an interval .Here, we introduce the IV Secondaryk-range Symmetric Neutrosophic FuzzyMatrices and introduce some basic operators on IVNFMs.

Research Gap

As mentioned in the above introduction section, Jayashri introduced the concept of k- RS Fuzzy Matrices and Meenakshi and Jayashri developed the notion of kernel symmetric in fuzzy matrices. Here, we have applied the concept of IV Secondary k-CS Neutrosophic FuzzyMatrices (IVNFM). This concept plays a significant role in hybrid fuzzy structure and we have applied the same in NFM and studied some of the results in detail. First we present equivalent characterizations of Secondary k-CSNeutrosophic fuzzy matrices. Finally we give the example of Secondary k- CS Neutrosophic fuzzy matrix.We discussed various g-inverse associated with a regular matrices and obtain characterization of set of all inverses by using Secondary s-k- CS Neutrosophic matrices.

Notations

IVNFM = Interval valued Neutrosophic Fuzzy Matrix,

IV =Interval valued, CS = Column Symmetric

$[P_\mu, P_\lambda, P_\nu]_L^T$ = Transpose of the IVNFM $[P_\mu, P_\lambda, P_\nu]_L$,

$[P_\mu, P_\lambda, P_\nu]_U^T$ = Transpose of the IVNFM $[P_\mu, P_\lambda, P_\nu]_U$,

$[P_\mu, P_\lambda, P_\nu]_L^+$ = Moore-Penrose inverse of IVNFM $[P_\mu, P_\lambda, P_\nu]_L$,

$[P_\mu, P_\lambda, P_\nu]_U^+$ = Moore-Penrose inverse of IVNFM $[P_\mu, P_\lambda, P_\nu]_U$,

$R\left([P_\mu, P_\lambda, P_\nu]_L\right)$ = Row space of $[P_\mu, P_\lambda, P_\nu]_L$

$R\left([P_\mu, P_\lambda, P_v]_U\right)=$ Row space of $[P_\mu, P_\lambda, P_v]_U$, $C\left([P_\mu, P_\lambda, P_v]_L\right)=$ Column space of $[P_\mu, P_\lambda, P_v]_L$, C $\left([P_\mu, P_\lambda, P_v]_U\right)=$ Column space of $[P_\mu, P_\lambda, P_v]_U$

Preliminaries and Definitions

Preliminary

If $\kappa(x)=(x_{k[1]}, x_{k[2]}, x_{k[3]},…, x_{k[n]})\in F_{n\times 1}$ for $x = x_1, x_2,..,x_n\in F_{[1\times n]},$ where K is involuntary, The corresponding Permutation matrix is satisfied using the conditions

$(P_{.2.1})KK^T=K^TK=I_n,$ $K=K^T, K^2 = I$

By the definition of V, and $R(x)=Kx$

$(P_{.2.2})$ $V=V^T,$ $VV^T=V^TV=I_n$ and $V^2=I$

$(P_{.2.3})C\left([P_\mu, P_\lambda, P_v]_L\right)= C\left([P_\mu, P_\lambda, P_v]_L\right)V, C\left([P_\mu, P_\lambda, P_v]_L\right)=C\left([P_\mu, P_\lambda, P_v]_L\right)K$

$\qquad C\left([P_\mu, P_\lambda, P_v]_U\right)=C\left([P_\mu, P_\lambda, P_v]_U\right)V, C\left([P_\mu, P_\lambda, P_v]_U\right)= C\left([P_\mu, P_\lambda, P_v]_U\right)K$

$(P_{.2.4})C\left([P_\mu, P_\lambda, P_v]_L V\right)^T = C\left(V[P_\mu, P_\lambda, P_v]_L{}^T\right), C\left(V[P_\mu, P_\lambda, P_v]_L\right)^T = C\left([P_\mu, P_\lambda, P_v]_L{}^T V\right)$

$\qquad C\left([P_\mu, P_\lambda, P_v]_U V\right)^T = C\left(V[P_\mu, P_\lambda, P_v]_U{}^T\right), C\left(V[P_\mu, P_\lambda, P_v]_U\right)^T = C\left([P_\mu, P_\lambda, P_v]_U{}^T V\right)$

Definition:2.1 IV Neutrosophic fuzzy matrix (IVNFM): An IV Neutrosophic fuzzy matrix P of order m×n is defined as P = $[x_{ij},<p_{ij\mu}, p_{ij\lambda}p_{ijv}>]_{m\times n}$ where $p_{ij\mu}$, $p_{ij\lambda}$ and p_{ijv} are the subsets of [0,1] which are denoted by $p_{ij\mu} = [p_{ij\mu L}, p_{ij\mu U}],$ $p_{ij\lambda}= [p_{ij\lambda L}, p_{ij\lambda U}]$ and $p_{ijv} = [p_{ijv L}, p_{ijv U}]$ which maintaining the condition $0\le p_{ij\mu U} + p_{ij\lambda U}+ p_{ijv U} \le 3,$ $0\le p_{ij\mu L} + p_{ij\lambda L}+ p_{ijv L} \le 3$, $0 \le p_{\mu L} \le p_{\mu U} \le 1, 0 \le p_{\lambda L} \le p_{\lambda U} \le 1, 0 \le p_{v L} \le p_{v U} \le 1$ for $i = 1,2,\cdots,m$ and $j = 1,2,\cdots,n.$

Example2.1 Consider an IV Neutrosophic Fuzzy Matrix

$$P = \begin{bmatrix} <[0,0],[1,1],[1,1]> & <[0.1,0.3],[0.2,0.4],[0.2,0.5]> \\ <[0.1,0.3],[0.2,0.4],[0.2,0.5]> & <[0,0],[1,1],[1,1]> \end{bmatrix}$$

Lower Limit NFM, $[P_\mu, P_\lambda, P_v]_L = \begin{bmatrix} <0,1,1> & <0.1,0.2,0,2> \\ <0.1,0.2,0.2> & <0,1,1> \end{bmatrix}$

Upper Limit NFM, $[P_\mu, P_\lambda, P_v]_U = \begin{bmatrix} <0,1,1> & <0.3,0.4,0.5> \\ <0.3,0.4,0.5> & <0,1,1> \end{bmatrix}$

and $Q = \begin{bmatrix} <[0,0],[1,1],[1,1]> & <[0.2,0.4],[0.3,0.5],[0.1,0.5]> \\ <[0.2,0.4],[0.3,0.5],[0.1,0.5]> & <[0,0],[1,1],[1,1]> \end{bmatrix}$

Then, $P+Q = \begin{bmatrix} <[0,0],[1,1],[1,1]> & <[0.2,0.4],[0.2,0.4],[0.1,0.5]> \\ <[0.2,0.4],[0.2,0.4],[0.1,0.5]> & <[0,0],[1,1],[1,1]> \end{bmatrix}$

$Q = \begin{bmatrix} <[0,0],[1,1],[1,1]> & <[0.1,0.3],[0.3,0.5],[0.2,0.5]> \\ <[0.1,0.3],[0.3,0.5],[0.2,0.5]> & <[0,0],[1,1],[1,1]> \end{bmatrix}$

$|P| = <[0,0],[1,1],[1,1]> <[0,0],[1,1],[1,1]> + <[0.1,0.3],[0.2,0.4],[0.2,0.5]> <[0.1,0.3],[0.2,0.4],[0.2,0.5]>$

$|P| = <[0,0],[1,1],[1,1]> + <[0.1,0.3],[0.2,0.4],[0.2,0.5]> = <[0.1,0.3],[0.2,0.4],[0.2,0.5]>$

Definition2.2. For IV Neutrosophic fuzzymatrix P is CS fuzzy matrix iff $C\left([P_\mu, P_\lambda, P_v]_L\right)=$

$C\left([P_\mu,P_\lambda,P_v]_L^T\right)$ and $C\left([P_\mu,P_\lambda,P_v]_U\right) = C\left([P_\mu,P_\lambda,P_v]_U^T\right)$.

Lemma2.1. For a matrix A belongs to F_n and a permutation fuzzy matrix P, R(A) = R(B) iff $R(PAQ^T)=R(PAQ^T)$.

Lemma2.2. For interval valued fuzzy matrix $P=KP^TK$ iff $KP=(KP)(KP)^T(KP)$, IV fuzzymatrix $\Leftrightarrow$ PK=(PK)(PK)^T(PK)IV fuzzymatrix.

Interval valued Secondary k-CS Neutrosophic fuzzy matrix

Definition3.1. For a Neutrosophic fuzzymatrix $P =< [P_\mu,P_\lambda,P_v]_L, [P_\mu,P_\lambda,P_v]_U > \in \mathrm{IVNFM}_{nn}$

is an IV s - symmetric fuzzymatrixiff $[P_\mu,P_\lambda,P_v]_L = V\left([P_\mu,P_\lambda,P_v]_L^T\right)V$ and $[P_\mu,P_\lambda,P_v]_U$

$= V\left([P_\mu,P_\lambda,P_v]_U^T\right)V$.

Definition3.2 For a Neutrosophic fuzzymatrix $P =< [P_\mu,P_\lambda,P_v]_L,[P_\mu,P_\lambda,P_v]_U > \in \mathrm{IVNFM}_{nn}$ is an IV s- CS fuzzymatrix iff

$$C\left([P_\mu,P_\lambda,P_v]_L\right) = C\left(V[P_\mu,P_\lambda,P_v]_L^T V\right),\ C\left([P_\mu,P_\lambda,P_v]_U\right) = C\left(V[P_\mu,P_\lambda,P_v]_U^T V\right).$$

Definition3.3. For a Neutrosophic fuzzymatrix $A =< [P_\mu,P_\lambda,P_v]_L, [P_\mu,P_\lambda,P_v]_U >$ is an IVs-k- CS fuzzymatrix iff

$$C\left([P_\mu,P_\lambda,P_v]_L\right) = C\left(KV[P_\mu,P_\lambda,P_v]_L^T VK\right),\ C\left([P_\mu,P_\lambda,P_v]_U\right) = C\left(KV[P_\mu,P_\lambda,P_v]_U^T VK\right).$$

Lemma3.1. For a Neutrosophic fuzzymatrix $P =< [P_\mu,P_\lambda,P_v]_L, [P_\mu,P_\lambda,P_v]_U > \in \mathrm{IVNFM}_{mn}$ is an IV s- CS Neutrosophic fuzzymatrix $\Leftrightarrow$ VA $=< V[P_\mu,P_\lambda,P_v]_L, V[P_\mu,P_\lambda,P_v]_U >$ IV CS Neutrosophic fuzzymatrix $\Leftrightarrow$ AV $=< [P_\mu,P_\lambda,P_v]_L V, [P_\mu,P_\lambda,P_v]_U V >$ is an IV CS Neutrosophic fuzzymatrix.

Proof. Let Neutrosophic fuzzymatrix $P =< [P_\mu,P_\lambda,P_v]_L,[P_\mu,P_\lambda,P_v]_U > \in \mathrm{IVNFM}_{nn}$ is s-CS fuzzymatrix

$\Leftrightarrow C\left([P_\mu,P_\lambda,P_v]_L\right) = C\left(V[P_\mu,P_\lambda,P_v]_L^T V\right)$ *[Definition3.2]*

$\Leftrightarrow C\left([P_\mu,P_\lambda,P_v]_L V\right) = C\left([P_\mu,P_\lambda,P_v]_L V\right)^T$

$\Leftrightarrow [P_\mu,P_\lambda,P_v]_L V$ is CS.   *[ByP.2.2]*

$\Leftrightarrow C\left(V[P_\mu,P_\lambda,P_v]_L VV^T\right) = C\left(VV[P_\mu,P_\lambda,P_v]_L^T V\right)$

$\Leftrightarrow C\left(V[P_\mu,P_\lambda,P_v]_L\right) = C\left(V[P_\mu,P_\lambda,P_v]_L\right)^T$

$\Leftrightarrow V[P_\mu,P_\lambda,P_v]_L$ is CS.

Similar manner

$\Leftrightarrow C\left([P_\mu,P_\lambda,P_v]_U\right) = C\left(V[P_\mu,P_\lambda,P_v]_U^T V\right)$

$$\Leftrightarrow C\left([\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U\,\mathrm{V}\right)=C\left([\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U V\right)^T$$

$$\Leftrightarrow [\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U\,\mathrm{V}\ is\ CS.$$

$$\Leftrightarrow C\left(\mathrm{V}[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U\,\mathrm{V}\mathrm{V}^T\right)=C\left(VV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U{}^T V\right)$$

$$\Leftrightarrow C\left(\mathrm{V}[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U\right)=C\left(\mathrm{V}[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U\right)^T$$

$$\Leftrightarrow \mathrm{V}[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U\ isCS.$$

Therefore, $\mathrm{VP}=<V[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_L, \mathrm{V}[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U>$ is an IV symmetric.

Example3.1 Let us consider IV NFM

$$P=\begin{bmatrix} <[0,0],[1,1],[1,1]> & <[0.1,0.3],[0.2,0.4],[0.2,0.5]> \\ <[0.1,0.3],[0.2,0.4],[0.2,0.5]> & <[0,0],[1,1],[1,1]> \end{bmatrix}$$

Lower Limit NFM, $[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_L=\begin{bmatrix} <0,1,1> & <0.1,0.2,0,2> \\ <0.1,0.2,0.2> & <0,1,1> \end{bmatrix}$,

Upper Limit NFM, $[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_v]_U=\begin{bmatrix} <0,1,1> & <0.3,0.4,0.5> \\ <0.3,0.4,0.5> & <0,1,1> \end{bmatrix}$

$$V=\begin{bmatrix} <0,0,0> & <1,1,0> \\ <1,1,0> & <0,0,0> \end{bmatrix},\ \mathrm{K}=\begin{bmatrix} <1,1,0> & <0,0,0> \\ <0,0,0> & <1,1,0> \end{bmatrix},$$

$$KVP_L{}^T VK=\begin{bmatrix} <1,1,0> & <0,0,0> \\ <0,0,0> & <1,1,0> \end{bmatrix}\begin{bmatrix} <0,0,0> & <1,1,0> \\ <1,1,0> & <0,0,0> \end{bmatrix}\begin{bmatrix} <0,1,1> & <0.1,0.2,0,2> \\ <0.1,0.2,0.2> & <0,1,1> \end{bmatrix}$$

$$\begin{bmatrix} <0,0,0> & <1,1,0> \\ <1,1,0> & <0,0,0> \end{bmatrix}\begin{bmatrix} <1,1,0> & <0,0,0> \\ <0,0,0> & <1,1,0> \end{bmatrix}$$

$$KVP_L{}^T VK=\begin{bmatrix} <0,1,0.2> & <0,0.2,0.2> \\ <0.1,0.2,0.2> & <0,1,0.2> \end{bmatrix}$$

$$KVP_L{}^T VK\neq P_L$$

Similarly, $KVP_U{}^T VK\neq P_U$

$$P_L=KP_LK$$

$$KP_LK=\begin{bmatrix} <1,1,0> & <0,0,0> \\ <0,0,0> & <1,1,0> \end{bmatrix}\begin{bmatrix} <0,1,1> & <0.1,0.2,0,2> \\ <0.1,0.2,0.2> & <0,1,1> \end{bmatrix}\begin{bmatrix} <1,1,0> & <0,0,0> \\ <0,0,0> & <1,1,0> \end{bmatrix}$$

$$KP_LK=\begin{bmatrix} <0,1,0.2> & <0.1,0.2,0.2> \\ <0.1,0.2,0.2> & <0.1,1,0.2> \end{bmatrix}\neq P_L$$

Similarly, $P_U\neq KP_UK$

N (P$_L$) = $N(KVP_L{}^T VK)=<0,0,0>$

Therefore P is symmetric NFM, Column symmetric NFM, kernel symmetric, but not both κ–symmetric and s-κ-symmetric NFM.

Example2.2. Let us consider IV NFM,

$$P = \begin{bmatrix} <[0.7,0.2],[0.3,0.4],[0.4,0.6]> & <[0.5,0.4],[0.3,0.3],[0.4,0.2]> \\ <[0.5,0.4],[0.3,0.3],[0.4,0.2]> & <[0.7,0.2],[0.3,0.4],[0.4,0.6]> \end{bmatrix} V$$

$$= \begin{bmatrix} <0,0,0> & <1,1,0> \\ <1,1,0> & <0,0,0> \end{bmatrix}, K = \begin{bmatrix} <1,1,0> & <0,0,0> \\ <0,0,0> & <1,1,0> \end{bmatrix},$$

Lower Limit NFM, $P_L = \begin{bmatrix} <0.7,0.3,0.4> & <0.5,0.3,0.4> \\ <0.5,0.3,0.4> & <0.7,0.3,0.4> \end{bmatrix},$

Upper Limit NFM, $P_U = \begin{bmatrix} <0.2,0.4,0.6> & <0.4,0.3,0.2> \\ <0.4,0.3,0.2> & <0.2,0.4,0.6> \end{bmatrix}$

$$KVP_L{}^TVK = \begin{bmatrix} <1,1,0> & <0,0,0> \\ <0,0,0> & <1,1,0> \end{bmatrix}\begin{bmatrix} <0,0,0> & <1,1,0> \\ <1,1,0> & <0,0,0> \end{bmatrix}\begin{bmatrix} <0.7,0.3,0.4> & <0.5,0.3,0.4> \\ <0.5,0.3,0.4> & <0.7,0.3,0.4> \end{bmatrix}$$

$$\begin{bmatrix} <0,0,0> & <1,1,0> \\ <1,1,0> & <0,0,0> \end{bmatrix}\begin{bmatrix} <1,1,0> & <0,0,0> \\ <0,0,0> & <1,1,0> \end{bmatrix}$$

$$KVP_L{}^TVK = \begin{bmatrix} <0.7,0.3,0.4> & <0.5,0.3,0.4> \\ <0.5,0.3,0.4> & <0.7,0.3,0.4> \end{bmatrix} = P_L$$

P is symmetric, CS, s-κ-symmetric and hences-k-kernel symmetric.

Example2.3. Let us consider IV NFM

Lower limit NFM, $[P_\mu, P_\lambda, P_v]_L = \begin{bmatrix} <0,0,0> & <0,0,0> & <1,1,0> \\ <0.5,0.3,0.4> & <1,1,0> & <0,0,0> \\ <0.4,0.2,0.6> & <0.5,0.3,0.4> & <0,0,0> \end{bmatrix}$

$$K = \begin{bmatrix} <0,0,0> & <1,1,0> & <0,0,0> \\ <1,1,0> & <0,0,0> & <0,0,0> \\ <0,0,0> & <0,0,0> & <1,1,0> \end{bmatrix}, V = \begin{bmatrix} <0,0,0> & <0,0,0> & <1,1,0> \\ <0,0,0> & <1,1,0> & <0,0,0> \\ <1,1,0> & <0,0,0> & <0,0,0> \end{bmatrix}$$

$$KV = \begin{bmatrix} <0,0,0> & <1,1,0> & <0,0,0> \\ <1,1,0> & <0,0,0> & <0,0,0> \\ <0,0,0> & <0,0,0> & <1,1,0> \end{bmatrix}\begin{bmatrix} <0,0,0> & <0,0,0> & <1,1,0> \\ <0,0,0> & <1,1,0> & <0,0,0> \\ <1,1,0> & <0,0,0> & <0,0,0> \end{bmatrix}$$

$$KV = \begin{bmatrix} <0,1,0> & <0,1,0> & <0,1,0> \\ <0,1,0> & <0,1,0> & <1,1,0> \\ <1,1,0> & <0,1,0> & <0,1,0> \end{bmatrix}$$

$$VK = \begin{bmatrix} <0,0,0> & <0,0,0> & <1,1,0> \\ <0,0,0> & <1,1,0> & <0,0,0> \\ <1,1,0> & <0,0,0> & <0,0,0> \end{bmatrix}\begin{bmatrix} <0,0,0> & <1,1,0> & <0,0,0> \\ <1,1,0> & <0,0,0> & <0,0,0> \\ <0,0,0> & <0,0,0> & <1,1,0> \end{bmatrix}$$

$$VK = \begin{bmatrix} <0,1,0> & <0,1,0> & <1,1,0> \\ <1,1,0> & <0,1,0> & <0,1,0> \\ <0,1,0> & <1,1,0> & <0,1,0> \end{bmatrix}$$

$$P_L{}^T VK = \begin{bmatrix} <0.5,0.8,0.4> & <0.4,0.8,0.6> & <0,0,0.4> \\ <0,0.7,0> & <0.5,0.7,0> & <0,0.7,0> \\ <0,0,0> & <0,0,0> & <1,0,0> \end{bmatrix}$$

$$KVP_L{}^T VK = \begin{bmatrix} <0,1,0> & <0,1,0> & <0,1,0> \\ <0,1,0> & <0,1,0> & <1,1,0> \\ <1,1,0> & <0,1,0> & <0,1,0> \end{bmatrix} \begin{bmatrix} <0.5,0.8,0.4> & <0.4,0.8,0.6> & <0,0,0.4> \\ <0,0.7,0> & <0.5,0.7,0> & <0,0.7,0> \\ <0,0,0> & <0,0,0> & <1,0,0> \end{bmatrix}$$

$$KVP_L{}^T VK = \begin{bmatrix} <0,0,0> & <0,0.2,0> & <0,0,0> \\ <0,0,0> & <0,0,0> & <1,0,0> \\ <0.5,0,0> & <0.4,0,0> & <0,0,0> \end{bmatrix} \neq P_L$$

$$P_L \neq KVP_L{}^T VK$$

Hence P is nots-k-symmetric and not RS. But s-k- kernel symmetric.
i.e) N(P_L)=N(KVP_L^T VK)= <0,0,0>

Theorem3.1. The following conditions are equivalent for $P \in \text{IVNFM}_n$

(i) $P = <[P_\mu, P_\lambda, P_v]_L, [P_\mu, P_\lambda, P_v]_U > \in \text{IVNFM}_{mn}$ is an IV s –κ CS.

(ii) $KVP = < KV[P_\mu, P_\lambda, P_v]_L, KV[P_\mu, P_\lambda, P_v]_U >$ is an IV CS.

(iii) $PKV = <[P_\mu, P_\lambda, P_v]_L KV, [P_\mu, P_\lambda, P_v]_U KV >$ is an IV CS.

(iv) $VP = <V[P_\mu, P_\lambda, P_v]_L, V[P_\mu, P_\lambda, P_v]_U >$ is an IV k- CS.

(v) $PK = <[P_\mu, P_\lambda, P_v]_L K, [P_\mu, P_\lambda, P_v]_U K >$ is an IV s- CS.

(vi)   P^T is an IV s-k CS.

(vii) $C([P_\mu, P_\lambda, P_v]_L) = (C[P_\mu, P_\lambda, P_v]_L{}^T VK), C([P_\mu, P_\lambda, P_v]_U) = (C[P_\mu, P_\lambda, P_v]_U{}^T VK)$

(viii) $C([P_\mu, P_\lambda, P_v]_L{}^T) = (C[P_\mu, P_\lambda, P_v]_L VK), C([P_\mu, P_\lambda, P_v]_U{}^T) = (C[P_\mu, P_\lambda, P_v]_U VK)$

(ix) $C(KV[P_\mu, P_\lambda, P_v]_L) = C(KV[P_\mu, P_\lambda, P_v]_L{}^T)^T, C(KV[P_\mu, P_\lambda, P_v]_U) = C(KV[P_\mu, P_\lambda, P_v]_U{}^T)^T$

(x) $[P_\mu, P_\lambda, P_v]_L = VK[P_\mu, P_\lambda, P_v]_L{}^T VKH_1, [P_\mu, P_\lambda, P_v]_U$

$= VK[P_\mu, P_\lambda, P_v]_U{}^T VKH_1$ for $H_1 \in IVNFM$

(xi) $[P_\mu, P_\lambda, P_v]_L = H_1 KV[P_\mu, P_\lambda, P_v]_L{}^T KV, [P_\mu, P_\lambda, P_v]_U$

$= H_1 KV[P_\mu, P_\lambda, P_v]_U{}^T VK$ for $H_1 \in IVNFM$

(xii) $[P_\mu, P_\lambda, P_v]_L{}^T = KV[P_\mu, P_\lambda, P_v]_L VKH_1, [P_\mu, P_\lambda, P_v]_U{}^T$

$= KV[P_\mu, P_\lambda, P_v]_U VKH_1$ for $H_1 \in IVNFM$

(xiii) $[P_\mu, P_\lambda, P_\nu]_L^T = H_1 KV[P_\mu, P_\lambda, P_\nu]_L$ KV, $[P_\mu, P_\lambda, P_\nu]_U$

$= H_1 KV[P_\mu, P_\lambda, P_\nu]_U$ VK for $H_1 \in IVNFM$

Proof: (i) iff (ii) iff (iv)

Let $A = < [P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U > \in IVNFM_{nn}$ is an IV s –κ CS

Let $[P_\mu, P_\lambda, P_\nu]_L$ is a s –κ CS.

$\Leftrightarrow C([P_\mu, P_\lambda, P_\nu]_L) = C(KV[P_\mu, P_\lambda, P_\nu]_L^T VK), C([P_\mu, P_\lambda, P_\nu]_U) = C(KV[P_\mu, P_\lambda, P_\nu]_U^T VK),$

(By Definition 3.3)

$\Leftrightarrow C(KV[P_\mu, P_\lambda, P_\nu]_L) = C(KV[P_\mu, P_\lambda, P_\nu]_L)^T, C([P_\mu, P_\lambda, P_\nu]_U) = C(KV[P_\mu, P_\lambda, P_\nu]_U)^T$

By (P.2.3)

$\Leftrightarrow$ KVP $= < KV[P_\mu, P_\lambda, P_\nu]_L, KV[P_\mu, P_\lambda, P_\nu]_U >$ is an IV CS

$\Leftrightarrow$ VP $= < V[P_\mu, P_\lambda, P_\nu]_L, V[P_\mu, P_\lambda, P_\nu]_U >$ is an IV κ- CS

As a conclusion (i) iff(ii) iff (iv) is true

(i) iff (ii) iff (v)

Let $A = < [P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U > \in IVNFM_{nn}$ is an IV s –κ CS

$\Leftrightarrow C(KV[P_\mu, P_\lambda, P_\nu]_L) = C(KV[P_\mu, P_\lambda, P_\nu]_L)^T, C(KV[P_\mu, P_\lambda, P_\nu]_U) = C(KV[P_\mu, P_\lambda, P_\nu]_U)^T,$

$\Leftrightarrow C(VK(KV[P_\mu, P_\lambda, P_\nu]_L)) = C((VK)[P_\mu, P_\lambda, P_\nu]_L^T VK(VK)^T),$

$C(VK(KV[P_\mu, P_\lambda, P_\nu]_U)) = C((VK)[P_\mu, P_\lambda, P_\nu]_U^T VK(VK)^T)$

$\Leftrightarrow AKV = \left[[P_\mu, P_\lambda, P_\nu]_L KV, [P_\mu, P_\lambda, P_\nu]_U KV \right]$ is an IV CS

$\Leftrightarrow AK = \left[[P_\mu, P_\lambda, P_\nu]_L K, [P_\mu, P_\lambda, P_\nu]_U K \right]$ is an IV s- CS

As a conclusion (i) $\Leftrightarrow$ (iii) $\Leftrightarrow$ (v) is true. (ii) $\Leftrightarrow$ (ix)

$KVA = \left[KV[P_\mu, P_\lambda, P_\nu]_L, KV[P_\mu, P_\lambda, P_\nu]_U \right]$ is an IV CS

$\Leftrightarrow C\left(KV[P_\mu, P_\lambda, P_\nu]_L \right) = C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_L \right)^T \right), C\left(KV[P_\mu, P_\lambda, P_\nu]_U \right)$

$= R\left(\left(KV[P_\mu, P_\lambda, P_\nu]_U \right)^T \right)$

(ii) $\Leftrightarrow$ (ix) is true. (ii) $\Leftrightarrow$ (vii)

$KVP = \left[KV[P_\mu, P_\lambda, P_\nu]_L, KV[P_\mu, P_\lambda, P_\nu]_U \right]$ is an IV CS.

$\Leftrightarrow C\left(KV[P_\mu, P_\lambda, P_\nu]_L \right) = C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_L \right)^T \right), C\left(KV[P_\mu, P_\lambda, P_\nu]_U \right.$

$= C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_U \right)^T \right)$

$\Leftrightarrow C\left([P_\mu, P_\lambda, P_\nu]_L \right) = C\left([P_\mu, P_\lambda, P_\nu]_L^T VK \right), C\left([P_\mu, P_\lambda, P_\nu]_U \right) = C\left([P_\mu, P_\lambda, P_\nu]_U^T VK \right)$ As a

conclusion (ii) $\Leftrightarrow$ (vii) is true. (iii) $\Leftrightarrow$ (viii) $PVK = \left[[P_\mu, P_\lambda, P_\nu]_L VK, [P_\mu, P_\lambda, P_\nu]_U VK \right]$

$$\Leftrightarrow C\left([P_\mu, P_\lambda, P_v]_L VK\right) = C\left(\left([P_\mu, P_\lambda, P_v]_L VK\right)^T\right), C\left([P_\mu, P_\lambda, P_v]_U VK\right)$$

$$= C\left(\left([P_\mu, P_\lambda, P_v]_U VK\right)^T\right)$$

$$\Leftrightarrow C\left([P_\mu, P_\lambda, P_v]_L VK\right) = C\left([P_\mu, P_\lambda, P_v]_L\right)^T, C\left([P_\mu, P_\lambda, P_v]_U VK\right) = C\left([P_\mu, P_\lambda, P_v]_U\right)^T$$

As a conclusion (iii) $\Leftrightarrow$ (viii) is true. (i) $\Leftrightarrow$ (vi)

Let $P = <[P_\mu, P_\lambda, P_v]_L, [P_\mu, P_\lambda, P_v]_U > \in \mathrm{IVNFM}_{nn}$ is an IV s –κ KS

$$\Leftrightarrow C([P_\mu, P_\lambda, P_v]_L) = C(KV[P_\mu, P_\lambda, P_v]_L^T VK), C([P_\mu, P_\lambda, P_v]_U) = C(KV[P_\mu, P_\lambda, P_v]_U^T VK),$$

(By Definition 3.3)

$$\Leftrightarrow (KVP)^T = (KV[P_\mu, P_\lambda, P_v]_L, KV[P_\mu, P_\lambda, P_v]_U)^T \text{ is an IV CS}$$

$$\Leftrightarrow P^T VK = ([P_\mu, P_\lambda, P_v]_L VK, [P_\mu, P_\lambda, P_v]_U VK) \text{ is an IV CS}$$

$$\Leftrightarrow P^T = \left([P_\mu, P_\lambda, P_v]_L^T, [P_\mu, P_\lambda, P_v]_U^T\right) \text{ is an IV s –κ CS}$$

As a conclusion (i) $\Leftrightarrow$ (vi) is true

(i) $\Leftrightarrow$ (xii) $\Leftrightarrow$ (xi)

Let $A = <[P_\mu, P_\lambda, P_v]_L, [P_\mu, P_\lambda, P_v]_U > \in \mathrm{IVNFM}_{nn}$ is an IV s –κ CS

Consider $[P_\mu, P_\lambda, P_v]_L$ is a s –κ CS

$$\Leftrightarrow C([P_\mu, P_\lambda, P_v]_L^T) = C(KV[P_\mu, P_\lambda, P_v]_L VK), C([P_\mu, P_\lambda, P_v]_U^T) = C(KV[P_\mu, P_\lambda, P_v]_U VK)$$

By (P.2.3)

$$\Leftrightarrow [P_\mu, P_\lambda, P_v]_L = H_1 KV[P_\mu, P_\lambda, P_v]_L^T VK, [P_\mu, P_\lambda, P_v]_U^T = H_1 KV[P_\mu, P_\lambda, P_v]_U VK$$

for $H_1 \in IVNFM$. As a result (i) $\Leftrightarrow$ (xii) $\Leftrightarrow$ (xi) true.

(ii) $\Leftrightarrow$ (xiii) $\Leftrightarrow$ (x)

$$\Leftrightarrow AVK = \left[[P_\mu, P_\lambda, P_v]_L VK, [P_\mu, P_\lambda, P_v]_U VK\right] \text{ is an IV CS}$$

$$\Leftrightarrow AV = \left[[P_\mu, P_\lambda, P_v]_L V, [P_\mu, P_\lambda, P_v]_U V\right] \text{ is an IV κ- CS}$$

$$\Leftrightarrow C(V[P_\mu, P_\lambda, P_v]_L) = C(K\left(V[P_\mu, P_\lambda, P_v]_L\right)^T K),$$

$$C(V[P_\mu, P_\lambda, P_v]_U) = C(K\left(V[P_\mu, P_\lambda, P_v]_U\right)^T K), \qquad\qquad \text{[By Definition 3.3]}$$

$$\Leftrightarrow C([P_\mu, P_\lambda, P_v]_L) = C\left([P_\mu, P_\lambda, P_v]_L\right)^T VK), C([P_\mu, P_\lambda, P_v]_U) = C\left([P_\mu, P_\lambda, P_v]_U\right)^T VK),$$

$$\Leftrightarrow C([P_\mu, P_\lambda, P_v]_L^T) = C\left(KV[P_\mu, P_\lambda, P_v]_L\right)^T K), C([P_\mu, P_\lambda, P_v]_U^T) = C\left(KV[P_\mu, P_\lambda, P_v]_U\right)$$

$$[P_\mu, P_\lambda, P_v]_L = VK[P_\mu, P_\lambda, P_v]_L^T VK\, H_1, [P_\mu, P_\lambda, P_v]_U = VK[P_\mu, P_\lambda, P_v]_U\, VK\, for\, H_1 \in IVNFM$$

As a conclusion (ii) $\Leftrightarrow$ (xiii) $\Leftrightarrow$ (x) is true

The above statement can be reduced to the equivalent requirement that a matrix be an IV s- RS for K = I in particular.

Corollary:3.1 The following statements are equivalent for $P \in \mathrm{IVNFM}_{nn}$

i. $P = <[P_\mu, P_\lambda, P_v]_L, [P_\mu, P_\lambda, P_v]_U > \in \mathrm{IVNFM}_{nn}$ is an IV s-CS.

ii. $VP = < V[P_\mu, P_\lambda, P_\nu]_L, V[P_\mu, P_\lambda, P_\nu]_U >$ is an IV CS.

iii. $PV = < [P_\mu, P_\lambda, P_\nu]_L V, [P_\mu, P_\lambda, P_\nu]_U V >$ is an IV CS.

iv. $P^T = < [P_\mu, P_\lambda, P_\nu]_L^T, [P_\mu, P_\lambda, P_\nu]_U^T >$ is an IV s – CS.

v. $C\left([P_\mu, P_\lambda, P_\nu]_L\right) = C\left([P_\mu, P_\lambda, P_\nu]_L^T V\right), C\left([P_\mu, P_\lambda, P_\nu]_U\right) = C\left([P_\mu, P_\lambda, P_\nu]_U^T V\right)$

vi. $C\left([P_\mu, P_\lambda, P_\nu]_L^T\right) = C\left([P_\mu, P_\lambda, P_\nu]_L V\right), C\left([P_\mu, P_\lambda, P_\nu]_U^T\right) = C\left([P_\mu, P_\lambda, P_\nu]_U V\right)$

vii. $C\left(KV[P_\mu, P_\lambda, P_\nu]_L\right) = C\left(V[P_\mu, P_\lambda, P_\nu]_L\right)^T, C\left(KV[P_\mu, P_\lambda, P_\nu]_U\right) = C\left(V[P_\mu, P_\lambda, P_\nu]_U\right)^T$

viii. $[P_\mu, P_\lambda, P_\nu]_L = V[P_\mu, P_\lambda, P_\nu]_L^T VH_1, [P_\mu, P_\lambda, P_\nu]_U = V[P_\mu, P_\lambda, P_\nu]_U^T VH_1$ for $H_1 \in IVNFM$

ix. $[P_\mu, P_\lambda, P_\nu]_L = H_1 V[P_\mu, P_\lambda, P_\nu]_L^T V, [P_\mu, P_\lambda, P_\nu]_U = H_1 V[P_\mu, P_\lambda, P_\nu]_U^T V$ for $H_1 \in IVNFM$

x. $[P_\mu, P_\lambda, P_\nu]_L^T = V[P_\mu, P_\lambda, P_\nu]_L VH_1, [P_\mu, P_\lambda, P_\nu]_U^T = V[P_\mu, P_\lambda, P_\nu]_U VH_1$ for $H_1 \in IVNFM$

xi. $[P_\mu, P_\lambda, P_\nu]_L^T = H_1 V[P_\mu, P_\lambda, P_\nu]_L V, [P_\mu, P_\lambda, P_\nu]_U = H_1 V[P_\mu, P_\lambda, P_\nu]_U V$ for $H_1 \in IVNFM$

Theorem 3.2. For $P = < [P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U > \in IVNFM_{nn}$ then any two of the conditions below imply the other

i. $P = < [P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U > \in IVNFM_{nn}$ is an IV κ- CS.

ii. $P = < [P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U > \in IVNFM_{nn}$ is an IV s-κ- CS.

iii. $C\left([P_\mu, P_\lambda, P_\nu]_L\right)^T = C\left(VK[P_\mu, P_\lambda, P_\nu]_L\right)^T, C\left([P_\mu, P_\lambda, P_\nu]_U\right)^T = C\left(VK[P_\mu, P_\lambda, P_\nu]_U^T\right)$

Proof: (i) and (ii) implies (iii)

Let $P = < [P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U > \in IVNFM_{nn}$ is an IV s –κ CS

$\Rightarrow C\left([P_\mu, P_\lambda, P_\nu]_L\right) = C\left([P_\mu, P_\lambda, P_\nu]_L^T VK\right), C\left([P_\mu, P_\lambda, P_\nu]_U\right) = C\left([P_\mu, P_\lambda, P_\nu]_U^T VK\right)$

[By Theorem 3.1]

$\Rightarrow C\left(K[P_\mu, P_\lambda, P_\nu]_L K\right) = C\left(K[P_\mu, P_\lambda, P_\nu]_L^T K\right), C\left(K[P_\mu, P_\lambda, P_\nu]_U K\right)$

$= C\left(K[P_\mu, P_\lambda, P_\nu]_U^T K\right)$ [By Lemma 2.2]

$\Rightarrow C[P_\mu, P_\lambda, P_\nu]_L^T = C\left(\left(VK[P_\mu, P_\lambda, P_\nu]_L\right)^T\right), C\left([P_\mu, P_\lambda, P_\nu]_U\right)^T = C\left(\left(VK[P_\mu, P_\lambda, P_\nu]_U\right)^T\right)$

(i) & (ii) implies (iii) is true

(i)& (iii) implies (ii)

$P = < [P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U >$ is an IV κ- CS

$\Rightarrow C\left(K[P_\mu, P_\lambda, P_\nu]_L K\right) = C\left(\left([P_\mu, P_\lambda, P_\nu]_L\right)^T\right), C\left(K[P_\mu, P_\lambda, P_\nu]_U K\right) = C\left(\left([P_\mu, P_\lambda, P_\nu]_U\right)^T\right)$

Therefore, (i) & (iii)

$$\Rightarrow C\left([P_\mu, P_\lambda, P_\nu]_L\right) = C\left([P_\mu, P_\lambda, P_\nu]_L{}^T VK\right), C\left([P_\mu, P_\lambda, P_\nu]_U\right) = C\left([P_\mu, P_\lambda, P_\nu]_U{}^T VK\right)$$

$$\Rightarrow C\left([P_\mu, P_\lambda, P_\nu]_L\right) = C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_L\right)^T\right), C\left([P_\mu, P_\lambda, P_\nu]_U\right) = C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_U\right)^T\right)$$

$P = <[P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U> \in \text{IVNFM}_{nn}$ is an IV s-k-CS   (By Theorem 3.1)

$\Rightarrow$ (ii) is true

(ii) & (iii) implies (i)

$P = <[P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U> \in \text{IVNFM}_{nn}$ is an IV s- κ- CS

$$\Rightarrow C\left(K[P_\mu, P_\lambda, P_\nu]_L K\right) = C\left(K[P_\mu, P_\lambda, P_\nu]_L{}^T K\right), C\left(K[P_\mu, P_\lambda, P_\nu]_U K\right) = C\left(K[P_\mu, P_\lambda, P_\nu]_U{}^T K\right)$$

Therefore,(ii) and (iii)

$$\Rightarrow C\left([P_\mu, P_\lambda, P_\nu]_L\right) = C\left(K[P_\mu, P_\lambda, P_\nu]_L{}^T K\right), C\left([P_\mu, P_\lambda, P_\nu]_U\right) = C\left(K[P_\mu, P_\lambda, P_\nu]_U{}^T K\right)$$

$P = <[P_{\mu L}, P_{\lambda L}, P_{\nu L}], [P_\mu, P_\lambda, P_\nu]_U> \in \text{IVNFM}_{nn}$ is an IV κ- CS .

Therefore, (i) is true, Hence the theorem.

IV s −κ Column symmetric regular Neutrosophic fuzzy matrices

In this section, it was discovered that there are various generalized inverses of matrices in IVNFM. The comparable standards for different g-inverses of an IV s-k CS Neutrosophic fuzzy matrix to be IV s-k CS are also established. The generalized inverses of an IV s −κ CS P corresponding to the sets P{1, 2}, P{1, 2, 3} and P{1, 2, 4} are characterized.

Theorem 4.1: Let $P = <[P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U> \in \text{IVNFM}_{nn}$, Z belongs to P{1,2} and PZ, ZP are an IV s- κ- CS.

Then P is an IV s- κ - CS iff $Z = <[Z_\mu, Z_\lambda, Z_\nu]_L, [Z_\mu, Z_\lambda, Z_\nu]_U>$ is an IV s- κ – CS.

Proof: Let $P = <[P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U> \in \text{IVNFM}_{nn}$

$$C\left(KV[P_\mu, P_\lambda, P_\nu]_L\right) = C\left(KV[P_\mu, P_\lambda, P_\nu]_L Z[P_{\mu L}, P_{\lambda L}, P_{\nu L}]\right) \subseteq C\left(Z[P_\mu, P_\lambda, P_\nu]_L\right)$$

$$= C\left(ZVV[P_\mu, P_\lambda, P_\nu]_L\right) \subseteq C\left(ZVKKV[P_\mu, P_\lambda, P_\nu]_L\right) \subseteq C\left(KV[P_\mu, P_\lambda, P_\nu]_L\right)$$

Hence, $C\left(KV[P_\mu, P_\lambda, P_\nu]_L\right) = C\left(Z[P_\mu, P_\lambda, P_\nu]_L\right)$

$$= C\left(KV\left(Z[P_\mu, P_\lambda, P_\nu]_L\right)^T VK\right) \qquad\qquad [\text{ZP is IV s- κ-CS}]$$

$$= C\left([P_\mu, P_\lambda, P_\nu]_L{}^T[Z_\mu, Z_\lambda, Z_\nu]_L{}^T VK\right)$$

$$= C\left([Z_\mu, Z_\lambda, Z_\nu]_L{}^T VK\right) = C\left(\left(KV[Z_\mu, Z_\lambda, Z_\nu]_L\right)^T\right)$$

$$C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_L\right)^T\right) = C\left([P_\mu, P_\lambda, P_\nu]_L{}^T VK\right)$$

$$= C\left(KV[P_\mu, P_\lambda, P_\nu]_L[Z_\mu, Z_\lambda, Z_\nu]_L\right) \quad [\text{ VP is s- κ − IV CS}]$$

$$= C\left(KV[Z_\mu, Z_\lambda, Z_\nu]_L\right)$$

Similarly,

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Hence, $C\left(KV[Z_\mu, Z_\lambda, Z_\nu]_U\right) = C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_U\right)^T\right)$ (KVZ is an IV CS)

$\Leftrightarrow C\left(KV[P_\mu, P_\lambda, P_\nu]_L\right) = C\left(\left(KV[P_{\mu L}, P_{\lambda L}, P_{\nu L}]\right)^T\right), C\left(KV[P_\mu, P_\lambda, P_\nu]_U\right) = C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_U\right)^T\right)$

$\Leftrightarrow C\left(KV[Z_\mu, Z_\lambda, Z_\nu]_L\right) = C\left(\left(KV[Z_\mu, Z_\lambda, Z_\nu]_L\right)^T\right),$

$C\left(KV[Z_\mu, Z_\lambda, Z_\nu]_U\right) = C\left(\left(KV[Z_\mu, Z_\lambda, Z_\nu]_U\right)^T\right)$

$\Leftrightarrow KVX = \left[KV[Z_\mu, Z_\lambda, Z_\nu]_L, KV[Z_\mu, Z_\lambda, Z_\nu]_U\right]$ is an IV CS

$Z = <[Z_\mu, Z_\lambda, Z_\nu]_L, [Z_\mu, Z_\lambda, Z_\nu]_U >$ is an IV CS.

Theorem 4.2:, Let $P = <[P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U >$, $Z = <[Z_\mu, Z_\lambda, Z_\nu]_L, [Z_\mu, Z_\lambda, Z_\nu]_U > \in P\{1,2,3\}$,

$C(KV[P_\mu, P_\lambda, P_\nu]_L) = C\left(KV[X_{\mu L}, X_{\lambda L}, X_{\nu L}]\right)^T$,$C(KV[P_\mu, P_\lambda, P_\nu]_U) = C\left(KV[Z_{\mu U}, Z_{\lambda U}, Z_{\nu U}]\right)^T$ .Then

$P = <[P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U > \in$ IVNFM$_{mn}$ is IV s-κ- CS $\Leftrightarrow$ $Z = <[Z_\mu, Z_\lambda, Z_\nu]_L, [Z_\mu, Z_\lambda, Z_\nu]_U >$ is IV s- κ – CS.

Proof: Given P$\{1,2,3\}$, Hence , $[P_\mu, P_\lambda, P_\nu]_L [Z_\mu, Z_\lambda, Z_\nu]_L [P_\mu, P_\lambda, P_\nu]_L = [P_\mu, P_\lambda, P_\nu]_L,$

$[Z_\mu, Z_\lambda, Z_\nu]_L [P_{\mu L}, P_{\lambda L}, P_{\nu L}][Z_\mu, Z_\lambda, Z_\nu]_L = [Z_\mu, Z_\lambda, Z_\nu]_L,$

$\left([P_\mu, P_\lambda, P_\nu]_L [Z_\mu, Z_\lambda, Z_\nu]_L\right)^T = [P_\mu, P_\lambda, P_\nu]_L [Z_\mu, Z_\lambda, Z_\nu]_L$

Consider, $C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_L\right)^T\right)$ = $C\left([Z_\mu, Z_\lambda, Z_\nu]_L^T [P_\mu, P_\lambda, P_\nu]_L^T VK\right)$[By using P $=$ PZP]

$= C\left(KV\left([P_\mu, P_\lambda, P_\nu]_L [Z_\mu, Z_\lambda, Z_\nu]_L\right)^T\right)$

$= C\left(\left([P_\mu, P_\lambda, P_\nu]_L [Z_\mu, Z_\lambda, Z_\nu]_L\right)^T\right)$ $[By\ P._{2.3}]$

$= C\left([P_\mu, P_\lambda, P_\nu]_L [Z_\mu, Z_\lambda, Z_\nu]_L\right)$

$= C\left([Z_\mu, Z_\lambda, Z_\nu]_L\right)$

$\left[By\ using\ [Z_\mu, Z_\lambda, Z_\nu]_L = [Z_\mu, Z_\lambda, Z_\nu]_L [P_\mu, P_\lambda, P_\nu]_L [Z_\mu, Z_\lambda, Z_\nu]_L\right]$

$= R\left(KV[Z_\mu, Z_\lambda, Z_\nu]_L\right)$ $[By\ P_{2.3}]$

Similarly, we can consider, $C\left(\left(KV[P_\mu, P_\lambda, P_\nu]_U\right)^T\right)$ = $C\left([Z_\mu, Z_\lambda, Z_\nu]_U^T [P_\mu, P_\lambda, P_\nu]_U^T VK\right)$

$= C\left(KV\left([P_\mu, P_\lambda, P_\nu]_U [Z_\mu, Z_\lambda, Z_\nu]_U\right)^T\right) = C\left(\left([P_\mu, P_\lambda, P_\nu]_U [Z_\mu, Z_\lambda, Z_\nu]_U\right)^T\right)$ $[By\ P._{2.3}]$

$= C\left([P_\mu, P_\lambda, P_\nu]_U [Z_\mu, Z_\lambda, Z_\nu]_U\right)$ $\left[(PZ)^T = PZ\right]$

$= C\left([Z_\mu, Z_\lambda, Z_\nu]_U\right)$ [By using Z $=$ ZPZ]

$= C\left(KV[Z_\mu, Z_\lambda, Z_\nu]_U\right)$ [By $P_{2.3}$]

If KVA is an IV CS

$$\Leftrightarrow C\left(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L\right) \;=\; \mathrm{C}\left(\left(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L\right)^T\right),$$

$$C\left(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_U\right) \;=\; \mathrm{C}\left(\left(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_U\right)^T\right)$$

$$\Leftrightarrow C\left(KV[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L\right) \;=\; \mathrm{C}\left(\left(KV[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L\right)^T\right),\; KVX =[KV[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L,KV[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_U]$$

is an IV CS.

$Z \;=< [\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L,[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_U >$ is an IV s-k CS.

Theorem 4.3: Let $P \;=< [\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L,[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_U >\in$ IVNFM$_{nn}$, Z $\in$ A {1, 2, 4}, $\mathrm{C}(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L)^T$

$= C\left(\mathrm{KV}[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L\right),\mathrm{C}(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_U)^T = C\left(\mathrm{KV}[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_U\right)$. Then KVP is an IV s- κ-CS iff

$Z \;=< [\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L,[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_U >$ is an IV s- κ- CS.

Proof: Given, P {1, 2, 4}, Hence $[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L=[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L,$

$[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L=[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L,$

$\left([\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L\right)^T=[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L$

Consider, $\mathrm{C}\left(\left(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L\right)^T\right) \;=\; \mathrm{C}\left([\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L{}^T[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L{}^T VK\right)$ [By using P = PZP]

$= C\left(KV\left([\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L\right)^T\right)$

$= C\left(\left([\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L\right)^T\right)$ $\left[By\ P_{2.3}\right]$

$= C\left([\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L\right) = C\left([\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L\right)$

$= C\left(\mathrm{KV}[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_L\right)$ $\left[By\ P_{2.3}\right]$

$C\left(\left(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_U\right)^T\right) \;=\; \mathrm{C}\left([\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_U{}^T[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_U{}^T VK\right)$ [By using P = PZP]

$= C\left(KV\left([\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_U[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_U\right)^T\right)$

$= C\left(\left([\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_U[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_U\right)^T\right)$ $\left[By\ P_{2.3}\right]$

$= C\left([\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_U[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_U\right)$ $\left[\ (PZ)^T = PZ\ \right]$

$= C\left([\mathrm{X}_{\mu U},\mathrm{X}_{\lambda U},\mathrm{X}_{\nu U}]\right) = C\left(\mathrm{KV}[\mathrm{Z}_\mu,\mathrm{Z}_\lambda,\mathrm{Z}_\nu]_U\right)$ $\left[By\ P_{2.3}\right]$

If KVP is an IV CS

$$\Leftrightarrow C\left(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L\right) \;=\; \mathrm{C}\left(\left(KV[\mathrm{P}_\mu,\mathrm{P}_\lambda,\mathrm{P}_\nu]_L\right)^T\right),$$

$$C\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{\lambda U},\mathrm{P}_{\nu U}]\right) \;=\; \mathrm{C}\left(\left(KV[\mathrm{P}_{\mu U},\mathrm{P}_{\lambda U},\mathrm{P}_{\nu U}]\right)^T\right)$$

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$$\Leftrightarrow C\left(KV[Z_\mu, Z_\lambda, Z_\nu]_L\right) = C\left(\left(KV[Z_\mu, Z_\lambda, Z_\nu]_L\right)^T\right),$$

$KVX = [KV[Z_\mu, Z_\lambda, Z_\nu]_L, KV[Z_\mu, Z_\lambda, Z_\nu]_U]$ is an IV CS.

$Z = <[Z_{\mu L}, Z_{\lambda L}, Z_{\nu L}], [Z_{\mu U}, Z_{\lambda U}, Z_{\nu U}] >$ is an IV s-k CS.

The aforementioned Theorems reduce to comparable criteria, in particular for K = I, for different g-inverses of interval valued s- CS to be IV secondary CS.

Corollary 4.1: For $P = <[P_\mu, P_\lambda, P_\nu]_L, [P_{\mu U}, P_{\lambda U}, P_{\nu U}] > \in IVNFM_{nn}$, $Z \in$ P {1, 2} and

$PZ = <[P_\mu, P_\lambda, P_\nu]_L[Z_{\mu L}, Z_{\lambda L}, Z_{\nu L}], [P_\mu, P_\lambda, P_\nu]_U[Z_\mu, Z_\lambda, Z_\nu]_U>,$

$ZP = <[Z_\mu, Z_\lambda, Z_\nu]_L[P_\mu, P_\lambda, P_\nu]_L, [Z_\mu, Z_\lambda, Z_\nu]_U[P_\mu, P_\lambda, P_\nu]_U>,$ are is an IV s- CS. Then P is an IV s- CS iff

$Z = <[Z_\mu, Z_\lambda, Z_\nu]_L, [Z_\mu, Z_\lambda, Z_\nu]_U >$ is an IV s- CS.

Corollary 4.2: For $A = <[P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U > \in IVNFM_{nn}$, $Z \in$ P {1, 2, 3}, $C(KV[P_\mu, P_\lambda, P_\nu]_L)$

$= C\left(V[Z_\mu, Z_\lambda, Z_\nu]_L\right)^T, C(KV[P_{\mu U}, P_{\lambda U}, P_{\nu U}]) = C\left(V[Z_\mu, Z_\lambda, Z_\nu]_U\right)^T.$

Then P is an IV s- CS iff $Z = <[Z_\mu, Z_\lambda, Z_\nu]_L, [Z_\mu, Z_\lambda, Z_\nu]_U >$ is an IV s- CS.

Corollary 4.3: For $P = <[P_\mu, P_\lambda, P_\nu]_L, [P_\mu, P_\lambda, P_\nu]_U > \in IVNFM_{nn}$, $Z \in$ P {1, 2, 4}, $C(V[P_\mu, P_\lambda, P_\nu]_L)^T$

$= C\left(V[Z_\mu, Z_\lambda, Z_\nu]_L\right)^T, C(V[P_\mu, P_\lambda, P_\nu]_U)^T = C\left(V[Z_\mu, Z_\lambda, Z_\nu]_U\right).$ Then P is an IV s- CS iff Z is an IV s-CS.

CONCLUSION

We present equivalent characterizations of an IVk- CS, IV CS, IV s- CS, IV s-k CS Neutrosophic FuzzyMatrices. Also, we give the example of s-k-symmetric fuzzy matrix is s-k- CS Neutrosophic fuzzy matrix the opposite isn't always true. We discuss various g-inverse associated with a regular matrices and obtain characterization of set of all inverses. Equivalent conditions for various g-inverses of an Interval Valued s-k-Column Symmetric and s-Column Symmetric Neutrosophic Fuzzy Matrices are determined. In future, we shall prove some related properties of Interval Valued Secondary k-Column Symmetric Neutrosophic Fuzzy Matrices.

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RESEARCH ARTICLE

Performance of Finger Millet Varieties with Different Source of Nutrition in Doon Valley of Uttarakhand

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ABSTRACT

To investigate the performance of finger millet varieties with different source of nutrition, an experiment was conducted during Kharif season 2022 at Experimental Research Farm, School of Agriculture Sciences, SGRR University, Dehradun, Uttarakhand. The experiment consists of three finger millet varieties (PRM-1, Dun Local, PRM-2) and three different sources of nutrition (Farm Yard Manure, Vermicompost and NPK application) along with control, which were replicated thrice in factorial randomize block design. Observation on various growth, yield and seed quality parameters was recorded during the experiment. Experimental data shows that the variety PRM- 1 with application of N.P.K. @ 40:20:20 kg/ha, respectively, gave maximum plant height (95.53 cm), number of leaves per plant (9.66), number of tillers per plant (9.00), number of fingers per plant (6.33), seed yield (14.00 q/ha), germination per cent (86.33 %), vigour index-I (408.76) and vigour index-II (4.31). Based on these experiments finding, it can be concluded that variety PRM-1 with the application of N.P.K perform best among all other treatments for higher growth, yield and quality of finger millet seeds.

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Keywords: Finger millet, yield, varieties and seed vigour

INTRODUCTION

Millets are minor cereals of the grass family, Poaceae. India is considered as pivot for these minor crops. Finger millet is commonly known as ragi and mandua in India. It is native of Ethiopia, but grown extensively in various regions of India and Africa, constitutes as a staple food that supply a major portion of calories and protein to large segments of the population in these countries especially for people of low income groups (Kennedy *et.al* 2006). In world, finger millet ranks fourth in importance among millets after sorghum, pearl millet and foxtail millet (Upadhyaya *et.al*, 2007). Improper selection of varieties also affects crop yield because performance of varieties vary corresponding with their genetic potential and adaptable environment. Thus there is scope for increasing crop yield by using climate resilient varieties (Hussain *et al.,* 2012). Many high yielding are losing their yield potential due to changes in various edaphic and environment conditions. Therefore, continuous selection of high yielding genotypes that have evolved various mechanism to cope up with heat stress which are rolling, shedding and thickening of leaves, reduction in leaf size, short duration of growth period and transpiration (Wahid *et al.,*2007). The use of inorganic fertilizers is constrained by high costs and inaccessibility, and a lack of economic returns (Cedrez *et al.* 2020) as well as low soil organic matter. At the same time, poor nutrient quality and amount of organic nutrients resources available on smallholder farms are constrains to their use and effectiveness in soil fertility management (Ridder *et al.* 2004). Strategies for fertility regeneration in smallholder farming systems can best be designed with the knowledge of field responsiveness to nutrient management interventions. Vanlauwe *et al.* (2010) propose a stepwise approach in targeting and adapting nutrient management interventions to local variations as a way to moving toward integrated soil fertility management. Research on nutrient limitations and management practices has concentrated more on major nutrients than on secondary nutrients and micronutrients (Wortmann *et al.* 2019). Keeping all above in mind the present investigation was planned to known the "Effect of varieties and source of nutrition on growth, yield and quality of finger millet seeds".

MATERIALS AND METHODS

The present study entitled performance of finger millet varieties with different source of nutrition was conducted during kharif season of 2022 at Agricultural Research Farm, Department of Seed Science and Technology, Shri Guru Ram Rai University, Dehradun, Uttarakhand. The experiment consists of three finger millet varieties (PRM-1, Dun Local, PRM-2) and three different sources of nutrition (Farm Yard Manure, Vermicompost and NPK application) along with control. The N.P.K. was applied @ of 40:20:20 kg/ha, respectively. These twelve treatments combinations were replicated thrice in factorial randomize block design. Total 36 experimental plots of 14 m² each were prepared for experimental work. The crop was sown on 21 June with spacing of 25 cm between row to row and 10 cm between plants to plant. All the agronomic practices were done time to time as per the crop requirement. The plant growth, yield and yield contributing parameters like plant height, number of leaves per plant, days to 50 % flowering number of fingers per plant, length of finger, seed yield were recorded during the experimental work. The seed quality parameters like test weight, germination per cent, vigour index-I and Vigout index-II were also calculated to check the quality of produced seeds. The vigour index-I and vigour index-II were calculated by method given by Abulbaki and Anderson (1973). The collected data from experimental work were statistically analyzed by analysis of variance (ANOVA) using the program SPSS. *F*- test was used to determine the significant effect of treatments.

RESULTS AND DISCUSSION

Plant height (cm)
Plant height is mainly controlled by the genetic makeup and also affected by environmental condition during the production as it varies from variety to variety. Plant height shows significant variation for different varieties after 40

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days of sowing (DAS) and at maturity. The maximum plant height after 40 days of sowing (30.45 cm) and at maturity (85.97 cm) was recorded with variety PRM-1, while minimum plant height at 40 days after sowing (27.59 cm) and at maturity (81.07 cm) was recorded with variety PRM-2. However, the variation between variety PRM-1 (V_1) and PRM-2 (V_2) was non-significant. This significant variation might be due to the genetic constitution of varieties in prevailing environmental condition which leads to variation in morphological character. Significant effects of varieties on plant height were also recorded by Nigade and More (2013). The plant height was significantly affected by source of nutrition at 40 DAS and maturity. The plant height was recorded maximum at 40 DAS (32.26 cm) and at maturity (94.42 cm) with treatment application of recommended dose of N.P.K (T_4). Examination of data shows that the minimum plant height was observed at 40 DAS (25.26 cm) and maturity (71.89 cm) without any nutrition application (T_1). This significant variation might be due to availability of suitable dose of nutrition under prevailing environmental conditions for growth and development of plants. Patil *et al*. (2015) found 60:30:00 kg per hectare application of N.P.K. respectively, gave the maximum height of finger millet plants. At 40 days after sowing and maturity the maximum plant height was recorded (34.06 and 95.53 cm, respectively) with treatment combination of variety PRM-1 and application of N.P.K. (V_1T_4) and minimum (24.66 and 70.66 cm, respectively) with treatment combination of variety PRM-2 and control (V_3T_1).This significant variation might be due to the genetic constitution of varieties in prevailing environmental condition.

Number of leaves per plant

Number of leaves per plant has a direct correlation with higher food synthesis as a result of photosynthesis. Number of leaves per plant shows non- significant variation for different varieties. The numbers of leaves per plant was affected significantly by source of nutrition. The numbers of leaves per plant was recorded maximum (9.33) with treatment of N.P.K. application (T_4) and minimum (7.33) from plants where no nutrition was applied (T_1). These findings are also in agreement with the findings of Ullasa *et al.* (2020). Interaction effect of varieties and source of nutrition were observed significant with respect to numbers of leaves per plant. Maximum number of leaves per plant was recorded (9.66) with treatment combination of PRM-1 and application of N.P.K fertilizer (V_1T_4). It was statistically at par to the treatment combination V_2T_4 (9.33), V_3T_4 (9.00), V_1T_3 (8.66), V_2T_2 (8.66), V_3T_3 (8.60). The minimum numbers of leaves per plant was found (6.66) with treatment interaction of variety Dun Local and without application of nutrition (V_2T_1).

Days to flowering

Number of days to 50 per cent flowering shows significant variation for different varieties. The maximum number of days to require for 50 per cent flowering was recorded (77.08) in variety PRM-1 (V_1), while minimum (65.58) with variety Dun local. This significant variation might be due to the genetic constitution of varieties in prevailing environmental condition which leads to variation in morphological characters and ultimately initiation of flowering. Walfula *et al*., (2016) also found significant effects of varieties on fifty per cent flowering of finger millet crop. Number of days of 50 per cent flowering was significantly varies with different source of nutrition. It was recorded minimum (68.11) with treatment of N.P.K. fertilizer application (T_4). Close examination of data shows that the crop plants in which no nutrition was applied (T_1) takes maximum number of days for 50 per cent flowering. Tsado *et al*., (2016) also found significant effect of source of nutrition on 50 per cent flowering. Interaction effect of varieties and source of nutrition was found significant with respect to number of days required for 50 per cent flowering. The minimum number of days required for 50 per cent flowering was recorded (63.00) with treatment combination of variety Dun local and application of N.P.K. fertilizer (V_2T_4). The maximum number of days were required to 50 per cent flowering (78.66) recorded with interaction of variety PRM-1 without application of nutrition (V_1T_1).

Number of tiller per plant

Significantly higher number of tillers is an indication of development of higher number of finger per plant and ultimately higher number of seeds setting in plants. The highest number of tillers per plant was recorded with variety PRM-1 (V_1) which was 7.75. It was statistically at par to the variety PRM-2 (V_3) *i.e*. 7.50 tillers per plant. Significant effects of varieties on plant height were also recorded by Sarawale *et al*. (2016). Number of tillers per plant responds significantly to different source of nutrition. Application of N.P.K. fertilizer @ 40:20:20 kg/ha (T_4) gives

maximum number of tillers per plant *i.e.* 8.44, However, it was statistically at par to treatment of application of vermicompost (T_3) *i.e.* 8.00. The minimum number of tillers per plant was recorded (5.77) in control plot (T_1) where no nutrition was applied. Nigade and More (2013) also recorded significant effects of nutrition source on number of tillers per plant. The maximum number of tillers per plant was recorded (9.00) with interaction of variety PRM-1 and application of N.P.K. (V_1T_4). The minimum number of tillers per plant was recorded (5.60) with interaction of variety dun Local and application of N.P.K. (V_2T_1). These findings are also in agreement with the finding of Nigade and More (2013).

Number of finger per plant
The number of fingers per plant show non-significant response with respect to varieties. The numbers of fingers per plant was affected significantly by source of nutrition. The number of finger per plant was recorded (6.11) maximum with treatment of N.P.K. application (T_4) and minimum (4.88) where no nutrition was applied (T_1). Tsado *et al.,* (2016) were found that the application of recommended dose of inorganic fertilizers produces highest number of fingers as compared to other treatments. The number of finger per plant was affected significantly with interaction of varieties and source of nutrition. The maximum number of finger per plant was recorded (6.33) with interaction of variety PRM-1 and application of N.P.K. (V_1T_4), The minimum number of finger per plant was recorded (4.66) with no nutrition application *i.e.* control (V_2T_1). Similar finding was also reported by Nigade and More (2013).

Seed yield
The significantly highest seed yield was recorded with variety PRM-1 (V_1) which was 13.00 q/ha. It is due to the better performance of varieties in terms of growth and yield attributing characters of variety. The minimum seed yield was recorded (11.58 q/ha) with variety PRM-2 (V_3). Sarawale *et al.* (2016) also observed significant effects of varieties on yield of finger millet. Seed yield was respond significantly with different source of nutrition applied to the crop. Seed yield was recorded maximum (13.22 q/ha) with treatment application of N.P.K. (T_4). The highest yield produced with the application of recommended dose of inorganic fertilizer could be attributed to the availability of nitrogen in their readily available forms at the root zone of the crop as at when required which might have enhanced the meristematic activities which translated into the elongation of vegetative characters and ultimately the yield of crop. Minimum seed yield was recorded (11.22 q/ha) where no nutrition was applied (T_1). Tsado *et al.,* (2016) also recorded significantly higher yield with application of inorganic fertilizer. The maximum seed yield was recorded (14.00 q/ha) with interaction of variety PRM-1 and application of N.P.K. (V_1T_4), which was statistically at par to the treatments interactions, V_1T_3 (13.33), V_1T_2 (13.00), V_3T_4 (12.33), V_3T_3 (12.00) and V_2T_3 (12.66). The minimum seed yield was recorded (10.66 q/ha) with interaction of variety PRM-2 without application of any nutrition (V_3T_1).

Germination percentage (%)
The significantly highest germination was recorded in variety PRM-1 (V_1) *i.e.* 87.66. and lowest with (84.83 %) with variety PRM-2 (V_2). Yogeshwari *et al.,* (2022) also found the significant effects of cultivars on germination per cent. Germination percentage was affected significantly by different source of nutrition. Germination was recorded maximum (90.11 %) with treatment application of N.P.K. application (T_4) and minimum (76.33 %) without application of nutrition (T_1). These findings are also in agreement with the findings of Patil *et al.,* (2018). The maximum germination per cent was recorded (91.33) with interaction of variety PRM-1 and application of N.P.K. (V_1T_4), which was statistically at par to the treatments interactions V_3T_3 (90.33), V_3T_4 (90.00) and V_2T_4 (89.00). The minimum germination per cent was recorded (80.00) with interaction variety PRM-1 without application of any nutrition (V_1T_1). These findings are also in agreement with findings of Thakur *et al.,* 2016.

Vigour index- I
Vigour index-I shows non-significant variation with respect to different varieties. Vigour index-I shows significantly variation with respect to different source of nutrition. Vigour index-I recorded maximum (386.21) with treatment of N.P.K. application (T_4). The minimum vigour index was recorded (251.89) with control treatment where no nutrition applied (T_1). Similar findings were also recorded by Patil *et al.,* 2018. The maximum vigour index-I was recorded (408.76) with interaction of variety PRM-1 and application of N.P.K. (V_1T_4), which was statistically at par to the

treatments interactions V_3T_3 (386.03), V_3T_4 (383.13), V_2T_3 (368.03) and V_2T_4 (366.73). The minimum vigour index-I was recorded (248.20) with interaction of variety Dun Local without application of nutrition (V_2T_1). Similar results were also reported by Thakur *et al.*, 2016.

Vigour index- II

Vigour index-II shows non-significant variation in respect to different varieties. Vigour index-II was affected significantly by different source of nutrition. The maximum vigour index-II was recorded (3.33) with treatment of application of vermicompost (T_3) which was statistically at par to treatment of application of N.P.K. (T_4) *i.e.* 3.31 and minimum (2.46) control plot where no any nutrition applied (T_1). Patil *et al.*, (2018) also found significant effects of nutrition source on vigour index of finger millet. Vigour index-II was affected significantly with interaction of varieties and source of nutrition. The maximum vigour index-II was recorded (4.31) with interaction of variety PRM-1 and application of N.P.K. (V_1T_4). It was recorded statistically at par to the treatments interactions V_1T_3 (3.81) and V_3T_4 (3.38). The minimum vigour index-II was recorded (2.18) with interaction of variety Dun Local without application of nutrition (V_2T_1). These findings are also in agreement with finding of Thakur *et al.*, 2016.

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Table 1. Effect of varieties and source of nutrition on growth parameters of finger millet.

Treatments	Plant height at 40 days (cm)	Plant height at maturity (cm)	Number of leaves per plant	Days to Flowering	Number of Tillers	Number of fingers per plant
Varieties						
V_1	30.45	85.97	8.58	77.08	7.75	5.41
V_2	28.26	85.94	8.16	65.58	6.83	5.58
V_3	27.59	81.02	8.14	71.50	7.50	5.41
Sem±	0.59	1.11	0.20	1.11	0.26	0.18
Cd at 5 %	1.74	3.28	NS	3.25	0.78	NS
Source of nutrition						
T_1	25.26	71.89	7.33	73.77	5.77	4.88
T_2	26.46	82.11	8.44	72.11	7.22	5.55
T_3	31.08	88.82	8.44	71.55	8.00	5.33
T_4	32.26	94.42	9.33	68.11	8.44	6.11
Sem±	0.68	1.29	0.23	1.28	0.31	0.21
Cd at 5 %	2.00	3.78	0.68	3.76	0.91	0.62
Interaction						
V_1T_1	25.83	70.70	7.66	78.66	6.00	5.00
V_1T_2	28.00	86.66	8.33	78.00	7.66	5.00
V_1T_3	33.93	91.00	8.66	78.00	8.33	5.33
V_1T_4	34.06	95.53	9.66	73.66	9.00	6.33
V_2T_1	25.30	74.33	6.66	69.66	5.66	4.66
V_2T_2	26.36	85.66	8.66	66.33	6.66	6.00
V_2T_3	29.83	88.96	8.00	63.33	7.33	5.33
V_2T_4	31.56	94.83	9.33	63.00	7.66	6.30
V_3T_1	24.66	70.66	7.66	73.50	5.66	5.00
V_3T_2	25.03	74.00	8.33	72.00	7.33	5.66
V_3T_3	29.50	86.50	8.60	73.33	8.33	5.33
V_3T_4	31.16	92.91	9.00	67.66	8.66	5.66
Sem±	1.18	2.23	0.40	2.22	0.53	0.36
Cd at 5 %	3.48	6.56	**1.17**	**6.51**	**1.57**	1.07

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Table 2. Effect of varieties and source of nutrition on seed yield and quality of finger millet.

Treatments	Seed yield (q/ha)	Germination percentage (%)	Vigour Index- I	Vigour Index- II
Varieties				
V_1	13.00	87.66	330.37	3.41
V_2	11.83	86.58	307.84	2.51
V_3	11.58	84.83	306.55	2.89
Sem±	0.31	0.43	8.54	0.17
Cd at 5 %	0.92	1.27	NS	NS
Source of nutrition				
T_1	11.22	81.33	251.89	2.46
T_2	12.44	85.44	270.95	2.66
T_3	13.00	88.55	350.54	3.33
T_4	13.22	90.11	386.21	3.31
Sem±	0.36	0.43	9.86	0.19
Cd at 5 %	1.06	1.20	28.93	0.57
Interaction				
V_1T_1	11.66	80.00	255.06	2.50
V_1T_2	13.00	81.33	265.50	3.03
V_1T_3	13.33	86.66	296.90	3.81
V_1T_4	14.00	91.33	408.76	4.31
V_2T_1	11.33	81.66	248.20	2.18
V_2T_2	12.00	87.00	248.40	2.56
V_2T_3	12.66	88.66	368.03	3.06
V_2T_4	12.30	89.00	366.73	2.23
V_3T_1	10.66	82.33	252.70	2.31
V_3T_2	11.33	88.00	298.96	2.76
V_3T_3	12.00	90.33	386.03	3.13
V_3T_4	12.33	90.00	383.13	3.38
Sem±	0.63	0.86	17.09	0.34
Cd at 5 %	1.85	2.55	50.12	1.00

RESEARCH ARTICLE

In-Vitro Anti Acne Potential of Ascidian

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ABSTRACT

Marine environment has been recognized to be a rich source of bioactive metabolites with varied biological and pharmacological activities. Ascidians rank second with most promising source of drugs. The aim of this work was to investigate the antiacne activity of the ethanolic extract of *Eudistoma viride*. The antiacne assay was measured by agar well diffusion method.The zone of inhibition noted was 4.5 ± 0.7 mm at the highest concentration of 500 µg/ml of ethanolic extract of *Eudistoma viride*. The result from the study showed that the ethanolic extract of *Eudistoma viride* can be used in skin-care products for the treatment of acne.

Keywords: Ascidians, *Eudistoma viride*, antiacne, zone of inhibition, *Propionibacterium acnes*

INTRODUCTION

Skin is a marker of health and beauty. Skin is the organ that comes into contact with the environment. Acne is one of the most frequent and chronic skin problems in teenagers and young adults. [1]. Acne can happen in adults, although it is more frequent in teenagers and young adults going through hormonal changes. Acne is most commonly observed on the face, upper chest, and back of persons with a greater number of oil glands [2]. Acne develops in four stages, beginning with excess sebum production and altered lipid composition in the sebaceous gland at the base of hair follicles, followed by pore blockage, then colonization by *Propionibacterium acnes* [3], which causes inflammation and pustule formation [4,5,6].Acne is often a moderate and self-limiting disorder, but in its most severe form, it can cause scarring and skin discoloration. Sequelae have a strong impact on the quality of life of individuals and are

often associated with the development of psychiatric disorders [7,8].Routinely, major treatment options for acne vulgaris include isotretinoin, use of antibiotics like tetracyclines and hormonal drugs. However, variables such as long-term usage of such medications, which have substantial side effects, as well as the emergence of antibiotic resistance among clinical strains of P. acnes, have posed significant constraints to the effective eradication and treatment of the disease[9,10].Natural products may be helpful in treating acne because there are adverse effects from conventional treatments. The antiacne effects of marine resources have received little attention. Marine environment has been recognized to be a rich source of bioactive metabolites with varied biological and pharmacological activities.Among the marine invertebrates, ascidians are the most closely related to humans; they constitute the biggest and most varied class of the sub-phylum Tunicata, comprising about 3000 described species[11]. Ascidians are marine invertebrates which ranks second with promising the source of drugs[12].Many different secondary metabolites have been produced by ascidians, some of which have physiological purposes, mostly for protection against natural predators [13]. Ascidians harbour a great microbial community (including bacteria, actinobacteria, cyanobacteria, and fungi), which represents an additional source of natural products, many of which are extremely potent and mainly cytotoxic and antimicrobial, but also antioxidant, anti-inflammatory properties [14].In India, studies on antiacne property of ascidians especially in *Eudistoma viride* are lacking. As ascidians are available along the Tuticorin coast an attempt has been made to assess antiacne property of ascidians.

MATERIALS AND METHODS

Samples of *Eudistoma viride* Tokioka, 1955 were collected during the low tide from the intertidal rocky area of Hare Island. The samples were washed with sea water to remove sand, mud and overgrowing organisms at the collection site and then transported to laboratory. The samples were dried and made into powder. Then the crude extract was prepared using Soxhlet extraction method and the solvent was separated by rotary evaporator.

Nutrient Agar Medium
The medium was prepared by dissolving 2.8 g of the commercially available Nutrient Agar Medium (HiMedia) in 100 ml of distilled water. The dissolved medium was autoclaved at 15 lbs pressure at 121°C for 15 minutes. The autoclaved medium was mixed well and poured into 100 mm petriplates (25-30ml/plate) while still molten.

Nutrient broth
Nutrient broth was prepared by dissolving 2.8 g of commercially available nutrient medium (HiMedia) in 100 ml distilled water and boiled to dissolve the medium completely. The medium was dispensed as desired and sterilized by autoclaving at 15 lbs pressure (121ºC) for 15 minutes.

Antimicrobial assay
The antimicrobial assay was measured by agar well diffusion method. Petri plates containing 20 ml nutrient agar medium were seeded with 24 hr culture of bacterial strains were adjusted to 0.5 OD value according to McFarland standard, (*Propionibacterium acnes*-1951)Wells were cut and ethanolic extract of *Eudistoma viride* was added at various concentration (500, 250, 100 and 50 µg/ml). The plates were then incubated at 37°C for 24 hours. The antibacterial activity was assayed by measuring the diameter of the inhibition zone formed around the wells. Gentamicin antibiotic was used as a positive control.

RESULTS

In the present investigation, ethanolic extract of *Eudistoma viride* were tested against gram positive, anaerobic bacteria *Propionibacterium acnes*. Table: 1; Figure: 1 and Plate: 1 depict the antiacne activity of *Eudistoma viride*.Antibiotic - Gentamicin was used as positive control. The zone of inhibition noted was 4.5±0.7mm at the highest concentration of 500 µg/ml of ethanolic extract of *Eudistoma viride*. Zone of inhibition was absent in 250, 100 and 50 µg/ml of ethanolic extract of *Eudistoma viride*. In control, the zone of inhibition was 14.5±0.7mm. Statistical analysis of the antimicrobial

activities showed that the p value was less than 0.05, which indicates that there was a significant difference in the antimicrobial activity of ethanolic extract of *Eudistoma viride*.

DISCUSSION

The ethanolic extract of *Eudistoma viride* showed antiacne effect against *Propionibacterium acnes*. The antibacterial activity of the oil of *Citrus limetta* against *P. acnes* may be due to the presence of flavonoids, phenols, tannins and L-ascorbic acid [15]. The *Apis cerana* honey from Banyuwangi has antiacne activity and it may be due to phenolics and flavonoids present in it[16]. The presence of antiacne activity possessed by sea cucumbers may be due to saponin compounds and terpenic compounds in sea cucumbers[17]. Flavonoids are well known antioxidant, with antibacterial and antimicrobial properties[18]. Flavonoids are reported to synthesize in plant by the stimulation of microbial infection, as effective antimicrobial substance. Therefore, it is considered as antimicrobial activity against wide range of microorganisms, possibly due to its capability of forming complex with bacterial cell walls by interacting with extracellular and soluble proteins. Further microbial membrane may also disrupt by lipophilic flavonoids[19]. *Eudistoma viride* contains phenols and flavonoids[20] and the antiacne activity of *Eudistoma viride* may be due to flavonoids and phenols present in it.

CONCLUSION

The animal which are considered as the nuisance and affect the economy by corrosion were used for this study. Such a natural product is good for health and devoid of side effects. The result from the study showed that the ethanolic extract of *Eudistoma viride* has confirmed a promising inhibitory effect in acne.The ethanolic extract of *Eudistoma viride* has great potential to be used in skin-care products for the treatment of acne.

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Table: 1 Antiacne activity of ethanolic extract of *Eudistoma viride* against *Propionibacterium acnes*

Zone of inhibition (mm)				
500 µg/ml	250 µg/ml	100 µg/ml	50 µg/ml	Gentamicin
4.5±0.7	0	0	0	14.5±0.7

Significance - p< 0.05
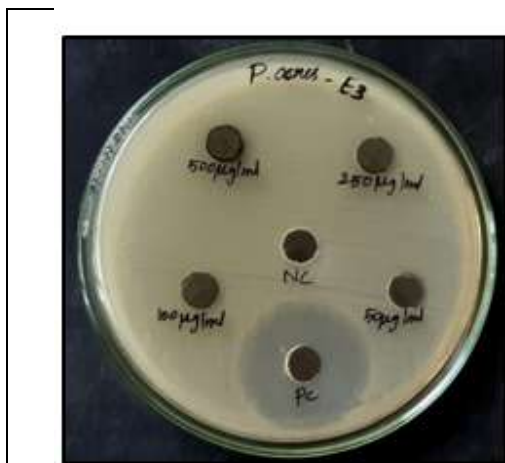
| Plate: 1 Antiacne activity of ethanolic extract of *Eudistoma viride* against *Propionibacterium acnes* | Figure: 1 Antiacne activity of ethanolic extract of *Eudistoma viride* against *Propionibacterium acnes* |
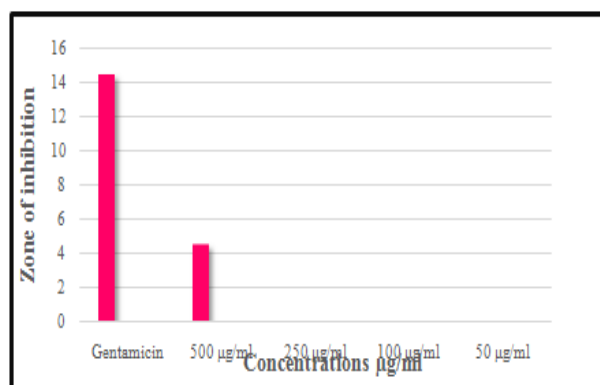
REVIEW ARTICLE

A Review on *In Vivo* and *In Vitro* Models of Anti Parkinson's Disease

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ABSTRACT

Parkinson's disease (PD) is a devastating neurological disorder that produces both movement and non-motor symptoms, primarily affecting the elderly. The following article presents an extensive overview of the in vivo and in vitro models utilized in Parkinson's disease (PD) research, as well as potential therapeutic methods. Key etiological factors such as age, heredity, and environmental factors are studied, as are associated symptoms and illness periods. Pesticide exposure, cigarette smoking, and caffeine use are among the risk factors highlighted, as are preventative measures such as regular exercise. Drug treatments for Parkinson's disease, such as catecholamines and neurotropic medications, have been demonstrated to be beneficial in reducing symptoms. Furthermore, medicinal herbs and flavonoids have showed promise neuroprotective properties in Parkinson's disease mice. *In vivo* models, including as chemical-induced and genetic models, are under consideration for their usefulness in simulating Parkinson's disease pathogenesis and evaluating potential therapeutics. In vitro procedures, such as trials using rat striatal slices, provide vital information about released neurotransmitters and drug metabolism in a controlled setting. Epidemiological features, such as illness distribution and genetic contributions, help to explain PD prevalence and familial risk factors. Overall, this review emphasizes the significance

of continuous research using a variety of models to increase our understanding of Parkinson's disease pathophysiology and create tailored therapeutic strategies for this intricate neurological condition.

INTRODUCTION

A degenerative neurological condition that primarily affects middle-aged and elderly people. It is distinguished by tremor, muscular rigidity, and slow, inaccurate movement. It has been linked to basal ganglia atrophy and a lack of dopaminergic neurotransmitters [1]. Options like regular exercise are discussed, providing insights into lifestyle modifications that may mitigate the risk of developing PD. In the realm of drug treatments, dopamine-related medications, particularly L-Dopa, continue to be the gold standard for managing PD symptoms. Neurotropic factors and medicinal herbs, including promising compounds like flavonoids, emerge as potential avenues for neuroprotection and symptom control. The exploration of in vivo models, encompassing chemical-induced and genetic models, provide   comprehensive understanding of PD pathology. These models serve as crucial tools for evaluating novel therapeutic approaches. In vitro approaches, such as tests on rat striatal slices, provide vital insights into neurotransmitter release mechanisms and pharmacological actions in controlled conditions. The review focuses on epidemiological features, revealing illness distribution patterns and genetic contributions, as well as giving a contextual framework for understanding Parkinson's disease prevalence and familial risks. This comprehensive review emphasizes the critical role that various research models play in improving our understanding of Parkinson's disease. Researchers want to untangle the complexity of Parkinson's disease causation and develop tailored treatment strategies for this challenging neurological ailment by exploring the interactions of genetic, environmental, and lifestyle factors

ETIOLOGY

Cigar smoking
Larger cohort studies support the majority of epidemiological research, which is case-control studies that show a lower risk of developing Parkinson's disease (PD). A large meta-analysis of 44 case-control studies and 8 cohort studies from 20 different countries discovered a positive link between smoking and Parkinson's disease (PD) [5,6]. The pooled relative risk for
current smokers were 0.39.

Caffeine
Caffeine, an adenosine A2A receptor antagonist, has been shown to have neuroprotective benefits in a mouse model of Parkinson's disease (PD), and it is believed to be protective in the case of PD. Previous reports have mentioned a 25% risk [7].

Pesticides
1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP) was first implicated in nigrostriatal degeneration in 1983, when many people who injected themselves with a prescription medicine laced with MPTP showed characteristic Parkinson's disease symptoms. MPTP undergoes conversion into the neurotoxic MPP+ (1-methyl-4-phenylpyridinium), a mitochondrial complex-I inhibitor that targets dopaminergic cells in the substantia nigra[8].

EPIDEMIOLOGY

Genetics and pathophysiology
Pathophysiology and genetics: Some Parkinson's disease (PD) patients have specific hereditary riskfactors. In 1997, Polymeropoulos et al. reported a mutation in the alpha-synuclein gene, or SNCA, that has been associated with uncommon families with autosomal dominant Parkinson's disease (43). Despite families possessing these highly dominant alleles are relatively unique, this pioneering study revealed that beta-sync plays a crucial part in Lewy bodies in people with sporadic Parkinson's disease. The finding of autosomal dominant Parkinson's disease (PD) families with alpha-synuclein gene duplications or triplications contributed to previous evidence that high alpha-synuclein levels contribute to the aetiology of Parkinson's disease (PD) (44).

Distribution of disease
According to health-care consumption estimates, the annual prevalence of Parkinson's disease ranges from 5/100,000 to more than 35/100,000 new cases. During between the sixth and ninth decade of your existence, prevalence doubles from 5 to tenfold. Parkinson's illness becomes more common as people get older. A meta-analysis of four North American categories revealed that prevalence rates have risen to fewer than 1% of men and women aged 45 to 54 (42).

SYMPTOMS
- Parkinson's disease manifestations may differ from person to person. Early signs may be subtle and overlooked. Even if symptoms arise on both sides of the body, they generally start on one and progress on the opposite side of the body.
- Tremors: also known as rhythmic shaking, typically start in one of the limbs, typically the palms or fingernails. Rub the middle of your thumb and fingers together rapidly. We call this tremor a pill-rolling tremor. Your hand may shake hands though it is not moving. There is an important decrease in trembling when exercising.
- Parkinson's disease can cause increasing loss of motion, making even simple chores difficult. Walking entails taking smaller steps. It could be tough to get out of a chair. When attempting to walk, shuffle or drag your legs.
- Muscle rigidity: stiffness. It could occur anywhere on the body. Because of stiff muscles, flexibility options may be limited and uncomfortable.
- Patients experiencing PDD struggle with equilibrium and posture, prompting them to stoop. In addition, Parkinson's disease can cause somebody to stumble or lose their equilibrium.
- Patients with the condition are devoid of spontaneous gestures, such as blinking, smiling, and swinging arms while strolling.
- Variations in speech: such as muttering, speaking fast or softly, or pausing before responding.
- Improvements to writing: Writing appears to be small and rough.

RISK FACTORS

Age
Parkinson's disease rarely affects young individuals. It usually begins in middle or late life, and as persons age, their risk increases. A sickness usually manifests itself at the age of 60 or older. If a young individual is diagnosed with Parkinson's disease, genetic counselling may help with family planning options. A senior with Parkinson's disease has unique demands in terms of relationships, career, and pharmaceutical side effects, all of which require careful consideration.

Heredity
Individuals who inherit the disorder from close relatives are more likely to get it. Unless you have a large number of Parkinson's disease-affected family members, your odds remain tiny.

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Sexual

Parkinson's disease is more common in men than in women.

Toxin exposure

Extended exposure to toxins may marginally raise your chance to acquire the PD. Because the aetiology of Parkinson's disease is uncertain, there are not commonly acknowledged, effective preventative strategies. According to studies, regular aerobic exercise might reduce the risk of disease. According to additional studies, persons who use caffeine—found in coffee, tea, and soda—are less likely to develop Parkinson's disease than those who do not. Furthermore, consuming green tea may lower your chances of having Parkinson's disease. However, it remains unknown whether caffeine has any further effects or prevents Parkinson's disease. There is currently inadequate proof to support the concept that drinking coffee may delay Parkinson's disease.

PREVENTION
DRUG TREATMENTS
Dopaminergic medications

In the realm of Parkinson's disease (PD), the "gold standard" for treatment remains L-DOPA, the most powerful anti-parkinsonian medication on the market. Dopamine-based medications are regarded to constitute the conventional course of treatment. Dopaminergic drugs are used to boost or imitate dopamine levels, as many Parkinson's disease (PD) symptoms, particularly movement-related ones, are caused by a lack of dopamine accessible for communication in the nigrostriatal pathway. However, its precursor can cross the blood-brain barrier more readily than dopamine itself [9].

Anticholinergics for early on

The first medications used to treat Parkinson's disease (PD) were anticholinergic. They work as an antagonist by minimizing acetylcholine activity at choline receptors, with the goal of restore the dopamine-acetylcholine balance that has been altered by Parkinson's disease[10].

NEUROTROPIC FACTORS
- Nerve cells require neurotrophic factors (NTFs), which are tiny natural proteins, in order to form and survive. The neurotropic nerves preserve their anatomical and behavioral characteristics. NTFs must be released at the target structures before neural networks may function. Nerve terminals convey NTFs retrogradely to the soma of projecting axons for production and preservation. The "neurotrophic hypothesis" explains this[11].
- •A gene is activated when NTFs arrive at the nucleus, promoting phenotypic specification and neuronal survival. A variety of proteins have been classified as NTFs due to their impact on neuronal survival, differentiation, electrophysical maturation, and plasticity [11].

STAGES OF PARKINSON DISEASE

Parkinson's Disease rating scales are used to assess an individual's quality of life as well as provide information on the condition's progression. The Hoehn and Yahr Scale offers suggestions based on disease severity statistics[12]. The stages of the H&Y scale are as follows:
- Stage 1: symptoms appear on one side exclusively (unilateral).
- Stage 2: Here is no loss of balance yet both sides have symptoms.
- Stage 3: Mild to moderate disease progression and deterioration of balance.
- Stage 4: Severe impairment, but yet capable of walking or standing alone.
- Stage 5: Requiring support to get out of their bed or having a wheelchair [12].

***IN VIVO* MODELS**

The chemically induced 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP) and 6-hydroxydopamine (6-OHDA) rats are two of the most widely utilized animal models of Parkinson's disease (PD). Both 6-OHDA and MPTP are dopamine transporter (DAT) clients and constitute neurotoxins. Because 6-OHDA can act as an anchor for the

norepinephrine transporter (NET), it is not limited to dopaminergic (DA) neurons when supplied alone. Because of their larger size, mice are generally avoided when it comes to MPTP and 6-OHDA; rats get the nod for this (easier operations and microinjections) due to their higher translational relevance and richer emotional profile. The chemically established Parkinson's disease models have high internal reliability for both the triggered motor phenotype and the loss of dopaminergic neurons. These are effective mimics of dopaminergic decline, especially when the ethology is irrelevant to the study. However, because these models only show the loss of dopaminergic neurons and cannot be used to examine the disease's pathophysiology across time, including the causes of neurodegeneration, they have extremely low construct validity. Furthermore, these models are unable to assess any of the non-dopaminergic changes known to be present in Parkinson's disease (PD), nor can they generate Lewy bodies, a key PD feature.

Genetic model
Genetic models of Parkinson's disease are now being developed using the genes known to be associated with familial Parkinson's disease. These models frequently involve either transgenic ally expressing a humanized form of the gene with a known mutation in humans or knocking off the target gene (Dawson TM) [25]. These models have traditionally been in mice since it is easy to change genes in animals. Common target genes in genetic models comprise alpha synuclein (Snca), leucine rich recite kinase 2 (Lrrk2), parkin (Park2), PTEN-induced putative kinase 1 (Pink1), and DJ-1 (Park7). Up until now, mice have been the only viable mammalian option for gene modification. Compared to the rat, the mouse is smaller, has a simpler yet more erratic cognitive pattern, and is generally more unintelligent [26].

Reserpine model
The reserpine-treated mouse was one of the earliest animal models utilized in studies on Parkinson's disease (PD). This model, albeit a relatively crude pharmacological mimic of the neurochemistry involved in Parkinson's disease, was important in determining the efficacy of L-DOPA, the most effective treatment for Parkinson's disease to date [27]. The reserpine model greatly advances our understanding of the relationship between monoamine depletion and parkinsonian disorder symptoms from the standpoint of the disease. [39] Reserpine, also known as VMAT2, restricts the vesicular monoamine transporter; usual dose: 4-5 mg•kg−1 sic. Depletion of brain (and peripheral) monoamines, such as dopamine, noradrenaline, and 5-HT, results from this lack of storage capacity. In order to theoretically prolong neurochemical abnormalities, AMPT (α-methyl-p-tyrosine) is given in conjunction with reserpine, which inhibits the synthesis of dopamine and noradrenalin. [28]

Haloperidol model
Rats administered with haloperidol represent another pharmacological model of Parkinson's disease (PD) with low construct plausibility. Haloperidol works by preventing the direct and indirect pathways of the motor circuit from being facilitated by the D2 and, to a lesser extent, the D1 dopamine receptors in medium spiny neurons [28]. In the haloperidol paradigm, the anti-parkinsonian efficacy of new drugs is evaluated based on rigidity or the reversal of catalepsy (as previously mentioned).[40] To boost data comparison between laboratories, the "bar test," which gauges catalepsy as the amount of time it takes an animal to remove its forepaws from a bar (also called descent latency), is frequently employed. Nevertheless, variations in the bar height (set at 6–10 cm), cut-off duration (60–300 s), and haloperidol dosage still make cross-lab comparisons difficult [29]. (0.5–10 mg•kg−1) as well as sensitivity in animals. As mentioned above, several drugs now utilized in clinical settings to treat Parkinson's disease (PD) have shown promise in the haloperidol model. These drugs include pramipexole, amantadine, L-DOPA, and trihexyphenidyl [30].

Classical toxin-induced rodent models of PD
The two frequently used animal models of Parkinson's disease are the MPTP-treated mouse and the standard 6-OHDA-treated rat. Out of all of them, the 6-OHDA model has been extensively utilized to test new symptomatic medicines, as well as to evaluate neuroprotective and repair techniques. The MPTP-treated mouse has an additional advantage of being easier to create than the 6-OHDA rat, yet it is unlikely to be the first model of choice for testing

symptomatic medicine due to its less powerful cognitive profile. It outlines a viable technique for secondary screening 6OHDA model. The hydroxylated analogue of dopamine, 6-OHDA, is characterized as a toxin that causes dopaminergic neuron degeneration in the nigrostriatal tract [31]. As an outcome, it has evolved into a popular approach of causing Parkinsonism in animals. Unlike MPTP (below), 6-OHDA cannot easily cross the blood-brain barrier and must be delivered directly to the brain. 6-OHDA is injected into the Nigro-striatal tract in one of three locations: the substantia nigra pars compacta (SNpc), which contains the A9 dopaminergic cell bodies; the median forebrain bundle (mfb), through which the dopaminergic Nigro-striatal tract ascends; or the striatum, which operates as the terminal region [31]. Other factors commonly determine the location of injection; for example, if direct mechanical damage to the SNpc is avoided, mfb or striatal injection models are favoured [32].

The MPTP-treated mouse model
Following intravenous injection, the lipophilic protoxin MPTP readily breaches the blood-brain barrier (usually abdominal or subcutaneous). When MPTP attains the brain, MAO-B (found primarily in glia and serotonergic neurons) transforms it to 1-methyl-4-phenyl-2,3, dihydropyridine (MPDP+), an intermediate, which is then rapidly and inadvertent oxidized to 1-methyl-4-phenylpyridinium (MPP+), the deadly component [33].

Rotenone model
Parkinson's disease (PD) was triggered by the finding that MPTP induced nigrostriatal tract degeneration by targeting mitochondrial complex I. The rotenone model of Parkinson's disease is the most well-known of them. However, rotenone has considerable systemic toxicity, primarily cardiovascular, in addition to its central toxicity. This leads in a high death rate (about 30% of animals), regardless of the manner of administration [34]. The initial study on the rotenone model promised a realistic Parkinson's disease (PD) model. Infusing modest amounts of rotenone (2-3 mg•kg−1/day) iv via osmotic mini-pumps over one to five weeks resulted in varied degrees of Nigro-striatal degeneration in approximately half of the animals [34].

MPTP primate model
The potential of MPTP to trigger Parkinsonism in people was identified, presenting an opportunity to develop a high-construct validity monkey model of Parkinson's disease (PD) using systemic toxin treatment. This has never been done before, and earlier models utilized surgical procedures to disrupt the Nigro-striatal hyperlink or the use of manganese toxicity, which causes pallidal rather than nigral neuronal death [35]. A parkinsonian condition arises almost immediately, if not sooner, after repeated systemic administration of MPTP over a period of up to five days by intraperitoneal, subcutaneous, and intravenous routes at levels that vary depending on the species and route [35].

IN VITRO **METHODS**
Experiment using rat striatal slices
Purpose and Rationale:
- Parkinson's disease primarily affects the brain striatum.
- Neurotransmitter release, such as acetylcholine and dopamine, is a reliable in vitro indicator of the test agent's activity.

Procedure
- Male rats weighing 150 to 250 grams are beheaded and their skulls split apart.
- The left and right striata are removed and immersed in ice-cold kerb solution.
- Using a tissue, cut the striata into 0.4 mm thick slices.
- After 30 minutes of incubation at 37°C, the thick slices are marked.
- Using dopamine (5ug/ml) and choline (2ug/ml) in the presence of 0.15ml pargyline chloride and 0.1ml ascorbic acid.
- Labelled slices are shipped to super fusion chambers and fused at a flow rate of 0.5 millilitres per minute at 37 degrees Celsius using Krebs solutions.

- The super Fuste portion is removed after five minutes of washing and reliability. In the perfusion buffer, 1M normotensive is utilized to prevent dopamine reuptake.

MEDICINAL PLANTS AND FLAVANOIDS IMPACT ON PARKINSON'S DISEASE

The terms "neurotoxicity," "Parkinson's disease," and "neuroprotective," as well as "Medicinal plants" and "flavonoids," were searched. Based on animal research and clinical observations, the components of natural therapies and extracts identified in this study have neuroprotective potential against Parkinson's disease (PD). These protective characteristics are mediated chiefly via the suppression of neuro-I, the lowering of oxidant indicators, the inhibition of dopamine metabolizing enzymes, and the increase of oxidant agents.

Mucuna pruriens

Mucuna pruriens, a Fabaceae plant, is used in Indian traditional medicine to treat illnesses such as Parkinson's disease[13]. L-dopa is a major component of the medicinal plant (14). L-dopa was less efficacious than the dietary endocarp of *M. pruriens* seeds (5 g/kg) or carbidopa (50 mg/kg). In mice tested for free ipsilateral spin caused by 6-hydroxydopamine (6-OHDA), the meal endocarp of pruriens mold seeds (5 g/kg) in combination with carbidopa (50 mg/kg) had a greater effect than L-dopa. In the *substantia nigra* of 6-OHDA-induced Parkinson's disease (PD) rats, *M. pruriens* powder (2.5 or 5 g/kg/d) dramatically increased the endogenous levels of L-dopa, dopamine, norepinephrine, and serotonin [13,14].

Vicia feba

Horse beans, field beans, and broad beans (*Vicia feba*) have long been used as food in Pakistan, China, India, and other Mediterranean countries. The seeds of this prolific natural supply of L-dopa contain carbohydrates, vitamins, proteins, and calcium[15]. V. Feba is used to manage Parkinson's disease by improving motor function. When L-dopa (125 mg) and carbidopa (12 5 mg) were combined, the similar outcome emerged.[37]. Three patients treated with *V. faba* appeared to exhibit dyskinesia of comparable degree to those treated with L-dopa. Furthermore, it has been observed that PD patients who use V[16]. Faba has significantly greater blood levels of L-dopa. *V. faba* was provided as part of an alternate study.

Nigella sativa **L**

Nigella sativa is a plant species from the Ranunculaceae family that may be found across the world. The medicinal plant's seeds are used to season Persian bread, salads, and pickles[17]. Also used as a food supplement. Comparing the rats' group extract to those provided with 3 mg/kg i.e. of chlorpromazine (CPZ), ethanolic extracts of *N. sativa* (200 and 400 mg/kg) significantly reduced catalepsy. Compared to the CPZ-treated group, *N. sativa* extracts significantly reduced lipid peroxidation and nitrite levels while increasing glutathione[18]. Black cumin seed essential oil has powerful pain-relieving and anti-inflammatory properties.

Carvacrol

Monoterpenoid phenol (CAR) is a phenol found in numerous aromatic plants, including *Nerium sativa*. Previous studies have shown that carvacrol has antioxidant and anti-inflammatory properties[19]. In one study, CAR (40 mg/kg) induced a significant neuroprotective effect against the unilateral 6-OHDA-induced Parkinson model in male mice, which was related with caspase 3 down regulation[20]. In a rat model of Parkinson's disease (PD) triggered by reserpine (RES), an intraperitoneal infusion of CAR (12.5 or 25 mg/kg) prevented the rise in catalepsy activity and the amount of vacuous gnawing motions, but it was unable to regain the decreased locomotor activity in an open field test [20,36].

Crocus sativus

Crocus sativus, often known as saffron, belongs to the Iridaceae family and is grown in a variety of countries including Iran, Turkey, Afghanistan, and Spain [21]. *C. sativus* and its ingredients are used to treat neurological and cognitive issues; in Iranian traditional medicine, this herb is also utilized as a smooth muscle relaxant. Animal studies have suggested that [22]. *C.sativus* and its elements could help treat neurodegenerative illnesses. In one study,

C. sativus was found to preserve dopaminergic cells in the substantia nigra pars compact and retina in a mouse model of acute Parkinson's disease caused by 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP). The mouse model was utilized to treat MPTP-induced L.

Curcuma longa
South-east Asian countries are the principal suppliers and cultivators of curcuma longa, also known as turmeric[23]. This medicinal plant contains non-flavonoids that cause oxidative harm to the nervous system and other body organs. It is a polyphenol chemical found in animals. Longa has been shown to have numerous pharmacological effects, including anti-inflammatory and anti-cancer activity. In one study, mice's monoamine oxidase A (MAOA), an enzyme that degrades dopamine, showed a significant decrease in activity when exposed to an aqueous extract of *C. longa* (560 mg/kg). Furthermore, the *C. longa* extract (0.001, 0.01, 0.05, 0.1, 0.2, and 0.4 mg/mL) inhibited mitochondria-derived ROS, decreased caspase 3 activity, and reduced palominol toxicity in human neuroblastoma cells (SH-SY5Y cells). It has been mentioned that a water-soluble curcumin extract(50-200mg/kg)[24,38].

Resveratrol
Resveratrol is a polyphenolic a compound that can be found in a variety of plants, including berries and grapes. Resveratrol has been demonstrated in animal models of Parkinson's disease to reduce oxidative stress, motor deficits, and the loss of TH neurons. Resveratrol limits the expression of TNF-a and COX-2 genes, as well as the production of chromatin and mitochondrial expansion.

Pergamum harmala
Nitroarene, which includes *Pergamum harmala*, suppresses the oxidation of proteins and fats in the brain, reduces muscle stiffness, and prevents dopaminergic neurons from degenerating. The ability of this herb to modulate angiotensin II activity is believed to be the basis of its neuroprotective properties. This reduces inflammation and nourishes the dopaminergic neurons.

Erythrina velutinid
(Fabaceae) This plant's ethanol extract has neuroprotective attributes. It has been shown to mitigate the neurotoxicity of 6-OHDA in SH-SYSY cells and neutralize free radicals, implying that it could be used to treat Alzheimer's illness.

Pueraria lobata
Pueraria (Fabaceae), as well as the accumulation of ubiquitin-conjugated proteins and other possibly toxic proteins, have been uncovered to prevent proteasomal dysfunction. Pueraria, on the other hand, reduces caspase-3 activity and the ratio of bel 2/box. Pueraria protects tyrosine hydroxylase (TH)-positive neurons from 6-OHDA-induced damage. Revive dopamine and its byproducts.

Baicalein
Plants that generate *Scutellarin baicalinase* (Labiatae) contain dried roots that are put to use to create the chemical compound baicalein. When PO12 tissues are examined for rotenone-induced neurotoxicity, Baicalein diminishes apoptosis, ROS accumulation, ATP depletion, and mitochondrial membrane rupture. Baicalein prevents dopamine levels in the basal ganglia from leaving while increasing dopamine and 5-hydroxytryptamine levels. In Hela and SH-SYSY cells, Baicalein inhibited a-synuclein aggregation and oligomerization.

Ginkgo biloba
The Chinese tree *Ginkgo biloba*, which belongs to the Ginkgoaceae family, has long been used to treat ailments related to the heart and lungs. *Ginkgo biloba* has three key elements: ginkgoid acid, flavonoids, and terpenoids. Prolonged treatment with EGb761 reduced the degeneration of dopaminergic nerve terminals resulting from 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine MPTP in a Parkinson's disease model in rats. EGb761, administered either before or after the surgery, was shown to protect against the dopaminergic cytotoxicity caused by MPTP. Also. EGb761 attenuated

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the neurotoxicity of levodopa in the 6-hydroxydopamine (6-OHDA) Parkinson's disease (PD) model. This implies that EGb761 could reduce the neurotoxicity of levodopa.

Quercus alba
Gallic Acid Rats triggered by 6-OHDA at 50, 100, and 200 mg/kg. Better passive avoidance memory. Increased Thio levels in brain cells. Increased GPx. Lower MDA levels in brain tissue for oak bark [53].

Oxalis corniculate
Oxalis corniculate was fed to C57 male mice at 250 and 500 mg/kg of MPTP. Decreased SOD activity. Enhanced activity of catalase [54].

Hypericum perforatum
Rat prompted by 6-OHDA at 200 mg/kg/day. Attenuated apomorphine-induced turning behaviour. Reduced the delay to start and the in general time on the wide beam work. Reduce MDA concentrations. Enhanced activity of catalase [55].

Carthamus tinctorius
Mice received stimulation with 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine at doses of 35 and 70 mg/kg/day. Increased gene expression of tyrosine hydroxylase, dopamine transporter, Increased dopamine levels. A decrease in acetylcholine levels [59].

Panax ginseng
The rats got 100 mg/kg/day of β-sitosterol β-D-glucoside. Reduced dopaminergic cell loss, microgliosis, and formation of a protein called aggregates [60].

Valeriana officinalis
Rotenone induces apoptotic in cells of human neuroblastoma SH-SY5Y at levels of 0.049, 0.098, and 0.195 mg/mL, leading to higher cell death [61].

Berberine
6-OHDA caused cytotoxicity in PC12 cells. Rats with 6-OHDA lesion received doses of 5, 10, and 30 μM. Depleted tyrosine hydroxylase-immune positive cells in the *substantia nigra*. Reduced dopamine and norepinephrine levels in the striatum [62].

Quercetin
Rat triggered by 6-OHDA at 50 mg/kg. Higher dopamine. Low protein carbonyl ratio [63].

Albizia adianthifolia
Rats caused by 6-OHDA at levels of 150 and 300 mg/kg. Enhanced working and reference memory. Reduced the contralateral circular imbalance [64].

Althaea officinalis
Rat triggered by 6-OHDA at 10 mg/kg Mitigated spin motion Reduced Mca levels.

Bacopa monniera
Rat caused by 6-OHDA at 20-40 mg/kg. Lowered MDA levels. Increased GSH content. Elevated SOD and CAT action [65].

Delphinium denudatum

Rats triggered by 6-OHDA at 200, 400, and 600 mg/kg.1. Lower MDA levels. Increased GSH levels. Accelerated SOD and CAT activity. Higher quantities of dopamine [66].

Gynostemma pentaphyllum

Rats caused by 6-OHDA at doses of 10 and 30 mg/kg. Recovered the levels of dopamine, 3,4 dihydroxyphenyl acetic acid, homovanillic acid, and norepinephrine in the striatum. Diminished the disappearance of TH immunopositively neurons in the substantia nigra area [67].

Portulaca oleracea

Rats triggered by 6-OHDA at 200 and 400 mg/kg. Increased crossings and raising in an open field test.

Chaenomeles speciosa

In vitro and *in vivo* experiments were performed on Chinese hamster ovary (CHO) cells and rats caused by 6-OHDA (MPTP)-lesioned mice at concentrations of 250, 500, and 1000 mg/kg. Greater tyrosine hydroxylase-positive cells in the *substantia nigra*. Optimized D8 viability of cells. Reduction of aberrant turns in apomorphine-induced rotational [68].

Hibiscus asper

Rats were stimulated by 6-OHDA as at doses of 50–100 mg/kg. Elevated SOD, GPX, and CAT action; increased GSH content. Lower MDA level.

CONCLUSION

This brief article provides an in-depth description of Parkinson's disease (PD), including its ethology, signs, hazards, prophylactic strategies, drugs therapies, and the potential for treatment of herbal remedies and flavonoid. The review underlines the crucial role of in vivo and in vitro studies in investigating Parkinson's disease pathology as well as developing therapeutic methods. The review also examines the potential beneficial effects of herbal remedies and polyphenols in Parkinson's disease (PD) treatment. A few plants and chemicals are being investigated for their protective properties on neurons. comprehensive overview of Parkinson's disease research, emphasizing the relevance of interdisciplinary approaches and the ongoing discovery of diverse models and therapeutic paths to combat this complicated neurological ailment.

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RESEARCH ARTICLE

The Influence of Health and Welfare Communication within Tribal Communities: A Study of the Santhal and Munda Tribes in Jharkhand

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ABSTRACT

Health communication is crucial for public health in India, involving activities to raise awareness and encourage positive health behaviors. This is especially complex due to India's diversity, necessitating culturally tailored approaches. The research used surveys, finding that education and income influence health program awareness, belief in modern medicine, and traditional remedies. The study presents a comprehensive overview of the role of health communication in India, its importance, challenges, and strategies. Research focused on the impact of health communication among the Santhal and Munda tribes of Jharkhand state. The research methodology employed survey research, and the study aimed to explore the relationship between education levels, income levels, beliefs, and treatment preferences within these tribal communities. The study's findings indicate significant associations between education, income, awareness, beliefs in allopathic and native medicine, and treatment preferences. The Chi-Square tests conducted support these associations, highlighting the interconnectedness of these factors in shaping health-related attitudes and behaviors within the tribal groups. Overall, the research contributes valuable insights into the dynamics of health-related perceptions and choices in the studied tribal communities.

Keywords: Health communication; Tribal community; Health programmes; Awareness; belief;

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INTRODUCTION

Health communication plays a vital role in promoting public health and improving healthcare outcomes in India. It encompasses a range of activities aimed at raising awareness, disseminating accurate information, and fostering positive health behaviours among the population. In a country as diverse as India, effective health communication strategies must consider cultural, linguistic, and socioeconomic factors to ensure messages are relevant, relatable, and accessible to all segments of society.

Importance of Health Communication
Health communication serves as a bridge between healthcare providers and the public, enabling the exchange of crucial information about disease prevention, treatment options, vaccination campaigns, maternal and child health, hygiene practices, and more. Clear and accurate communication can empower individuals to make informed decisions about their health, ultimately contributing to disease prevention and better health outcomes.

Challenges and Strategies
Several challenges exist in implementing effective health communication in India. Low health literacy rates, linguistic diversity, and disparities in access to healthcare services are some of the key challenges. To address these issues, strategies such as using local languages, culturally appropriate messaging, and leveraging various communication channels like mass media, community radio, social media, and mobile technology have been employed. Tribal health communication in India involves tailored strategies to effectively address the unique healthcare needs of indigenous communities. It emphasizes culturally sensitive messaging, local languages, and community engagement. Considering the diversity among tribal groups, communication approaches encompass oral traditions, visual aids, and digital platforms. Collaboration with community leaders and healthcare providers is crucial for successful dissemination of health information, promoting awareness, preventive measures, and healthcare access within these marginalized populations. In conclusion, effective health communication in India is a multifaceted endeavour that requires tailored approaches to address the diverse population's needs. By employing culturally sensitive messaging and utilizing various communication channels, India can make significant strides in improving public health awareness, behavior change, and overall healthcare outcomes.

RESEARCH METHOD

Survey research is used method in social sciences and other fields to collect data from a specific sample of individuals. This method involves the administration of structured questionnaires or interviews to gather information about attitudes, opinions, behaviors, and characteristics of the target population. Surveys provide valuable insights into patterns, trends, and relationships within the population, aiding in drawing meaningful conclusions and making informed decisions.

Locale of study
The area of research covered four districts namely Godda, Dumka, Khuti and Ranchi of Jharkhand with maximum population of Santhal and Munda Tribes. The study is specific to diffusion of health information among the tribes and tests the theory of diffusion of innovation.

Sample
Convenient or snowball sampling method was employed to select sample from four districts of Jharkhand, Godda, Dumka, Khunti and Ranchi. These districts under study have the maximum tribal population.

Sample size:
Munda: 485
Santhal: 490

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Analysis and findings

Awareness of programmes organized on health in the tribal community The table displays the distribution of responses about awareness of health programs in the respondents' tribal community, based on their education level and monthly income. There are two tribal groups, "Munda" and "Santhal," and it presents the distribution of percentages for each combination of variables.

Interpretation

Munda Tribal Group

The majority of Munda respondents across all education levels and income categories fall into the "Yes to some extent" awareness category, with percentages ranging from 29.1% to 74.5%. The distribution shows that respondents with higher education levels and higher income tend to be more aware of health programs.

Santhal Tribal Group

Similar to the Munda group, the majority of Santhal respondents across all education and income categories fall into the "Yes to some extent" awareness category. Likewise, there's a trend where higher education levels and income are associated with higher awareness levels. In summary, the table provides a detailed breakdown of awareness of health programs among the "Munda" and "Santhal" tribal groups, considering their education levels and income categories. It suggests that, generally, higher education levels and incomes are associated with a higher level of awareness of health programs among both groups. The table contains the results of Chi-Square tests conducted to explore the relationship between education level and awareness of health programs within two tribal groups, "Munda" and "Santhal".

Interpretation

Munda Group

The Pearson Chi-Square statistic for the Munda group is 301.663. The p-value for both Pearson and Likelihood Ratio tests is very small (close to 0). This indicates a significant association between education level and awareness of health programs among the Munda group. In other words, education level is not independent of awareness of health programs for this group.

Santhal Group

The Pearson Chi-Square statistic for the Santhal group is 183.023. Just like in the Munda group, the p-values for both Pearson and Likelihood Ratio tests are very small (close to 0) for the Santhal group as well. This signifies a significant association between education level and awareness of health programs among the Santhal group.

Combined Total

The combined total Chi-Square statistics (Pearson and Likelihood Ratio) for all cases is 388.511 and 419.921, respectively. The p-value for the combined total tests is very small (close to 0), indicating a significant association between education level and awareness of health programs across both tribal groups.

Conclusion

The Chi-Square test results suggest a statistically significant relationship between education level and awareness of health programs for both the Munda and Santhal tribal groups. The low p-values indicate that education level and awareness are not independent; they are associated with each other. The table shows the results of Chi-Square tests conducted to analyse the relationship between monthly income and awareness of health programs within two tribal groups, "Munda" and "Santhal".

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Interpretation
Munda Group
The Pearson Chi-Square statistic for the Munda group is 113.906. The p-value for both Pearson and Likelihood Ratio tests is very small (close to 0). This indicates a significant association between monthly income level and awareness of health programs among the Munda group. In other words, monthly income level is not independent of awareness of health programs for this group.

Santhal Group
The Pearson Chi-Square statistic for the Santhal group is 85.706. Just like in the Munda group, the p-values for both Pearson and Likelihood Ratio tests are very small (close to 0) for the Santhal group as well. This signifies a significant association between monthly income level and awareness of health programs among the Santhal group.

Combined Total
The combined total Chi-Square statistics (Pearson and Likelihood Ratio) for all cases is 134.677 and 144.866, respectively. The p-value for the combined total tests is very small (close to 0), indicating a significant association between monthly income level and awareness of health programs across both tribal groups

Conclusion
In conclusion, the Chi-Square test results suggest a statistically significant relationship between monthly income level and awareness of health programs for both the Munda and Santhal tribal groups. The low p-values indicate that monthly income level and awareness are not independent; they are associated with each other. However, these tests do not provide information about the strength or direction of the association—only that a significant relationship exists.The central government organises a number of programmes for health and welfare of tribal community. The question relates to the awareness about the various programmes among the tribal community. The programmes listed are Iodine Deficiency Disorders; Leprosy Eradication; Oral Health; Control of Blindness & Visual Impairment; Tobacco Control; Tuberculosis Control; and Prevention and Control of Cancer. The respondents were asked to indicate their cognizance to the programmes. The data provided is breakdown of responses to a survey question regarding awareness about the about various health and welfare programmes of central government. The programme likely aims to raise awareness about and prevent disorders, which can lead to various health issues.

Interpretation
Neutral (8.0%): This group seems to have a neutral opinion or might not be sure about their awareness regarding various health and welfare programmes. No not at all (16.3%): Around 16.3% of respondents indicated that they are not aware of the program at all. No to some extent (18.4%): 18.4% of respondents mentioned that they have some awareness, but it's limited or incomplete. Yes, to a large extent (32.0%): A significant portion, 32.0%, claimed to have a high level of awareness about the National Iodine Deficiency Disorders Control Programme. Yes, to some extent (25.3%): 25.3% of respondents indicated that they have some level of awareness about the program. In summary, it seems that the majority of respondents (32.0% + 25.3% = 57.3%) have some degree of awareness about various health and welfare programmes. However, a notable portion (16.3%) is completely unaware of the program, and an additional percentage (18.4%) has limited awareness. On the positive side, a significant group (32.0%) is highly aware of the program's objectives and activities. The table presents data related to people's beliefs in modern allopathic medicine, showing the extent to which, they believe in its effectiveness. The table includes various response options, the frequency of each response, and the corresponding percentages.

Interpretation
The majority of respondents fall into the categories of believing in modern allopathic medicine to some extent. Specifically, 36.1% of respondents strongly believe in it ("Yes to a large extent"), and 33.5% believe in it to a lesser degree ("Yes to some extent"). There are varying degrees of scepticism as well. About 16.3% of respondents have some doubts about modern allopathic medicine ("No to some extent"), and 6.1% do not believe in it at all ("No not at

all"). A small percentage of respondents (8.0%) hold a neutral stance on this matter. The cumulative percentage shows that a substantial majority (66.5%) of respondents have some level of belief in modern allopathic medicine, while 14.1% hold a more sceptical view, and 8.0% remain neutral. The table provides insights into the diversity of opinions regarding modern allopathic medicine's effectiveness, highlighting varying levels of belief and scepticism among the respondents surveyed. The table provides insights into the extent of belief in modern allopathic medicine among two different groups, namely the "Munda" and "Santhal" ethnic groups, based on their education level and monthly income.

Interpretation
"Munda" ethnic group
The majority of respondents across all education levels and income categories fall into the "Yes to some extent" belief category, with percentages ranging from 33.5% to 69.1%. There is a noticeable trend where higher education levels correspond to higher levels of belief in modern allopathic medicine. For instance, respondents with "Post Graduate" education have percentages of 80.0% and 20.0% for "No not at all" and "Yes to a large extent" categories, respectively. A similar trend can be observed in income categories. Respondents with higher incomes tend to have higher belief percentages.

"Santhal" ethnic group
Comparable to the "Munda" group, the majority of respondents across all education and income categories fall into the "Yes to some extent" belief category. Education and income trends also apply to the "Santhal" group, where higher education levels and incomes correlate with higher belief percentages. In summary, the table provides a detailed breakdown of belief in modern allopathic medicine among the "Munda" and "Santhal" ethnic groups, considering their education levels and income categories. It suggests that, generally, higher education levels and incomes are associated with a stronger belief in modern allopathic medicine among both groups. The table provided contains the results of Chi-Square tests performed on the relationship between education level and belief in allopathic medicine within two tribal groups, "Munda" and "Santhal".

Munda Group
The Pearson Chi-Square statistic for the Munda group is 171.777. The p-value for both Pearson and Likelihood Ratio tests is very small (close to 0). This indicates that there is a significant association between education level and belief in allopathic medicine among the Munda group. In other words, education level is not independent of belief in allopathic medicine for this group.

Santhal Group
The Pearson Chi-Square statistic for the Santhal group is 147.804. The p-value for both Pearson and Likelihood Ratio tests is again very small (close to 0). This signifies that there is a significant association between education level and belief in allopathic medicine among the Santhal group.

Combined Total
The combined total Chi-Square statistics (Pearson and Likelihood Ratio) for all cases is 257.995 and 320.953, respectively. The p-value for the combined total tests is very small (close to 0), indicating a significant association between education level and belief in allopathic medicine across both tribal groups.

Conclusion
Overall, the Chi-Square test results indicate a statistically significant relationship between education level and belief in allopathic medicine among both the Munda and Santhal tribal groups. The low p-values strongly suggest that education level and belief are not independent; they are associated with each other. However, the tests themselves do not reveal the direction or strength of the association—only that it exists. The table contains the results of Chi-Square tests that were conducted to assess the relationship between income level and belief in allopathic medicine within the two tribal groups, "Munda" and "Santhal".

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Munda Group:

The Pearson Chi-Square statistic for the Munda group is 96.364. The p-value for both Pearson and Likelihood Ratio tests is very small (close to 0). This indicates that there is a significant association between income level and belief in allopathic medicine among the Munda group. In other words, income level is not independent of belief in allopathic medicine for this group.

Santhal Group

The Pearson Chi-Square statistic for the Santhal group is 107.062. Just like in the Munda group, the p-values for both Pearson and Likelihood Ratio tests are very small (close to 0) for the Santhal group as well. This suggests that there is a significant association between income level and belief in allopathic medicine among the Santhal group.

Combined Total

The combined total Chi-Square statistics (Pearson and Likelihood Ratio) for all cases is 140.790 and 197.101, respectively. The p-value for the combined total tests is very small (close to 0), indicating a significant association between income level and belief in allopathic medicine across both tribal groups.

Conclusion

The Chi-Square test results suggest a statistically significant relationship between income level and belief in allopathic medicine for both the Munda and Santhal tribal groups. The small p-values indicate that income level and belief are not independent; they are associated with each other. However, these tests do not provide information about the strength or direction of the association—only that a significant relationship exists.

The table presents data regarding individuals' beliefs in native medicine and the extent to which they hold those beliefs. Cumulative Percent: This column shows the cumulative percentage up to a certain response option. For instance, the "Cumulative Percent" for the "Yes to a large extent" group (197 respondents) is 66.5%, indicating that 66.5% of respondents believe in native medicine to some degree or more.

Interpretation

The majority of respondents fall into the categories of believing in native medicine to some extent. Specifically, 40.2% of respondents strongly believe in it ("Yes to a large extent"), and 33.5% believe in it to a lesser degree ("Yes to some extent"). There are varying degrees of scepticism as well. About 12.2% of respondents have some doubts about native medicine ("No to some extent"), and 6.1% do not believe in it at all ("No not at all").A small percentage of respondents (8.0%) hold a neutral stance on this matter. The cumulative percentage shows that a substantial majority (66.5%) of respondents have some level of belief in native medicine, while 14.1% hold a more doubtful view, and 8.0% remain neutral. The table provides insights into the diversity of opinions regarding native medicine's effectiveness, highlighting varying levels of belief and disbelief among the surveyed individuals. The table displays the distribution of responses about the extent of belief in native medicine among two different tribal groups, "Munda" and "Santhal," based on their education level and monthly income. The table presents the percentage distribution of responses for each tribal group and income category.

Interpretation

Munda Tribal Group

The majority of Munda respondents across all education levels and income categories fall into the "Yes to a large extent" belief category, with percentages ranging from 39.0% to 66.7%. There is a noticeable trend where higher education levels correspond to higher levels of belief in native medicine. For instance, respondents with "Post Graduate" education have percentages of 40.0% and 20.0% for "No not at all" and "Yes to a large extent" categories, respectively. A similar trend can be observed in income categories, where respondents with higher incomes tend to have higher belief percentages.

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Santhal Tribal Group

Like the Munda group, the majority of Santhal respondents across all education and income categories fall into the "Yes to a large extent" belief category. Comparable education and income trends are observed for the Santhal group as well. In summary, the table provides a detailed breakdown of belief in native medicine among the "Munda" and "Santhal" tribal groups, considering their education levels and income categories. It suggests that, generally, higher education levels and incomes are associated with a stronger belief in native medicine among both groups The table contains the results of Chi-Square tests conducted to analyse the relationship between education level and belief in native medicine within two tribal groups, "Munda" and "Santhal".

Interpretation

Munda Group

The Pearson Chi-Square statistic for the Munda group is 165.577. This value represents the extent of discrepancy between the observed distribution of responses and the distribution that would be expected if the variables (education and belief) were independent. The p-value for both Pearson and Likelihood Ratio tests is very small (close to 0). This indicates that there is a significant association between education level and belief in native medicine among the Munda group. In other words, education level is not independent of belief in native medicine for this group.

Santhal Group

The Pearson Chi-Square statistic for the Santhal group is 111.980. Similar to the Munda group, this statistic measures the association between education and belief in native medicine for the Santhal group. As in the other groups, the p-values for both Pearson and Likelihood Ratio tests are very small (close to 0) for the Santhal group. This indicates that there is a significant association between education level and belief in native medicine among the Santhal group.

Combined Total

The combined total Chi-Square statistics (Pearson and Likelihood Ratio) for all cases is 175.031 and 196.760, respectively. The p-value for the combined total tests is very small (close to 0), indicating a significant association between education level and belief in native medicine across both tribal groups.

Conclusion

The Chi-Square test results imply a statistically significant relationship between education level and belief in native medicine for both the Munda and Santhal tribal groups. The low p-values indicate that education level and belief are not independent; they are associated with each other.

The table y shows the results of Chi-Square tests conducted to explore the relationship between monthly income (PM) and belief in native medicine within two tribal groups, "Munda" and "Santhal".

Interpretation

The Pearson Chi-Square statistic for the Munda group is 158.471. The Likelihood Ratio statistic is 161.573 for the Munda group. The p-value for both Pearson and Likelihood Ratio tests is very small (close to 0). This indicates a significant association between monthly income level and belief in native medicine among the Munda group. In other words, monthly income level is not independent of belief in native medicine for this group.

Santhal Group

The Pearson Chi-Square statistic for the Santhal group is 97.626. This statistic assesses the association between monthly income and belief in native medicine for the Santhal group. Just like in the Munda group, the p-values for both Pearson and Likelihood Ratio tests are very small (close to 0) for the Santhal group as well. This signifies a significant association between monthly income level and belief in native medicine among the Santhal group.

Combined Total

The combined total Chi-Square statistics (Pearson and Likelihood Ratio) for all cases is 199.761 and 227.451, respectively. The p-value for the combined total tests is very small (close to 0), indicating a significant association between monthly income level and belief in native medicine across both tribal groups.

Conclusion

In conclusion, the Chi-Square test results suggest a statistically significant relationship between monthly income level and belief in native medicine for both the Munda and Santhal tribal groups. The low p-values indicate that monthly income level and belief are not independent; they are associated with each other. The represents the distribution of treatment methods used in the case of a health issue. The respondents were asked about the type of treatment they prefer or use for addressing health problems. The two options mentioned are "Allopathic" and "Native. Allopathic (70.0%): This group indicates that 70.0% of the respondents use or prefer allopathic treatment methods when dealing with health issues. Allopathy is a conventional medical approach commonly practiced by medical doctors and involves using drugs or interventions to counteract symptoms or diseases. Native (30.0%): The remaining 30.0% of respondents mentioned using or preferring "Native" treatment methods. This term is often used to describe traditional or alternative treatments that may have cultural or traditional roots and could include practices like herbal medicine, homeopathy, acupuncture, Ayurveda, or other non-conventional approaches. In summary, the data suggests that a significant majority of respondents (70.0%) prefer or use allopathic treatment methods for addressing health issues. However, a substantial minority (30.0%) opt for "Native" or traditional treatment methods. This breakdown provides insights into the distribution of treatment method preferences among the surveyed population for dealing with health problems.

SUMMARY AND CONCLUSION

The research findings revolve around awareness, beliefs, and treatment preferences related to health programs and medicinal approaches within the "Munda" and "Santhal" tribal communities. The data has been analyzed using Chi-Square tests to explore the relationships between variables.

Awareness of Health Programs

The data suggests that within both the "Munda" and "Santhal" groups, there exists a moderate level of awareness regarding health programs. Higher education and income levels are associated with increased awareness. The Chi-Square tests reveal a significant relationship between education level and awareness, as well as between income level and awareness, in both tribal groups.

Belief in Allopathic Medicine

A significant majority of respondents across both groups hold some level of belief in modern allopathic medicine. The degree of belief varies, with a considerable portion expressing strong belief, followed by moderate belief. The Chi-Square tests indicate a strong and significant relationship between education level and belief in allopathic medicine, as well as between income level and belief, for both "Munda" and "Santhal" groups.

Belief in Native Medicine

The research reveals that a majority of respondents have varying degrees of belief in native medicine, with a substantial proportion expressing strong belief and moderate belief. A smaller percentage expresses doubt or skepticism. The Chi-Square tests demonstrate a significant relationship between education level and belief in native medicine, as well as between income level and belief, within both tribal groups.

Treatment Preferences

In terms of treatment preferences for addressing health issues, the data shows that a significant majority of respondents (70.0%) prefer or utilize allopathic methods, while a substantial minority (30.0%) opt for traditional

"Native" methods. This provides insight into the distribution of treatment preferences among the surveyed individuals. Overall, the research underscores the connections between education levels, income levels, beliefs, and preferences for health programs and treatment methods within the "Munda" and "Santhal" tribal communities. Chi-Square tests consistently reveal significant associations, indicating that these factors are not independent of each other and are interconnected in shaping health-related attitudes and behaviors within these groups. However, while the Chi-Square tests establish the presence of relationships, they do not provide insights into the strength or direction of these associations. To sum up, the research findings provide a comprehensive analysis of awareness and beliefs related to health programs and treatment methods within the "Munda" and "Santhal" tribal communities. The data reveals significant insights into the connection between education levels, monthly income, and these aspects. Across both tribal groups, a moderate level of awareness is observed regarding health programs, with higher education and income levels associated with increased awareness. Similarly, belief in modern allopathic medicine and native medicine shows a similar trend, with higher education and income levels corresponding to stronger belief. The Chi-Square tests conducted further strengthen these associations, indicating a statistically meaningful relationship between education level and awareness, as well as belief in both allopathic and native medicine. The tests highlight the non-independence of education level and income with these factors, emphasizing their interconnectedness. Furthermore, the data sheds light on the distribution of treatment preferences, showing that a significant majority of respondents favor or utilize allopathic treatments, while a substantial minority opt for traditional or "Native" methods. This distribution reflects the diverse perspectives and choices within the surveyed population when addressing health issues. In conclusion, the research findings provide valuable insights into the dynamics of awareness, beliefs, and treatment preferences within the "Munda" and "Santhal" tribal communities. The data underscores the influence of education levels and monthly income on these aspects and highlights the intricate relationships that exist among these variables. This information contributes to a deeper understanding of health-related perceptions and choices within these tribal groups.

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Table 1: Awareness of programmes organized on health in the tribal community

Variable		Munda					Santhal				
		Neutral	No not at all	No to some extent	Yes to a large extent	Yes to some extent	Neutral	No not at all	No to some extent	Yes to a large extent	Yes to some extent
Education	1		School level		15.6%	0.7%	74.5%	9.2%		15.5%	3.5%

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	2	PUC/Diploma		3.3%	3.3%	56.7%	36.7%	10.0%	5.0%	5.0%		
	3	Graduate	0.8%	10.0%	22.5%	33.3%	33.3%	1.4%	10.0%		
	4	Post Graduate	40.0%		16.0%	6.0%	38.0%		10.0%		
	5	Illiterate	6.3%	30.6%	14.6%	8.3%	40.3%	15.3%	22.2%	23.8%	
Income (PM)	1	≤ 10000	10.2%	21.0%	16.9%	30.6%	21.2%	7.6%	22.5%	13.6%	
	2	10000 – 20000	2.9%	2.9%	2.9%	51.5%	39.7%	1.1%	9.7%	6.8%	
	3	20000 – 30000		16.7%		53.3%	30.0%	10.0%	5.0%	15.0%	
	4	30000 – 40000	10.0%			10.0%	80.0%	22.5%	5.0%	22.5%	
	5	≥ 40000		10.0%			90.0%	5.0%	5.0%		
Total			6.2%	16.3%	12.0%	36.5%	29.1%	8.4%	17.6%	13.3%	33.9%	26.9%

Table 2: Education as variable with Programmes on health

Chi-Square Tests				
Tribal		**Value**	**df**	**Asymp. Sig. (2-sided)**
Munda	Pearson Chi-Square	301.663[b]	16	.000
	Likelihood Ratio	293.734	16	.000
	N of Valid Cases	485		
Santhal	Pearson Chi-Square	183.023[c]	16	.000
	Likelihood Ratio	206.577	16	.000
	N of Valid Cases	490		
Total	Pearson Chi-Square	388.511[a]	16	.000
	Likelihood Ratio	419.921	16	.000
	N of Valid Cases	975		

Table 3: Income as variable with Programmes on health

Chi-Square Tests				
Tribal		**Value**	**df**	**Asymp. Sig. (2-sided)**
Munda	Pearson Chi-Square	113.906[b]	16	.000
	Likelihood Ratio	122.716	16	.000
	N of Valid Cases	485		
Santhal	Pearson Chi-Square	85.706[c]	16	.000
	Likelihood Ratio	97.981	16	.000
	N of Valid Cases	490		
Total	Pearson Chi-Square	134.677[a]	16	.000
	Likelihood Ratio	144.866	16	.000
	N of Valid Cases	975		

Table 4: Awareness of health programmes sponsored by central government

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Neutral	39	8.0	8.0	8.0
	No not at all	80	16.3	16.3	24.3
	No to some extent	90	18.4	18.4	42.7
	Yes to a large extent	157	32.0	32.0	74.7
	Yes to some extent	124	25.3	25.3	100.0
	Total	490	100.0	100.0	

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Table 5: Extent of belief in modern allopathic medicine among

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Neutral	39	8.0	8.0	8.0
	No not at all	30	6.1	6.1	14.1
	No to some extent	80	16.3	16.3	30.4
	Yes to a large extent	177	36.1	36.1	66.5
	Yes to some extent	164	33.5	33.5	100.0
	Total	490	100.0	100.0	

Table 6: Extent of belief in modern allopathic medicine

Variable			Munda					Santhal				
			Neutral	No not at all	No to some extent	Yes to a large extent	Yes to some extent	Neutral	No not at all	No to some extent	Yes to a large extent	Yes to some extent
Education	1	School level	7.1%	6.4%		40.4%	46.1%	7.0%	7.0%		40.1%	45.8%
	2	PUC/Diploma				100.0%					100.0%	
	3	Graduate			8.3%	83.3%	8.3%			14.3%	57.1%	28.6%
	4	Post Graduate				80.0%	20.0%				100.0%	
	5	Illiterate	6.3%	12.5%		75.0%	6.3%	11.7%	8.1%	28.2%	20.2%	31.9%
Income (PM)	1	≤ 10000	3.6%	10.9%		66.8%	18.6%	10.5%	8.1%	18.8%	28.8%	33.9%
	2	10000 – 20000	9.3%			64.8%	25.9%				44.1%	55.9%
	3	20000 – 30000			11.1%	77.8%	11.1%			33.3%	66.7%	
	4	30000 – 40000				66.7%	33.3%				100.0%	
	5	≥ 40000				100.0%					100.0%	
Total			3.9%	5.6%	2.1%	69.1%	19.4%	8.0%	6.1%	16.3%	36.1%	33.5%

Table 7: Education as variable on Belief in allopathic medicine

Chi-Square Tests				
Tribal		Value	df	Asymp. Sig. (2-sided)
Munda	Pearson Chi-Square	171.777[b]	16	.000
	Likelihood Ratio	184.018	16	.000
	N of Valid Cases	485		
Santhal	Pearson Chi-Square	147.804[c]	16	.000
	Likelihood Ratio	185.715	16	.000
	N of Valid Cases	490		

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Total	Pearson Chi-Square	257.995[a]	16	.000
	Likelihood Ratio	320.953	16	.000
	N of Valid Cases	975		

Table 8: Income as variable on Belief in allopathic medicine

Chi-Square Tests				
Tribal		**Value**	**df**	**Asymp. Sig. (2-sided)**
Munda	Pearson Chi-Square	96.364[b]	16	.000
	Likelihood Ratio	101.027	16	.000
	N of Valid Cases	485		
Santhal	Pearson Chi-Square	107.062[c]	16	.000
	Likelihood Ratio	142.625	16	.000
	N of Valid Cases	490		
Total	Pearson Chi-Square	140.790[a]	16	.000
	Likelihood Ratio	197.101	16	.000
	N of Valid Cases	975		

Table 9: Extent of belief in native medicine

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Neutral	39	8.0	8.0	8.0
	No not at all	30	6.1	6.1	14.1
	No to some extent	60	12.2	12.2	26.3
	Yes to a large extent	197	40.2	40.2	66.5
	Yes to some extent	164	33.5	33.5	100.0
	Total	490	100.0	100.0	

Table 10: Extent of belief in native medicine with education and income as variables

Variable			Munda					Santhal				
			Neutral	No not at all	No to some extent	Yes to a large extent	Yes to some extent	Neutral	No not at all	No to some extent	Yes to a large extent	Yes to some extent
Education	1	School level	7.1%	13.5%	28.4%	19.1%	31.9%	7.0%	7.0%		40.1%	45.8%
	2	PUC/Diploma		33.3%	33.3%	33.3%					100.0%	
	3	Graduate	16.7%	16.7%	58.3%	8.3%				14.3%	57.1%	28.6%
	4	Post Graduate		40.0%	20.0%	40.0%					100.0%	
	5	Illiterate	6.3%	33.3%	41.0%	13.2%	6.3%	11.7%	8.1%	20.2%	28.2%	31.9%
Income (PM)	1	≤ 10000	3.6%	27.1%	36.0%	18.6%	14.6%	10.5%	8.1%	13.4%	34.1%	33.9%
	2	10000 – 20000	9.3%	18.5%	46.3%	9.3%	16.7%				44.1%	55.9%

	3	20000 – 30000	22.2%	11.1%	55.6%	11.1%				33.3%	66.7%	
	4	30000 – 40000		66.7%		33.3%					100.0%	
	5	≥ 40000				100.0%					100.0%	
Total			8.0%	24.1%	39.0%	17.7%	11.1%	8.0%	6.1%	12.2%	40.2%	33.5%

Table 11: Education as variable on Belief in native medicine

Chi-Square Tests				
Tribal		Value	df	Asymp. Sig. (2-sided)
Munda	Pearson Chi-Square	165.577[b]	16	.000
	Likelihood Ratio	170.815	16	.000
	N of Valid Cases	485		
Santhal	Pearson Chi-Square	111.980[c]	16	.000
	Likelihood Ratio	146.293	16	.000
	N of Valid Cases	490		
Total	Pearson Chi-Square	175.031[a]	16	.000
	Likelihood Ratio	196.760	16	.000
	N of Valid Cases	975		

Table 12: Income as variable on Belief in native medicine

Chi-Square Tests				
Tribal		Value	df	Asymp. Sig. (2-sided)
Munda	Pearson Chi-Square	158.471[b]	16	.000
	Likelihood Ratio	161.573	16	.000
	N of Valid Cases	485		
Santhal	Pearson Chi-Square	97.626[c]	16	.000
	Likelihood Ratio	130.054	16	.000
	N of Valid Cases	490		
Total	Pearson Chi-Square	199.761[a]	16	.000
	Likelihood Ratio	227.451	16	.000
	N of Valid Cases	975		

Table 13: In specific health related issue which kind of treatment is adopted

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Allopathic**	343	70.0	70.0	70.0
	Native	147	30.0	30.0	100.0
	Total	490	100.0	100.0	

RESEARCH ARTICLE

Effect of Bio-Enzyme on Biochemical of Flat Bean Seedling

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ABSTRACT

Using bio-enzyme in agriculture supports sustainable farming while also reducing the environment impact of traditional farming practices. These enzyme improve soil health, reduce chemical inputs because they use as fungicide, insecticide and also used as detergent. Bio-enzyme also promotes the healthy ecosystem. The effect of citrus-banana Bio-enzyme on biochemical of Flat bean seedlings leaves was determined. After 2 days of germination Flat bean were treated with different concentration (2%, 4%, 6%, 8%, 10%) of bio-enzyme. An assess the effect of this bio-enzyme on biochemical like Phenol , Protein , Starch , Reducing sugar , Total sugar content of Flat bean seedling leaves. Highest amount of Phenol and Protein were found in 6% treated flat bean seedlings leaves. More amount of starch were found in control untreated seedlings leaves. Highest amount of Reducing sugar and Total sugar were found in 8% and 4% respectively.

Keywords: Flat bean, Seedling, Citrus-banana Bio-enzyme, Biochemical, Estimation.

INTRODUCTION

The United Nations Environment Programmer's Food Waste Index Report 2021 shows that about 50 kg of food is thrown away annual per person in Indian homes. In India, daily near 7.5 tons of food were wasted; this food is disposed of in trash cans alongside sewage, which increase its overall waste production. There's a shortage of awareness of food waste. Food waste is often disposed of in landfills, which adds to the overall volume of garbage there and increase greenhouse gas emission and other forms of pollution. Additionally, chemical herbicides and fertilizer are widely used in agriculture cultivation, which reduces the soil's ability to bind nutrient [7]. An alternative way to chemical based and solid based natural fertilizer is bio-enzyme. It is natural, easy to use for plant's

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absorption, biodegradable, cheap, recycle the waste products and non-toxic to environment. There are various names are found for Bio-enzyme such as Garbage enzyme, eco-enzyme, fruit enzyme, Terrazyme and Flower enzyme [6]. First to develop the bio-enzyme from solid waste was Dr. Rosukon Poompanvong [7]. A mixture of jiggery/molasses, fruits and vegetable peels, kitchen waste and water is work as raw material for fermentation process to make bio-enzyme. Some microorganism also helps to form a bio-enzyme [8].

MATERIALS AND METHODS

Soil preparation
75% soil and 25% fertilizer were mixed in ratio of 3:1 and six pots of was equally filled with prepared soil mixture.

Plant growing
Seed of flat bean was grown in six pots in January month of 2024 and equal amount of water was sprinkled in each pots after one day of time interval.

Bio-enzyme treatment
Citrus and Banana Bio-enzyme was used to treat the seed of flat bean after germination. One of grown flat bean seedling pot was not treated with bio-enzyme, remain untreated called as control. Remains five pots treated with respective different concentration of bio-enzyme such as 2%, 4%, 6%, 8%, 10%. And this treatment repeated after 8 days of time interval for 16 days and also labeled the pots.

Biochemical test
After 16 days leaves of control and treated seedling with concentration of Bio-enzyme 2% , 4% , 6% , 8% , 10% collected for an estimation of Phenol , Protein , Starch , Reducing sugar and Total sugar.

Estimation of Phenol
Phenol estimation Folin-Ciocalteu reagent method was performed. 100 milligram fresh leaves of flat bean from control and treated seedling with various concentration of bio-enzyme was taken. Separate grind it with 10 ml 80% boiling ethanol in mortal pastel. Centrifuge it at 5000 rpm for 10 min and take supernatant I in other test tube. Now, add 10 ml 80% ethanol in residue and again centrifuge at 5000 rpm for 10 minutes. Take supernatant II and mix the supernatant I & II and discard the residue. Take 1 ml aliquot and 1 ml 20% Na_2CO_3 in test tube and add 0.5 ml 1 N Folin-Ciocalteu reagent. Now boil the mixture in water bath for 10 min and cool it. Make the final volume of 20 ml with distilled water. Check Absorbance at 600 nm for Phenol estimation[2].

Estimation of Protein
Estimation of Protein in flat bean seedling leaves was performed using Bradford's method. Take 1 gram fresh leaves of flat bean control and treated seedling with various concentration of bio- enzyme. Future separate grind it in 10 ml phosphate buffer (pH-7.2) using mortal pestle. Now centrifuge it at 10,000 rpm for 15 min. Take 0.2 ml supernatant and discard the residue. Add 5 ml Bradford reagent in the mixture. Now check absorbance at 595 nm [1].

Estimation of Starch
Starch estimation in flat bean seedlings leaves was done using Hedge's method. Separately Take 100 milligram fresh leaves of flat bean from control and treated seedling. Grind it with 10 ml 80% boiling ethanol in mortal pestle. Now centrifuge it at 5000 rpm for 10 min and discard the supernatant. Add 10 ml 80% ethanol in the residue and again centrifuge at 5000 rpm for 10 min. discard the supernatant. Put residue in water bath for drying. Now add 5 ml water and 6.5 ml 52% $HClO_4$ in the mixture. Put it in 0°C for 20 min. centrifuge it. Take supernatant II and mix it with supernatant I, discard residue. Make 100 ml of final volume by adding distilled water and add 0.2 ml aliquot. Add water make volume up to 1 ml. now add 4 ml anthron in them. Boiling for 8 min and cool rapidly. Green color appearance in the mixture. Check absorbance at 630 nm [3].

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Estimation of reducing sugar
Somogayi's method was performed to estimate reducing sugar in leaves of flat bean seeding. Take 100 milligram fresh leaves of flat bean from control and treated seedlings. Separate grind it with 10 ml 80% boiling ethanol in mortal pestle. Centrifuge it at 5000 rpm for 10 min and Take the supernatant I in other test tube. Add 10 ml 80% ethanol in residue. Again centrifuge it at 5000 rpm for 10 min. take supernatant II in other test tube and mix both supernatant I & II and the discard residue. Now take 1 ml aliquot in test tube and add 1 ml nelson somogayi reagent boil the mixture at 100 °C for 10 min. add 1 ml arsenomolybdate in them. Check absorbance at 680 nm [5].

Estimation of Total sugar
Estimation of total sugar Nelson's method was performed. Take 100 milligram fresh leaves of flat bean from control and treated seedlings. Separate grind it with 10 ml 80% boiling ethanol in mortal pestle. Centrifuge it at 5000 rpm for 10 min. take supernatant I in other test tube and add 10 ml 80% ethanol in the residue. Centrifuge it again at 5000 rpm for 10 min. take supernatant II in other test tube and mix both supernatant I & II, discard the residue. Now take 1 ml aliquot and incubate it for 30 min at 49 °C. Add 1-2 drop methyl red indicator in the mixture. Add 1 M NaOH drop wise till color change Pink to Yellow). Now add 1 ml Nelson somogayi reagent and incubate it for 20 min in water bath. Add 1 ml arsenomolybdate and make final volume of 20 ml with distilled water. Check absorbance at 620 nm [4].

RESULTS

After 16 days, plant growth was found more in various concentrated bio-enzyme treated flat bean seedlings than controlled flat bean seedlings.

Estimation of Phenol
Table 1 and Graph 1, show the highest amount of phenol 5.38 µg/ml was reported in 6% treated leaves of flat bean seedling with bio-enzyme which was greater than 4.03 µg/ml phenolic content in control leaves of flat bean seedling. 4.21 µg/ml and 4.13 µg/ml phenolic content respectively founds in 4% and 10% treated seedling's leaves. In 2% and 8% treated flat bean seedling's leaves respectively shows the less amount of phenolic content 3.78 µg/ml and 2.55 µg/ml.

Estimation of Protein
Table 2 and Graph 2, show the highest amount of protein 0.298 mg/ml was reported in 6% treated leaves of flat bean with bio-enzyme which is greater than 0.266 mg/ml in untreated control seedling's leaves. 0.264 mg/ml and 0.263 mg/ml protein contain respectively found in 2% and 4% treated leaves of flat bean. 0.288 mg/ml and 0.279 mg/ml respectively reported in 8% and 10% treated leaves of seedling.

Estimation of Starch
Table 3 and Graph 3, show highest amount of 0.0994 mg/ml starch was reported in untreated control leaves of flat bean seedling. 0.0984 mg/ml, 0.0982 mg/ml respectively found in 2% and 4%, lowest amount of starch 0.0974 mg/ml found in 8% treated leaves of flat bean with bio-enzyme. 6% and 10% treated leaves shows the same 0.0979 mg/ml starch contain.

Estimation of reducing sugar
Table 4 and Graph 4, show highest amount of 0.505 mg/ml was reported in 8% treated leaves of flat bean seedling. Which is greater than 0.279 mg/ml reducing sugar in control. 0.267 mg/ml, 0.334 mg/ml and 0.398 mg/ml reducing sugar respectively found in 2%, 4% and 10% treated leaves of flat bean seedling. Treated leaves of flat bean with 6% bio-enzyme shows the 0.469 mg/ml reducing sugar.

Estimation of Total Sugar

Table 5 and Graph 5, show the more amount 1.409 mg/ml and 1.359 mg/ml total sugar are respectively found in 4% and 10% treated leaves of flat bean seedling. Which was greater than 0.801 mg/ml in control leaves of flat bean seedling. 0.680 mg/ml, 0.788 mg/ml and 0.870 mg/ml total sugar respectively found in 2%, 6% and 8% treated leaves of flat bean seedling.

DISCUSSION

Phenolic content, Protein Content, reducing sugar and total sugar founds more in citrus and banana's Bio-enzyme treated leaves of flat bean seedlings. Starch content founds more amount in untreated control leaves of flat bean seedling than treated flat bean seedling's leaves. Phenolic and protein content found more in 6% treated leaves of flat bean seedling with bio-enzyme. Reducing sugar and total sugar respectively found more in 8% and 4% treated leaves of flat bean. Protein content gradually decrease after 6% treated leaves of flat bean seedlings and treated leaves with 2% and 4% concentration of bio-enzyme shows minute change in protein content with untreated leaves of flat bean seedling. For more accumulation of protein in flat bean seedling's leaves 6% concentration of citrus banana's bio-enzyme would be beneficial. Reducing sugar gradually increase in flat bean seedlings as concentration of citrus-banana's bio-enzyme increases. For total sugar content 4% concentrated, for reducing sugar 8% concentrated, for phenolic content 6% concentrated citrus-banana's bio-enzyme would be beneficial to leaves of flat bean seedling.

CONCLUSION

A present study concluded that leaves of flat bean seedling treated with bio-enzyme shows more concentration of total sugar , reducing sugar , protein and phenolic content that untreated control leaves of flat bean seedling. Where starch found in more amount in control untreated leaves of flat bean seedling. In flat bean seedling the phenol and protein shows the higher concentration in 6% treated leaves of flat bean with citrus banana bio-enzyme. Reducing sugar shows higher concentration in 8% and total sugar shows higher concentration in 4% treated leaves of flat bean seedling.

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Table 1: Concentration and Absorbance of Phenol in Control and Treated leaves of Flat bean Seedling.

Sample	Concentration (µg/ml)	Absorbance 660 nm
control	4.03	0.228
2%	3.78	0.214
4%	4.21	0.238
6%	5.38	0.304
8%	2.55	0.145
10%	4.13	0.234

Table 2: Concentration and Absorbance of Protein in Control and Treated leaves of Flat bean Seedling.

Sample	Concentration (mg/ml)	Absorbance 595 nm
control	0.266	0.845
2%	0.264	0.772
4%	0.263	0.745
6%	0.298	1.852
8%	0.288	1.542
10%	0.279	1.248

Table 3: Concentration and Absorbance of Starch in Control and Treated leaves of Flat bean Seedling.

Sample	Concentration (mg/ml)	Absorbance at 630 nm
control	0.0994	0.091
2%	0.0984	0.072
4%	0.0982	0.068
6%	0.0979	0.064
8%	0.0974	0.054
10%	0.0979	0.063

Table 4: Concentration and Absorbance of Reducing Sugar in Control and Treated leave of Flat bean Seedling.

Sample	Concentration (mg/ml)	Absorbance at 620 nm
control	0.279	0.393
2%	0.267	0.381
4%	0.334	0.448
6%	0.469	0.583
8%	0.505	0.62
10%	0.398	0.512

Table 5: Concentration and Absorbance of Total sugar in Control and Treated leave of Flat bean Seedling.

Sample	Concentration (mg/ml)	Absorbance 620 nm
control	0.801	0.120
2%	0.680	0.101
4%	1.409	0.216
6%	0.788	0.118
8%	0.870	0.131
10%	1.359	0.208

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Graph 1: Effect of Bio-enzyme on Phenolic Content of leaves of Flat bean Seedling.

Graph 2: Effect of Bio-enzyme on Protein Content of leaves of Flat bean Seedling.

Graph 3: Effect of Bio-enzyme on Starch Content of Leaves of Flat bean Seedling.

Graph 4: Effect of Bio-enzyme on Reducing Sugar Content of leaves of Flat bean Seedling.

Graph 5: Effect of Bio-enzyme on Total Sugar Content of leaves of Flat bean Seedling.

RESEARCH ARTICLE

Enhancing the Security of Classical Ciphers: A Novel Approach using K-Means Clustering to Improve the Polybius Square Key Matrix in Playfair and Polybius Ciphers

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ABSTRACT

This research proposes a novel approach to enhance the security of Play fair and Polybius ciphers by improving the 10x10 Polybius Square Key Matrix using K-Means Clustering. The extended key matrix has historically suffered from low entropy when using short keys, leading to potential vulnerabilities. By applying K-Means Clustering, this study aims to increase the complexity and entropy of the key matrix, thereby improving the security of the ciphers. The results demonstrate a significant enhancement in the average avalanche effect, ensuring a more robust encryption process, especially in scenarios where an unmodified key matrix would yield a minimal avalanche effect.

Keywords: Cryptography, Playfair cipher, Polybius cipher, Key matrix, K-Means Clustering, Encryption, Avalanche effect

INTRODUCTION

From classical to modern ciphers, cryptography has remained one of the most powerful and oldest techniques for ensuring information security. Ciphers have been used as a reliable means of protecting sensitive information from prying eyes. To keep up with today's state of encryption, many of these ciphers need to be improved due to their inherent insecurity. (1). One of the first encryption methods ever documented is the Polybius Square Key Matrix,

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which is also regarded as one of the most popular encryption techniques used in ciphers. The key matrix was initially employed in the Polybius Cipher, which bears its name. Subsequently, it was refined and expanded upon by various ciphers that are still in use today(10). Modernization of the algorithm has benefited from improving the Polybius Square key matrix from a 5 by 5 matrix to a 10 by 10 matrix. This expansion greatly increased the number of characters that could be used for encryption and decryption, from 26 characters of the alphabet to 100 characters x, usually in ASCII(8). Modernizing the algorithm has benefited from expanding the Polybius Square Key Matrix from its original 5x5 matrix to a 10x10 matrix. This expansion has greatly increased the number of characters that can be used for encryption and decryption, from the 26 letters of the alphabet to 100 characters, usually in ASCII(11). This study proposes securing an enlarged 10x10 square of the key matrix using k-means clustering. This enhancement improves efficiency, security, and usability. To protect information, data is converted to an obfuscated format using a variety of ciphers and encryption technologies. The Polybius cipher is believed to be one of the most widely used among them. Polybius created one of the earliest known encryption methods. The Polybius square is among the first techniques created for fractionating letters to replace numbers in unencrypted communications. Based on classical to modern ciphers, one of the most powerful and oldest techniques for assuring information security has been cryptography. Throughout time, classical ciphers have been utilized as an accurate means of protecting valuable data from unauthorized others. It is important to take measures and pass information from the sender to the receiver to ensure that a third party can't find it. The encryption-decryption procedure, in which the sender encrypts the message using a secret key that the recipient of the message just understands, is one technique for protecting data. Using the same secret key, the message is decoded once it reaches the recipient. Symmetric encryption is the name for this kind of encryption. Cryptography is a Greek word that means secret writing. Today this term refers to the science and art of transforming messages to make them secure and immune to attacks(3). The Polybius Square Key Matrix has expanded largely because of the increasing number of available characters and the enlargement of the matrix. However, when using shorter keys, the increased 10x10 Polybius square matrix shows little to no avalanche effect. Small changes in the short key have little to no effect on the outputted ciphertext, as demonstrated by testing the avalanche effect of the augmented matrix by flipping the bits of each key while increasing the array of characters and converting the Polybius square key matrix into a 10x10 matrix. Cryptographic techniques play a significant role in any communication network's security design. Symmetric key algorithms are a type of these algorithms that employ one key to encode and translate data. The stream cipher, in which the encryption rule is developed based on a plaintext symbol's position in the stream of plaintext symbols, and the block cipher, which encrypts several plaintext symbols at once in a block, are essential techniques ways to create a stronger cipher(8).

LITRATURE SURVEY

Maintaining the Integrity of the Specifications(1). The original 5x5 matrix Playfair cipher is modified to a 7x4 matrix Playfair cipher in this paper. The symbols "*" and "#" are included in the matrix, resulting in a one-to-one connection between the plaintext and the ciphertext. As an outcome, the procedures for decryption and encryption are clear and simple. The suggested method differs in that it may be applied to any language by simply selecting an appropriate matrix that will accommodate all alphabets of that language(3). The traditional Playfair cipher's basic drawback is that plain text can contain only 25 capital characters. After decoding, one letter must be omitted and cannot be reassembled. Also, lowercase letters, white space, numbers, and other printable characters cannot be handled by the traditional cipher. This signifies that this cipher cannot handle entire sentences. In plaintext, a space between two words is not considered one character. When the plaintext word has an odd number of characters, a spare letter X is appended. In this study, we examined the advantages and disadvantages of the original Playfair cipher. The modified Playfair cipher with a 10 x 9 matrix was then discussed. We utilized all alphanumeric characters as well as some special characters in this matrix. Six distinct keys and six iteration stages are utilized in this modified Playfair cipher to make the encrypted message stronger than the conventional Playfair cipher(4). The proposed algorithm outperforms current 8 x 8 matrices. It improves security, using increasing complexity to hack the original text. This algorithm uses different types of keys for the Four-square encryption process. When using a symmetric key cryptosystem, the keys are utilized to modify the plaintext, converting the 5x5 matrix into an enhanced format of

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10x10 matrixes(7). We analyzed any modifications made to the Playfair cipher. To solve the problems using the traditional Playfair cipher, the first modification is to implement an 8*8 matrix(12). This study modifies the 5x5 Polybius square by dynamically shifting the elements in the grid determined through the keys' ASCII code. Simulation results revealed that the proposed method is more secure against the unmodified Polybius cipher(15). The Playfair cipher is a well-known multiple-letter encryption cipher. The plaintext diagrams are treated as single units and transformed into corresponding cipher text diagrams. However, because of the drawbacks inherent in the 5*5 Playfair cipher which adversely affects the security we proposed an 8*8 Playfair cipher(17). Researchers have expressed a strong desire to develop and adapt the Playfair Cipher algorithm to address its shortcomings. The previous decade saw a surge in cryptographic research for the Playfair cipher. While the classic Playfair Cipher is incapable of encrypting numeric characters, the technique is incompatible with many current technologies. The encryption of spaces between words is required because post-processing of the decrypted message is confused without it. This paper presents a Playfair Cipher modification that can encrypt both alphanumeric letters and spaces. The study achieves its aim by increasing the dimension of the key matrix from 5 by 5 to 6 by 6 and presenting a mechanism for replacing gaps in the reduced key matrix with configurable digraphs(18). However, due to a few flaws in the original 5 × 5 Playfair cipher, a recently enhanced version of the Playfair encryption, known as the Extended 88 Playfair cipher, has been developed. To conceal the presence of any such communications, an extended Playfair cipher with the Least Significant bit of steganography is used in this study. The primary goal of this effort is to create a secure system for sending and receiving communications. The results suggest that combining the extended 8 × 8 Playfair cipher with steganography improves message security over the existing standard Playfair ciphers(20). Drawbacks of Traditional Playfair Cipher: The original Playfair is a 5*5 grid of 25 letters that can only be uppercase and cannot encrypt lowercase letters, whitespaces, or different printable characters. Furthermore, one letter will be eliminated due to the 25 squares. Because this is the major disadvantage, various new approaches have been considered.

PROPOSED METHOD

Polybius Square-based ciphers apply different encryption algorithms, but all use the Polybius Square as the key matrix upon which the encryption is built. In the 10x10 expansion of the square matrix, there are 100 ASCII characters within the square, with 95 legible ASCII characters and 5 extended ASCII characters. It uses a key to initialize the square matrix's characters and is encoded into each cell of the square from top left to right row by row, ignoring the key's repeated characters. Once all of the key's characters have been encoded into the square, all additional square matrix characters not contained in the key are added to the remaining cells in the 10x10 square's default sequence of characters(21). The 10x10 Polybius Square Key Matrix base system, the K-Means augmented 10x10 Polybius Square Key Matrix, and the ciphers and performance metrics used to assess the key matrices were all created in Python for this study using Google Colab, with dependencies on NumPy and PIP. The 95 readable ASCII characters and the 5 special characters from the expanded ASCII are used to encode a 10x10 2D array. Next, entropy is added to the square using a user-supplied keyword. Under PIP, the model is set to 128 bits, and the taps are configured to output the maximum number of bits in an 8-character keyword. The k-Means Cluster is imported from pylfsr(14). The binary output is transformed into a collection of ASCII characters using the same keyword that served as the LFSR model's seed. The distinct characters are then encoded into a brand-new 10x10 2D array. The five unique extended ASCII characters are added after all 95 distinct ASCII characters have been encoded into the array by repetition of this operation. The Polybius, Bifid, and Playfair ciphers will be the main subjects of the investigation. The numerous literatures cantered on each cipher will serve as the foundation for the mechanics of these ciphers(21).

RESULTS AND DISCUSSION

The avalanche effect test will be used to quantify the improvements of the new algorithm compared to the current method. The baseline will be the initially expanded 10x10 Polybius Square Key Matrix. Both the baseline and the suggested encryption methods will employ three ciphers, and each performance metric will be applied to a different

cipher. The Polybius Cipher and the Playfair Cipher will be the ciphers utilized. To measure the power of a cryptographic method, the avalanche effect is tested using the least amount of keyword changes. The "avalanche effect" in cryptography refers to the property where even a small alteration in the input, such as one bit, would have a significant impact on the output[11]. Ten keywords for each cipher would be used to encrypt one plaintext in order to evaluate the avalanche effect. The same keywords would then be utilized to encrypt the plaintext, with one letter modified for each keyword. The original keyword's ciphertext and ciphertext to depict the avalanche effect, different keywords will be clustered together by computing the percentage difference between the two ciphertexts. The average avalanche impact of the cipher will next be evaluated by computing the percentage average of these ten results. The average avalanche impact of every used cipher is significantly improved by the cluster-enhanced key matrix as compared to the base key matrix. Some of the base matrix's keywords exhibit moderate gains, while others exhibit a 0% avalanche effect, which indicates that the ciphertext of the two distinct keywords is the same. These keywords are significantly improved by the cluster-enhanced key matrix. The findings demonstrate that the k-means cluster augmentation may be able to lessen the avalanche impact of other Polybius Square-based ciphers, which in some cases may also exhibit a 0% avalanche effect.

CONCLUSION

According to the study's findings, ciphers can enhance the avalanche effect of the extended 10x10 Polybius Square Key Matrix by utilizing the K-means Cluster as a key stretching function to simulate a longer key for short keys. This is particularly true in situations where the avalanche effect of the base 10x10 key matrix would otherwise result in 0%. For future work, the researchers recommend further examination of the K-Means Clustering to utilize a model with higher bits to increase the probability of entropy. Additionally, the researchers suggest applying the K-Means-enhanced 10x10 Polybius Square Key Matrix to other Polybius Square-based ciphers that were not more thoroughly covered in the study, such as the Two-Square cipher and Four-Square cipher. Further studies in these areas could provide valuable insights into the effectiveness and applicability of the proposed methods.

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Table1.Indexed Polybius cipher modifications

Sr. No.	Title	Authors/ Year	Methods	Purpose	Significant Results
1	An Extended Version of the Polybius Cipher	Kondo & Mselle (2013)	Modified the Polybius cipher with the introduction of 8x8 Polybius square grid	To improve cipher capabilities, enlarge the usual 5x5 grid Polybius square.	Plaintext comprising numerals, special symbols, and alphabets may now be encrypted using the expanded Polybius square. Furthermore, the letters I and j are now separated, reducing uncertainty during the ciphering process.
2	A Modified Version of Polybius Cipher Using Magic Square and Western Music Notes	Maity (2014)	Modified Polybius Cipher with the introduction of a 6x6 magic square and musical notes	To bring variation into the classic Polybius cipher substitution process using the magic square theory, and to construct a music sequence from ciphertext.	The suggested approach provides a unique substitution process since the arrangement of alphabets is dependent on the unique magic squares created, making cracking challenging. In this study, no two characters are housed in the same cell.
3	A Hybrid Polybius-Playfair Music	C. Kumar, Dutta, &	Hybrid Polybius and Playfair	To include music cryptography into	The research has cleared the door for the

	Cipher	Chakraborty (2015)	ciphers with a secret key	ciphertext generation utilizing a key matrix for safe encryption and decryption using a hybrid Polybius-Playfair technique.	development of musical sequences utilizing a dual encryption approach. The hybrid approach provides suitable musical sequences without jeopardizing the security of the secret information. Characters In this proposed strategy, I and J continue to share the same cell
4	Development of Modified Polybius Technique for Data Security	P. Kumar & Rana (2015)	Modified the Polybius cipher with the introduction of a 6x6 Polybius square grid following a different arrangement of characters	To enhance the cipher's capacity by employing a 6x6 Polybius square and to provide a new technique of letter arrangement.	The study introduces a new character sequencing in the grid. The cipher may accommodate additional characters to be encoded and decoded with the addition of digits. Furthermore, because there are ample places for all letters and numerals, the characters I and J are split into different cells.
5	Design of a Modified AES Algorithm for Data Security	P. Kumar & Rana (2016)	Modified the Polybius cipher with the introduction of 6x6 Polybius square grid	To convert the Polybius square into a 6x6 matrix for use in the key generation process of another cryptographic system.	The suggested change enables the processing of all letters and integers. As a result, the AES algorithm's key generation process has become safer and more advanced.
6	A Novel Structure of Advanced Encryption Standard (AES) with 3-Dimensional S-box, RSA-based Key Scheduling, and modified 3-Dimensional Polybius Cube Encipherment	Rahman et al., (2017)	Modified the Polybius cipher with the introduction of 9x9x9 Polybius cube	To provide a novel 3-dimensional Polybius cube for the key scheduling algorithm (KSA) that can accommodate letters, integers, and symbols.	The work presents a novel key generation procedure for the AES algorithm that employs a 3D dynamic substitution box with a ciphertext output of a trigram rather than a bigram. The cipher can handle capital letters, lowercase letters, digits, and most special characters with a larger capacity.
7	A Modified Polybius Square-Based Approach for	Manikandan, Rajendiran, Balakrishnan,	Modified the ciphertext generation	To present several transmutation techniques for the	The modified Polybius cipher offers diverse ciphertext generation

	Enhancing Data Security	& Thangaselvan (2018)	process of the 6x6 Polybius cipher through matrix transmutation	Polybius square as well as the usage of a key for more secure cryptography.	techniques with the introduction of square ring rotation, transpose, and reversal key generation schemes that increase the time complexity of breaking the encoded message.
8	Embedding Data Crypted with Extended Shifting Polybius Square Supporting Turkish Character Set	Macit, Koyun, & Yüksel (2019)	Modified the Polybius Cipher with the introduction of 10x7 Polybius square grid	To adapt the classic Polybius square grid to allow Turkish keyboard letters and to rearrange components in the table using a key.	More characters, particularly those found in the Turkish alphabet, can be encrypted and decrypted using the suggested method. This research introduces matrix shifting, spaces can already be encrypted, and letters I and J are now split into distinct cells. In the field of picture steganography, the proposed approach was effectively applied.
9	Implementation of Nihilist Cipher Algorithm in Securing Text Data with Md5 Verification	Haryana too, Zulfadly, Daifiria, Akbar, & Lazuly (2019)	Altered the placement of the elements in the Polybius square grid	To employ the Polybius square with different character arrangement components in conjunction with the Nihilist cipher and MD5 technology for more secure encryption and decoding.	Because of the layers and different methods used, the suggested technique created a more secure ciphertext.

Table 2.Average Avalanche Effect Base 10x10 Key Matrix

Plaintext	Avalanche Effect %	
	Polybius Cipher	Playfair Cipher
Password	3.375	15.75
Helloworld	5.8	14.6
crYptoGraphy	4.083	15.33
CE123467	3.875	15.5
Decryption	5.1	14.8
encrypti0n	4.8	15.8
tre$bien	3.375	16.5
gain0a23	1.75	15.5
Average	**4.01975**	**15.4725**

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avalanche		

Table 3. Average Avalanche Effect K-Means Cluster 10x10 Key Matrix

Plaintext	Avalanche Effect %	
	Polybius Cipher	Playfair Cipher
Password	50.00	12.50
Helloworld	0.00	70.00
crYptoGraphy	41.67	33.33
CE123467	50.00	25.00
Decryption	10.00	20.00
encrypti0n	40.00	70.00
tre$bien	37.50	50.00
gain0a23	0.00	87.50
Average avalanche	**28.64325**	**46.04125**

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f	g	h	i	j	k	l	m	n	o
p	q	r	s	t	u	v	w	x	y
z	{	|	}	~	¡	¢	£	¤	¥

Fig 1. Default Extended 10x10 Polybius Square Key Matrix

RESEARCH ARTICLE

MSADCR : Multi-Level Semantic Augmentation and Dynamic Context Refinement in Hate Speech Detection

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ABSTRACT

The rapid proliferation of online communication platforms has magnified the prevalence and impact of hate speech, posing significant challenges for content moderation. This research aims to enhance the accuracy and sensitivity of hate speech detection systems by integrating advanced natural language processing techniques that can more effectively discern the subtleties and complexities of language.This paper introduces the MSADCR model, an advanced version of the BERT framework enhanced with Semantic Multi-level Augmentation (MSA) and Dynamic Context Refinement (DCR). MSA enriches the model's word embeddings with external semantic knowledge, providing deeper insights into the meanings of words and phrases. DCR dynamically adjusts the context windows during the model's attention phases, focusing on the most relevant textual elements. The model was trained and validated on several high-quality datasets, including Davidson-ICWSM, Waseem-EMNLP, and Waseem-NAACL, which contain diverse examples of hate speech. When compared to baseline models like Naive Bayes and SVM, MSADCR achieved superior performance metrics, with increases in accuracy (91%), precision (90%), recall (89%), and F1-score (89%) on the Davidson-ICWSM dataset. Similar gains were observed on other datasets, confirming the model's robustness and effectiveness. The novel integration of MSA and DCR into the BERT architecture represents a significant advancement in the field of hate speech detection.

Keywords: Hate Speech Detection, Semantic Augmentation, Context Refinement, Natural Language Processing, MSADCR.

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INTRODUCTION

The increasing complexity of online communication has made it clear that more sophisticated solutions are necessary. This has led researchers and technologists to delve into advanced natural language processing (NLP) techniques designed to accurately interpret the intricacies of human language. The development and implementation of such technologies are vital for enhancing content moderation systems, maintaining discourse standards, and protecting users from harmful content on digital platforms. Against this backdrop, this paper explores innovative methods that could fundamentally transform how online hate speech is detected and managed. The motivation behind enhancing hate speech detection technology stems from the need to address the limitations of current systems in moderating online platforms effectively. Traditional methods, which often rely on straightforward keyword searches and basic language patterns, frequently misunderstand the context or miss subtle cues, leading to incorrect classifications. This can either unfairly censor innocent communications or fail to prevent the spread of genuinely harmful content.

Given the vast and diverse nature of online interactions, there is a critical need for a system that not only understands words and phrases but also grasps the nuances of context, intent, and cultural differences. Such a system would significantly improve the accuracy of content moderation, reducing the burden on human moderators and limiting the exposure of users to potentially damaging speech. The growing impact of online hate speech on society, including its potential to incite violence, discriminate against marginalized groups, and influence public opinion negatively, underscores the urgency for more advanced and effective detection methods. By focusing on improving hate speech detection technologies, it aims to contribute to safer online environments and more respectful and constructive discourse on digital platforms.

This model aims to address the current challenges faced by traditional content moderation systems by enhancing the accuracy, efficiency, and adaptability of hate speech detection across various digital platforms. Specifically, the research is designed to achieve the following goals:

- *Enhance Linguistic Understanding:* Implement MSA to enrich the semantic processing capabilities of the MSADCR model, allowing it to grasp deeper meanings and subtle nuances in language that are often indicative of hate speech.
- *Improve Contextual Sensitivity:* Integrate DCR to dynamically refine the context in which words and phrases are analyzed, ensuring that the model considers relevant linguistic surroundings that can alter the intent and meaning of speech.
- *Reduce False Positives and Negatives:* By improving semantic and contextual analysis, the model is expected to more accurately differentiate between true hate speech and non-hateful content that may contain similar words or phrases, thereby reducing errors in content moderation.

The organization of this paper follows a systematic structure designed to present the research on the MSADCR model for hate speech detection comprehensively. The paper begins with an Introduction, setting the stage by discussing the significance of the problem and the motivations behind the study. This is followed by a detailed Literature Review that contextualizes the research within existing works. The Methodology section delineates the theoretical framework, the model's architecture, and the specific algorithms employed, providing a deep dive into the technical aspects. In the Results and Discussion section, the findings are presented and compared against baseline models. The paper concludes with the Conclusion, summarizing the study's contributions and suggesting directions for future research.

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LITERATURE REVIEW

The exponential growth of digital platforms has transformed the landscape of communication, allowing individuals worldwide to share ideas, opinions, and information instantaneously (Gawer, 2022). While this advancement in connectivity has numerous benefits, it has also given rise to significant challenges, one of the most pressing being the proliferation of hate speech (Mathew et al., 2020). Hate speech poses severe social, emotional, and psychological impacts on individuals and communities (Castaño-Pulgarín et al., 2021). As digital platforms continue to grow, the volume and velocity of online content make it increasingly difficult for traditional moderation systems to monitor and manage hate speech effectively (Zuo et al., 2024). These systems often rely on keyword-based filters or simple machine learning models that fail to capture the contextual subtleties and cultural nuances essential for identifying hate speech accurately (Al Maruf et al., 2024). The result is a high rate of both false positives, where benign content is incorrectly flagged as hate speech, and false negatives, where actual hate speech goes undetected (Fenza et al., 2024).

Moreover, the dynamic nature of language, with constantly evolving slang and new colloquialisms, adds another layer of complexity to the detection process (Sundaram et al., 2024). Perpetrators of hate speech frequently use coded language, sarcasm, and context-dependent phrases to evade detection, further complicating the moderation efforts (Gandhi et al., 2024). Davidson et al. (2021) demonstrated the effectiveness of context-aware learning models in distinguishing nuanced expressions of hate speech across diverse online platforms, emphasizing the need for models that dynamically adapt to evolving linguistic contexts. Additionally, Waseem and Hovy (2016) explored the role of multimodal data integration, utilizing both textual and visual cues to enhance the detection accuracy of potential hate speech instances. Their work illustrates the benefits of combining multiple data sources to better understand the context and intent behind user-generated content. Deep learning frameworks like BERT have been particularly noted for their superior performance in processing complex language patterns (Vidgen and Derczynski, 2020).

METHODOLOGY

Theoretical Framework
Semantic Multi-level Augmentation (MSA)

Overview of MSA
MSA represents a key innovation in enhancing the semantic processing capabilities of natural language processing models, particularly in the domain of hate speech detection. MSA aims to enrich the model's embeddings by incorporating external semantic knowledge, which provides a deeper understanding of the context and subtleties associated with language use in social media. This augmentation facilitates a more nuanced interpretation of potential hate speech by bridging the gap between surface-level text features and underlying semantic meanings. MSA is grounded in the need to deepen the semantic interpretability of embeddings within NLP models, particularly those engaged in the complex task of hate speech detection. Traditional embeddings efficiently capture syntactic relationships but often lack the semantic depth required to discern subtle nuances in language that differentiate benign discourse from hate speech. The foundation of MSA is the enrichment of base model embeddings through the integration of semantic layers from expansive knowledge bases such as WordNet. These databases provide detailed semantic networks, encompassing relationships like synonyms, antonyms, hypernyms (broader terms), and hyponyms (narrower terms), crucial for a nuanced understanding of language.

Example of MSA
Consider the application of MSA to the word dog in different contexts:
1. Pet Context: The dog played in the yard.
2. Derogatory Context: You are a dog.

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In a traditional embedding setup, dog would maintain a consistent vector across both sentences. However, MSA modifies this approach by dynamically augmenting the vector based on context-specific semantic relationships:

- In the Pet Context, MSA enriches the word dog with semantic associations like 'animal' and 'pet', aligning with benign meanings.
- In the Derogatory Context, the process involves adjusting the semantic vector to associate dog with terms such as 'insult' or 'slur', reflecting its pejorative use, which could be sourced from lexical databases detailing non-literal and culturally specific meanings.

During preprocessing, the context of each instance of dog is analyzed. A context-specific semantic vector is generated for the term:

- For the Pet Context, the vector is weighted towards positive and neutral connotations.
- For the Derogatory Context, the vector shifts towards negative connotations, emphasizing the derogatory usage detected based on the semantic relationships in the knowledge base.

Implementation of MSA

The implementation begins by identifying the base embeddings E generated by the pre-trained BERT model. Each word or token w in the vocabulary is associated with an embedding vector e_w $from$ E. To augment these embeddings with semantic information, an external knowledge base is queried to retrieve semantic relationships for each word. For each word w, retrieve related semantic concepts such as synonyms, hypernyms, and antonyms from a semantic database. Each semantic concept s related to w is represented by its embedding e_s, which can be sourced from the same initial embedding model to maintain consistency in vector space. The augmentation of the base embedding e_w with its related semantic embeddings e_s is performed using a weighted combination. Mathematically, the augmented embedding e'_w for word w is given in the equation 1:

$$e'_w = \alpha e_w + \sum_{s \in S(w)} \beta_s e_s \ \text{............................ (1)}$$

where:
- α is the weight for the original embedding $\boldsymbol{e_w}$.
- β_s are the weights for each semantic embedding $\boldsymbol{e_s}$, which are adjusted based on the relevance of each semantic relationship to the context of use.
- $S(w)$ represents the set of all semantic concepts related to w.

The weights α and β_s are crucial as they determine the influence of the original word embedding versus the semantic augmentations. These weights can be learned through training on a development set, optimized to enhance performance on specific tasks like hate speech detection. Alternatively, they may be set manually based on empirical observations or expert linguistic input. Once the augmented embeddings e'_w are prepared, they replace the original embeddings in the MSADCR model. This replacement ensures that during the model training and inference phases, the model uses embeddings that are rich in semantic content, enhancing its ability to understand and process complex language patterns typical of nuanced hate speech. MSA equips the MSADCR model with an advanced capability to understand not just the literal meaning of words but also their contextual implications. For instance, words that might typically appear neutral or benign can take on aggressive or derogatory connotations based on their usage in specific social or cultural contexts. MSA helps to capture these nuances by providing a richer semantic representation of each word. Let's consider a text sample X composed of words $w_1, w_2, \ldots, w_n$. The traditional BERT embedding for each word w_i is e_{w_i}. With MSA, the embedding is augmented to e'_{w_i} as given in the equaiton 2:

$$e'_{w_i} = \alpha e_{w_i} + \sum_{s \in S(w_i)} \beta_s e_s \qquad \text{..................... (2)}$$

The output vector y from the MSADCR model, which predicts whether text X is hate speech, is influenced by these augmented embeddings:

$$y = f\left(e'_{w_1}, e'_{w_2}, \ldots, e'_{w_n}\right) \qquad \text{..................... (3)}$$

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where f represents the model's classification function, which could involve multiple layers of neural network processing. One of the direct impacts of integrating MSA is the reduction in false negatives, where hate speech might previously have been missed. This improvement occurs because the model now better understands contexts where certain terms or phrases are used with hateful intent, despite possibly appearing benign in isolation. Similarly, the model also reduces false positives by recognizing when seemingly harsh words are used in non-hateful contexts.

Dynamic Context Refinement (DCR)
DCR is a sophisticated technique designed to enhance the contextual processing capabilities of NLP models, particularly in the MSADCR framework. This methodology focuses on dynamically adjusting the contextual window around each word or phrase, enabling the model to better capture and interpret the surrounding linguistic environment, especially in complex scenarios like hate speech detection.

Overview of DCR
DCR operates by refining how context is utilized within the transformer architecture of BERT. Unlike static approaches that consider a fixed contextual range, DCR adapts the contextual focus based on the semantic importance and relevance of surrounding words. This adaptation allows MSADCR to pay more attention to contextually significant words that influence the meaning of the target phrase. Consider a sentence S with words $w_1, w_2, \ldots, w_n$. In a standard BERT model, the context window for each word w_i is static. DCR modifies this by introducing a variable context window size c_i for each word, influenced by its semantic and contextual importance. The refined embedding e'_{w_i} for each word w_i in the context of DCR can be represented as:

$$e'_{w_i} = \sum_{j=i-c_i}^{i+c_i} \gamma_{ij} \, e_{w_j} \qquad\qquad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where e_{w_j} is the embedding of the j-th word in the window and γ_{ij} are the attention weights dynamically computed based on the relevance of each word w_j to the central word w_i.

Dynamic Adjustment of Context Windows
The size of the context window c_i and the weights γ_{ij} are determined by a combination of factors including the part of speech, semantic roles of the surrounding words, and their contributions to the overall sentence meaning. Techniques like attention mechanisms or reinforcement learning can be used to learn these parameters effectively during the training phase.

Example of DCR
Sentence Example: He threw a stone at the dog in jest.
In a typical static context model, equal importance might be given to all words around stone. However, with DCR:
- The words threw and at the dog are more contextually relevant to understanding the action involving the stone than in jest.
- Hence, DCR would dynamically increase the attention weights γ for threw and at the dog, while decreasing it for in jest.

This dynamic adjustment allows the model to focus more on the part of the sentence that conveys the main action and intent, aiding in more accurately determining the tone and context of the action described.

Model Architecture
The main model is based on multi-layer transformer encoder and the text input is transformed using self-attention and feed-forward sub-mappings. Every layer of the transformer helps in the understanding of linguistic relation between the elements of the input text. MSADCR consists of 12 transformer blocks, all of which have a hidden size of 768 units. This configuration is the same as in BERT-base and it is sufficient to provide the model with a rather large representational capacity, which allows it to learn a wealth of language phenomena effectively. Each

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transformer block within the BERT-base model includes two main components: The design of the transformer consists of a multi-head self-attention mechanism and a position-wise fully connected feed-forward network. The actual size of 768 in each transformer block to accommodate input sequences is hidden, and the feed-forward networks of each of these blocks have a hidden size of 3072 units. These dimensions are important when the model has to train on often huge amount of textual data.

MSA is implemented at the embedding layer, where each input token's embedding is dynamically enhanced with additional semantic information derived from external databases. This enhancement enriches the input representations with broader linguistic and contextual awareness before they are processed by subsequent transformer layers.DCR is integrated within the attention mechanisms of the transformer layers. It modifies the self-attention operation to weight the importance of different words within the input sequence dynamically. This is achieved by adjusting the attention scores based on the contextual relevance of each word, allowing the model to focus more on significant contextual cues and less on irrelevant information. To integrate the enhancements from MSA and DCR, additional dense layers may be incorporated into the model architecture. These layers typically align with the hidden size of 768 units to ensure that the augmented semantic and contextual information is effectively synthesized within the existing BERT architecture. The output layer, tailored for the classification task, is designed to output probabilities across the designated classes (hate speech, offensive but not hate speech, and neither), facilitating precise and actionable predictions.

MSADCR Algorithm
The algorithm is structured to preprocess text data, enrich word embeddings with additional semantic information, refine these embeddings based on contextual relevance, and ultimately classify the text into appropriate categories. By formalizing this process through specific computational steps and mathematical notations, it aims to provide a clear and systematic understanding of how the MSADCR model processes and analyzes text for detecting hate speech effectively.

Algorithm: MSADCR Model for Hate Speech Detection
Input: Set of documents $D = \{d_1, d_2, \dots, d_n\}$
Output: Set of classifications $C = \{c_1, c_2, \dots, c_n\}$, where $c_i \in \{HateSpeech, Offensive, Neither\}$

Procedure:
Preprocess each document d_i:
        Convert to lowercase: $d_i' \leftarrow \text{lower}(d_i)$
        Tokenize: $T_i \leftarrow \text{tokenize}(d_i')$
        Clean tokens: $T_i' \leftarrow \text{clean}(T_i)$
        Lemmatize: $T_i'' \leftarrow \text{lemmatize}(T_i')$
Augment tokens using MSA:
        For each token $t \in T_i''$:
                Retrieve semantic info: $S_t \leftarrow \text{semantic\_lookup}(t)$
                Augment token: $e_t \leftarrow \alpha e_t + \sum_{s \in S_t} \beta_s e_s$
Refine context using DCR:
        For each token $t \in T_i''$:
                Define context window: $W_t \leftarrow \text{context\_window}(t)$
                Compute contextual embedding: $e_t' \leftarrow \sum_{w \in W_t} \gamma_{tw} e_w$
Feed into transformer:
        Construct sequence embedding: $E_i \leftarrow \text{concat}(e_t' \mid t \in T_i'')$
        Compute transformed embedding: $H_i \leftarrow \text{transformer}(E_i)$
Classify:
        Compute logits: $L_i \leftarrow \text{dense\_layer}(H_i)$

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Apply softmax: $P_i \leftarrow \text{softmax}(L_i)$
Classify document: $c_i \leftarrow \text{argmax}(P_i)$

Return:

Return classifications: $C \leftarrow \{c_1, c_2, \dots, c_n\}$

End.

RESULTS AND DISCUSSION

Experimental Setup
Training the MSADCR model involves specific settings to optimize performance:
- Learning Rate: 2e-5.
- Batch Size: The model is trained with batch size32.
- Epochs: The training generally extends over 5 epochs.

The Adam optimizer is employed to handle the optimization of this model, which is particularly suited for these tasks due to its handling of weight decay, improving training stability. A dropout rate of 0.1 is used within the transformer blocks to enhance the model's generalization capabilities by mitigating the risk of overfitting through the random omission of units during training.

Datasets
The experimental setup for evaluating the MSADCR model's performance in hate speech detection utilizes multiple datasets, sourced from a variety of contexts to ensure robust testing across different types of language use and social media platforms. The following datasetsprovide a comprehensive basis for training and testing the model, encompassing a wide range of linguistic expressions, demographic variations, and types of hate speech. The datasets are as follows: Davidson-ICWSM Dataset(Davidson et al., 2017), Waseem-EMNLP Dataset(Waseem & Hovey 2016) and Waseem-NAACL Dataset(Waseem & Hovey 2016). The use of these datasets allows for rigorous evaluation of the MSADCR model under varying conditions and across different types of hate speech. The datasets are split into training, validation, and testing sets, with typically 70% used for training, 15% for validation, and 15% for testing. This split ensures that the model is trained on a substantial amount of data while also allowing for frequent evaluation and testing to monitor and optimize its performance throughout the training process.

RESULTS

The results section presents a comprehensive comparison of the MSADCR model's performance, with and without the integration of MSA and DCR, across the various datasets mentioned. Additionally, the performance of MSADCR is compared against several baseline methods traditionally used in hate speech detection. The following table 1, 2 and 3 summarize the performance metrics of the MSADCR model under different configurations and against baseline models. The graph in the figure 1 illustrates the performance of various models on the Davidson-ICWSM dataset. It is evident that the MSADCR model, which integrates both Semantic Multi-level Augmentation (MSA) and Dynamic Context Refinement (DCR), outperforms all other configurations across all metrics. Notably, the model achieves a peak accuracy of 0.91, which highlights its efficiency in correctly identifying hate speech. The progression from basic models like Naive Bayes and SVM to more sophisticated configurations underscores the benefit of integrating advanced NLP techniques. The incremental improvements seen from MSADCR (No MSA, No DCR) to MSADCR (MSA Only) and MSADCR (DCR Only) suggest that each component MSA and DCR contributes uniquely to enhancing the model's sensitivity. In Figure 3, the data from the Waseem-EMNLP dataset showcases a similar trend, where the fully enhanced MSADCR model demonstrates superior performance, reaching an accuracy of 0.90. This dataset, known for its complexity due to nuanced expressions of hate speech, provides a robust platform for testing the efficacy of the SMART-BERT enhancements. The results here reinforce the observation that the combined application of MSA and DCR significantly enhances model capabilities, which is critical for practical applications

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where diverse and subtle language use must be accurately interpreted. Finally, Figure 4 focuses on the Waseem-NAACL dataset, revealing that the MSADCR model maintains high performance, with an accuracy nearing 0.89. This dataset, incorporating various forms of hate speech, challenges the models to differentiate between closely related categories of speech. The graph reflects that while standalone applications of MSA or DCR yield substantial improvements over baseline models, the synergy between these two enhancements in the full MSADCR model provides the most effective approach for managing the complexities of hate speech detection across linguistically diverse datasets.

Baseline Models: Naive Bayes and SVM show lower performance metrics across all categories when compared to MSADCR configurations. These models, while effective in simpler text classification tasks, struggle with the complexity and subtleties of hate speech. MSADCR Variations: The version of MSADCR without MSA and DCR already outperforms the baseline models, indicating the strength of the underlying BERT architecture in handling complex linguistic tasks. Impact of MSA and DCR: Incorporating either MSA or DCR individually improves the performance, with MSA generally showing slightly higher effectiveness than DCR alone. This suggests that semantic augmentation plays a critical role in enhancing model sensitivity to nuanced language.
Combined Effect: The combination of both MSA and DCR provides the highest scores inall metrics, underlining the synergy between semantic enhancement and dynamic context adjustment. This configuration effectively captures both the overt and subtle expressions of hate speech, significantly reducing both false positives and false negatives.

CONCLUSION

The deployment of the MSADCR model, enhanced with MSA and DCR, has demonstrated substantial improvements in hate speech detection across various datasets. The integration of MSA and DCR has effectively increased the model's accuracy, precision, recall, and F1-score, notably achieving an accuracy of up to 91%, precision of 90%, recall of 89%, and an F1-score of 89% on the Davidson-ICWSM dataset. Similar improvements were observed on the Waseem-EMNLP and Waseem-NAACL datasets, where the combined enhancements led to top performance metrics, significantly surpassing those of baseline models like Naive Bayes and SVM. These results underline the efficacy of incorporating advanced semantic and contextual analysis techniques into NLP models, significantly elevating their ability to discern complex and subtle linguistic cues associated with hate speech.

Future research could focus on optimizing the computational efficiency of models like MSADCR, possibly through more sophisticated model compression techniques or more efficient training algorithms. Further exploration into multilingual capabilities and the incorporation of more diverse semantic resources could enhance the model's applicability across global platforms. Additionally, investigating the impacts of different types of bias in training data and developing methodologies to mitigate these biases will be crucial for ensuring the fairness and neutrality of automated content moderation systems.

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Table 1: Performance Metrics on Davidson-ICWSM Dataset

Model	Accuracy	Precision	Recall	F1-Score
Naive Bayes	0.79	0.75	0.72	0.73
SVM	0.82	0.80	0.78	0.79
MSADCR (No MSA, No DCR)	0.87	0.85	0.84	0.84
MSADCR (MSA Only)	0.89	0.87	0.86	0.86
MSADCR (DCR Only)	0.88	0.86	0.85	0.85
MSADCR	0.91	0.90	0.89	0.89

Table 2: Performance Metrics on Waseem-EMNLP Dataset

Model	Accuracy	Precision	Recall	F1-Score
Naive Bayes	0.76	0.73	0.70	0.71
SVM	0.80	0.78	0.77	0.77
MSADCR (No MSA, No DCR)	0.85	0.83	0.82	0.82
MSADCR (MSA Only)	0.88	0.87	0.86	0.86
MSADCR (DCR Only)	0.87	0.85	0.84	0.84
MSADCR	0.90	0.89	0.88	0.88

Table 3: Performance Metrics on Waseem-NAACL Dataset

Model	Accuracy	Precision	Recall	F1-Score
Naive Bayes	0.74	0.71	0.69	0.70
SVM	0.78	0.76	0.75	0.75
MSADCR (No MSA, No DCR)	0.84	0.82	0.81	0.81
MSADCR (MSA Only)	0.86	0.85	0.84	0.84
MSADCR (DCR Only)	0.85	0.83	0.82	0.82
MSADCR	0.89	0.88	0.87	0.87

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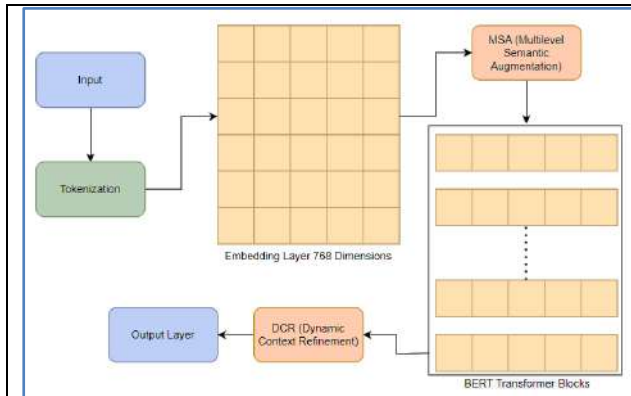
Figure 1. Proposed MSADCR Architecture	**Figure 2: Performance Metrics on Davidson-ICWSM Dataset**
Figure 3: Performance Metrics on Waseem-EMNLP Dataset	**Figure 4: Performance Metrics on Waseem-NAACL Dataset**
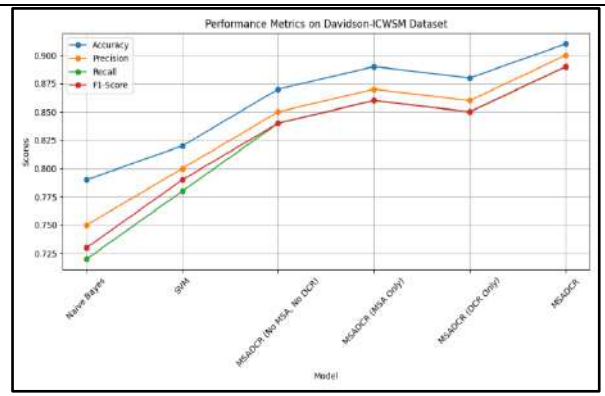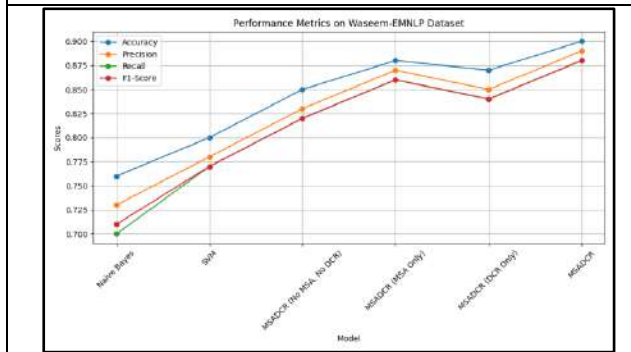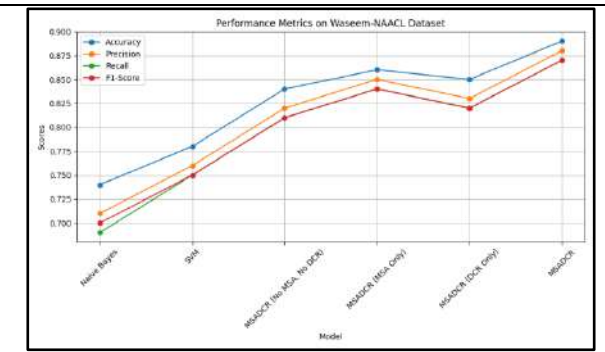
RESEARCH ARTICLE

The Science of Learning: Shanjamo Jungi's Educational Journey from Nagaland to America

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ABSTRACT

A young man named Shanjamo Jungi left his home in Nagaland, a remote state in the mountainous northeast corner of India, and traveled to the United States in 1905.He studied at Port Norris Public School under the tutelage of a missionary couple who had returned to Port Norris, New Jersey. Demonstrating remarkable promise as a scholar, Shanjamo established his life's work as an educator among his fellow natives of the Naga Hills. His commitment to this goal inspired those around him at Port Norris, garnering their support. Additionally, he attended Northfield Mount Hermon School in Massachusetts and Trendon Junction Public School in Massachusetts. After completing his studies, Shanjamo returned to Nagaland with a wealth of knowledge and enthusiasm, embarking on a career in teaching and Christian missionary work. As the first Naga to attend an American school, Jungi's story embodies a remarkable voyage of tenacity, fortitude, and the transformational power of education. His steadfast dedication to diversity and high standards of education has rewritten the history of cultural representation in American schools, leaving a lasting legacy that continues to uplift and empower future generations.

Keywords: Missionaries, Education, American Baptist Missionaries, Nagaland, Impur, Wokha Baptist, Church.

INTRODUCTION

The story of Shanjamo Jungi, the first Naga to receive an education in America, is a profound narrative of bravery, tenacity, and the transformative power of education. Born on January 2, 1882, in Yikhum Village, Wokha, Nagaland, Shanjamo embarked on a remarkable journey that would bridge the traditional and modern worlds through the lens of education. In 1905, amid the American Baptist Missionaries' endeavors in Nagaland, Shanjamo was brought to the United States by Reverend Samuel Alden Perrine and his wife, Rose Ermina Perrine, to pursue advanced studies. His educational journey spanned across various institutions, including Port Norris Public School in New Jersey and Northfield Mount Hermon School in Massachusetts, where he was exposed to cutting-edge educational technologies and methodologies of the time. Shanjamo's quest for knowledge was not merely an individual endeavor but a pioneering path that illustrated the profound impact of educational science in bridging cultural divides. His experience in America was characterized by an immersion in scientific pedagogy and technological advancements that were unparalleled in his homeland. This exposure to diverse educational tools and techniques empowered Shanjamo to return to Nagaland with a wealth of knowledge and enthusiasm, which he channeled into his career as a teacher and Christian missionary. The study explores the scientific and technological aspects of Shanjamo Jungi's educational journey, how his experience in American schools not only expanded his own horizons but also served as a catalyst for educational and cultural transformation in Nagaland. Through his story, we explore the intersection of traditional indigenous knowledge with modern educational practices, underscoring the enduring legacy of Shanjamo Jungi in the realm of education. The study employs a historical-analytical methodology, utilizing primary sources such as letters, missionary records, and school documents, alongside secondary sources including books, articles, and oral histories. By examining these diverse materials, the study reconstructs Shanjamo Jungi's educational journey and its impact on educational practices in Nagaland.

ORIGIN OF YIKHUM VILLAGE

One of the oldest settlements in the Lotha is Yikhum, which is part of the Wokha region. Although the exact date of the village's founding is unknown, oral traditions suggest that it was established somewhere in the 12th century A.D. First, the village was formerly known as Khumyanpan, which translates to "place of worship or village of worship." Before beginning to settle, the ancestors of those times explored the area, performed certain rites, and worshipped the location; for this reason, the area was known as Khumyanpan. Later, though, the name was altered to Yikhum (Yikhum), which means "believe in word." The terms Oyi, which means word, and Khuma, which means faith or worship, are combined to form the name Yikhum. Numerous academics and authors have proposed that these people first moved, most likely from Manchuria, in the eleventh or twelfth century AD, traveling over the Himalayan foothills. They left the Mongoloid race and moved here. They continued to migrate from one location to another. They travelled via Manipur and Burma before settling in Yikhum.

THE PERRINES

On February 19, 1859, Rev. Samuel Alden Perrine was born in Greensburg, Indiana. On June 9, 1891, he took Rose Ermina Lamb in marriage. Lucile and Linden LaRue were their two children. The American Baptist Missionaries sent the Perrines to work in the Naga Hills on March 28, 1892. Since there were no written languages for the Naga tribes, the Perrines put a lot of effort into creating texts that would educate the youth of the Naga people. Shanjamo was brought to study in the United States by Rev. Samuel Alden Perrine and Rose Ermina Lamb Perrine.

EARLY LIFE

On January 2, 1882, Shanjamo Jungi was born in Yikhum Village, Wokha, Nagaland. He was born in Nagaland into the Lotha Naga tribe. He was Sichio Jungi's second son. When he was a small boy, his mother died. His uncle Pvuchinyimo Jungi, the village's Assistant GB at the time, reared him following the death of his mother. Shanjamo was taken to Dr. Clark's School in Impur by his older brother Nkhao Jungi when he reached 16 in 1898 in order to pursue a better education. He studied here from 1898 to 1904, passing class 5 (the fifth grade) with success. Shanjamo was baptised by Rev. W.F. Dowd on January 4, 1899, and thereafter became a member of the Impur Baptist

Church.Dr. Clark thought highly of Shanjamo, a brilliant student, and advised Rev. and Mrs. Perrine to send him to the United States for additional education. It seems that Dr. Clark was a planner, a visionary who saw the importance of keeping the ministry going. Consequently, he decided to completely prepare Shanjamo for ministry by sending him to the United States for education. Shanjamo was found at the Impur School, which Dr. Edward Winter Clark founded, and his wife Mary Mead Clark, the first American Baptist Missionaries to the Naga Hills.

FOREIGN EDUCATION

On the advice of Dr. Clark, Rev. and Mrs. Perrine took him to the United States to further his education. On December 27th 1904, Rev. and Mrs. Perrine and Shanjamo started their journey to America from Impur via Guwahati, Calcutta, Delhi, Jaipur, Bombay, Egypt, Joppa, Palestine, Italy, Germany, Belgium and London taking six months to reach America. Shanjamo studied in three schools in America. In 1905, he studied in Trendon Public School, Port Norris Public School in New Jersey in 1906 and Northfield Mount Hermon School in Massachusets in 1907, and successfully passed class 8 becoming the first Naga to obtain foreign education.

MINISTRY IN THE NAGA HILLS

On September 10, 1908, Shanjamo departed from the United States and landed in Guwahati, Assam, on November 21. On November 27, 1908, he reached Impur, Naga Hills. He preached the message of Jesus Christ to the native tribes upon his return to Nagaland. He had exceptional abilities as a teacher, evangelist, preacher, and linguist. After coming back to the Naga Hills from the United States, Shanjamo was deeply interested in ministry. In 1909, he was invited back to Impur to help the American Baptist missionaries, and he became a mission center teacher there. In future years, he provided his services as a pastor in various communities, including Changtongya Baptist Church (Ao tribe), Yikhum Baptist Church (Lotha tribe), ancient Changsu Baptist Church (Lotha tribe) and Litami Baptist Church (Sema tribe). In addition, he started working as a teacher at the Vankhosung Mission Center, where he did so from 1930 until 1937. He contributed Rupees 100 towards the establishment and purchase of the center, along with Dr. Bailey, who was one of the school's founding leaders. After spending a few years returning to his hometown of Yikhum, he was asked to return and continue teaching at the Vankhosung Mission Center until 1948. From 1909 till 1910, Shanjamo was the pastor of Changtongya Baptist Church (Ao Tribe). In 1910, according to the Houstons (American Baptist Missionaries), Shanjamo was appointed as the pastor of Okotso Baptist Church's (Lotha Tribe) temporary associate. From 1912 to 1913, Shanjamo was also the pastor of Changbang Village Baptist Church, which belonged to the Lotha Tribe. In 1914, he spent a year preaching at Yikhum Village Baptist Church as the pastor. He went back to Impur Mission Center (Ao Tribe) in 1915–1917 to serve as the American Baptist Missionaries' assistant to conduct the choirs. Shanjamo commanded the Naga Labour Corps to France in March 1917 as part of World War I. He returned in 1918 and settled in Kohima, where he collaborated closely as an accounts clerk and interpreter with the deputy commissioner of the British Colonial government, filing accounts and records and distributing money to veterans of the war. He returned to serve as the pastor of Yikhum Village Baptist Church (Lotha Tribe) from 1919 to 1920. Shanjamo was a native of Yikhum village, where he held two terms as the church's pastor. From 1921 to 1922, he is the pastor of Old Changsu Baptist Church, which belongs to the Lotha Tribe. Yikhum Village is not far from Old Changsu Village

FAMILY LIFE

On Sunday, April 11, 1909, Shanjamo wed NoksanglemlaLemtur, an Ao woman from Longpa village. There were no kids raised by them. Since there was no internet, cell phones, telephones, or other form of communication back then, it was frequently impossible to communicate with loved ones. With the Naga Labour Corps, Shanjamo departed for France on March 1, 1917, and he didn't return to Kohima, Naga Hills, until June 17, 1918. Because of this, his wife fled for her village when Shanjamo departed for the war, purely out of fear that he might not return. Shanjamotraveled to his wife's village to bring her home once he got back. Sadly, he learned that she had already married again.Following that, in 1919, Shanjamo got married to Chomoni, a Lotha girl from the village of Riphym. They adopted three children instead of having children of their own: Mr. Yanrenthung from Old Riphym, Ms. Sumalmvu from Old Riphym, and Mr. Sathungo Jungi from Juti village, who was given the name Moses.

Mr. Sathungo's account
Sathungo Moses had a single son and was married. His wife was rather eloquent and upbeat.

Ms. Sumlamvu's account
Sumlamvu never got married and took on the role of taking care of her father from the time of his death till his later years. Before he passed away, Shanjamo told his daughter Sumlamvu that his time on earth was running out and asked to God to take him home before something terrible happened. The Indian Army arrived shortly after his death on February 28, 1956, and on July 29, 1956, they destroyed the village of Yikhum.

Mr. Yanrenthung's Account
Yanrenthung wed and gave birth to a son. Along with being the church's long-term caretaker, he was a member of the Yikhum Baptist Church choir. He resided in Wokha with his son, daughter-in-law, and grandchildren. The last gasp he made was in February 2019.

Shanjamo Memorial Baptist High School
Following a thorough deliberation, the executive members of the Lotha Baptist Association convened on November 22, 1968, and resolved to rename the Baptist English School in Wokha Town in honor of Shanjamo's efforts to the evangelization of the Naga people, specifically the Lothas. Back then, there were only two Christian private schools, one of which was the Shanjamo Memorial Baptist English School. The Catholic Don Bosco School was the other private establishment. The community's children are still served by the school.

CONCLUSION

Shanjamo Jungi's experience as the first Naga in American education is a motivational example of the strength of willpower, resiliency, and the quest for knowledge. Shanjamo has not only made a name for himself in academia or mission work but has also created opportunities for people from marginalized areas by shattering down obstacles and forging new routes. Shanjamo Jungi, the first Naga in American school, has made a lasting impression and encouraged numerous others to follow their dreams in the face of overwhelming challenges.His story also serves as a reminder of how diversity enhances our educational institutions and how every person's distinct experiences and viewpoints add to a livelier and more dynamic classroom. His legacy will inspire future generations since his story is a celebration of bravery, perseverance, and the unwavering pursuit of knowledge.

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RESEARCH ARTICLE

Modeling of a High Gain Small Folded Printed Quadrifilar Helix Antenna for Global Positioning System Applications

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ABSTRACT

In this research, a novel approach to the design of a folded printed quadrifilar helix antenna (FPQHA) is described. A dual band antenna with exceptional gain and circular polarization is developed for the L1/L2 Global Positioning System application. This research work's main objective is to reduce antenna size in comparison to traditional PQHA. The second objective of this work is dual band operation, which typically results in distinct issues when using several frequencies. By describing a multiple arm technique with a novel design strategy, a multi band PQHA may be obtained. The third objective of this research is to incorporate several techniques to attain a good band width in the axial mode. A multiband printed quadrifilar helix antenna design and optimization proposal is given. With the advancement of GPS and satellite navigation systems, increasingly demanding applications now require an antenna that can cover dual or even triple frequencies. The difficulty of using traditional FPQHA at several frequencies is one of its current issues. This work describes several ways that would allow this antenna to operate in two frequency bands. Because of its low cost, good axial ratio, circular polarization, hemispherical radiation, and good axial ratio, the folded printed quadrifilar helix antenna (FPQHA) is a particularly appealing choice for many applications, including global positioning systems, broadcasting satellite systems, and mobile satellite communications. However, for certain applications, a traditional PQHA's bandwidth might not be adequate. As a result, the method for boosting an FPQHA's bandwidth by using meandering line approaches is provided. The goal of the novel folded printed quadrifilar helix antenna (FPQHA) is to attain a good axial-mode bandwidth. Furthermore, the production of FPQHA requires relatively little space, money, or effort because the arms are printed on a single substrate face.

Keywords: Printed quadrifilar helix antenna, circular polarization, axial ratio

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INTRODUCTION

The use of satellite communication systems, such as GPS and broadcasting satellite systems, has increased significantly in the twenty-first century in response to urgent needs. Since the polarization rotation of the ionosphere won't influence circular polarization antennas, they are a good choice for signal transmission in these systems. More specifically, the GPS requires hemispherical radiation patterns with strong circular polarization in the bandwidth between terrestrial antenna receivers and satellites. For these purposes, the Folded Printed Quadrifilar Helix Antenna is a particularly appealing antenna. The many noteworthy qualities of Folded Printed Quadrifilar Helical Antennas (FPQHA), such as their low cost, light weight, hemispherical coverage, and strong circular polarization, have drawn a lot of interest in recent years in a variety of applications, including GPS and mobile communication. Numerous authors have employed meandering techniques to minimize the dimensions of wire antennas, including monopole and loop antennas. They include the use of continuously folded wire antennas, which have a tendency to resonate at frequencies far lower than those of a regular antenna of the same length. There are numerous techniques in the literature to shrink the printed QHA while it operates in a single band and has an integrated feeding network utilizing various pitch angles.

As it is unaffected by anomalies in the ionospheric atmosphere, the folded printed quadrifilar helix antenna (FPQHA) is typically employed in mobile satellite communication. Systems requiring great radiation performance and good beam width over the frequency band include satellite mobile communication and position-based services. The folded printed quadrifilar helix antennas' (FPQHA) radiating pattern makes them ideal for satellite mobile communications. In order to feed four helical weaponry with the same power and a 90° phase shift between ports, a large low frequency band conventional PQHA is needed. As a result, small-scale FPQHAs using a straightforward feeding network are needed. An integrated compact feeding network-equipped folded printed quadrifilar helix antenna (FPQHA) is presented in this letter. A 50% reduction in the axial length of FPQHA can be achieved by appropriately folding the helix arms into several identical pieces.

An antenna with a folded printed quadrifilar helix has a small profile and is lightweight. It is a wide beam antenna that is easily produced using printed circuit technology. For example, a continuous metallic layer serves as the ground plane on one side of the substrate and a metallic layer in a certain shape is bonded to a dielectric substrate to form a radiating element. Any continuous shape can be utilized as the radiating patch; it's not just limited to basic shapes. The mechanically robust, low-profile FPQHA antenna is easily fabricated on both planar and coplanar surfaces. FPQHA has a size of l / 2. Because these antennas are utilized at very high frequencies below microwave frequencies, the FPQHA is used above microwave frequencies.

Problem statement

Many researchers have employed meandering approaches to minimize the size of wire antennas, including monopole and loop antennas. Compared to a regular antenna of the same length, they have continuously folded wire that tends to resonate at lower frequencies. As GPS and satellite navigation systems have developed, more demanding applications now need an antenna that can span dual or even triple frequencies. The difficulty of using traditional PQHA at several frequencies is one of its current issues. In published work, numerous techniques that will increase the antenna's capability to dual frequency bands have been explained. Circularly polarized (CP) waves are used by the majority of satellite communication and navigation systems to send signals over large distances through the atmosphere with favorable propagation characteristics. Then, you need circularly polarized (CP) antennas with a suitable axial ratio spanning both the desired beam width and the operational frequency spectrum. Antennas with strong axial ratio throughout a multiband and wide beam width are especially needed for navigation applications that use Global Navigation Satellite Systems.

Jesavath Kiran Naik

Existing System

It is possible to create an FPQHA in a novel approach. The helix is spiral-shaped when printed. The antenna is smaller than it was with PQHA. A dual band antenna with exceptional gain and circular polarization is created for use in L1/L2 Global Positioning Systems applications. The suggested antenna is offered in order to produce a printed quadrifilar helix antenna with many bands. With the advancement of GPS and satellite navigation systems, increasingly demanding applications now require an antenna that can cover dual or even triple frequencies. The difficulty of using traditional PQHA at several frequencies is one of its current issues. This work explains a number of techniques that will enable the antenna to operate in two frequency bands.

Because of its low cost, strong axial ratio, circular polarization, hemispherical radiation, and good axial ratio, the PQHA is a better antenna for a variety of applications, including GPS, satellite mobile communications, and broadcasting systems. However, for certain applications, a traditional PQHA's bandwidth might not be adequate. Consequently, this method of adding a shorted parasitic helix to a PQHA increases its bandwidth. The goal of the novel folded printed quadrifilar helical antenna (FPQHA) is to attain a good axial-mode bandwidth. Furthermore, the FPQHA production is very easy, inexpensive, and requires little space because the arms are printed on a single substrate face.

RESEARCH METHODOLOGY

1. The traditional printed quadrifilar helical antenna is made smaller with a superior radiation pattern across many bands by using the meander line approach.
2. Looked at a cutting-edge multiple arm technique design approach to create a multiband.
3. The folded (FPQHA) printed quadrifilar helix antenna has been suggested; it provides a good axial ratio over a broad beam width and a big frequency bandwidth, making it more appropriate for use in navigation systems.

Proposed System

- The size reduction is obtained for the overall axial lengths of the PQHA structure, to satisfy require space limitations of a satellite mobile terminal with good performance.
- The proposed antenna to cover the L1/L2 frequency bands of GPS.

ELEMENT FOLDING AND MEANDERING METHODS

This method combines two miniaturization techniques: meandering of the helical elements and element flop, which was previously utilized for FPQHA miniaturization. Two segments are produced by folding the helical parts of an FPQHA: the straight segment (SS) and the meandering segment (MS). Figure 1 shows an illustration of a folded PQHA (FPQHA) and its unwrapped structure.

The folded FPQHA structure's dimensions, the length of the helical elements is separated into five components, a, b, c, d, and e, to facilitate the design process of an FPQHA. The length of a mean segment is equal to the total of the lengths of b, c, d, and e, whereas the length of a straight segment is represented by a. In this technique, the helical elements' turn was altered to maintain the same pitch angle as the standard FPQHA, in contrast to the previous element folding method that used the same number of turns after the helical elements were folded. Consequently, determining an FPQHA's axial length which is based on the value of a can be done by using the following steps:

SIMULATION OF PRINTED QUADRFILAR HELIX PATCH ANTENNA

With the specifications listed in section 4.2, the printed quadrifilar helix monopole patch antenna is virtually realized in antenna magus [--]. The first design is typically entirely optimized, and it is standard procedure to make model adjustments to further fine-tune the dimensions. The antenna's final dimensions are shown in Figure 5.1.The patch is built on a high-frequency laminate board made of FR4 material with a thickness of 2 mm, a relative permittivity of 4.4, and a 20 □m copper metallization layer. The patch antenna substrate's diameter (ground plane) is 18.01 mm, its

length (ground plane) is 132.5 mm, with 1.068 turns. The printed quadrifilar of the helix antenna has a width of 4 mm. Patch thickness and the thickness of the ground plane 0.2 mm and 2 mm respectively. The width of the feed element (FL) is 2 mm.

SIMULATION RESULTS OF THE PROPOSED FOLDED PRINTED QUADRIFILAR HELIX ANTENNA

With Antenna Magus Software, a folded printed Quadrifilar Helix patch antenna is simulated. Plots of many characteristics, including as return loss, impedance, and VSWR as functions of frequency, can be obtained with this software. Figures 5.1 and 5.35 display prototypes of the suggested antenna, while table 5.1 provides specific dimensions. The diameter plane and helix patch are essential for achieving a broad bandwidth in the suggested printed quadrifilar helix patch antenna. In order to obtain the best outcomes, a mender line analysis is performed by adjusting the diameter beginning at 16 mm. The impedance bandwidth of an 18 mm diameter patch antenna ranges from 1.22 GHz to 1.575 GHz, with a return loss that varies from -10 dB to -10 dB by reaching minimum levels of -28 dB and -27 dB.

 This analysis shows that when the diameter increases from 16 mm to 18 mm, there is a monotonic increase in the impedance bandwidth and a decrease in the lowest amount of return loss. The minimum level of return loss increases and the impedance bandwidth decreases beyond 18 mm in diameter. Hence, the printed quadrifilar helix patch antenna's 18 mm diameter is its ideal configuration. It is evident that this antenna radiates in an unidirectional manner. The gain of the antenna improves monotonically from 3.5 dBi to 4.25 dBi. Below is a display of the simulation results that Antenna Magus Software calculated.

The return loss of the FPQHA is plotted in Figure 4 from which, it is shown   that return loss of the antenna is below -10 dB for the frequencies in the range of 1.22 GHz and 1.575 GHz. The simulated return loss attained in this case is -28 dB and -27 dB only.

The VSWR of the FPQHA with 18 mm diameter is plotted in Figure 5 from which, it is shown that VSWR of the antenna is below 2 for the frequencies in the range of 1.22 GHz and 1.575 GHz. The maximum VSWR attained in this case is 0.9833 and 0.9917 only.

The Figure 6 shows real and imaginary parts of the impedance for the frequency range of 1.22 GHz and 1.575 GHz. The antenna possesses the enough impedance (36 – 70 Ohm) in this frequency range. These impedance values are apt for the FPQHA patch with good performance

Figure 7 shows the simulated LHC polarized gain components of the FPQHA with an innate ground plane, of which the main beam is scanned to different angles. This illustrates the good axial ratio that is achieved over most of the hemisphere.

CONCLUSION

It is possible to design a compact folded PQHA in a new approach. A highly desirable option for numerous applications, including global positioning systems and mobile satellite broadcasting systems, is the folded printed quadrifilar helix antenna (FPQHA). The FPQHA's axial-mode design aims to achieve a good bandwidth. The Folded Printed QHA design requires very little space, money, or effort.

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Table 1. Parameters of proposed antenna

Name	Description	Value
P	Polarization (transmitting)	Right hand circular
N	Number of turns	1.068
Rh	QHA radius	18.2 mm
Rg	Ground plane radius	18.01 mm
Ph	QHA height	132.5 mm
D	Patch width	4 mm
T	Thickness of patch and Ground plane thickness	0.2 mm and 2 mm
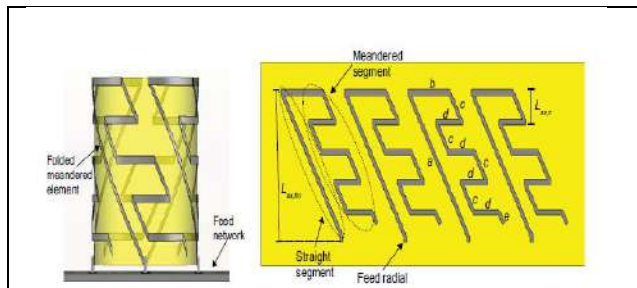
Figure 1. Folded FPQHA in wrapped and unwrapped configurations

Figure 2. Geometrical shape of proposed FPQHA antenna
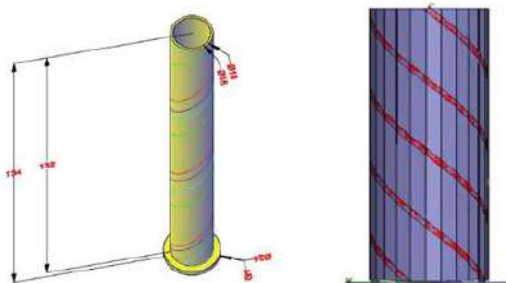
Figure 3 . Simulated proposed folded printed quadrifilar Helix Antenna
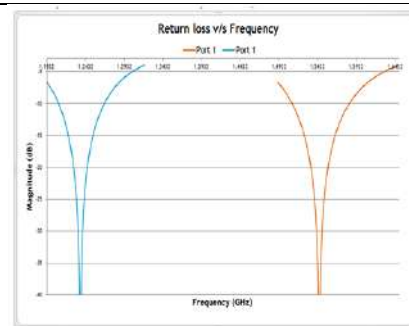
Figure 4. Return loss v/s Frequency of FPQHA

Jesavath Kiran Naik
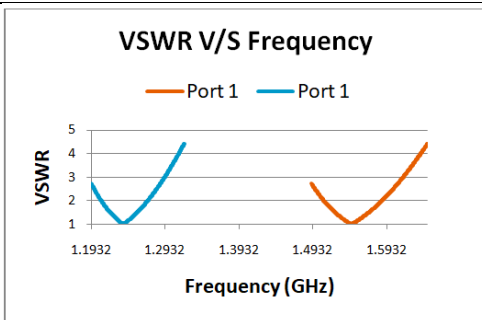
Figure 5. VSWR V/S Frequency 18 mm diameter of FPQHA
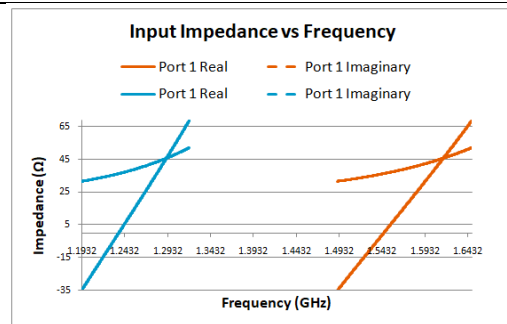
Figure 6. Impedances Z1, 1 and Y
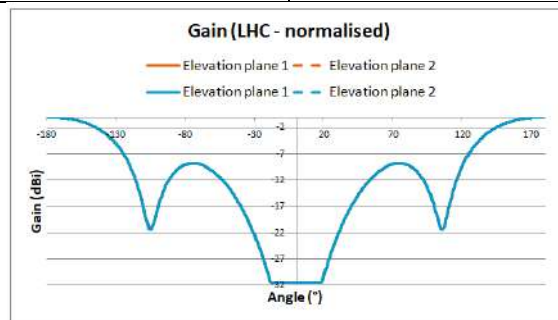
Figure 7. The simulated Gain (LHC - Normalized)

RESEARCH ARTICLE

To Compare the Effect of Core Strengthening with Physio Ball and without Physio Ball Inprimary Dysmenorrhea

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ABSTRACT

Dysmenorrhea is one of the gynaecological disorder prevailing in the women. Dysmenorrhea means painful menstruation .It has two types. (a) Primary (b) secondary. Primary dysmenorrhea is one where there is no identifiable pelvic pathology. Clinical features include the pain which is spasmodic and confined to abdomen which may radiate to back and medial aspect of thighs. Core stability exercise is beneficial intervention for management of several medical problems. The study aims to see the effectiveness of core strengthening with physio ball or without physio ball in patients with the primary dysmenorrhea. Total 40 female students were taken for participating in the study from Ahmedabad Physiotherapy College. After the initial assessment with the outcome measures(Visual analogue scale, Mc gill core endurance test, Biering Sorensen test), patients were explained about both the interventions, exercise with physio ball and without physio ball. The subjects were divided into two equal groups; group a core strengthening with physio ball and group b core strengthening without physio ball. Significance tests for difference in means was done using paired t tests. According to the results the study concludes that both the groups, are effective in reducing menstrual pain and strengthening of core muscles but group A was more effective than group B.

Keywords: primary dysmenorrhea, core strengthening, physio ball, menstrual pain intensity, *VAS.*

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INTRODUCTION

Dysmenorrhea is one of the gynaecological disorder prevailing in the women[1]. The name "dysmenorrhea" comes from the Greek word "dys" which means "difficult, unpleasant, abnormal," "meno" which means "month," and "rhea" which means "flow"[6].   Although primary dysmenorrhea is rarely life threatening, it does have certain socioeconomic consequences, such as increased sick leave, higher health-care costs, disruption of everyday activities, and social isolation[1]. The prevalence rate of primary dysmenorrhea ranges between 67-90% among the 17-24 aged girls[7]. According to the International Association for the Study of Pain, about 10-15% of women are unable to work for 1-3 days during their menstrual period[7]. Dysmenorrhea means painful menstruation .It has two types. (a) Primary (b) secondary[3]. Primary dysmenorrhea is one where there is no identifiable pelvic pathology[3].The causes of pain in primary dysmenorrhea may be due to psychosomatic factors like tension and anxiety[3].It may be due to the abnormal anatomical and functional aspect of myometrium, imbalance in the autonomic nervous control of uterine muscle , more synthesis and release of prostaglandins , increased vasopressin release , platelet activating factor and endothelins stimulating myometria contractions[3].Clinical features include the pain which is spasmodic and confined to abdomen which may radiate to back and medial aspect of thighs [3]. Discomforts like nausea, vomiting,fatigue,diarrhea, headache and tachycardia may be associated[3].In the medical treatment the drugs used are prostaglandin synthetase inhibitors and oral contraceptives[3]. The pain begins with onset of menstrual bleeding and can last for 12 hours – 72 hours[4].The pain is often described as cramped and intermittent[4].The pain mainly experienced in inguinal region, lower back, posterior thigh . Extroverted uterus, lack of exercise, psychological and social stress are the factors which worsens the pain6.Cramping pain results due to hypoxia in primary dysmenorrhea[6]. Many therapies are used to treat dysmenorrhea, including medicines, acupuncture, local application of heat and massage, herbal therapy, TENS, vitamins and minerals such vitamin B1, B6, E, and magnesium[1]. For primary dysmenorrhea, nonsteroidal anti-inflammatory medications (NSAIDs) and prostaglandin inhibitors are the first-line treatments[1].Physical exercise has been suggested as a non-medical approach for the management of symptoms and also effective in reducing the frequency and severity of dysmenorrhoeal syndrome[5]. Life style factor are responsible for primary and hence improving it can reduce the severity of primary dysmenorrhea[6]. Core stability exercise is beneficial intervention for management of several medical problems[1].

Core stability exercise strengthen the abdominal, lumbar, pelvic region muscles[1]. With the help of core strengthening, little intrinsic muscle surrounding the lumbar spine is conditioned for increased performance[5]. The goal of core training is to integrate the principles of lumbar stabilisation and core strengthening since instability can lead to injury and suffering, especially when the female body is under stress, and dysmenorrhea is one of those stressful times[2]. If a section of the lumbar spine becomes weak at any moment, its ability to handle functional stress is impaired, which can cause pain in the abdomen, low back, or thighs[2]. Core strengthening causes the muscles surrounding the lumbar spine to strengthen and become stronger, allowing them to manage daily demands of normal biomechanics even when the body is stressed by the menstrual cycle[2]. Improved metabolism aids in the alleviation of dysmenorrhea symptoms[2]. Menstrual discomfort is thought to be exacerbated by uterine muscular contractions, which are derived from the neurological system and innervated by the sympathetic nerve. As a result of the sympathetic nervous system's hyperactivity, stress causes uterine muscle contractility to rise, resulting in menstruation symptoms[2]. Exercise with physio ball is effective in stabilization of torso[9]. Movements with gym ball increase activity of other muscles and also stimulate other body parts, so it is effective on pain relief and blood flow smoothness[9].Exercise with physio ball helps to strengthen gluteus muscles, abdominal muscles, and back muscles[8]. It aids in the development of lower back, gluteus, and hamstring strength and stability [8]. It aids in the reduction of menstruation discomfort by boosting blood flow to core muscles following core muscle stretching and strengthening[8]. It also helps to lessen menstruation discomfort by improving balance, stability, and blood supply.[8]

MATERIALS AND METHODS

Source of data– Ahmedabad Physiotherapy College, Bopal, Ahmedabad
Study Design– Comparative study
Sampling method – convenient random sampling
Sample-young females
Sample size – 40
Study duration– 8weeks of study (3 session per week)
Materials used in the study areLow mat / yoga mat, Plinth,Pencil, Consentform, Paper, Physio ball,60^0 wedge

INCLUSION CRITERIA
- Written consent for participation in the study.
- Having regular menstrual cycles
- Females having primary dysmenorrhea
- Age criteria :18 to 25 years

EXCLUSION CRITERIA
- Pregnancy
- Known genital diseases
- Chronic diseases (heart disease, respiratory, kidney, blood pressure, asthma, diabetes, epilepsy, migraine, thyroid, anaemia, nervous disorders)
- Participation in other sports program

METHODOLOGY

Total 40 female students were taken for participating in the study from Ahmedabad Physiotherapy College. Subjects were selected on the basis of inclusion criteria and exclusion criteria and questionnaire(modified moos menstrual distress questionnaire) that was filled by the subjects .After the initial assessment , patients were explained about both the interventions , exercise with physio ball and without physio ball and their consent was taken for the same. The subjects were divided into two equal groups by simple random sampling namely Group A CORE STRENGTHENING WITH PHYSIO BALL and Group B CORE STRENGTHENING WITHOUT PHYSIO BALL. Before the treatment given to each group, the intensity of pain experienced by the subject was measured with the help of pain rating scale (Visual analogue scale) and Abdominal flexors was assessed with mc gill core endurance test (60^0 trunk flexor test), side flexors with mc gill core endurance test (right and left bridge test) and extensors were assessed with the Biering Sorensen test.

GROUP – A (CORE STRENGTHENINGWITH PHYSIO BALL)
In this group total 20 young females were taken. After the subjects have rated their level of pain on VAS and assessment of core muscles with endurance test. The group received core strengthening with physio ball for 8 weeks for three time in a week Each session lasted 45-60 minutes, beginning with a 10-minute warm-up, followed by 25-40 minutes of the main programme, and concluding with a 10-minute cool-down. In this group exercises included were (1)Ball crunch,(2) Crunch with feet on the ball,(3) Leg curl on the ball,(4) Ball bridge fall off,(5)Ball pendulum,(6)Bridging,(7)Oblique ball crunches,(8)Wall squat,(9)Ball squat , sideways , single leg,(10)Ball hip adduction,(11)Ball squeeze,(12)Back extension,(13)Knee tuck from plank,(14)Opposition raise

GROUP B(CORE STRENGTHENING WITHOUT PHYSIO BALL)
In this group also total 20 young females were taken. After the subjects have rated their level of pain on VAS and assessment of core muscles with endurance test. The group received core strengthening without physio ball for 8 weeks for   three time in a week Each session lasted 45-60 minutes, beginning with a 10-minute warm-up, followed

by 25-40 minutes of the main programme, and concluding with a 10-minute cool-down. In this group exercises included are; (1)Pelvic bridge,(2) Plank,(3) Cat and camel,(4) Single leg abdominal press,(5) Double leg abdominal press,(6) Curl up

OUTCOME MEASURE
1. VAS(Visual analogue scale)
2. Mc gill core endurance test
3. Biering Sorensen test

RESULTS AND TABLES

Total   43 female students were taken with primary dysmenorrhea as subjects in this study in which 3 students not completed the study, so finally 40 were included for the study. These 40 subjects were randomly divided into two group ,20 subjects in group A (Exercise with physio ball) and 20 subjects in the group B(Exercise without physio ball).The data taken from Ahmedabad physiotherapy college was entered and analysed by using SPSS (statistical package for social sciences) software version 25. Significance tests for difference in means was done using paired t tests. The test was applied as the data followed the condition of normality. Table1.1: table shows within group comparison of vas, 60^0 trunk flexor endurance test , biering sorensen test ,right side bridge endurance test Left side bridge endurance test in group a Table 1.2 table shows within group comparison of vas, 60^0 trunk flexor endurance test, biering sorensen test ,right side bridge endurance test, Left side bridge endurance test in group b Table1.3 table shows between groups comparison of group a and group b Graph1.1:showsbetween groups comparison intervention of 60^0 trunk flexor endurance test , biering sorensen test ,right side bridge endurance test, left side bridge endurance test of group a   and group b Graph 1.2graph shows VAS between groups comparison of group a and group b As shown by the results for group A and group B both have significant effect on decreasing pain intensity and increasing core strength. But when comparing both group A and group B, group A has more effect on pain intensity and increasing core strength. Hence alternative hypothesis in favour of exercise with physio ball and without physio ball is accepted and null hypothesis of no difference is rejected.

DISCUSSIONS

The present study was designed to find the effect of core strengthening exercise with physio ball and without physio ball in primary dysmenorrhea on pain and strengthening of core muscle. This was conducted on 43 female students of primary dysmenorrhea with age 18-25 years according to the inclusion and exclusion criteria. They were divided into two groups and both the groups underwent core strengthening protocol one with physio ball and second without physio ball. Due to 3 dropouts from the study, there were total 40 female students remaining at the end. Both the groups were assessed before and after the treatment to measure the level of reduction of pain as well as strength of muscle with the help of VAS and mc gill core endurance test and biering Sorensen test. At the end of 8 weeks, the female students in both the groups showed significant improvement in reduction of pain and increase in strength of core muscle. But the strengthening exercise with physio ball group showed more significant improvement than core strengthening exercises without physio ball. According to a study done by shahnaz shahrjerdi et al (2019), in journal of modern rehabilitation. The goal of this study was to see how core stability exercises affected pain severity, pain duration, and drug intake in adult females with primary dysmenorrhea. The study was done on 34 girls divided into two groups experimental group and control group in which experimental group was given core stability exercises 3 session per week for 8 weeks. In primary dysmenorrhea, core stability exercises were found to be useful in lowering pain severity, duration, and the use of pain relievers[1]. Hence, in this literature they have mentioned that 18 to 25 years aged girls have primary dysmenorrhea and for that they take analgesics. The core stability exercises are beneficial in reducing pain severity and duration during menstruation, and the need of painkillers is reduced greatly. It appears to be linked to the overall health benefits of physical activity, such as stress reduction, reduced sympathetic irritation, and increased endorphin production. So reduction in sympathetic system activity and stress

reduction can decrease the symptoms of primary dysmenorrhea[1]. Core stability exercise leads to conditioning of core muscles via neural drive increment and effective contraction and conditioning of core muscles might increase the circulation and metabolism in pelvic region and hence results in improvement of primary dysmenorrhea. One more study done by himani parikh et al (2021) in journal of Indian journal of physiotherapy and occupational therapy aimed to compare the effect of heat application and core strengthening exercise on relieving pain of primary dysmenorrhea among young females. This study was done on 50 girls divided into two groups core strengthening exercise group and moist pack application group. The intervention was continued for three consecutive months. The study concluded that core strengthening exercise group was effective in reducing pain of dysmenorrhea as compared with moist pack application. Hence it can be said that there are positive effect of core strengthening exercise in the treatment of primary dysmenorrhea[11]. Due to insufficient core musculature, the body is unable to bear the stresses required for regular movement and function during menstruation, resulting in inappropriate biomechanical function of tissues close to the lumbar spine[7].The pain in the abdomen, low back, and thighs could be caused by a lumbar spine that is weak or incapable of handling functional stress. The body is supported by the inert structures against any external forces. The muscles operate as dynamic guy wires, supplying counterforces to gravity torque and body stability, preventing loads from being put on inert structures[10]. Hence with the strengthen musculature we can reduce the stress on the body provided by external forces   As shown in table 1.1 and 1.2, the pain intensity reduced from 5.050 to 1.760 in group A and 4.930 to 3.055 in group B. This finding is consistent with the report by Sandeep Kaur where pain reduction was found to be from 9.09 to 4 in 4 weeks to 0.97 in 8 weeks measured by using NPRS[7]. Physio ball helps to strengthen the muscles around abdomen, legs, arms and back region and it also improves stability, balance, blood supply which helps to case menstrual pain[8]. Thus core strengthening with physio ball or without physio ball helps to reduce the menstrual pain intensity and strengthen the core muscle to manage the primary dysmenorrhea.

CONCLUSION

According to the results the study concludes that both the groups, group A-core strengthening with physio ball and group B- core strengthening without physio ball are effective in reducing menstrual pain and strengthening of core muscles but group A was more effective than group B. Hence core strengthening with physio ball can be a very useful adjunct in female students with primary dysmenorrhea. The limitation of the study is Mid-term (0-4 week) follow up not taken, Long term follow up is not done. The future recommendations areto find out effect of exercise on quality of life in such populations,the study can be done on young from 18 years age of females. As the present study conclude that core strengthening with physio ball is more effective when compared with core strengthening without physio ball in female students with primary dysmenorrhea. Hence core strengthening with physio ball can be an effective adjunct to a management program to females with primary dysmenorrhea and can be used in clinics.

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Table1. table shows within group comparison of vas, 60^0 trunk flexor endurance test , biering sorensen test ,right side bridge endurance test Left side bridge endurance test in Group A

OUTCOME	PRE MEAN	POST MEAN
VAS	5.050	1.760
60^0 TRUNK FLEXOR ENDURANCE TEST	36.75	57.15
BIERING SORENSEN TEST	23.30	36.15
RIGHT SIDE BRIDGE ENDURANCE TEST	19.35	31.75
LEFT SIDE BRIDGE ENDURANCE TEST	19.30	31.65

Table 2 : table shows within group comparison of vas, 60^0 trunk flexor endurance test, biering sorensen test ,right side bridge endurance test, Left side bridge endurance test in Group B

OUTCOME	PRE MEAN	POST MEAN
VAS	4.930	3.055
60^0 TRUNK FLEXOR ENDURANCE TEST	33.75	42.15
BIERING SORENSEN TEST	20.70	26.70
RIGHT SIDE BRIDGE ENDURANCE TEST	23.90	30.20
LEFT SIDE BRIDGE ENDURANCE TEST	23.95	30.35

Table 3: table shows between groups comparison of GroupA and Group B

OUTCOME	GROUP	MEAN±SD	UNPAIRED T TEST	P VALUE
VAS	GROUP A	1.760±0.5256	-6.152	
	GROUP B	3.055±0.7810	-6.152	
60^0 TRUNK FLEXOR ENDURANCE TEST	GROUP A	57.15±15.899	3.731	
	GROUP B	42.15±8.400	3.731	
BIERING SORENSEN TEST	GROUP A	36.15±13.291	2.945	<0.001
	GROUP B	26.70±5.411	2.945	

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RIGHT SIDE BRIDGE ENDURANCE TEST	GROUP A	31.75±8.188	0.647	
	GROUP B	30.20±6.910	0.647	
LEFT SIDE BRIDGE ENDURANCE TEST	GROUP A	31.65±8.022	0.554	
	GROUP B	30.35±6.753	0.554	
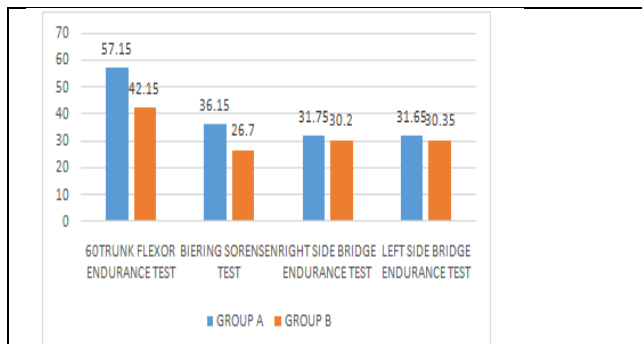
Graph1:shows between groups comparison intervention of 600 trunk flexor endurance test , biering sorensen test ,right side bridge endurance test, left side bridge endurance test of group a and group b
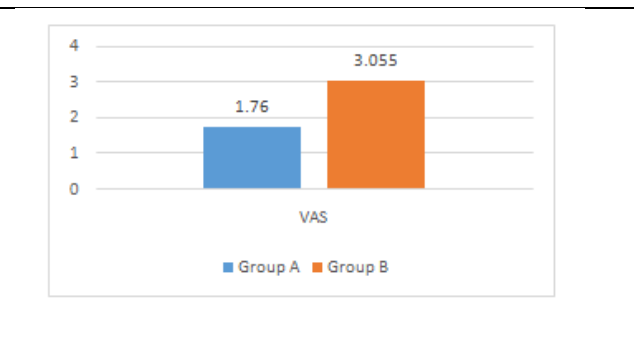
Graph 2: graph shows VAS between groups comparison of group a and group b

RESEARCH ARTICLE

On Statistical Hypothesis Testing Cricket Run Rate in T20 Format Based On Interval Valued Type-2 Hexagonal Fuzzy Numbers

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ABSTRACT

Conventional methods for hypothesis testing are insufficient for tackling ambiguous data. The emergence of the concept of fuzzy sets has resulted in endeavors to address the difficulty of evaluating hypothesis to deal with such ambiguous data. A method to determine crisp and fuzzy hypotheses is provided for natural fuzzy observations. The fuzzy test statistic is computed using crisp or fuzzy hypotheses as well as fuzzy data. During testing hypotheses, we might come across situations where data is taken as fuzzy, rather than crisp. In such cases, standard methods of hypothesis testing are inadequate and must be modified. In the challenge of evaluating hypotheses with data that is uncertain, an IPL match's run rate is fuzzy rather than precise. The paper, we focus data on fuzzy rather than data on crisp, along with we provide an approach for hypothesis testing with vague information that employs interval type -2 specialized hexagonal numbers that are uncertain.

Keywords: Hypothesis testing, Generalized hexagonal fuzzy number (Interval Type-2)
Mathematical Subject Classification: 62F03

INTRODUCTION

Preface
Basic statistical testing of hypotheses requires that the basic hypothesis and the offered data are clear. Furthermore, testing statistical hypothesis is an effective technique meant for drawing conclusions in whole-world scenarios.

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Typically, the core information is expected to be accurate numbers; however, it is significantly more practical to investigate fuzzy numbers, known as non-precision records. From this case, the statistical test will produce inaccurate results. Numbers of authors have explored statistical hypothesis testing in fuzzy contexts, employing fuzzy set theory notions proposed by Zadeh [10] in 1965. Arnold [1, 2, 3] described a method for assessing fuzzily expressed hypotheses using unambiguous evidence. S.M.Taheri et.al [9] investigated the problem of testing fuzzy hypothesis, in which the hypothesis are uncertain but the data are unambiguous. Kalpanapriya and Pandian [8] suggested a one-sample t-test for interval numbers that uses triangular unclear figures. A.Hari Ganesh and N.Jaimaruthi[4,5,6,7] presented a test of statistical hypothesis testing under fuzzy environment and interval using interval type 2 hexagonal fuzzy numbers. It's structured as follows: Section 2 covers the fundamental principles and definitions related to interval type-2 hexagonal numbers that are unclear and their alpha cut. Section 3 discusses the fundamentals of the T20 format as well as the run rate. Section 4 demonstrated how the data (run rate) of an IPL match is examined using a particular sample t-test for unique interval data. Section 5 provides an example of an IPL run rate evaluated with a particular sample t-test for unique interval data, based on the process of employing alpha cut of ITHFN [4].Finally, Section 6 concludes this study.

PRELIMINARIES

Fuzzy Number (**Definition**)

A set $\tilde{M}$ is fuzzy a term for a set that includes numbers in real. R is considered to be a fuzzy number if the membership of its functions exhibits the following properties.

(i) $\tilde{M}$ is convex, i.e., $\tilde{M}(\lambda t_1 + (1-\lambda)t_2) = \min\{\tilde{M}(t_1), \tilde{M}(t_2)\}$, for all $t_1, t_2 \in R$ and $\lambda \in [0,1]$.

(ii) $\tilde{M}$ is normal, i.e., there exists an $t_0 \in R$ such that $\tilde{M}(t_0) = 1$

(iii) $\tilde{M}$ is piecewise continuous

Hexagonal Fuzzy Number (Definition)

A fuzzy number $\tilde{M}$ is a hexagonal fuzzy number denoted by $\tilde{M} = (m_1, m_2, m_3, m_4, m_5, m_6)$, where $m_1 \leq m_2 \leq m_3 \leq m_4 \leq m_5 \leq m_6$ are real numbers satisfying $m_2 - m_1 \leq m_3 - m_2$ and $m_5 - m_4 \leq m_6 - m_5$, if its membership functions $\mu_{\tilde{M}}(t)$ is given by

$$\mu_{\tilde{M}}(t) = \begin{cases} 0 & t < m_1 \\ \dfrac{1}{2}\left(\dfrac{t-m_1}{m_2-m_1}\right) & m_1 \leq t \leq m_2 \\ \dfrac{1}{2} + \dfrac{1}{2}\left(\dfrac{t-m_2}{m_3-m_2}\right) & m_2 \leq t \leq m_3 \\ 1 & m_3 \leq t \leq m_4 \\ 1 - \dfrac{1}{2}\left(\dfrac{t-m_4}{m_5-m_4}\right) & m_4 \leq t \leq m_5 \\ \dfrac{1}{2}\left(\dfrac{m_6-t}{m_6-m_5}\right) & m_5 \leq t \leq m_6 \\ 0 & t > m_6 \end{cases}$$

Definition (Interval Type-2 Hexagonal Fuzzy Number)

A number $\tilde{M}$ that is fuzzy is a type-2 hexagonal uncertain quantity defined by

$$\tilde{M} = \left[\tilde{M}^L, \tilde{M}^U\right] = \left[(m_1^L, m_2^L, m_3^L, m_4^L, m_5^L, m_6^L), (m_1^U, m_2^U, m_3^U, m_4^U, m_5^U, m_6^U)\right],$$

where $(m_1^L \le m_2^L \le m_3^L \le m_4^L \le m_5^L \le m_6^L), (m_1^U \le m_2^U \le m_3^U \le m_4^U \le m_5^U \le m_6^U)$ are real numbers satisfying

$m_2^L - m_1^L \le m_3^L - m_2^L, \quad m_5^L - m_4^L \ge m_6^L - m_5^L, m_2^U - m_1^U \le m_3^U - m_2^U$ and $\quad m_5^U - m_4^U \ge m_6^U - m_5^U$, if its

membership functions $\mu_{\tilde{M}^L}(t)$ and $\mu_{\tilde{M}^U}(t)$ are given

by

$$\mu_{\tilde{M}^L}(t) = \begin{cases} 0 & t < m_1^L \\ \frac{1}{2}\left(\frac{t - m_1^L}{m_2^L - m_1^L}\right) & m_1^L \le t \le m_2^L \\ \frac{1}{2} + \frac{1}{2}\left(\frac{t - m_2^L}{m_3^L - m_2^L}\right) & m_2^L \le t \le m_3^L \\ 1 & m_3^L \le t \le m_4^L \\ 1 - \frac{1}{2}\left(\frac{t - m_4^L}{m_5^L - m_4^L}\right) & m_4^L \le t \le m_5^L \\ \frac{1}{2}\left(\frac{m_6^L - t}{m_6^L - m_5^L}\right) & m_5^L \le t \le m_6^L \\ 0 & t > m_6^L \end{cases}$$

2.4.

$$\mu_{\tilde{M}^U}(t) = \begin{cases} 0 & t < m_1^U \\ \frac{1}{2}\left(\frac{t - m_1^U}{m_2^U - m_1^U}\right) & m_1^U \le t \le m_2^U \\ \frac{1}{2} + \frac{1}{2}\left(\frac{t - m_2^U}{m_3^U - m_2^U}\right) & m_2^U \le t \le m_3^U \\ 1 & m_3^U \le t \le m_4^U \\ 1 - \frac{1}{2}\left(\frac{t - m_4^U}{m_5^U - m_4^U}\right) & m_4^U \le t \le m_5^U \\ \frac{1}{2}\left(\frac{m_6^U - t}{m_6^U - m_5^U}\right) & m_5^U \le t \le m_6^U \\ 0 & t > m_6^U \end{cases}$$

Definition (α - cut of an Interval Type-2 Hexagonal Fuzzy Number**)**

The form of an α - cut Interval Type-2 Hexagonal fuzzy set is

$${}^{\alpha}\tilde{M} = \left[\begin{cases} \left[\tilde{M}_\alpha^U, \tilde{M}_\alpha^L\right], \alpha \in [0, \lambda) \\ \left[\tilde{M}_\alpha^U, \tilde{M}_\alpha^L\right], \alpha \in [\lambda, 1] \end{cases}, \begin{cases} \left[\tilde{M}_\alpha^L, \tilde{M}_\alpha^U\right], \alpha \in [\lambda, 1] \\ \left[\tilde{M}_\alpha^L, \tilde{M}_\alpha^U\right], \alpha \in [0, \lambda) \end{cases} \right]$$

$${}^{\alpha}\tilde{M} = \left[\begin{cases} \left[2\alpha(m_2^U - m_1^U) + m_1^U, 2\alpha(m_2^L - m_1^L) + m_1^L\right], \alpha \in [0, \lambda) \\ \left[2\alpha(m_3^U - m_2^U) - m_3^U + 2m_2^U, 2\alpha(m_3^L - m_2^L) - m_3^L + 2m_2^L\right], \alpha \in [\lambda, 1] \end{cases}, \right.$$
$$\left. \begin{cases} \left[-2\alpha(m_5^L - m_4^L) + 2m_5^L - m_4^L, -2\alpha(m_5^U - m_4^U) + 2m_5^U - m_4^U\right], \alpha \in [0, \lambda) \\ \left[-2\alpha(m_6^L - m_5^L) + m_6^L, -2\alpha(m_6^U - m_5^U) + m_6^U\right], \alpha \in [\lambda, 1] \end{cases} \right]$$

TWENTY -TWENTY CRICKET FORMAT

Cricket has approximately 500 years of history, with the International Cricket Council serving as its regulating council since 1909. The ICC now recognizes three worldwide formats: Test, ODI, and T20I, and has 104 associated nations that are members to International Cricket Council. Only twelve elite nations compete in all three formats, while the rest are limited to playing a single-day and Twenty20 cricket internationally. The essential regulations for all three variants are the identical and have some similarities to the actual game of softball. The game is carried out by two squads of eleven teammates each one, with the team that bats seeking to get in numerous runs as feasible

opposing the team that fields till their innings is over. In the subsequent innings, the batting and bowling sides adopt opposing positions. A defending side bowler "bowls" in six-delivery sets referred to as "over's." Over's are delivered periodically from both ends of the wicket. At any given point, two batters from the team that is batting occupy the two extremes of the pitch, often referred to as the "creases." Striker batters try for scoring runs by hitting the bowling ball with their bats. Runs are obtained by going across the two stumps on opposite sides of the pitch. Runs are determined by the volume of repetitions the player who strikes and non-striker exchange ends, which might vary from zero to three. If a hitter can hit the ball out of the boundaries, he gets four or six runs for completing the outer boundary without a bounce within. An inning concludes when all 10 batsmen are lost (one hitter is 'not out' since no one is at the opposing end of the field). A test game lasts five days, with each day permitting 90 over's of bowling and each squad striking for two innings respectively. At last, after two innings, the side with the most runs wins.

In contrast, limited over's formats such as ODI and T20I take place through one inning per side, with 50 and 20 over's, respectively. Test performances are the ultimate test of skills, determination, patience, tenacity, and endurance over five days, and they can occasionally provide a vivid picture of effort, sorrow, ecstasy, strategy, and, above all, skill. But test matches seem to have lost their appeal in this era of lightning-fast short-over's cricket, notably T20I. With fewer over's, the shorter game has evened out the playing the field, which makes it more difficult and unexpected. This has resulted in a tremendous lot of enjoyment and excitement for those who see it while involving very little time input. High viewership generated significant media rights and sponsorships, resulting in ballooning player pay and a bustling industry surrounding the game. The promise of big money enticed cricketers of all levels to this shortened format. Even experienced players are leaving Test cricket to pursue longer T20 careers.

RUN RATE

In cricket, the run rate (RR), also referred to as runs per over (RPO), is the mean number of runs secured by a batting side in each over. It includes all of the runs secured by the batting side in the innings leading up to that point in the match, as well as any additional runs conceded by the bowling team. What constitutes a good run rate varies according to the quality of the pitch, the kind of match, and the level of play. A five-day Test match often has a lower run rate than a limited-over's game, as batters take a more conservative approach. In the past few years, the mean Test run rate has been between 3 and 3.5 runs per over, sometimes considerably lower, but in short-format cricket, batters must take a more enthusiastic attitude in order to get the required total to win. The mean run rate in One Day International (50-over) cricket has risen from approximately four when the format was originally introduced in the 1970s to more than five in recent years. Only England has ever achieved more than 9 runs per over; scoring 8 or 7 is a reasonable run rate given the 50 over's, and dropping wickets is always a concern. In 20-over Twenty20 International cricket, the mean run rate is 8 to 9 runs per over. This is the quickest format of the game, and hitting out is essential. The maximum run rate ever recorded was about 13-14. Excluding extras and overthrows, the greatest conceivable run rate is 36 - if every ball is struck for six, which has never happened in an entire match and only occurs in a single over extremely seldom. The primary usage of run rate in limited over's cricket is for comparing the batting team's run rate (runs scored per finished over) to the run rate necessary to win the game. Teams typically strive to enhance their run rate in the last over. Cricket officials utilize fielding limitation restrictions, also referred to as Power plays, to promote speedier scoring in the early stages of the innings.

RUN RATE PREDICTION

The run rate will be change are depends upon the batsman skills, bowler, fielding and etc.,
The run rate will change from the following condition:

BATSMAN VIEW

i.   If a batsman can hit both pace and spin bowlers. (strike rate is high)
ii. If a batsman struggle with spin or with pace bowler.(strike rate is medium)
iii. If a batsman struggle to get score in the both spin and pace bowler.(strike rate is low)

BOWLER VIEW

i. If a bowler can take wicket and not to allow batsman to hit boundaries. (Economic rate is low).
ii. If a bowler can give batsman to hit boundaries.(Economic rate is medium)

iii.   If a bowler not to get wicket and allow the batman to hit boundaries and give extras.(economic rate is high)

FIELDING VIEW
i.   If a team has a fielding set up very strong, the batsman struggle to hit a run or boundaries.
ii.   If a team has a fielding set up very moderate the batsman can easily hit run or boundaries.
iii.   If a team has a fielding setup very low, the batsman easily hit run or boundaries and they won't get run out.

The run rate will define in the following method:
(i) All balls are fair delivery and all balls scored one run.
(ii) All balls are not fair delivery and all balls scored one, two, three and less boundaries.
(iii) All balls are not fair delivery and all balls scored high runs.

ALL BALLS ARE FAIR DELIVERY AND ALL BALLS SCORED ONE RUN:
RUN RATE IS CRISP: 6.0

ALL BALLS ARE NOT FAIR DELIVERY AND ALL BALLS SCORED HIGH RUNS:
RUN RATE IS FUZZY AND RUN RATE POSSIBILITY:
The run rate of a cricket match will be possible only by the batsman hits from 1 run to maximum 36 runs.

Example: In an IPL match a team scored in the 5th over is 63 runs of having run rate as 12.6. If the next over (6th over) possibilities
(i)In the 6th over no run will be scored. (Maiden over)
(ii) Only one run will be scored. (Economic rate≤1)
(iii) Scored 2, 3, 4 ... And maximum run will be scored is all balls hits as 6 runs(Economic rate≥ 1)

Hypothesis testing for Interval data (special)

Let $\left\{\left\{\left[q_{1i}, r_{1i}\right]\left[q_{2i}, r_{2i}\right]\right\}, \left\{\left[q_{3i}, r_{3i}\right]\left[q_{4i}, r_{4i}\right]\right\}\right\}, i = 1,2,\ldots\ldots n\right\}$ be a random sample with size n (<30) such that

$\left\{q_{1i}, i = 1,2,3,\ldots\ldots n\right\}, \left\{q_{2i}, i = 1,2,3,\ldots\ldots n\right\}, \left\{q_{3i}, i = 1,2,3,\ldots\ldots n\right\}, \left\{q_{4i}, i = 1,2,3,\ldots\ldots n\right\},$

$\left\{r_{1i}, i = 1,2,3,\ldots\ldots n\right\}, \left\{r_{2i}, i = 1,2,3,\ldots\ldots n\right\}, \left\{r_{3i}, i = 1,2,3,\ldots\ldots n\right\}, \left\{r_{4i}, i = 1,2,3,\ldots\ldots n\right\}$ are the eight selected at random from normal individuals, and the population of the mean of the collection be

$\left[\left\{\left[\psi_1, \upsilon_1\right]\left[\psi_2, \upsilon_2\right]\right\}, \left\{\left[\psi_3, \upsilon_3\right]\left[\psi_4, \upsilon_4\right]\right\}\right]$

Right now, the null hypothesis will be checked for the population's mean of the provided sample

$\left[\left\{\left[\psi_1, \upsilon_1\right]\left[\psi_2, \upsilon_2\right]\right\}, \left\{\left[\psi_3, \upsilon_3\right]\left[\psi_4, \upsilon_4\right]\right\}\right]$ is equal to a specific interval

$\left[\left\{\left[\psi_{1o}, \upsilon_{1o}\right]\left[\psi_{2o}, \upsilon_{2o}\right]\right\}, \left\{\left[\psi_{3o}, \upsilon_{3o}\right]\left[\psi_{4o}, \upsilon_{4o}\right]\right\}\right],$ that is, $\psi_1 = \psi_{1o}, \psi_2 = \psi_{2o}, \psi_3 = \psi_{3o}, \psi_4 = \psi_{4o}$ and

$\upsilon_1 = \upsilon_{1o}, \upsilon_2 = \upsilon_{2o}, \upsilon_3 = \upsilon_{3o}, \upsilon_4 = \upsilon_{4o}$.

Take into consideration a random sampling of fewer values from the provided special interval data.

$S_{L1} = \left\{q_{1i}, i = 1,2,3,\ldots\ldots n\right\}, S_{L2} = \left\{q_{2i}, i = 1,2,3,\ldots\ldots n\right\}, S_{L3} = \left\{q_{3i}, i = 1,2,3,\ldots\ldots n\right\},$

$S_{L4} = \left\{q_{4i}, i = 1,2,3,\ldots\ldots n\right\}, S_{U1} = \left\{r_{1i}, i = 1,2,3,\ldots\ldots n\right\}, S_{U2} = \left\{r_{2i}, i = 1,2,3,\ldots\ldots n\right\},$

$S_{U3} = \left\{r_{3i}, i = 1,2,3,\ldots\ldots n\right\}, S_{U4} = \left\{r_{4i}, i = 1,2,3,\ldots\ldots n\right\}.$

Now, the sample mean of $S_{L1}, S_{L2}, S_{L3}, S_{L4}, S_{U1}, S_{U2}, S_{U3}$ and S_{U4} are $\overline{q}_1, \overline{q}_2, \overline{q}_3, \overline{q}_4, \overline{r}_1, \overline{r}_2, \overline{r}_3$ and $\overline{r}_4$ correspondingly and sample standard deviations (S.D) of $S_{L1}, S_{L2}, S_{L3}, S_{L4}, S_{U1}, S_{U2}, S_{U3}$ and S_{U4} are $s_{q_1}, s_{q_2}, s_{q_3}, s_{q_4}, s_{r_1}, s_{r_2}, s_{r_3}, s_{r_4}$ and s_{r_4} respectively.

Test statistics:

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$$t_{L_1} = \frac{(\bar{q}_1 - \psi_1)\sqrt{n}}{s_{q_1}}, t_{L_2} = \frac{(\bar{q}_2 - \psi_2)\sqrt{n}}{s_{q_2}}, t_{L_3} = \frac{(\bar{q}_3 - \psi_3)\sqrt{n}}{s_{q_3}}, t_{L_4} = \frac{(\bar{q}_4 - \psi_4)\sqrt{n}}{s_{q_4}} \text{ and}$$

$$t_{U_1} = \frac{(\bar{r}_1 - \upsilon_1)\sqrt{n}}{s_{r_1}}, t_{U_2} = \frac{(\bar{r}_2 - \upsilon_2)\sqrt{n}}{s_{r_2}}, t_{U_3} = \frac{(\bar{r}_3 - \upsilon_3)\sqrt{n}}{s_{r_3}}, t_{U_4} = \frac{(\bar{r}_4 - \upsilon_4)\sqrt{n}}{s_{r_4}}$$

The refusing zone of an alternative hypothesis for the α level is shown below:

Now, if $\left| t_{L_i} \right| < t_{\alpha, n-1}, i = 1,2,3,4$ (one -tailed test) and $\left| t_{U_i} \right| < t_{\alpha, n-1}, i = 1,2,3,4$ (one -tailed test), the difference between $\left[\{ [\psi_1, \upsilon_1 \| \psi_2, \upsilon_2] \}, \{ [\psi_3, \upsilon_3 \| \psi_4, \upsilon_4] \} \right]$ and $\left[\{ [\psi_{1o}, \upsilon_{1o} \| \psi_{2o}, \upsilon_{2o}] \}, \{ [\psi_{3o}, \upsilon_{3o} \| \psi_{4o}, \upsilon_{4o}] \} \right]$ is not important at this α level. Following this, the population mean for the given sample $\left[\{ [\psi_1, \mu_1 \| \psi_2, \mu_2] \}, \{ [\psi_3, \mu_3 \| \psi_4, \mu_4] \} \right] = \left[\{ [\psi_{1o}, \upsilon_{1o} \| \psi_{2o}, \upsilon_{2o}] \}, \{ [\psi_{3o}, \upsilon_{3o} \| \psi_{4o}, \upsilon_{4o}] \} \right]$. That is, the null hypothesis is accepted. Otherwise, the alternative hypothesis is accepted.

Now, if $\left| t_{L_i} \right| < t_{\alpha/2, n-1}, i = 1,2,3,4$ (two- tailed test) and $\left| t_{U_i} \right| < t_{\alpha/2, n-1}, i = 1,2,3,4$ (two -tailed test), the difference between $\left[\{ [\psi_1, \upsilon_1 \| \psi_2, \upsilon_2] \}, \{ [\psi_3, \upsilon_3 \| \psi_4, \upsilon_4] \} \right]$ and $\left[\{ [\psi_{1o}, \upsilon_{1o} \| \psi_{2o}, \upsilon_{2o}] \}, \{ [\psi_{3o}, \upsilon_{3o} \| \psi_{4o}, \upsilon_{4o}] \} \right]$ is not important at this α level. Following this, the population mean for the given sample $\left[\{ [\psi_1, \upsilon_1 \| \psi_2, \upsilon_2] \}, \{ [\psi_3, \upsilon_3 \| \psi_4, \upsilon_4] \} \right] = \left[\{ [\psi_{1o}, \upsilon_{1o} \| \psi_{2o}, \upsilon_{2o}] \}, \{ [\psi_{3o}, \upsilon_{3o} \| \psi_{4o}, \upsilon_{4o}] \} \right]$. For us, the fact that the null hypothesis has been accepted. Nevertheless, the alternative hypothesis is acceptable.

Right now, the 100(1-α)% confidence level for the population mean $\left[\{ [\psi_1, \upsilon_1 \| \psi_2, \upsilon_2] \}, \{ [\psi_3, \upsilon_3 \| \psi_4, \upsilon_4] \} \right]$ corresponding to the given below:

$$\left[\left\{ \begin{array}{c} \left[\bar{q}_1 - t_{\alpha/2,n-1}\left(\frac{s_{q_1}}{\sqrt{n}}\right), \bar{r}_1 - t_{\alpha/2,n-1}\left(\frac{s_{r_1}}{\sqrt{n}}\right) \right] \\ \left[\bar{q}_2 - t_{\alpha/2,n-1}\left(\frac{s_{q_2}}{\sqrt{n}}\right), \bar{r}_2 - t_{\alpha/2,n-1}\left(\frac{s_{r_2}}{\sqrt{n}}\right) \right] \end{array} \right\}, \left\{ \begin{array}{c} \left[\bar{q}_3 - t_{\alpha/2,n-1}\left(\frac{s_{q_3}}{\sqrt{n}}\right), \bar{r}_3 - t_{\alpha/2,n-1}\left(\frac{s_{r_3}}{\sqrt{n}}\right) \right] \\ \left[\bar{q}_4 - t_{\alpha/2,n-1}\left(\frac{s_{q_4}}{\sqrt{n}}\right), \bar{r}_4 - t_{\alpha/2,n-1}\left(\frac{s_{r_4}}{\sqrt{n}}\right) \right] \end{array} \right\} \right]$$

$$< \left[\{ [\psi_1, \upsilon_1 \| \psi_2, \upsilon_2] \}, \{ [\psi_3, \upsilon_3 \| \psi_4, \upsilon_4] \} \right] <$$

$$\left[\left\{ \begin{array}{c} \left[\bar{q}_1 + t_{\alpha/2,n-1}\left(\frac{s_{q_1}}{\sqrt{n}}\right), \bar{r}_1 + t_{\alpha/2,n-1}\left(\frac{s_{r_1}}{\sqrt{n}}\right) \right] \\ \left[\bar{q}_2 + t_{\alpha/2,n-1}\left(\frac{s_{q_2}}{\sqrt{n}}\right), \bar{r}_2 + t_{\alpha/2,n-1}\left(\frac{s_{r_2}}{\sqrt{n}}\right) \right] \end{array} \right\}, \left\{ \begin{array}{c} \left[\bar{q}_3 + t_{\alpha/2,n-1}\left(\frac{s_{q_3}}{\sqrt{n}}\right), \bar{r}_3 + t_{\alpha/2,n-1}\left(\frac{s_{r_3}}{\sqrt{n}}\right) \right] \\ \left[\bar{q}_4 + t_{\alpha/2,n-1}\left(\frac{s_{q_4}}{\sqrt{n}}\right), \bar{r}_4 + t_{\alpha/2,n-1}\left(\frac{s_{r_4}}{\sqrt{n}}\right) \right] \end{array} \right\} \right]$$

The computation example below illustrates the solution approach.

Illustration

In IPL the run rate of the CSK matches between one opponent team is between {[6.1, 7.1][6.8, 7.3]} and {[8.2, 10][9.5, 10.5]} that is, first power play and middle over between 6.1 to 7.1 run rate and 6.8 to 7.3 run rate respectively as well as middle over and dead over between 8.2 to 10 and 9.5 to 10.5 respectively. Only ten matches from the IPL are chosen at random. The run rate between the first ten over's and the last ten over's is therefore expressed in the following unique interval form:

[{[6.3, 6.2][6.4, 6.7]}, {[8.1, 9.0][9.5, 9.3]}],   [{[5.5, 7.2][6.1, 7.4]}, {[7.4, 9.5][9.3, 10.0]}]
[{[6.4, 6.4][6.9, 7.0]}, {[8.8, 9.2][10.8, 9.1]}],   [{[3.5, 7.9][7.8, 7.5]}, {[8.0, 10.2][8.4, 9.9]}] [{[6.7, 6.8][7.3, 6.9]}, {[8.3, 9.8][9.6, 9.8]}],   [{[4.0, 7.3][6.6, 7.1]}, {[8.1, 10.9][9.9, 10.1]}]
[{[5.1, 6.0][7.4, 6.8]}, {[7.9, 10.1][10.8, 9.4]}],   [{[6.4, 7.0][7.2, 7.4]}, {[8.7, 10.1][8.2, 10.7]}]

[{[3.5, 6.5][7.0, 7.1]}, {[6.9, 9.5][9.5, 10.7]}],   [{[6.9, 7.6][6.3, 7.8]}, {[8.0, 10.7][9.5, 10.6]}]

Presently, we will consider testing the hypothesis

H_0 : $\left[\left\{\left[\psi_1, \upsilon_1\right]\psi_2, \upsilon_2\right\}, \left\{\psi_3, \upsilon_3\right]\psi_4, \upsilon_4\right\}\right] = \left[\left\{\left[\psi_{1o}, \upsilon_{1o}\right]\psi_{2o}, \upsilon_{2o}\right\}, \left\{\psi_{3o}, \upsilon_{3o}\right]\psi_{4o}, \upsilon_{4o}\right\}\right]$

H_A : $\left[\left\{\left[\psi_1, \upsilon_1\right]\psi_2, \upsilon_2\right\}, \left\{\psi_3, \upsilon_3\right]\psi_4, \upsilon_4\right\}\right] \neq \left[\left\{\left[\psi_{1o}, \upsilon_{1o}\right]\psi_{2o}, \upsilon_{2o}\right\}, \left\{\psi_{3o}, \upsilon_{3o}\right]\psi_{4o}, \upsilon_{4o}\right\}\right]$

Then consider the sample size, n = 10 and the population mean is $\left[\left\{\left[\psi_{1o}, \upsilon_{1o}\right]\psi_{2o}, \upsilon_{2o}\right\}, \left\{\psi_{3o}, \upsilon_{3o}\right]\psi_{4o}, \upsilon_{4o}\right\}\right]$ =
[{[6.1, 7.1] [6.8, 7.3]}, {[8.2, 10][9.5, 10.5]}] with an undefined standard deviation. We utilize the 5% level of significance.

Right now, the mean value of the lower and higher interval values are $\overline{q}_1 = 6.0,\ \overline{q}_2 = 6.9,\ \overline{q}_3 = 8.0,\ \overline{q}_4 = 9.6$, $\overline{r}_1 = 7.0,\ \overline{r}_2 = 7.2,\ \overline{r}_3 = 9.9,\ \overline{r}_4 = 10.0$ respectively and the sample standard deviation of the lower and upper interval values are $s_{q_1} = 0.81, s_{q_2} = 0.30, s_{q_3} = 0.31, s_{q_4} = 0.72,\ s_{r_1} = 0.47, s_{r_2} = 0.12, s_{r_3} = 0.38, s_{r_4} = 0.34$.

Now, the table shows that the value of t for 9 degrees of freedom at the 5% level is 1.833.

The current lowest values are $\psi_{1o} = 6.1, \psi_{2o} = 6.8, \psi_{3o} = 8.2, \psi_{4o} = 9.5$ and the current upper values are $\upsilon_{1o} = 7.1, \upsilon_{2o} = 7.3, \upsilon_{3o} = 10, \upsilon_{4o} = 10.5$.

Test statistics:

$t_{L_1} = \dfrac{(\overline{q}_1 - \psi_1)\sqrt{n}}{s_{q_1}} = -0.390, t_{L_2} = \dfrac{(\overline{q}_2 - \psi_2)\sqrt{n}}{s_{q_2}} = 1.054, t_{L_3} = \dfrac{(\overline{q}_3 - \psi_3)\sqrt{n}}{s_{q_3}} = -2.040,$

$t_{L_4} = \dfrac{(\overline{q}_4 - \psi_4)\sqrt{n}}{s_{q_4}} = 0.439, t_{U_1} = \dfrac{(\overline{r}_1 - \upsilon_1)\sqrt{n}}{s_{r_1}} = -0.673, t_{U_2} = \dfrac{(\overline{r}_2 - \upsilon_2)\sqrt{n}}{s_{r_2}} = -2.636,$

$t_{U_3} = \dfrac{(\overline{r}_3 - \upsilon_3)\sqrt{n}}{s_{r_3}} = -0.832, t_{U_4} = \dfrac{(\overline{r}_4 - \upsilon_4)\sqrt{n}}{s_{r_4}} = -4.650$

Now, since $\left|t_{L_1}\right| < t_{0.05}, \left|t_{L_2}\right| < t_{0.05}, \left|t_{L_3}\right| < t_{0.05}, \left|t_{L_4}\right| < t_{0.05}, \left|t_{U_1}\right| < t_{0.05}, \left|t_{U_2}\right| < t_{0.05}, \left|t_{U_3}\right| < t_{0.05}, \left|t_{U_4}\right| < t_{0.05}$, the null hypothesis H_0 is accepted and the 95% confidence limits for the population mean

$$[\{[5.53, 6.7][6.73, 7.13]\}, \{[7.82, 9.68][9.18, 9.80]\}] < \left[\left\{\left[\psi_1, \upsilon_1\right]\psi_2, \upsilon_2\right\}, \left\{\psi_3, \upsilon_3\right]\psi_4, \upsilon_4\right\}\right] <$$
$$[\{[6.47, 7.27][7.07, 7.13]\}, \{[8.18, 9.68][10.01, 10.20]\}]$$

Hypothesis testing for Interval valued type-2 Hexagonal fuzzy Numbers

Interval valued type-2 hexagonal fuzzy number $\left[(m_1^L, m_2^L, m_3^L, m_4^L, m_5^L, m_6^L), (m_1^U, m_2^U, m_3^U, m_4^U, m_5^U, m_6^U)\right]$ can be expressed as a specific interval value by utilizing the α - cut method as follows:

$$\left[(m_1^L, m_2^L, m_3^L, m_4^L, m_5^L, m_6^L), (m_1^U, m_2^U, m_3^U, m_4^U, m_5^U, m_6^U)\right]$$

$$= \left[\begin{cases} \left[2\alpha(m_2^U - m_1^U) + m_1^U, 2\alpha(m_2^L - m_1^L) + m_1^L\right], \alpha \in [0, \lambda) \\ \left[2\alpha(m_3^U - m_2^U) - m_3^U + 2m_2^U, 2\alpha(m_3^L - m_2^L) - m_3^L + 2m_2^L\right], \alpha \in [\lambda, 1] \end{cases}, \right.$$
$$\left. \begin{cases} \left[-2\alpha(m_5^L - m_4^L) + 2m_5^L - m_4^L, -2\alpha(m_5^U - m_4^U) + 2m_5^U - m_4^U\right], \alpha \in [0, \lambda) \\ \left[-2\alpha(m_6^L - m_5^L) + m_6^L, -2\alpha(m_6^U - m_5^U) + m_6^U\right], \alpha \in [\lambda, 1] \end{cases} \right]$$

- (5.1)

Assume that the supplied sample is type 2 fuzzy data with values of type 2 hexagonal fuzzy numbers, and we need to test the hypothesis regarding the population mean. Using the connection (5.1) and the provided test strategy for special interval data, we may test the hypothesis by converting type 2 fuzzy data to special intervals. The solution process is shown using the following example.

Illustration

The sports department wishes to declare that the lowest and highest run rates in the IPL for the specific team are 5.5 and 10.5 respectively. Only 12 matches from the IPL were documented. The lowest and greatest run rates recorded in the IPL for a specific team were around a certain figure. As a result, the lowest and greatest run rates were calculated using interval type 2 hexagonal fuzzy numbers, as shown below.

[(5.09, 5.17, 5.31, 5.43, 5.50, 5.59), (10.25, 10.29, 10.42, 10.45, 10.49, 10.54)]
[(5.29, 5.37, 5.38, 5.50, 5.57, 5.65), (10.03, 10.08, 10.12, 10.16, 10.20, 10.25)]
[(5.20, 5.28, 5.42, 5.54, 5.62, 5.69), (10.48, 10.54, 10.55, 10.60, 10.64, 10.73)]
[(5.18, 5.26, 5.39, 5.51, 5.58, 5.65), (10.14, 10.19, 10.34, 10.38, 10.69, 10.78)]
[(5.40, 5.47, 5.61, 5.74, 5.81, 5.89), (9.96, 10.04, 10.22, 10.29, 10.33, 10.39)]
[(5.57, 5.65, 5.78, 5.90, 5.97, 6.05), (10.61, 10.67, 10.78, 10.83, 10.87, 10.91)]
[(5.38, 5.47, 5.61, 5.73, 5.80, 5.88), (10.10, 10.15, 10.69, 10.73, 10.79, 10.82)]
[(5.34, 5.42, 5.57, 5.69, 5.76, 5.85), (10.04, 10.10, 10.12, 10.17, 10.73, 10.79)]
[(5.68, 5.76, 5.90, 6.03, 6.10, 6.18), (10.16, 10.22, 10.41, 10.46, 10.51, 10.57)]
[(5.41, 5.49, 5.63, 5.74, 5.81, 5.89), (10.06, 10.13, 10.32, 10.38, 10.44, 10.52)]
[(5.29, 5.37, 5.51, 5.64, 5.71, 5.78), (9.99, 10.06, 10.17, 10.23, 10.29, 10.36)]
[(5.39, 5.47, 5.61, 5.73, 5.79, 5.88), (10.14, 10.20, 10.34, 10.39, 10.44, 10.53)]

Now, we are considering the testing hypotheses $\tilde{H}_o : \quad \tilde{\upsilon} \approx \tilde{5.5} \text{ to } \tilde{10.5}$ and $\tilde{H}_A : \quad \tilde{\upsilon} \succ \tilde{5.5} \text{ to } \tilde{10.5}$

where $\tilde{5.5} \text{ to } \tilde{10.5}$ is recognized as linguistic data. Hence, we may process the hypotheses.

$\tilde{H}_o :$ The lowest and highest run rate is around 5.5 to around 10.5.

$\tilde{H}_A :$ The lowest and highest run rate is approximately greater than around 5.5 to around 10.5.

We may suppose that the membership function of

$\tilde{5.5} \text{ to } \tilde{10.5}$ = [(5.1, 5.2, 5.3, 5.4, 5.5, 5.6), (10.1, 10.2, 10.3, 10.4, 10.5, 10.6)]

Presently, the sample measures 12, and the population mean is

$\tilde{\upsilon}_o$ = [(5.1, 5.2, 5.3, 5.4, 5.5, 5.6), (10.1, 10.2, 10.3, 10.4, 10.5, 10.6)] with an undetermined sampling standard deviation.

Now, applying the relation (5.1), we transform the type 2 fuzzy interval data, and subsequently, we find that the average of the lowest and higher interval estimations of the special interval

$\overline{q}_1 = 0.1178\alpha + 10.164$, $\overline{r}_1 = 0.1610\alpha + 5.3498$, $\overline{q}_2 = 0.3017\alpha - 10.373$, $\overline{r}_2 = 0.2593\alpha + 16.421$,

$\overline{q}_3 = -0.1410\alpha + 5.8213$, $\overline{r}_3 = -0.2262\alpha + 10.648$, $\overline{q}_4 = -0.1610\alpha + 5.831$, $\overline{r}_4 = -0.1242\alpha + 10.597$

accordingly, and the sample standard deviation of the mean value of the smallest and higher interval values is

$s_{q_1} = \sqrt{0.0137\alpha^2 - 0.0016\alpha + 0.0388}$

$s_{r_1} = \sqrt{0.0001\alpha^2 + 0.0002\alpha + 0.0264}$, $0 \le \alpha < \lambda$

$s_{q_2} = \sqrt{0.0758\alpha^2 - 0.0529\alpha + 0.0453}$

$s_{r_2} = \sqrt{0.0054\alpha^2 + 0.0137\alpha + 0.2447}$, $\lambda \le \alpha \le 1$

$$s_{q_3} = \sqrt{0.0001\alpha^2 - 0.0003\alpha + 0.0296}$$

$$s_{r_3} = \sqrt{0.1021\alpha^2 - 0.1536\alpha + 0.0957}, \qquad\qquad 0 \le \alpha < \lambda$$

$$s_{q_4} = \sqrt{0.00006\alpha^2 - 0.00034\alpha + 0.02964}$$

$$s_{r_4} = \sqrt{0.0014\alpha^2 + 0.0023\alpha + 0.0429}, \qquad\qquad \lambda \le \alpha \le 1$$

We apply the 5% level of significance to the table value of t for 11 degrees of freedom.

$t_{0.05} = 1.796$.

Now, the interval representation of $\tilde{\upsilon}_0$, $\qquad [\tilde{\upsilon}_0] = \left[\left\{ \left[\psi_{1o}, \upsilon_{1o} \right] \left[\psi_{2o}, \upsilon_{2o} \right] \right\}, \left\{ \psi_{3o}, \upsilon_{3o} \right] \left[\psi_{4o}, \upsilon_{4o} \right] \right\} \right]$

where

$$\psi_{1o} = 0.117\alpha + 10.1, \ \upsilon_{1o} = 0.16\alpha + 5.34$$

$$\psi_{2o} = 0.3\alpha - 10.3, \ \upsilon_{2o} = 0.25\alpha + 5.3$$

$$\psi_{3o} = -0.14\alpha + 5.82, \ \upsilon_{3o} = -0.22\alpha + 10.6$$

$$\psi_{4o} = -0.1\alpha + 5.83, \ \upsilon_{4o} = -0.12\alpha + 10.5$$

Now, let $\lambda = 0.5$, we have the test statistics

$$t_{L_1} = \frac{(\bar{q}_1 - \psi_1)\sqrt{n}}{s_{q_1}} = \begin{cases} 1.1176, \alpha = 0 \\ 1.0439, \alpha = 0.49 \end{cases}, t_{L_2} = \frac{(\bar{q}_2 - \psi_2)\sqrt{n}}{s_{q_2}} = \begin{cases} 1.3544, \alpha = 0 \\ 1.3610, \alpha = 0.49 \end{cases},$$

$$t_{L_3} = \frac{(\bar{q}_3 - \psi_3)\sqrt{n}}{s_{q_3}} = \begin{cases} 0.9365, \alpha = 0.5 \\ 0.8654, \alpha = 1 \end{cases}, t_{L_4} = \frac{(\bar{q}_4 - \psi_4)\sqrt{n}}{s_{q_4}} = \begin{cases} 1.4147, \alpha = 0.5 \\ 1.4754, \alpha = 1 \end{cases},$$

$$t_{U_1} = \frac{(\bar{r}_1 - \upsilon_1)\sqrt{n}}{s_{r_1}} = \begin{cases} 1.2800, \alpha = 0 \\ 1.2723, \alpha = 0.49 \end{cases}, t_{U_2} = \frac{(\bar{r}_2 - \upsilon_2)\sqrt{n}}{s_{r_2}} = \begin{cases} 0.7120, \alpha = 0 \\ 0.7902, \alpha = 0.49 \end{cases}$$

$$, t_{U_3} = \frac{(\bar{r}_3 - \upsilon_3)\sqrt{n}}{s_{r_3}} = \begin{cases} 0.6672, \alpha = 0.5 \\ 0.0522, \alpha = 1 \end{cases}, t_{U_4} = \frac{(\bar{r}_4 - \upsilon_4)\sqrt{n}}{s_{r_4}} = \begin{cases} 0.8429, \alpha = 0.5 \\ 0.6320, \alpha = 1 \end{cases}$$

Since for α, $0 \le \alpha < 0.5$, $t_{L_1} < t_{0.05}$, $t_{L_2} < t_{0.05}$, $t_{U_1} < t_{0.05}$ and $t_{U_2} < t_{0.05}$ and for α, $0.5 \le \alpha \le 0.92$, $t_{L_3} < t_{0.05}$,

$t_{L_4} < t_{0.05}$, $t_{U_3} < t_{0.05}$ and $t_{U_4} < t_{0.05}$. Therefore, $\tilde{H}_o$: The lowest and highest run rate is around 5.5 to around 10.5 is allowed depending on the specified fuzzy data and criteria

$0 \le \alpha \le 0.92$.

CONCLUSION

In this study, we addressed the challenge of evaluating statistical hypotheses for cricket run rate using interval valued type-2 Hexagonal fuzzy numbers. The key advantage of this method is that it allows the statistical hypothesis to be tested when the available data falls within the interval of fuzzy numbers. Finally, numerical examples are provided to show the practicality of the suggested technique.

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Table: 1 batsman view

Batsman	Pace bowler		Spin bowler		Strike rate
	Runs	over	Runs	over	
1	45	3	35	2	$\frac{(45+35)}{30}*100=$**266.7**
2	14	3	25	2	$\frac{(14+25)}{30}*100=$**130**
3	4	3	6	2	$\frac{(4+6)}{30}*100=$**33.3**

Table: 2 Bowler view

Bowler	Over	Run	Economic rate
1	4	20	20/4=**5**
2	4	25	25/4=**6.25**
3	4	40	40/4=**10**

Table:3 Run rate is crisp

OVER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

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RUN	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
TOTAL	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
RUNRATE	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0

Table: 4 Run rate is fuzzy

OVER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
RUN	6	7	9	12	7	19	9	2	5	3	11	9	4	6	8	5	14	13	2	16
TOTAL	6	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96	102	108	114	120
RUNRATE	4.0	7.0	6.7	5.8	7.4	9.2	8.6	8.0	7.4	7.1	6.9	6.8	6.5	6.4	6.8	6.9	7.7	8.1	7.8	8.1

Table: 5 Run rate possibilities

	RUNS POSSIBLE IN THAT OVER(6th OVER)	RUN RATE
Team A Vs Team B Batting: Team A Runs: 63/2 Over: 5 Run rate:12.6	(0,1,2)	(10.5,10.7,10.8)
	(3,4,5,6,7,8)	(11.0,11.2,11.3,11.5,11.8)
	(9,10,11,12,13,14)	(12.0,12.2,12.3,12.5,12.7,12.8)
	(15,16,17,18,19,20)	(13.0,13.2,13.3,13.5,13.7,13.8)
	(21,22,23,24,25,26)	(14.0,14.2,14.3,14.5,14.7,14.8)
	(27,28,29,30,31,32)	(15.0,15.2,15.3,15.5,15.7,15.8)
	(33,34,35,36)	(16.0,16.2,16.3,16.5)

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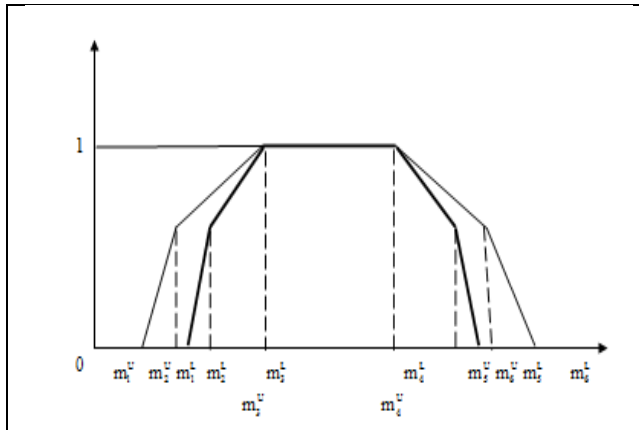
Figure 1: Hexagonal Fuzzy Number in interval type-2 form
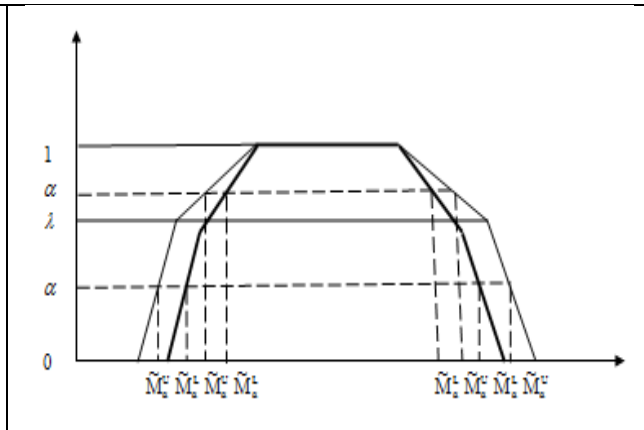
Figure 2: α - cut of an IT2HFN
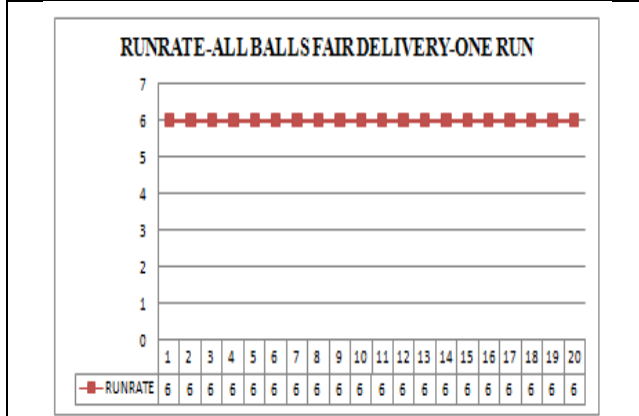
Figure:3 Run rate –All balls fair delivery-one run
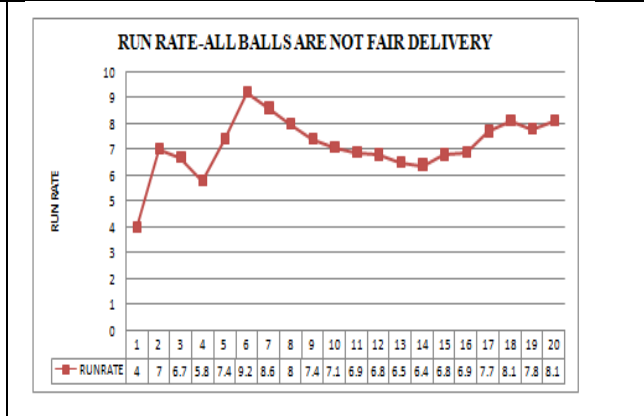
Figure: 4 Run rate is fuzzy

RESEARCH ARTICLE

Improve the KDD CUP 1999 Data by Comparing and Removing the Count Attribute

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ABSTRACT

Systems like intrusion detection, fraud detection, and system monitoring depend heavily on anomaly detection. Regrettably, false positives are a common problem with these systems, which can lead to alarm fatigue, diminished effectiveness, and lowered system confidence. This abstract will examine several strategies for handling false positives in anomaly detection. We will talk about strategies that can help reduce the false positive rate and increase the accuracy and robustness of the system, like semi-supervised learning, ensemble methods, and threshold tweaking. By putting these strategies into practice, you may lessen alert fatigue, boost productivity, and boost user confidence in anomaly detection systems—all of which can make them useful for a variety of applications.

Keywords: Accuracy, robustness, efficiency, confidence, alert fatigue, semi-supervised learning, ensemble techniques, intrusion detection, fraud detection, system monitoring, and threshold tweaking.

INTRODUCTION

In response to the widespread misuse of computers by individuals, network intrusion has become a major worry for enterprises in recent years. Malicious assaults can still happen even with encryption, VPNs, and firewalls installed, which is why having a monitoring system in place is essential. Intrusion detection is an important technology that, through the analysis of hostile data and counterattacks, offers dynamic protection to companies. One such system is the Network-Based IDS (NIDS), which keeps an eye on network traffic to spot possible threats coming from outside the network. Three types of intrusion detection systems (IDS) exist: signature-based, anomaly-based, and protocol modelling-based. All three approaches are combined by most IDS systems to improve security.

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Categories of Intrusion Detection System [2]
Detection Systems based on Signature
Comparing network traffic or system behavior to a database of predefined attack signatures is a technique for identifying known assaults. The patterns that match the distinctive qualities of a known attack are known as attack signatures. There are two primary stages to the process:

Signature Generation
Creating an attack signature database is the first step in the signature-generating process. Usually, to do this, patterns in network traffic or system logs are identified by examining the behavior of known assaults. The intrusion detection system uses the generated signatures to identify upcoming assaults by adding them to the database.

Signature Matching
When using signature-based intrusion detection, the system searches network traffic or computer system behavior for patterns of known attacks. It alerts you if it discovers a match. While this is a quick method for identifying known assaults, it is ineffective against undiscovered ones. Attackers can modify their strategies to avoid being discovered. More recent intrusion detection systems utilize machine learning and other cutting-edge methods to learn from previous attacks and recognize strange behavior to uncover these new attacks.[8]

Detection System based on Anomaly
An instrument that searches a computer network for anomalous activity is called an anomaly-based detection system. After establishing a profile of what is typical, it keeps an eye out for deviations. This system is capable of identifying anomalous behaviors or denial-of-service attacks. It locates these items with intelligent technologies. This system's ability to identify previously unseen assault kinds is one of its advantages. However, if the system changes or if it is unaware of what normal is, it may also make mistakes. It is crucial to define normal clearly and to change it as necessary to improve the functionality of this system. To keep things safe, it's also critical to employ additional security measures like passwords and virus scans.

Protocol Modelling
Computer network protocols can be analyzed using a technique called protocol modeling. It models the protocol, mimicking its actions and spotting potential security risks. This model's behavior is controlled by a variety of states and messages. Testing the protocol's resilience to various attacks and identifying its vulnerabilities are beneficial. Researchers and experts in network security utilize protocol modeling to make networks more secure and to ensure that new protocols are developed with performance and security requirements in mind.

LITERATURE SURVEY

V. chandola et al, employed several clustering strategies and data processing methods. The Hybrid Detection Framework provides the foundation for this [1]. Francesco Mercaldo, specialized in anomaly identification utilizing data processing methods such as classification trees and support vector machines. Based on the 1999 KDD Cup data, the trials showed that the algorithm C4.5 is superior to SVM in terms of identifying false alarm rates and network anomalies[2]. Symbolic dynamic filtering (SDF), a feature-derived algorithm, is used by the D. Denning algorithm [3]. Probabilistic finite-state automata (PFSA), which are features for pattern classification, can be generated by dividing the information into symbolic sequences in SDF [4]. Ugo Fiore et al, in this paper, initially noticed how the learning process worked as noise levels increased and how it could affect the method's ability to extract accurate rules. Three criteria are used to measure this method's effectiveness: "Max rule confidence," "Precision," and "Recall" [5]. Cluster analysis is used by T. Bhavani et al. to detect anomalies. Our method preferred for K-mean clustering is a straightforward and widely recognized technique. Compared to many other algorithms, it requires less computing power, which makes it more appealing for bigger datasets [6]. S. Lina et al, these user-provided fixed cluster counts are not an acceptable estimate for high-dimensional datasets since they cause different deviations or inappropriate

data distribution[7]. B. Thuraisingham, Network intrusion detection systems employ data mining or signature-based techniques that rely on labeled training data. Principal Component Analysis (PCA) is used in the anomaly network intrusion detection conduct to minimize data, and Fuzzy Adaptive Resonance Theory (Fuzzy ART) can be utilized for the classifier[8]. S. wu et al, A novel hybrid intrusion detection system incorporates simplified swarm optimization for intrusion data classification and intelligent dynamic swarm-based rough set (IDS-IR) for feature selection[9]. B. Singh et al, through simulation, the technique is thoroughly improved and then used in an industrial case study. The results point to a productive application of decision-making in production management. Work order data is the foundation for the algorithms used for developing a dynamic network[10]. For IDS, M. Xue et al. employed a hybrid strategy based on data mining. By strengthening the detection rate, the clustering analysis method attempts to lower the false alarm rate[11]. K.Wankhede et al, in this paper, Support Vector Machine (SVM) and Entropy of network features-based anomalous traffic detection systems are examined. Furthermore, a hybrid approach that combines support vector machines and network feature entropy is contrasted with freestanding methodologies[12]. Samad, A. focuses on an extensive examination of many different anomaly detection frameworks for various types of network intrusion detection[13]. J. Jonathan proposed a "new density-based and grid-based clustering algorithm" that is suitable for the detection of unknown abnormalities[14].

PROBLEM IDENTIFICATION
An intrusion detection system (IDS) guards and safeguards a network. It has the automated ability to identify unusual activities. An intrusion detection system handles intrusions. The need to defend computer networks and systems against attacks and security breaches is the primary issue that intrusion detection systems (IDS) [9] attempt to address. Specifically, intrusion detection systems (IDS) are made to identify and counteract any efforts to jeopardize the availability, confidentiality, or integrity of network resources.The following are some particular issues that intrusion detection systems handle:

Identifying Attacks
Reliability in real-time attack identification is one of the primary obstacles in intrusion detection. This calls for the capacity to discern between benign and malevolent network traffic as well as the ability to spot attacks as they happen.

False Positives
False alarms or alerts from IDS may result in resource and time waste. Numerous things, such as incorrect setups, unusual network activity, or genuine traffic that seems suspicious, might result in false positives.[11]

False Negatives
Additionally, IDS may be unable to identify assaults, leaving networks open to security risks. Attacks that are intended to avoid detection or flaws in the detection methods the IDS uses can result in false negatives.

Scalability
IDS needs to be able to manage high network traffic volumes and evolve with the traffic on the network. To identify and analyze network traffic, this calls for scalable and effective algorithms.

Adaptability
IDS needs to be flexible enough to react to new and developing security threats as well as changing network settings. This necessitates constant observation and upgrading of the IDS's detection rules and algorithms.
There are two categories of procedures used in the identification of aberrant activity: -

Predefined Normal Behavior
The term "predefined normal behavior" in intrusion detection refers to a standard that is established for the typical behavior of a computer network or system. This standard is based on the typical operation of the system or network. Before setting this standard, we observe the system and network for a while to determine what is typical. Next, we

create a set of guidelines that specify what constitutes appropriate behavior. Upon obtaining this information, we can deploy tools to monitor the network and system for any non-compliant activity. As a result, the IDS can identify possible security threats or assaults and notify security staff of them [10]. This aids in the detection of potential issues. Having predetermined normal conduct offers several advantages, such as:

Improved accuracy
IDS can more precisely detect deviations from typical usage patterns by setting up a baseline of usual activity, which can lower the number of false positives and false negatives.

Increased efficiency
By streamlining the detection process, predefined usual behavior enables intrusion detection systems to concentrate on questionable activity that deviates from typical usage patterns.

Better scalability
IDS can better manage high amounts of network traffic and scale to meet the demands of expanding networks by creating a baseline of typical behavior. It examines normal conduct in accordance with the stored pattern after first storing the pattern of the user's typical behavior in the database. A sufficiently large deviation may indicate the presence of unusual activity. A high detection rate, accuracy, and low false alarm rate are necessary for an intrusion detection system (IDS). Typically, the effectiveness of an IDS is assessed using the following formula, which takes into account the detection rate (DR), accuracy (AC), and false alarm rate (FAR): In general, one of the most crucial methods for spotting security risks and defending computer networks and systems against infiltration is the use of specified usual behavior in intrusion detection.

Predefined Intrusion Behavior
It is a collection of well-known attack patterns or signatures that security professionals have recognized and categorized. To find potential security threats and attacks, intrusion detection systems (IDS) might make use of predetermined intrusion behavior. IDS are designed with a collection of policies or rules that specify how an intrusion behaves in response to recognized attack patterns. These rules can be used to keep an eye out for indications of intrusion on system activity and network traffic. Numerous attack types, including port scanning, password guessing, buffer overflow, and many more, can be included in predefined intrusion behavior. Security specialists can develop rules or policies that enable intrusion detection systems (IDS) to promptly identify and address potential security issues by classifying and recognizing these incursion patterns. There are some restrictions attached to the usage of specified incursion behavior, though. Adversaries are always coming up with new and cutting-edge ways to get around security measures and evade detection. Therefore, predetermined intrusion behavior may not identify new or developing threats over time and may become outdated. Anomaly-based detection, which focuses on spotting odd or unexpected activity that deviates from typical usage patterns, is another tool that IDS can employ to get around this restriction.IDS can offer a more thorough method of intrusion detection and improve network security by combining both specified intrusion behavior and anomaly-based detection. [6] It initially records the pattern of malevolent activity associated with intrusion and then assesses the likelihood of intrusion based on the pattern discovered. Its detection accuracy is good and its false alarm rate is minimal. Its primary drawback is that it can only identify intrusions using specified patterns.

1. Detection Rate = (TP) / (TP+FP)
2. Accuracy = (TP+TN) / (TP+TN+FP+FN)
3. False Alarm Rate = (FP) / (FP+TN)

Actual	Predicted Normal	Predicted Attack
Normal	TN	FP
Intrusions	FN	TP

An attack has been identified in the attack data.

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True negative (TN): Occurs when normal data is identified as negative.

False-positive (FP): Occurs when normal data is mistakenly identified as malicious.

False-Negative (FN): Normal detection was made of the attack data.

This research uses the KDD Cup 1999 dataset to assess several intrusion detection techniques. MIT Lincoln Labs developed and oversaw the dataset in 1998 as a component of the DARPA Intrusion Detection Evaluation Program. This study aims to investigate and assess several intrusion detection methods. This study addresses the issue of detecting intrusions when regular data is mistakenly labeled as such. There was no plagiarism in the original material. The KDD Cup 1999 data, which was created by MIT Lincoln Labs for the DARPA Intrusion Detection Evaluation Program in 1998, is the dataset that was used in this study. It's a military network environment with both regular data and incursions for assessment. The dataset has become a standard for examining intrusion detection systems. There are 41 attributes used in this dataset to determine whether the input belongs to a normal or anomaly class. These attributes include duration, protocol type, service, flag, source bytes, destination bytes, and various rates such as error rates and same server rates. The class is either normal or anomaly. 41 attributes are :- Attribute 1, represented as P1, is the duration while Attribute 2, P2, is the protocol type. Attribute 3 is the service represented as P3, and Attribute 4, P4, is the flag. The amount of source bytes is represented as P5 while P6 represents the amount of destination bytes. The attribute P7, land, indicates whether the connection is from/to the same host/port. P8, wrong_fragment, represents the number of wrong fragments received. P9, urgent, indicates the number of urgent packets received. P10, hot, represents the number of "hot" indicators in the content. P11, num_failed_logins, is the number of failed login attempts. P12, logged_in, indicates whether the user is logged in. P13, num_compromised, represents the number of compromised conditions. P14, root_shell, represents whether the user has root access. P15, su_attempted, represents whether the user has attempted to escalate their privileges. P16, num_root, represents the number of root accesses. P17, num_file_creations, represents the number of file creations. P18, num_shells, represents the number of shell prompts. P19, num_access_files, represents the number of operations on access control files.

P20, num_outbound_cmds, represents the number of outbound commands in an FTP session. P21, is_host_login, indicates whether the login is a host login. P22, is_guest_login, indicates whether the login is a guest login. P23, count, represents the number of connections to the same host as the current connection. P24, srv_count, represents the number of connections to the same service as the current connection. P25, serror_rate, represents the percentage of connections that have "SYN" errors. P26, srv_serror_rate, represents the percentage of connections that have "SYN" errors to the same service as the current connection. P27, rerror_rate, represents the percentage of connections that have "REJ" errors. P28, srv_rerror_rate, represents the percentage of connections that have "REJ" errors to the same service as the current connection. P29, same_srv_rate, represents the percentage of connections to the same service. P30, diff_srv_rate, represents the percentage of connections to different services. P31, srv_diff_host_rate, represents the percentage of connections to different hosts. P32, dst_host_count, represents the number of connections to the same destination host as the current connection. P33, dst_host_srv_count, represents the number of connections to the same service as the current connection to the same destination host. P34, dst_host_same_srv_rate, represents the percentage of connections to the same service to the same destination host. P35, dst_host_diff_srv_rate, represents the percentage of connections to different services to the same destination host. P36, dst_host_same_src_port_rate, represents the percentage of connections to the same source port to the same destination host. P37, dst_host_srv_diff_host_rate, represents the percentage of connections to different hosts to the same service as the current connection to the same destination host. P38, dst_host_serror_rate, represents the percentage of connections that have "SYN" errors to the same destination host. P39, dst_host_srv_serror_rate, represents the percentage of connections that have "SYN" errors to the same service as the current connection to the same destination host. P40, dst_host_rerror_rate, denotes the proportion of connections encountering 'RE

For example, four data points from the KDD Cup 1999 dataset can be analyzed using these attributes.

The 41 qualities play a critical role in identifying any malicious activity when it comes to recognizing unusual behavior. The trick, then, is to identify these behaviors effectively without raising the false alarm rate. A way to improve efficiency is to minimize the amount of characteristics, but remember that accurate detection is the ultimate aim. By comparing values to the mean, these 41 properties may be used to detect potentially abnormal behavior, with

variations from the mean suggesting possible anomalies. The count characteristic can be removed as one solution to the false positive issue in IDS, but timely attack detection is still a concern. Effective intrusion detection ultimately comes down to striking the correct balance between accuracy and efficiency.

PROPOSED METHODOLOGY
An increase in false-positive rates has been attributed to the count property. Two performance metrics—detection rate and false alarm rate—are the main focus of system modifications. To calculate the false alarm rate, divide the total number of normal instances that were mistakenly identified as intrusions by the total number of normal instances. Similarly, to calculate the detection rate, divide the total number of intrusion patterns in the dataset by the number of correctly identified intrusion patterns. The percentage of intrusions the system can accurately detect and the number of detection errors made are the two measures of successful execution. On sample data, these values can be computed to assess performance. The count attribute can be deleted and replaced with a one-time password (OTP) given to the user's phone number or email address to solve authentication issues. OTP is a dependable fix for this issue.[1]

Algorithm 1: Registration
1.   Begin
2.   Enter details in a registration form and complete all mandatory fields.
3.   If all mandatory information is not filled in the registration form.

Algorithm 2: Login
1.   Begin   // (i represent how many times the user can attempt to complete   CAPTCHA or I am not a Robot checkbox Repeat steps 1 and 2.
2.   Fill in the username and password field and also log in)
3.   If both the details are valid then login successfully.
4.   Else (for i=1 to i=5)
5.   One-time password is generated and sent to the user's email address
6.   If OTP match then repeat step 1 and 4.

EXPERIMENT AND RESULTS

Figures 5.1–5.4 display the clustering methods' outcomes. The output of the Simple K-mean clustering procedure with the count attribute added is displayed in Figure 5.1, it reveals that the clustering time was 0.42 seconds. With the count property removed, Figure 5.2 shows the output of the same technique with a 0.26-second faster clustering time. Figures 5.5–5.8 display the clustering methods' outcomes. The output of the Canopy clustering procedure with the count attribute added is displayed in Figure 5.5, and it reveals that the clustering time was 0.32 seconds with the count attribute. Figure 5.6 shows the clustering time was 0.12 without the count attribute, Figure 5.7 shows the output of Fastest first with the count attribute which is 0.05 seconds and Figure 5.8 displays the clustering time was 0.04 seconds without the count attribute.

CONCLUSION

People struggle to remember all the passwords for their accounts on multiple platforms, thus it has become a regular problem these days. This frequently leads to several tries to access an account; in the case of banks, the user's account is blocked for a whole day by the bank website following three unsuccessful attempts. This study suggests removing the count characteristic to enhance system performance to overcome this problem. The simple K-mean value dropped from 0.42 to 0.16 and the filter clustered value dropped from 0.16 to 0.11 wherease Fastestfirst value

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dropped from 0.05 to 0.04 and Canopy Clustering value dropped from 0.32 to 0.12. These enhancements lower the false alarm rate by increasing efficiency and cutting down on the amount of time needed for detection. Since a breach is less likely to occur with faster discovery, this enhancement may contribute to an increase in security. Rapid detection and response are essential for system maintenance because delayed detection can compromise the system.

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Table :1 Improving Efficiency of Intrusion Detection System by Combining Filtered Cluster Algorithm and

Make-Density Based Clustering Algorithm with Authentication without Count Attribute

Attributes	Example 1	Example 2	Example 3	Example 4
P1	0	0	0	0
P2	Udp	tcp	tcp	Tcp
P3	other	http	finger	Private
P4	SF	SF	S0	S0
P5	146	232	0	0
P6	0	8153	0	0
P7	0	0	0	0
P8	0	0	0	0
P9	0	0	0	0
P10	0	0	0	0
P11	0	0	0	0
P12	0	1	0	0
P13	0	0	0	0
P14	0	0	0	0
P15	0	0	0	0
P16	0	0	0	0
P17	0	0	0	0
P18	0	0	0	0
P19	0	0	0	0
P20	0	0	0	0
P21	0	0	0	0
P22	0	0	0	0
P24	13	5	0	48
P25	1	5	24	16
P26	0.00	0.20	12	1.00
P27	0.00	0.20	1.00	1.00
P28	0.00	0.00	1.00	0.00
P29	0.00	0.00	0.00	0.00
P30	0.08	1.00	0.00	0.14
P31	0.15	0.00	0.50	0.06
P32	0.00	0.00	0.00	0.00
P33	255	255	255	255
P34	1	30	59	15
P35	0.00	1.00	0.23	0.06
P36	0.60	0.00	0.04	0.07
P37	0.88	0.03	0.00	0.00
P38	0.00	0.04	0.00	0.00
P39	0.00	0.03	1.00	1.00

P40	0.00	0.01	1.00	1.00
P41	0.00	0.00	0.00	0.00
P42	0.00	0.01	0.00	0.00
Class	Normal	Normal	Anomaly	Anomaly

Table 2: Final cluster centroids of simpleK-mean with count attribute:

Class	normal	anomaly	normal
P1	305.0541	533.1584	162.3509
P2	tcp	tcp	tcp
P3	http	private	http
P4	SF	S0	SF
P5	24330.6282	39374.1009	14919.3572
P6	3491.8472	115.1045	5604.3541
P7	0	0	0
P8	0.0237	0.0175	0.0276
P9	0	0	0.0001
P10	0.198	0.0018	0.3208
P11	0.0012	0.0002	0.0018
P12	0	0	1
P13	0.2279	0	0.3704
P14	0.0015	0.0001	0.0025
P15	0.0013	0.0002	0.0021
P16	0.2498	0.0005	0.4058
P17	0.0147	0.001	0.0233
P18	0.0004	0	0.0006
P19	0.0043	0	0.007
P20	0	0	0
P21	0	0	0
P22	0	0	0
P23	84.5912	166.3895	33.4178
P24	27.6988	9.9234	38.8191
P25	0.2863	0.7253	0.0117
P26	0.2838	0.7212	0.0101
P27	0.1186	0.2467	0.0385
P28	0.1203	0.2486	0.04
P29	0.6606	0.163	0.9718
P30	0.0624	0.1195	0.0266
P31	0.0959	0.0013	0.1551
P32	182.5321	245.2073	143.3221
P33	115.063	12.5472	179.1975
P34	0.5198	0.0554	0.8103
P35	0.0825	0.1512	0.0396

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P36	0.1475	0.0636	0.1999
P37	0.0318	0.0067	0.0476
P38	0.2858	0.7215	0.0133
P39	0.2798	0.7179	0.0058
P40	0.1178	0.2368	0.0434
P41	0.1188	0.2478	0.038

Time taken to build model (full training data) : 0.42 seconds

Model and evaluation on training set
Clustered Instances
0   9695 (38%)
1   15497(62%)

Table 3: Final cluster centroids of simpleK-mean without count attribute:

P1	305.0541	531.8419	162.6027
P2	tcp	Tcp	tcp
P3	http	Private	http
P4	SF	S0	SF
P5	24330.63	39277.0561	14942.38
P6	3491.847	114.8202	5613.047
P7	0	0	0
P8	0.0237	0.021	0.0255
P9	0	0	0.0001
P10	0.198	0.0017	0.3213
P11	0.0012	0.0002	0.0018
P12	0	0	1
P13	0.2279	0	0.371
P14	0.0015	0.0001	0.0025
P15	0.0013	0.0002	0.0021
P16	0.2498	0.0005	0.4064
P17	0.0147	0.001	0.0233
P18	0.0004	0	0.0006
P19	0.0043	0	0.007
P20	0	0	0
P21	0	0	0
P22	0	0	0
P24	27.6988	9.9546	38.8443
P25	0.2863	0.7236	0.0117
P26	0.2838	0.7194	0.0101
P27	0.1186	0.2461	0.0386
P28	0.1203	0.248	0.04
P29	0.6606	0.165	0.9719
P30	0.0624	0.1193	0.0266

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P31	0.0959	0.0013	0.1553
P32	182.5321	245.2217	143.155
P33	115.063	12.5829	179.4335
P34	0.5198	0.0555	0.8114
P35	0.0825	0.1513	0.0393
P36	0.1475	0.0648	0.1994
P37	0.0318	0.0067	0.0476
P38	0.2858	0.7197	0.0132
P39	0.2798	0.7161	0.0058
P40	0.1178	0.2364	0.0433
P41	0.1188	0.2472	0.0381
P42	normal	anomaly	Normal
Time taken to build model (full training data) : 0.14 seconds			
=== Model and evaluation on training set ===			
Clustered Instances			
0 9719 (39%)			
1 15473 (61%)			

Table 4: Final cluster centroids of Filter Clusterer with count attribute:

P1	305.0541	533.1584	162.3509
P2	tcp	tcp	tcp
P3	http	private	http
P4	SF	S0	SF
P5	24330.6282	39374.1009	14919.3572
P6	3491.8472	115.1045	5604.3541
P7	0	0	0
P8	0.0237	0.0175	0.0276
P9	0	0	0.0001
P10	0.198	0.0018	0.3208
P11	0.0012	0.0002	0.0018
P12	0	0	1
P13	0.2279	0	0.3704
P14	0.0015	0.0001	0.0025
P15	0.0013	0.0002	0.0021
P16	0.2498	0.0005	0.4058
P17	0.0147	0.001	0.0233
P18	0.0004	0	0.0006
P19	0.0043	0	0.007
P20	0	0	0
P21	0	0	0
P22	0	0	0

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P23	84.5912	166.3895	33.4178
P24	27.6988	9.9234	38.8191
P25	0.2863	0.7253	0.0117
P26	0.2838	0.7212	0.0101
P27	0.1186	0.2467	0.0385
P28	0.1203	0.2486	0.04
P29	0.6606	0.163	0.9718
P30	0.0624	0.1195	0.0266
P31	0.0959	0.0013	0.1551
P32	182.5321	245.2073	143.3221
P33	115.063	12.5472	179.1975
P34	0.5198	0.0554	0.8103
P35	0.0825	0.1512	0.0396
P36	0.1475	0.0636	0.1999
P37	0.0318	0.0067	0.0476
P38	0.2858	0.7215	0.0133
P39	0.2798	0.7179	0.0058
P40	0.1178	0.2368	0.0434
P41	0.1188	0.2478	0.0381
Class	normal	anomaly	Normal
Time is taken to build the model (full training data): 0.16 seconds			
=== **Model and evaluation on training set** === **Clustered Instances** 0 9695 (38%) 15497 (62%)			

Table 5: Final cluster centroids of Filter Clusterwithout count attribute:

P1	305.0541	531.8419	162.6027
P2	Tcp	Tcp	Tcp
P3	http	Private	http
P4	SF	S0	SF
P5	24330.6282	39277.0561	14942.3821
P6	3491.8472	114.8202	5613.047
P7	0	0	0
P8	0.0237	0.021	0.0255
P9	0	0	0.0001
P10	0.198	0.0017	0.3213
P11	0.0012	0.0002	0.0018
P12	0	0	1
P13	0.2279	0	0.371
P14	0.0015	0.0001	0.0025

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P15	0.0013	0.0002	0.0021
P16	0.2498	0.0005	0.4064
P17	0.0147	0.001	0.0233
P18	0.0004	0	0.0006
P19	0.0043	0	0.007
P20	0	0	0
P21	0	0	0
P22	0	0	0
P24	27.6988	9.9546	38.8443
P25	0.2863	0.7236	0.0117
P26	0.2838	0.7194	0.0101
P27	0.1186	0.2461	0.0386
P28	0.1203	0.248	0.04
P29	0.6606	0.165	0.9719
P30	0.0624	0.1193	0.0266
P31	0.0959	0.0013	0.1553
P32	182.5321	245.2217	143.115
P33	115.063	12.5829	179.4335
P34	0.5198	0.0555	0.8114
P35	0.0825	0.1513	0.0393
P36	0.1475	0.0648	0.1994
P37	0.0318	0.0067	0.0476
P38	0.2858	0.7197	0.0132
P39	0.2798	0.7161	0.0058
P40	0.1178	0.2364	0.0433
P41	0.1188	0.2472	0.0381
P42	Normal	anomaly	Normal

Time is taken to build the model (full Training Data): 0.11second

=== Model and evaluation on training set ===
Clustered Instances
0 9719 (39%)
1 1573 (61%)

Table 6: Distribution of Canopy

	Canopy(%)
0	6919(27%)
1	8167(32%)
2	534(2%)
3	1948(8%)
4	2306(9%)
5	1392(6%)
6	627(2%)

7	950(4%)
8	520(2%)
9	95(0%)
10	631(3%)
11	25(0%)
12	434(2%)
13	14(0%)
14	319(1%)
15	48(0%)
16	24(0%)
17	54(0%)
18	85(0%)
19	45(0%)
20	55(0%)

Table 7: Distribution of Canopy without count attribute

	Canopy(%)
0	6926(27%)
1	8106(32%)
2	521(2%)
3	1914(8%)
4	2213(9%)
5	1091(4%)
6	722(3%)
7	902(4%)
8	721(3%)
9	93(0%)
10	614(2%)
11	26(0%)
12	452(2%)
13	14(0%)
14	33(0%)
15	19(0%)
16	58(0%)
17	86(0%)
18	433(2%)
19	42(0%)
20	64(0%)
21	142(1%)

Table 8 : Outcome of Filter-Based Clustering algorithm and Simple K – mean Clustering comparison.

Time taken	**Simple K-mean Clustering**	**Filter-Based Clustering**	**Fastestfirst Clustering**	**Canopy-Clustering**
Including count attribute	0.42 seconds	0.41 seconds	0.05 seconds	0.32 seconds
Excluding count attribute	0.16 seconds	0.11 seconds	0.04 seconds	0.12 seconds

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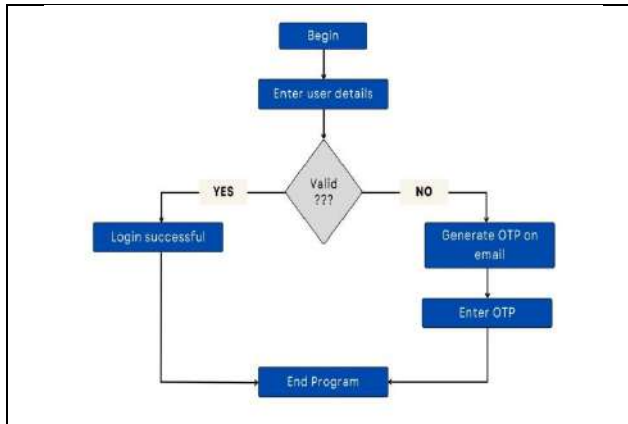
Figure 1: Flowchart of the Algorithm
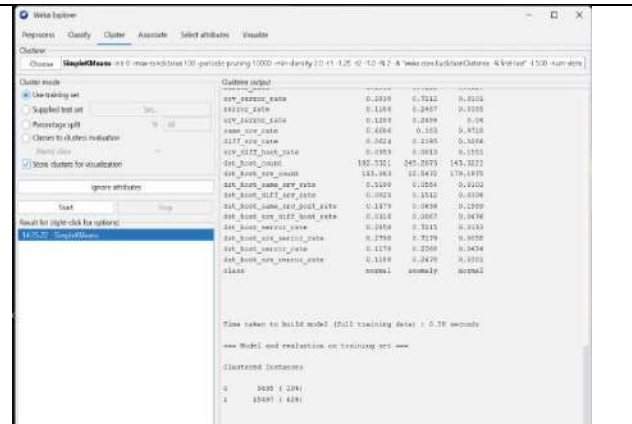
Figure 2: The outcome of an experiment using a Simple K-Means Clustering algorithm (including count attribute)
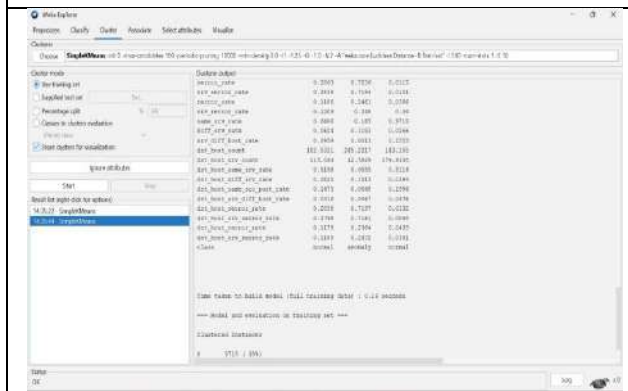
Figure 3:The outcome of an experiment using a Simple K-Means Clustering algorithm (without count attribute)
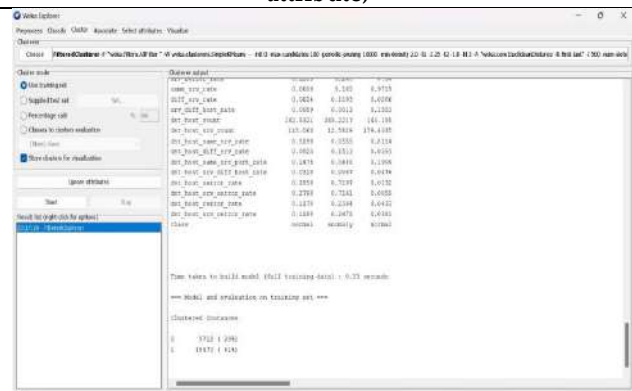
Figure 4: The outcome of an experiment using the Filter Clusterer Clustering algorithm (including the count attribute)
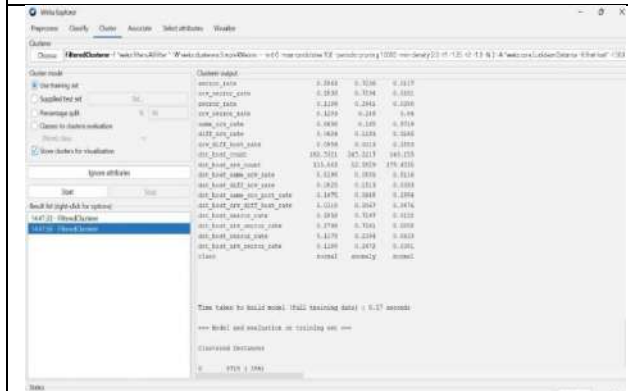
Figure 5: The outcome of an experiment using the Filter Clusterer Clustering algorithm (the count attribute)
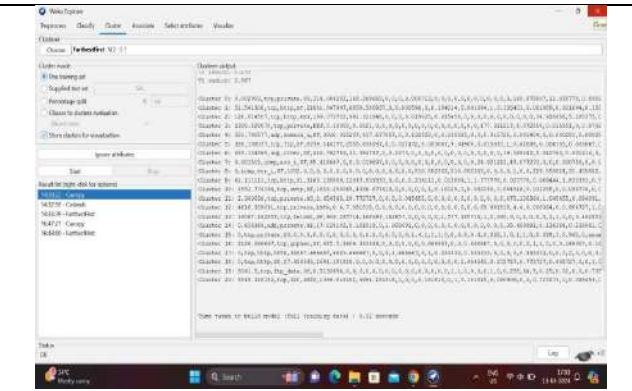
Figure 6: The outcome of an experiment using a canopy Clustering algorithm (including count attribute)

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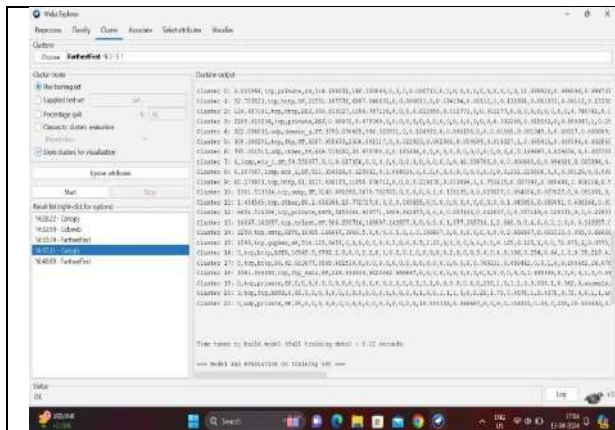
Figure 7: The outcome of an experiment using a Canopy Clustering algorithm (without count attribute)	**Figure 8: The outcome of an experiment using a fastes first Clustering algorithm (with count attribute)**
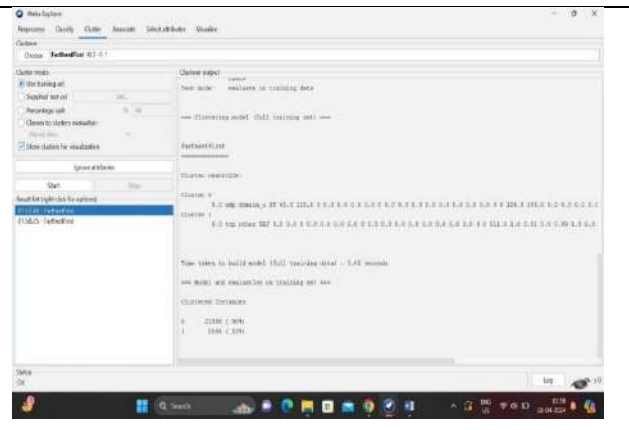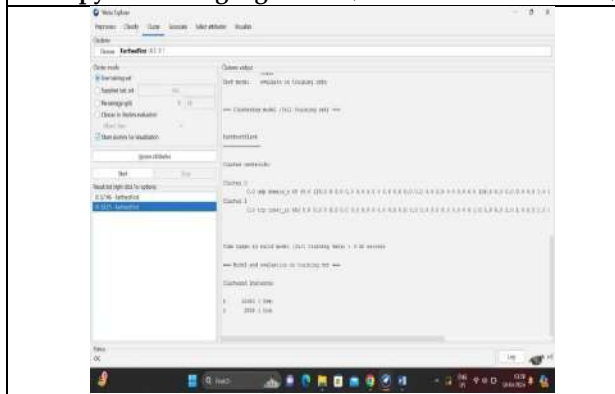
Figure 9: The outcome of an experiment using a fastest first Clustering algorithm (without count attribute)	**Figure 10: Processing data of KDD**
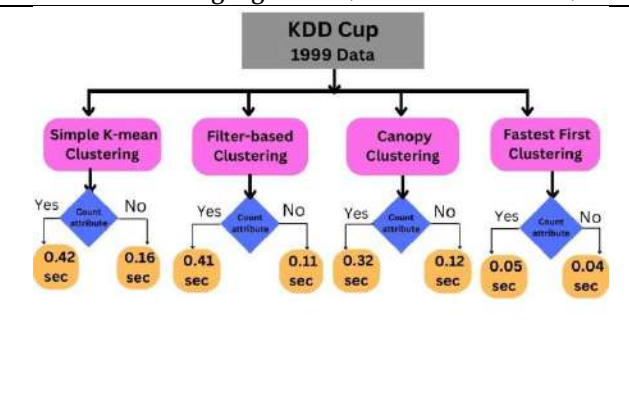
RESEARCH ARTICLE

Extraction, Phytochemical Analysis and Antibacterial Activity of *Punica granatum* Peel (PGP) Extracts

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ABSTRACT

This present investigation evaluated the phytochemistry, and anti-bacterial potential of *Punicagranatum*Peel extract. Phytochemical analysis of pomegranate fruit peel extracts in methanol, ethanol, diethyl ether, and water showed the presence of glycosides, alkaloids, tannins, saponins, glycosides, flavonoids, quinones, and flavonoids; steroids, terpenoids, and phenols were exclusionary. The in-vitro agar well diffusion method was used to test different concentrations of methanolicPGP extract (three different concentrations) against pathogenic bacterial strains. A standard medication was employed as a positive control, and all of the formulations demonstrated good action.

Keywords: *Punicagranatum*, phytochemical analysis, and anti-bacterial, gentamycin**.**

INTRODUCTION

Eighty percent of the global population uses some form of complementary or alternative medicine, therefore there has been a huge uptick in research into the potential medicinal benefits of plants in the last several decades. Phytoplants have emerged as viable substitutes for synthetic chemical antimicrobials and antibiotics, which pose significant risks such as resistance to these drugs, the development of new, rare infections, and the occurrence of harmful side effects[1]. Clinicians should caution patients about side effects such as urticaria, changes in taste, increased calculus formation, tooth and mucous membrane staining, and, in rare cases, desquamation of the oral mucosa and swelling of the parotid glands before prescribing chlorhexidine mouthwash as an antimicrobial. Of the 250,000–500,000 species of plants and animals on Earth, hardly 1% have had their medicinal potential investigated. The effects of native Iranian plant extracts have been documented in manuscripts[2-3]. A member of the Lythraceae

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family, the pomegranate tree or shrub (*Punicagranatum* L.) is a popular fruiting plant grown in many parts of the world, including South Africa. Due to its various health benefits, all components of the plant, including fruit juice, are highly sought for. The fruit's peel is the most valuable yet wasted part, making up about 49% to 55% of the fruit's weight[4]. Its antibacterial, free radical scavenging, and anticancer properties are unparalleled by any other component of the pomegranate plant. The chemical makeup of pomegranate peel, especially the phenolics, is intimately linked to these biological activities since it includes numerous bioactive compounds, including ellagitannins, flavonoids, and phenolic acids, among many others. Even though there are a lot of different kinds of pomegranates available and more are being grown all the time, the "Wonderful" kind is still the most popular in South Africa due to its high yields and exceptional qualities. The pomegranate, or PGP, is a natural fruit of the area between Iran and northern India. However, it is currently grown extensively in certain regions of Africa, Mexico, Arizona, and Southwest America. Even ancient Greek and Egyptian writings make reference to the pomegranate's pharmacological benefits. Some of the many possible effects of pomegranate have been discovered in recent investigations[5-7]. These include: anthelmintic, stimulant, vermifuge, antifungal, antiviral, immunological modulation, styptic, astringent, stomachic, laxative, diuretic, and bacteriocidal. The cultivars 'Acco' and 'Herskawitz,' which together account for 9% of the market, are the second most prevalent. Several studies have shown that the beneficial compounds in pomegranate skin might differ across cultivars[8].

In addition, it helps lessen the negative effects of cardiovascular illness, vaginitis, denture stomatitis, erectile dysfunction, obesity, Alzheimer's disease, and baby brain ischemia are among the many medical diseases that it helps alleviate [9]. The pomegranate's seed oil, peels, and juice retain its numerous cancer-fighting and therapeutic characteristics. The plant also contains estriol, testosterone, 17-alphaestradiol, stigmasterol, campesterol, gamma-tocopherol, estriol, punicie acid, and coumesterol. Because of its many beneficial medicinal properties, the pomegranate deserves investigation from various branches of medicine [10]. In spite of this, a study is documented that aims to investigate the antibacterial characteristics of PGP peel extracts against four distinct pathogenic microorganisms. Additional objectives of this research include analyzing the peel extracts' phytochemical composition and determining which of the most promising extracts include biologically active components. To investigate the phytochemical properties (varieties of extracts) and antimicrobial investigation, we employed a suite of analytical tools.

MATERIALS AND METHODS

Preparation of Plant Extract
Getting the plant extract ready to start, fresh pomegranates (500 gr) were bought from a market in the city of Tiupattur so that fresh extraction could be made. The peels of pomegranates were separated and dried for 7 days at 33°C in an oven. An electric grinder was used to turn the dried peels into a powder, which was then put in plastic bags and kept for the next step. 200 ml of methanol (99.9%) was mixed with 100 grams of powder in an electric mixer for 30 minutes. For 30 days, this solution was filtered three times a day. It was always a new methanol dissolvent that was used. The methanol was then taken away in a rotating evaporator to make a dry powder[11]. The samples were then sent to the Institute of Biological Science to be tested for phytochemicals and antibacterial activity.

Preparation of Extracts for Phytochemical Constituents
Before being chopped into bits and allowed to dry in the shade at room temperature, the selected medicinal plants were rinsed with distilled water after being cleaned with clean water. We crushed and sieved the dry samples before putting them in plastic bags to make sure they weren't contaminated. Using organic solvents instead of water is the optimal method for extracting bioactive chemicals, according to multiple research[12]. In this study, the powder was extracted from the peel of PGP using 80% methanol alcohol. Following that, there was a mixture of ethanol, diethyl ether, and water. This solvent triumphed due to its expanded extraction capabilities and higher yields of secondary bioactive chemicals. Two thousand milliliters of plant extract and one hundred grams of powdered material made up each reagent vial. Then, we filled each bottle with 1000 mL of methanol. Using an orbital shaking machine, the bottles

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were shaken after being left at room temperature for 24 hours. The leftover liquid was then filtered using a Whatman No. 1 strainer. Following filtration, the procedure was carried out twice using new solvent. Under reduced pressure and 40 ◦C, the methanol filtrate was concentrated using a rotary evaporator. Then, to remove any residual organic solvents, it was moved to beakers & dried in a water bath set at 40 ◦C. A final step was to keep the samples at 2-8 ◦C until they could be analyzed further.[13].

Phytochemical Analysis of PGP Extract
Initial phytochemical evaluation
The presence of secondary metabolites was investigated through a first phytochemical screening using standard, well-established methods[14].

Alkaloid detection
The presence of alkaloids was confirmed by the use of Mayer's test reagent in precipitation processes. Along the inside of a test tube, a couple of drops of Mayer's reagent were delicately applied to a little amount of plant extract. When alkaloids are present, a white, creamy precipitate will occur.

Polyphenol detection
The ferric chloride assay, as employed before by Peter et al., was utilized to determine if the extracts contained total polyphenols or not. A 5% ferric chloride solution was added to 1 mL of the crude extract in a volume of 2 mL. If you notice a blue-green hue, it means that phenols are present.

Saponin detection
The presence of saponins could be detected using the foaming test. The process began with forcefully mixing about 3 milliliters of plant extracts with 3 milliliters of distilled water. A favorable sign of saponin presence was the observation of steady and persistent foam production.

Identifying Terpenoids
Two milliliters of chloroform, three milliliters of sulphuric acid, and five milliliters of plant extracts were used in a chemical method to identify terpenoids. It was thought that terpenoids were present when a reddish-brown color was present.

Detection of steroids
Steroids were identified using the Salkowski test. About 2 milliliters of the sample solution and 5 milliliters of chloroform were mixed. Then, while being careful to add it all the way along the inside of the test tube, 1 mL of sulphuric acid that was 98% concentrated was added to the previously indicated mixture. Steroids are present when a reddish-brown ring appears at the interface of the two layers.

Flavour compound identification
The plant extracts were tested for flavonoids using an alkaline reagent assay. As part of this experiment, a 10% sodium hydroxide solution was mixed with 3 milliliters of plant extract. One way to tell if flavonoids were present was when a bright yellow hue developed.

Detection of Tannins
Finding tannins required the use of the gelatin test. A 1% w/v gelatin solution containing 10% sodium chloride was used to treat a sample solution. The presence of tannins was confirmed by the presence of a white precipitate.

Tested Bacterial Species
We tested their antimicrobial properties on four reference strains of bacteria from the American Type Culture Collection (ATCC). Bacillus subtilis ATCC 6633, Staphylococcus aureus ATCC 10876, Pseudomonas aueogenisa, and Escherichia coli ATCC 10536 were the bacterial strains that were evaluated. The SAIDAL group's microbiology unit

in Media (Algeria) generously supplied them. Sacred Heart College (Autonomous), Tirupattur'sPomegranate and Research Microbiology lab, which is a part (TMMRD), kept the germs at a temperature of -78∘C[15].

Inoculum Preparation
To ensure uniformity, a suspension was prepared by combining three or five test organism colonies from a pure culture with nutrient broth. Afterwards, a UV-Visible spectrophotometer was used to test the suspension's absorbance at 625 nm. The light path was 1 cm. The measurement was repeated until an absorbance range of 0.08-0.1 was reached. This measurement is indicative of a bacterial concentration of 1×10^1 CFU/mL. Following that, enough broth was added to these suspensions in a 1:10 ratio until a concentration of approximately 1×10^1 CFU/mL was reached. This concentration was used to evaluate the extract's antibacterial activity by comparing it to positive and negative controls.

Antibacterial activity of Methanolic extraction of PomegranatePeel extract
In accordance with the methodology described earlier by Degu et al. [21], the antibacterial effectiveness of crude extracts obtained from particular medicinal plants was evaluated by means of the agar well diffusion. The selected organisms for testing were inoculated into Mueller Hinton agar plates after being prepared in a sterile saline solution. The 8 mm diameter circular holes were bored using a cork borer. Next, 100 μl of methanol extracts from PGPP Peel were added to each well, with concentrations of 50 mg/mL, 100 mg/mL, and 150 mg/mL respectively. The same was true for Gram-positive and Gram-negative bacterial strains; standard benchmarks such as Tetracycline (5 μg), Streptomycin (5 μg), Erythromycin (5 μg), and gentamycin (5 μg) were used. The Petri plates were then incubated at 37 ∘C for 24 hours[16]. Afterwards, a measuring equipment was used to assess the inhibitory zones. An equal number of trials were carried out.

RESULTS AND DISCUSSION

Phytochemical screening of PGP Extract
Important therapeutic properties are provided by secondary metabolites for the benefit of human health. Some of these chemicals, in particular, show promise as cancer preventives and suppressors. For the treatment or prevention of a wide range of diseases, people turn to dietary supplements and pharmaceuticals containing compounds from the carbohydrate, alkaloids, quinones, and steroid families. After being washed with running tap water, the chosen fruits of the peel were carefully rinsed in distilled water. They were then let too dry at room temperature for approximately one month in the open air. The dried fruit was ground into a powder and placed in a sterile container for future use. The four solvents—ethanol, methanol, water, and diethyl ether—were used in 100 mL increments to extract the PGP powder from storage. Using air drying and an evaporator set at 40°C, the solvents were removed to get crude extract after the extraction step. Following the standard protocol, the phytochemical screening of the peel extract was conducted. Phytochemical analysis of plant sources in aqueous, methanolic, and ethanolic extracts showed the presence of a wide range of phytochemicals, including carbs, tannins, saponins, alkaloids, flavonoids, quinones, and glycosides; however, steroids, terpenoids, and phenols were not detected[17-18]. Table 1 lists the phytochemical components of the *Punicagranatum* peel extracts that are suggested.

Antibacterial Activity
Using the conventional zone of inhibition assay, we assessed the antibacterial activity of the PGP methanolic extract that was produced. Utilizing a sterile cotton scrub, a pathogenic organism culture was swabbed from a new culture of 1.5×10^8 CFU/mL of the bacterial species on a Muller Hinton Agar plate. A 1 mg/1 mL stock solution of PGP extract was produced in sterile distilled water. The sterile disk was filled with varying volumes of PGP extract, ranging from 50 to 100 μL. The discs containing the drugs were then placed on top of the swab culture plate. The mille meter was used to measure the zones of inhibition after incubating the plate for 24 hours at 37ºC[19]. Because of this, it hinders the system's normal functioning, which in turn causes the bacteria to die because it disrupts their respiration mechanism. In order to analyze the surface morphological alterations of the test pathogens, all of the

photos were captured (Figure 1). Traditional medicinal plants in Tirupattur District had high informant consensus factor values; antibacterial tests were done to confirm their therapeutic effects. The results showed that almost all of the therapeutic plant extracts tested had antibacterial effects against at least one of the Gram-positive and Gram-negative bacteria. From Table 2 showed that the concentrations of 100 and 150 mg/ml, the crude PGP extract exhibited a much larger mean zone of inhibition against *Pseudomonas aeruginosa* than the positive control, *streptomycin.* Likewise, against *Bacillus subtilis*, the Peel extract of Escherichia coli showed the largest mean zone of inhibition at a dosage of 150 mg/ml. No previous research has ever looked at the effects of PGP extract like this one. This precludes any meaningful comparisons between the results of this study and those of related studies carried out in the same or similar locations around the world.

CONCLUSION

Based on the results of this investigation, pomegranate peel extract outperformed the other plant sources in terms of yield.The recommended Peel extracts showed promise in antibacterial activity testing and preliminary phytochemical analyses of different extractions. Selected extracts from the peel of the Pomegranate tree were discovered to be extremely sensitive to four different bacterial strains, one each of Gram positive and Gram negative. According to the study's findings, *Punicagranatum* peel extracts had greater mean zones of inhibition against a number of harmful bacteria, including *Staphylococcus aureus, Escherichia coli, Bacillus subtilis,* and *pseudomonas aeruginosa. Staphylococcus aureus, bacillus subtilis*, in comparison to the conventionally prescribed medications. Therefore, in order to create antimicrobial agents that are more effective against harmful microbes, it is necessary to undertake extensive research. Alkaloids, polyphenols, saponins, terpenoids, steroids, flavonoids, and tannins were also identified through phytochemical study. The abundance of these secondary chemicals may explain why extracts from peel are so efficient against bacteria, whether they are gram-positive or gram-negative. Consequently, in order to create new antibiotics, it is crucial to undertake more in-depth research to extract the bioactive secondary components from PGPpeel and identify them. But scientists should look into the phytochemical and antibacterial properties of these plants in vitro before they isolate and characterize the bioactive components.

Conflict of Interest: Nil

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Table: 1 Phytochemical Analysis PGP Extracts

Phytochemical Constituents	Extraction of *Punicagranatum* Peel			
	Methanol	Aqueous	Ethanol	Diethyl ether
Carbohydrates	+	+	+	+
Alkaloids	+	+	+	-
Flavonoids	+	+	+	+

Steroids	+	-	-	-
Terpenoids	+	+	+	+
Tannins	+	+	+	+
Quinones	+	+	-	-
Saponins	+	_	+	+
Glycosides	+	+	+	-
Phenols	+	+	+	-

Table 2: Anti-bacterial activity of *Punicagranatum*Peel

S.NO	Organisms	NC DMSO	Zone of inhibition (mm in dm)			
			PC	50µg/ml	100µg/ml	150µg/ml
1.	*Bacillus subtilis*	Nil	(Gen) 20 (mm)	25	23	20
2.	*Escherichia coli*	Nil	(Gen) 20 (mm)	20	21	23
3.	*Pseudomonas aeruginosa*	Nil	(Gen) 20 (mm)	15	18	22
4.	*Staphylococcus aureus*	Nil	(Strep) 20 (mm)	25	27	28

Pseudomonas aeruginosa   *Staphylococcus aureus*   *Escherichia coli*   *Bacillus subtilis*

Figure 1: Antibacterial Activity of PGP Extract

RESEARCH ARTICLE
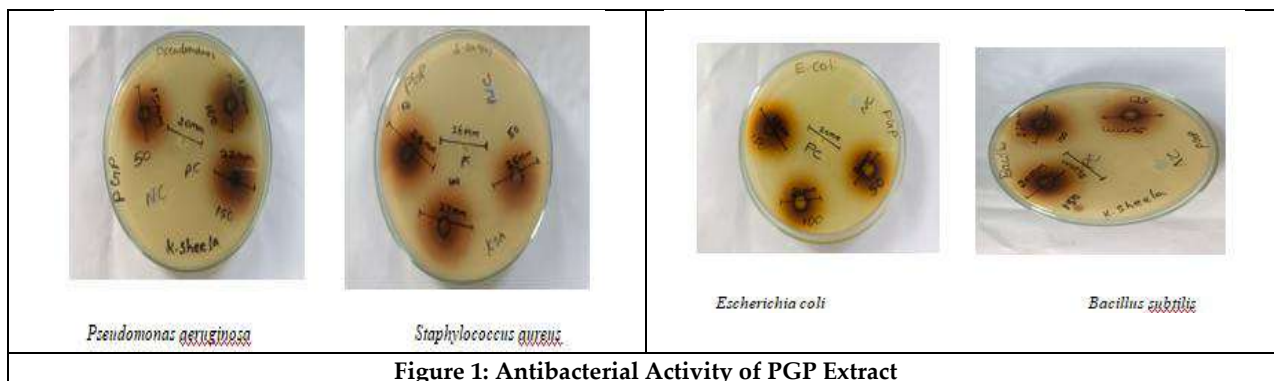
Deep Learning Algorithm to Diagnosis Diabetic Retinopathy of Fundus Image Features by Convolution Neural Network

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ABSTRACT

Diabetic Retinopathy (DR) is an ocular disorder that primarily impacts patients with diabetes and is a significant contributor to adult blindness. Diabetic Retinopathy (DR) is a condition that occurs due to Diabetes Mellitus, leading to the formation of many abrasions on the retina of the human eye.These lesions obstruct vision and in severe situations, they might result in permanent vision loss.Diabetic retinopathy (DR) affects 80% of long-standing diabetes patients. Manual diagnosis is cumbersome, unreliable, and resource-intensive. Deep learning, specifically Convolutional Neural Networks (CNNs), minimizes human intervention. Researchers used PyTorch to identify DR, aiming to enhance patient care.Our objective is to utilize Deep Learning Algorithms to create a model capable of analyzing retinal imagery and accurately categorizing them according to the level of Diabetic Retinopathy. The objective of this project is to develop a computerized and effective method to aid healthcare practitioners in the diagnosis and classification of diabetic retinopathy. The ultimate goal is to enhance patient care and minimise the likelihood of vision impairment. The research involved training and testing the enhanced CNN model using two datasets, namely IDRiD and Kaggle. The suggested model attained a training accuracy of 93% for IDRiD datasets and 95% for Kaggle datasets. The proposed model using the Kaggle dataset has demonstrated superior accuracy compared to their state-of-the-art approach in diagnosing diabetic retinopathy using retinal fundus images.

Keywords: Diabetic Retinopathy, Fundus Image, Convolutional Neural Network, Image Classification

INTRODUCTION

Individuals with diabetes are more susceptible to severe ocular complications. It can result in profound visual impairment and potentially lead to complete loss of eyesight. However, diabetic eye disease can frequently be addressed prior to the onset of vision impairment. Diabetic retinopathy is the leading cause of vision impairment in adults in the United States. The illness is caused by changes in the blood vessels of the retina, which is the light-sensitive layer of the eye. During the initial phase of diabetic retinopathy, the blood vessels develop minute enlargements known as microaneurysms. Microaneurysms have the ability to release fluid and blood. In the event of this occurrence, the cells in your retina are deprived of the necessary oxygen and nutrients for their survival. This leads to the formation of neovascularization on the retinal surface, which is characterised by the growth of fragile blood vessels that frequently experience leakage. This stage of retinopathy, known as proliferative retinopathy, is responsible for the impairment of vision and eventual blindness. Individuals with diabetic retinopathy may be unaware of their condition. This implies that your retina can sustain significant damage prior to any noticeable alteration in your vision. Occasionally, you may experience visual blurring or see the presence of strings, cobwebs, or particles floating in your field of vision. While it may not be possible to completely avoid diabetic retinopathy, you can reduce the likelihood of developing it by undergoing an annual eye examination. Glaucoma and cataracts are two more ocular complications associated with diabetes. Glaucoma is a medical disorder characterised by the impairment of the optic nerve due to increased pressure within the eyeball. As a result, there is a loss of vision. Individuals with diabetes have a higher likelihood of experiencing glaucoma compared to those without the condition. Typically, glaucoma-induced damage to the optic nerve does not result in noticeable symptoms. A cataract is the condition in which the transparent lens of the eye turns opaque. Clouding obstructs the transmission of light rays through your lens, impeding their ability to focus on your retina. The light-sensitive tissue lining located at the posterior part of your eye is referred to as the retina. The clouding of the lens occurs due to the aggregation of certain proteins, resulting in impaired vision. Individuals with diabetes have a higher likelihood of developing cataracts compared to those without the disease. One is more prone to developing them during early stages of life. The symptoms of cataracts can vary from person to person. Possible symptoms encompass hazy or indistinct vision, the presence of glare or halos around lights, or lights appearing excessively bright, impaired vision in low light conditions, the occurrence of multiple or double vision, diminished colour perception, frequent alterations in eyeglass or contact lens prescriptions, and visual distortion in either eye. A CNN technique has been devised to expedite the procedure and provide accurate forecasts. CNN has been successfully utilised for accurate predictions in many domains such as healthcare [1,2] and intelligent automation [3].This work utilises CNN to diagnose diabetic retinopathy and effectively identify eye images based on their severity, by comprehending its robustness. This technology will automatically diagnose diabetic retinopathy without any input or action required from the user. The suggested models are evaluated using the Kaggle and IDRID datasets [4], which contain a vast collection of high-resolution retinal images taken under different imaging settings. A healthcare practitioner has evaluated the existence of Diabetic Retinopathy in each image and given a score on a scale from 0 to 1, which corresponds to the following classifications:

0-> Diabetic Retinopathy
1->No Diabetic Retinopathy

This research presents a technique for identifying diabetic retinopathy by employing transfer learning. The authors optimise a pre-trained Inception-ResNet-v2 model by incorporating supplementary proprietary CNN layers. The model is assessed using the Messidor-1 diabetic retinopathy dataset and the APTOS 2019 blindness detection dataset from Kaggle. The test accuracy obtained for Messidor-1 is 72.33%, whereas for APTOS it is 82.18% [1].This research provides a comprehensive analysis of transfer learning techniques used for detecting diabetic retinopathy. The authors conduct a comprehensive analysis of the current literature and provide a concise summary of the many transfer learning approaches employed in this particular situation. Instead of concentrating on a particular dataset, they offer valuable information about the broader scope of transfer learning research for diabetic retinopathy [2].This research presents a methodology that utilises transfer learning to diagnose and identify diabetic retinopathy. The

authors employ a Convolutional Neural Network (CNN) architecture based on InceptionV3, utilising transfer learning. However, the dataset lacks specific specifics. The evaluation encompasses many parameters including accuracy, AUC, F1 score, and other metrics [3].Using deep learning and transfer learning to diagnose diabetic retinopathy. Five phases of DR (0-4) are completed. The hybrid convolutional Neural Network (CNN) incorporating DenseNet architecture has been identified as the optimal model for automated detection of diabetic retinopathy (DR) [4].This paper examines new research on the identification of diabetic retinopathy utilising effective deep learning methods, particularly convolutional neural networks (CNN) and AlexNet. These models are exceptionally efficient at identifying the characteristics of diabetic retinopathy in retinal pictures. The study highlights the significance of precise classification of diagnosed photos by utilising related images as input in convolutional semantic networks. The Django web framework demonstrates the results of the suggested methodology [5].Diabetic retinopathy (DR) is a significant global contributor to human vision impairment. Early intervention is crucial in order to mitigate the deleterious effects of this condition. While there are affordable options for ophthalmologists to treat individuals with diabetes, diagnosing diabetic retinopathy remains a significant barrier for medical professionals. This study examines new studies on the detection of diabetic retinopathy utilising extremely efficient deep learning algorithms, including convolutional neural networks (CNN) and ALEXNET.

These methods are widely employed to identify features of diabetic retinopathy from images. The CNN and ALEXNET methods for detecting diabetic retinopathy offer the advantage of time and cost efficiency. Furthermore, it is also more efficient. Therefore, it is more advantageous for the detection of diabetic retinopathy [6].This study centres on the identification and categorization of fundus images associated with diabetic retinopathy through the utilisation of advanced deep learning methodologies. The suggested methodology utilises a Convolutional Neural Network (CNN) algorithm to identify and categorise fundus images according to the stage of the disease. The method attains a precision of 92.26% and a mean squared error (MSE) of 0.06281 [7].This study utilises deep learning techniques to automatically detect diabetic retinopathy (DR). The suggested method attains a peak accuracy of 80% in contrast to conventional machine learning techniques, which only obtain a maximum accuracy of 48% on the identical IRDiR Disease Grading Dataset [8].The proposed approach accurately detects hard exudates. The method employs a fusion of background removal and de-correlation stretch techniques. When evaluated using the DiaretDB database, it demonstrates superior performance compared to current cutting-edge methods [9].This study utilises a combination of Convolutional Neural Network (CNN) for identifying lesions and Long Short-Term Memory (LSTM) for creating descriptive words from retinal fundus images. The suggested model successfully correlates images with phrases and attains a precision level of approximately 90% when evaluated on the MESSIDOR dataset. The user's text is "[10]."Diabetic retinopathy (DR) is a significant consequence of diabetes and a primary factor in adult blindness. This work presents a novel method for detecting blood vessels in retinal pictures. The strategy is based on regional recursive hierarchical decomposition using quadtrees, followed by post-filtration of edges. This approach offers insights into the structure of retinal blood vessels, facilitating the early identification of diabetic retinopathy [11].

The main aim of the paper is to classify diabetic retinopathy and normal retinal images using Convolutional Neural Networks (CNN) and Support Vector Machines (SVM). However, the abstract [12] lacks specific performance metrics. This survey examines techniques for segmenting magnetic resonance imaging (MRI) and computed tomography (CT) pictures of brain tumours. The article addresses the difficulties in segmenting brain pictures caused by the similarities in characteristics between hard and soft muscle tissue [13]. The study examines the utilisation of deep convolutional neural network methodology to automatically categorise diabetic retinopathy using colour fundus images. The suggested model has a 94.5% accuracy on their dataset, outperforming conventional approaches[14]. The abstract lacks precise performance measures. The research concentrates on employing data augmentation methods to improve the diagnosis of proliferative diabetic retinopathy in eye fundus images[15].This research presents an automated method for identifying and categorising diabetic retinopathy (DR) using retinal fundus pictures. The technique employs a Convolutional Neural Network (CNN) methodology, attaining a precision of 92.26% on three distinct datasets: Kaggle, a self-generated custom dataset, and an improved custom dataset[16].Prior to this, other models were suggested for the detection of Diabetic Retinopathy by utilising deep learning models in conjunction with image analysis. This study employed the CNN-based Efficient CNN pre-trained

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deep learning model to accelerate the identification of intensity levels in Diabetic Retinopathy. The model acquired features from the retinal images[17].This study investigates the application of transfer learning in the analysis of medical images. Transfer learning differs from traditional deep learning methods such as convolutional neural networks in terms of its simplicity, efficiency, and minimal training expenses. It efficiently tackles the problem of little datasets. Medical image processing is indispensable for both scientific investigation and clinical diagnosis. However, the act of categorising medical pictures with labels is restricted and insufficient. Transfer learning is a method that leverages pre-trained models built on large datasets unrelated to medicine to improve the accuracy of medical picture analysis. This article presents a comprehensive analysis of the structure of Convolutional Neural Networks (CNNs), the fundamental knowledge of transfer learning, various methods of transfer learning, the application of transfer learning in various areas of medical image analysis, and the potential future developments of transfer learning in this field[18].This research examines the use of transfer learning in the processing of medical images. The text emphasises the benefits of transfer learning, particularly for limited medical imaging datasets. The paper discusses the architecture of Convolutional Neural Networks (CNNs), provides background information on transfer learning, explores alternative transfer learning algorithms, and examines their applications in diverse sub-fields of medical picture processing. This article offers valuable information for novices and decision-makers regarding the future potential of transfer learning in this domain [19].This study provides an overview of different evaluation criteria employed in the classification of medical images. This text offers a comprehensive summary of research studies focused on the application of convolutional neural networks (CNNs) in the field of medical image processing. The report provides a concise overview of current patterns and potential future advancements in deep learning techniques used to the analysis of medical images[20].This review paper examines the most advanced deep learning methods currently used in the field of medical image processing. The main focus is on CNN-based approaches and how they are applied in medical imaging. The report offers valuable insights into the latest advancements and emerging trends in this particular subject [21].

MATERIALS AND METHODS

Proposed System
This project uses PyTorch, a well-liked deep learning framework, to use Convolutional Neural Networks (CNNs) for diabetic retinopathy identification. Our goal is to create a model that can categorize retinal images accurately according to the severity of diabetic retinopathy by utilizing the capabilities of deep learning algorithms. In order to improve patient care and lower the risk of vision loss, this project aims to develop an automated and effective method to help medical professionals diagnose and grade diabetic retinopathy.Our suggested model is made up of a Deep Learning Convolutional Neural Network (CNN) that was trained on a set of 4,231 images of the fundus. A different test dataset with 487 fundus images was used to test the model. There are images of two types of diabetic retinopathy (DR) in both the training and test collections. To see how well they work, the dataset of interest is used to train and test each DL model individually. There are different training and evaluation values for the suggested model, and it shows how these models behave in a logical order. A goal size of (255 × 255), the built-in preprocessing of the CNNs, a batch size of 32, and fully connected classification layers with the softmax activation function are used to train the DL models. As part of their 60-epoch training process, the deep learning models also use the cutting-edge Adam optimizer, which has a learning rate of 0.0001, and the category cross entropy loss function.

Experimental Environment
The proposed framework employs a 64-bit operating system, an x64-based processor, Windows 10 Pro, the DL package torchvision from Pytorch, Python 3.10, Pytorch version 2.1.1, 64GB RAM, and an Intel(R) Xeon(R) W-2155 CPU @ 3.30GHz 3.31 GHz.

Image Dataset Acquisition
The performance of the DL architectures in this model is evaluated using a sizable dataset of fundus images. It is a highly disproportionate model that makes use of the IDRiD and Kaggle datasets [14]. The Kaggle dataset contains

541 images out of 2155 images, which are used by the model to be validated using 2076 images obtained during training. The dataset has a long tail distribution is described in Figure 4. and Fundus image label with DR and No_DR in Figure 5.

RESULTS AND DISCUSSION

The image preprocessing module is a component of the convolutional neural network (CNN) that follows the image dataset acquisition process and is responsible for making the image data more suitable for analysis. The fundus images are original high-resolution images that need to be downsampled to meet the compatibility requirements of various CNN architectures. The image is downsampled to a size of 255 × 255 pixels. This enhances the model's ability to accurately understand the image. Moreover, there is uncertainty in identifying high-intensity structures such as EXs and Optic Disc (OD), as EXs suggest a lesion while OD represents the normal anatomical structure of the retina.An atypical optical density (OD) might result in inconspicuous lesions that go unnoticed because of their high brightness. Hence, the utilisation of image preprocessing techniques is crucial in order to accurately identify and distinguish between artefacts and lesions, thereby enhancing the detection of the disease. Furthermore, it is crucial to identify lesions that result in intermediate phases of diabetic retinopathy (DR) in order to detect DR at an early stage. The suggested approach utilises the CNN's inherent pre-processing capabilities to extract specific details from images through convolution and pooling. This involves applying various filters and kernels, as well as employing picture striding and padding. Nevertheless, these deep learning convolutional neural network (CNN) models possess an opaque character, and the process of improving images occurs in real-time. Consequently, it is not feasible to observe the enhanced image output. However, it is possible to extract only the gradient details and edges during the process of feature extraction for classification.

Features Extraction and classifications

Convolutional neural networks (CNNs) are neural networks that make use of non-linear activation functions. The next phase in the proposed system involves the extraction of features and classification using CNN-DL. The DL models include many layers of convolution and pooling, as well as normalisation and activation techniques, to carry out feature extraction. These models have the ability to learn and generate new features based on existing features through representation learning. These features can include lines, borders, points, edges, corners, vascular structure, and so on. This process helps to simplify detection.By utilising high-performance computation and Graphical Processing Units (GPUs), it becomes possible to smoothly transition from encoding with modest feature dimensions to deeper Convolutional Neural Networks (CNNs). These networks have seen significant changes, investigated various patterns of connectedness, and extracted features at multiple levels using skip-connections, inception modules, and dense blocks. In addition, the utilisation of cross-layer connections and architectural advances involves the incorporation of small multi-layer perceptrons into the convolutional layer kernels to extract intricate information. In addition, auxiliary classifiers are used to supervise the inner layers. This helps to strengthen the gradients that are expected from previous layers in highly supervised networks. It also allows for the integration of transitional layers from different base networks or the expansion of networks with paths that minimise reconstruction losses.

Convolutional Neural Network Model

Each input image has dimensions of (3, 255, 255). Torch typically operates on photos in fixed-size batches. Therefore, an additional dimension is incorporated for this specific objective. As the batch size is considered a variable, its value varies based on the size of the dataset. -1 stands for the size. Consequently, the shape of the input is transformed to (-1, 8, 253, 253). Applying convolution to an image of size 253x253 with a filter of size 2x2, using strides and a dilation rate of 1, and 'same' padding, yields an output of size 253x253. Due to the presence of 16 filters, the resulting shape becomes (16, 124, 124). The MaxPooling layer, with a stride of 2, receives the output of the convolution layer as its input. The pooling layer reduces the dimensions of the image by a factor of 2, resulting in an output shape of (32, 60, 60). This pattern can be applied to all Conv2D and MaxPooling layers. The flattening layer transforms the pixels into

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a single-dimensional vector. Thus, when the input dimensions are (64, 28, 28), the input is flattened to (128, 12, 12), resulting in a total of 18496 parameters. The equation (1) provides the formula for calculating the number of parameters in a Conv2D layer.

Parameter = (Kernel height * kernal width * input channel * output channel) + (output channels that use bias) (1)

The CNN model is trained for 70 epochs using the Kaggle dataset and 60 epochs using the IDRiD dataset, with observations in each. The accuracy and loss are computed for each epoch. Once the training procedure is complete, the model is evaluated using the test images. A confusion matrix is generated, which includes the counts of true positives, true negatives, false positives, and false negatives. The confusion matrix obtained is displayed in Figure . The CNN model demonstrates higher accuracy on the Kaggle dataset in comparison to the IDRiD dataset.

Comparison of Performance

Diabetic Retinopathy can be predicted utilising advanced techniques such as deep learning, machine learning, and image processing algorithms. A variety of functional classifiers were utilised. Image processing and augmentation techniques were employed to enhance the brightness and contrast of the photographs. The performance is compared and analysed by tabulating the accuracy achieved through the implementation of different approaches. Applying transfer learning approaches to deep learning classifiers improves the accuracy of predicting diabetic retinopathy, even with a small dataset. The table displays the accuracy achieved in comparison to existing research efforts.

CONCLUSION

The objective of this study is to analyse several machine learning algorithms and deep learning techniques in order to accurately diagnose and classify diabetic retinopathy, including its stage. The use of advanced image processing techniques has effectively enhanced the visibility of exudates, blood vessels, and cotton wool patches. After analysing and comparing different methodologies, it can be inferred that deep learning algorithms, along with transfer learning, have significant potential for predicting diabetic retinopathy. Conventional machine learning classifiers such as Support Vector Machine (SVM), Decision Tree (DT), Naïve Bayes (NB), and Random Forest (RF) have not been successful in reliably classifying images. While CNN outperformed classical algorithms, the requisite accuracy without overfitting was only attained by employing transfer learning methods such as ResNet and DenseNet. So, using a custom CNN model along with pre-trained models and the right image processing methods, such as image enhancement, made it possible to accurately predict the presence of diabetic retinopathy. The hybrid Convolutional Neural Network (CNN) incorporating DenseNet achieved a superior accuracy of 95%, surpassing the performance of existing models. By utilising the established model, physicians can propose proactive interventions at an earlier stage, effectively preventing vision loss in patients.

Future Enhancement

In the future, there will be technological improvements in the realm of medicine. Currently, individuals are unable to access timely medical intervention and care. Automating disease prediction will reduce the time required, enabling individuals to proactively take preventive steps. In the future, the algorithms' parameters can be meticulously adjusted to get superior outcomes, and the model's accuracy can be enhanced through the utilisation of additional effective optimisation strategies. Furthermore, there are plans to utilise similar techniques for forecasting additional ailments such as brain tumour or breast cancer identification, which likewise necessitates professionals to analyse the scanned brain or breast report. It is possible to incorporate these advanced deep learning algorithms into electronic health record systems used in clinics. This would alleviate the workload of the doctors. The project can be improved by implementing a user interface, which will allow real-time access for users.

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Table 1. Total Fundus Image Present in each Datasets

Class	Kaggle Fundus Image	IDRiD Fundus Image
DR (0)	1050	1103
NO_DR (1)	1026	1052
Total	**2076**	**2155**

Table 2:Model summary of CNN Network

```
----------------------------------------------------------------
        Layer (type)            Output Shape          Param #
================================================================
            Conv2d-1         [-1, 8, 253, 253]              224
            Conv2d-2         [-1, 16, 124, 124]           1,168
            Conv2d-3         [-1, 32, 60, 60]             4,640
            Conv2d-4         [-1, 64, 28, 28]            18,496
            Linear-5                  [-1, 100]         1,254,500
            Linear-6                    [-1, 2]               202
================================================================
Total params: 1,279,230
Trainable params: 1,279,230
Non-trainable params: 0
----------------------------------------------------------------
Input size (MB): 0.74
Forward/backward pass size (MB): 7.05
Params size (MB): 4.88
Estimated Total Size (MB): 12.67
```

Table 3: Metrics obtained during Training

Data Set	Class	Precision	Recall	Fi-score	Support
Kaggle	DR	0.96	0.94	0.95	1050
	No_DR	0.94	0.96	0.95	1026
IDRiD	DR	0.95	0.91	0.93	1103
	No_DR	0.91	0.95	0.93	1052

Table 4: Metrics obtained during Validation

Data Set	Class	Precision	Recall	Fi-score	Support
Kaggle	DR	0.94	0.91	0.93	245
	No_DR	0.93	0.95	0.94	296
IDRiD	DR	0.92	0.91	0.91	262
	No_DR	0.92	0.93	0.92	128

Table 5: Metrics obtained during Testing

Data Set	Class	Precision	Recall	Fi-score	Support
Kaggle	DR	0.96	0.92	0.94	113
	No_DR	0.93	0.97	0.95	118
IDRiD	DR	0.91	0.93	0.92	128
	No_DR	0.93	0.91	0.92	128

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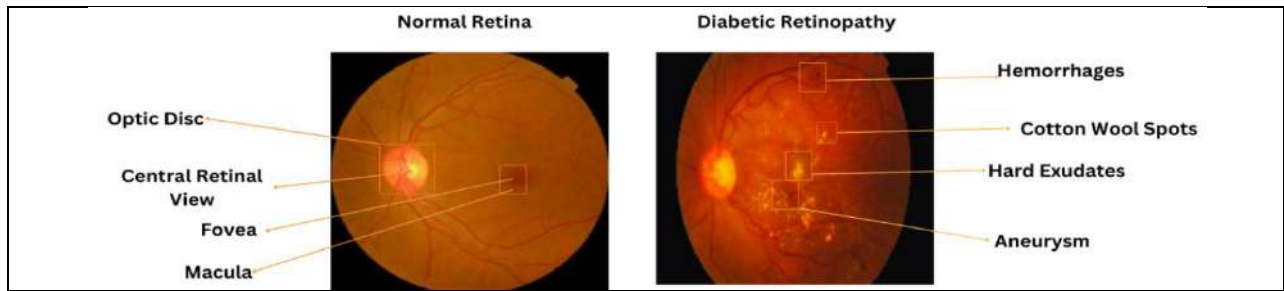
Figure 1: 1-No Diabetic Retinopathy	Figure 2: 0- Diabetic Retinopathy
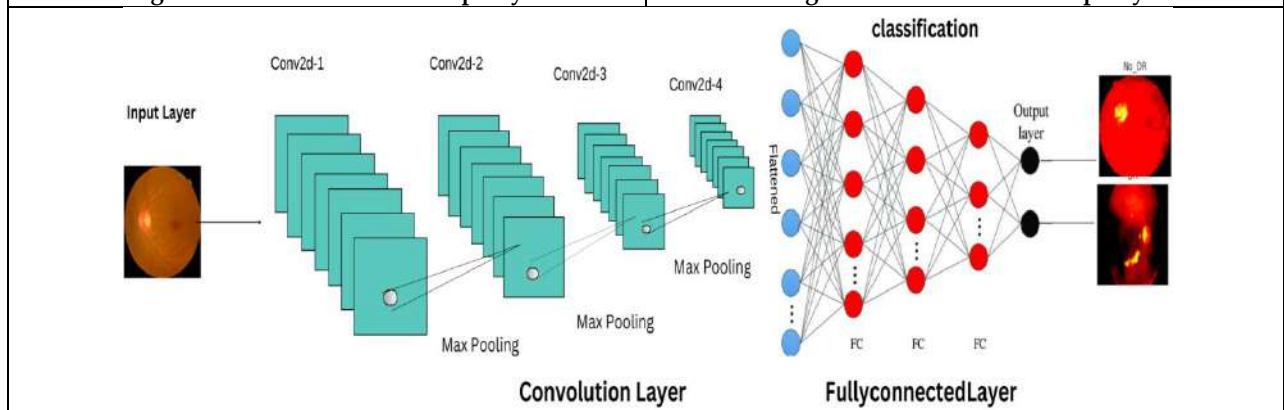
Figure 3.CNN Architecture of Proposed Model
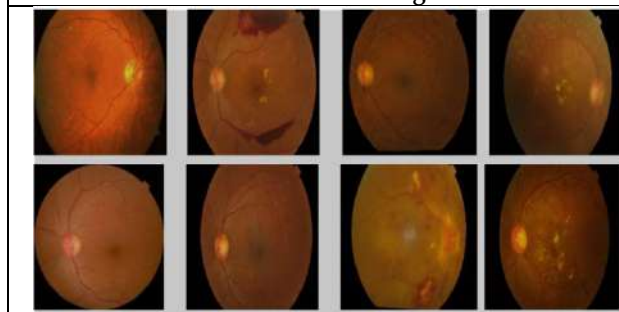
Figure 4.Long tail distribution of the dataset	Figure 5 , Fundus image label with DR and No DR
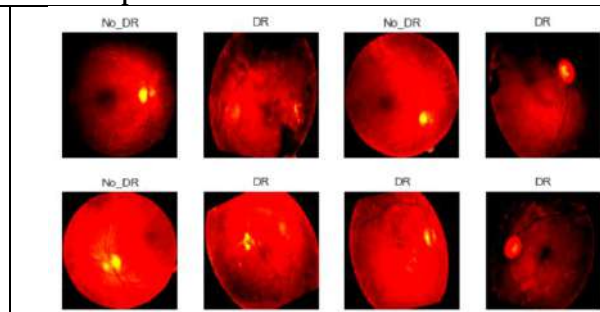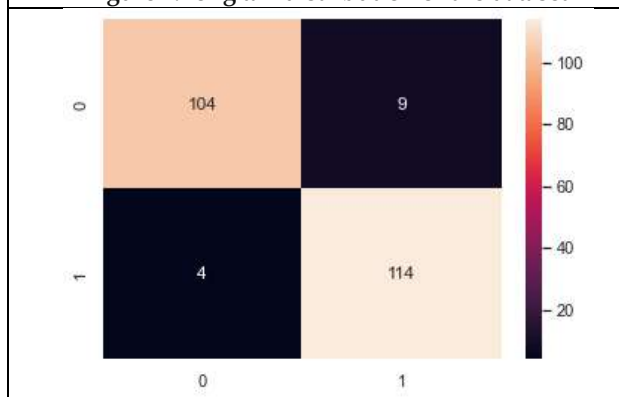
Figure 6: Confusion Matrix for Kaggle dataset	Figure 7: Confusion Matrix for IDRiD dataset
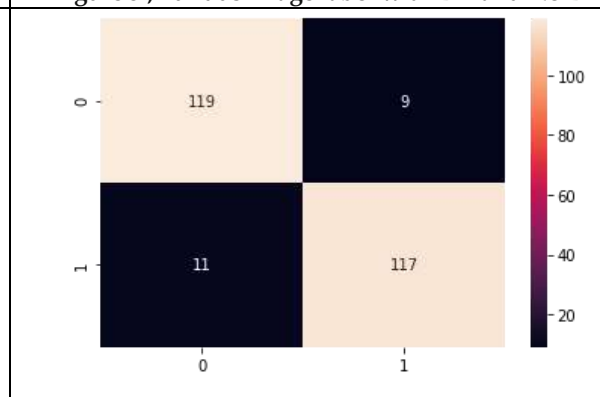
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Dataset	Loss %	Accuracy %
Kaggle Dataset ACC 95%		
IDRiD Dataset ACC 93%		
Figure 8: Comparison of Plot between loss and accuracy history between train and valid set		

RESEARCH ARTICLE
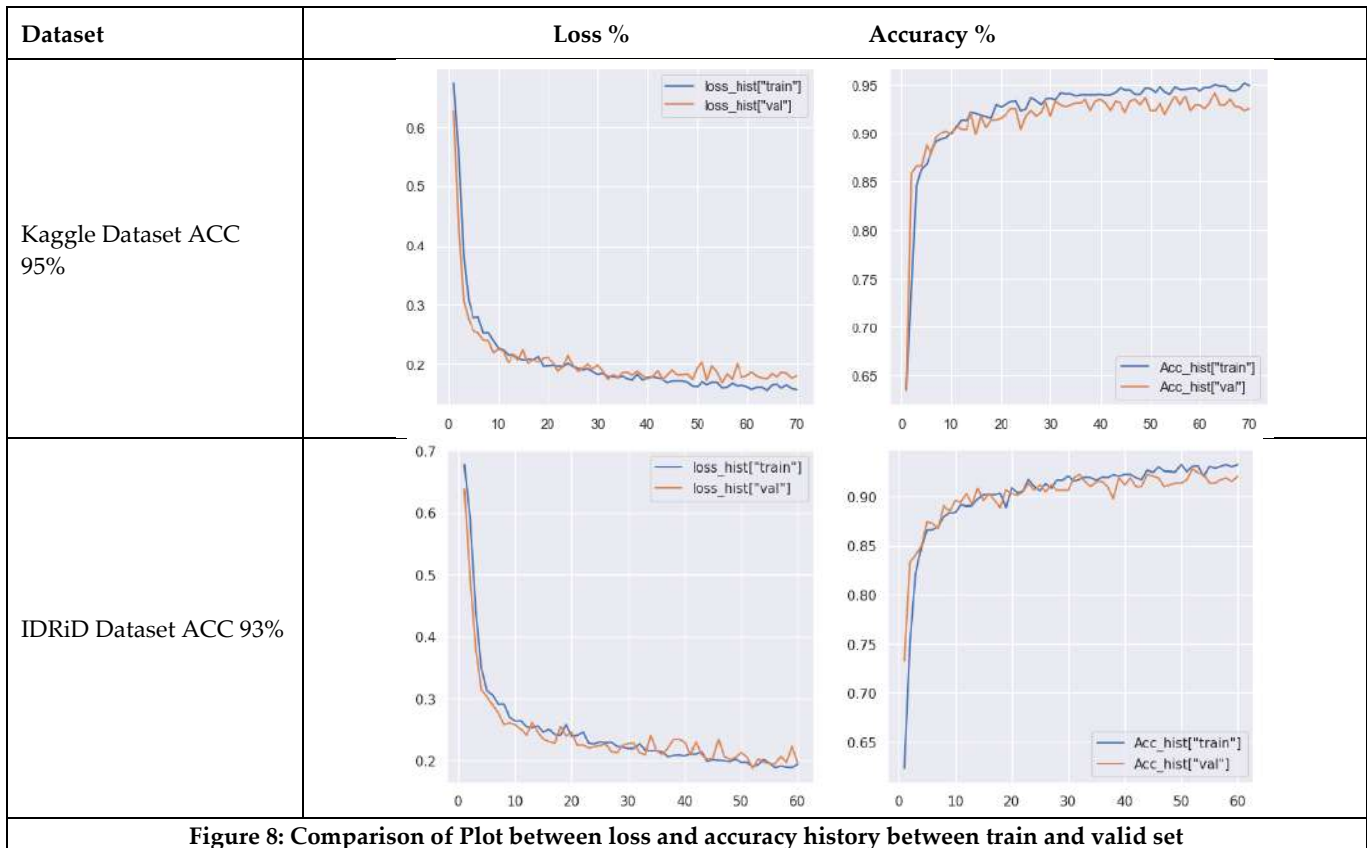
Lukasiewicz Intuitionistic Fuzzy Subalgebra in Bm-Algebra

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ABSTRACT

In *BM*-algebra, we have utilized the notion of Lukasz logic theory in Intuitionistic *fuzzy* set theory to make a way for the creation of Lukasz Intuitionistic *fuzzy* subalgebra. In which the properties and characterizations of Lukasz *fuzzy* subalgebra are discussed and the relation among them are illustrated with some examples.

Keywords: BM-algebra, Intuitionistic $\mathcal{F}uzzy$ set, Lukasiewicz Intuitionistic $\mathcal{F}uzzy$ set, Lukasiewicz Intuitionistic $\mathcal{F}uzzy$ subalgebra.

INTRODUCTION

BCI and BCK algebra were introduced by Y. Imai, K. Iseki and S. Tanaka in 1966. The term BCK was taken from C.A. Meredith's BCK system. These are algebraic structures of universal algebra which describe fragments of propositional calculus. Apart from the two algebraic structures BCI and BCK algebras, there were various algebraic structures which were attempted for the generalizations. In 1983, Atanassov gave an extension of Zadeh's notion of *fuzzy* set, which is commonly called as Intuitionistic Fuzzy sets. The elements in the set have the degree of both membership and non-membership value. Jan Lukasiewicz was a logician and Philosopher. He gave rise to the improvement ofproportional logic. Lukasiewicz or Lukasz logic is an unconventional and exceedingly valued logic, which is of Lukasz t-norm.[9]The concept of Lukasz *fuzzy* subalgebra in *BCK/BCI*-algebras was built by Jun using the

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thoughts of Lukasz t-norm. Later, he extended it to Lukasz *fuzzy* ideal in BCK/BCI-algebras in 2023[8].Their capacity to handle partial truth values, include *fuzzy*principles and integrate them into the decision-making process leads to a variety of applications. To build an advanced algorithm for the solution of real-life problems, we can explore various algebraic structures. In this study of BM-algebra, we apply the concept of Lukasiewicz logic in Intuitionistic *fuzzy* set which give rise to the introduction of Lukasiewicz Intuitionistic *fuzzy* sub algebra in BM-algebra and investigated some of their properties and relations with some examples.

PRELIMINARIES

Definition 2.1
The set $\mathfrak{G}$ be a non-empty set.The**BM-algebra**satisfies the given axioms under binary operation $" * "$ with a constant element "0".
$(BM_1)p * 0 = p$
$(BM_2)(r * p) * (r * q) = q * r, \forall p, q, r \in \mathfrak{G}$

Proposition 2.2
Every BM-algebra satisfies
1. $p * p = 0$
2. $0 * (0 * p) = p$
3. $0 * (p * q) = q * p$
4. $(p * r) * (q * r) = p * q$
5. $p * q = 0 \Leftrightarrow q * p = 0$ for all $p, q, r \in \mathfrak{G}$.

Definition 2.3
A $\mathcal{F}$uzzy set $U$is called $\mathcal{F}$**uzzy sub algebra** of a BM-algebra $\mathfrak{G}$if it satisfies:
$(FA_1)U(p * q) \geq min\{U(p), U(q)\}, \forall p, q \in \mathfrak{G}$

Definition 2.4
An **Intuitionistic** $\mathcal{F}$**uzzy**set$H$ in BM-$algebra$$\mathfrak{G}$ is of the form,
$$H = \{(p, \alpha_H(p), \beta_H(p))| p \in \mathfrak{G}\}$$
where the functions $\alpha_H: \mathfrak{G} \to [0,1]$ and $\beta_H: \mathfrak{G} \to [0,1]$ denote the degree of membership and the degree of non-membership respectively, and $0 \leq \alpha_H(p) + \beta_H(p) \leq 1$, $\forall p \in \mathfrak{G}$. The set can also be denoted as $H = (\alpha_H, \beta_H)$.

Definition 2.5
An Intuitionistic $\mathcal{F}$uzzy set $H = (\alpha_H, \beta_H)$in a set $\mathfrak{G}$ of the form
$$\alpha_H(q) = \begin{cases} u \in (0,1] & if \ q = p \\ 0 & if \ q \neq p \end{cases} \text{ and } \beta_H(q) = \begin{cases} v \in [0,1) & if \ q = p \\ 1 & if \ q \neq p \end{cases}$$
is said to be **Intuitionistic** $\mathcal{F}$**uzzy point** with support p and membership value u and non-membership value v. It is denoted by $[p/u]$and $[p/v]$ respectively.

Definition 2.6
For an Intuitionistic $\mathcal{F}$uzzy set $H = (\alpha_H, \beta_H)$ in a set $\mathfrak{G}$, we say that an Intuitionistic $\mathcal{F}$uzzy membership point $[p/u]$ and non-membership point $[p/v]$ is
(i) **contained** in H, denoted by $[p/u] \in \alpha_H$ and $[p/v] \in \beta_H$, if $\alpha_H(p) \geq u$ and $\beta_H(p) \leq v$.
(ii) **quasi-coincident** with H, denoted by $[p/u]q\alpha_H$ if $\alpha_H(p) + u > 1$ and $[p/v]q\beta_H$ if $\beta_H(p) + v < 1$.

Definition 2.7
An Intuitionistic $\mathcal{F}$uzzy set $H = (\alpha_H, \beta_H)$ in BM-$algebra$$\mathfrak{G}$ is called an **Intuitionistic** $\mathcal{F}$**zzy subalgebra** of $\mathfrak{G}$ if it satisfies:

$(IFA_1)\alpha_H(p*q) \geq min\{\alpha_H(p), \alpha_H(q)\}$

$(IFA_2)\beta_H(p*q) \leq max\{\beta_H(p), \beta_H(q)\}, \forall\, p, q \in G$

Lukasiewicz Intuitionistic $\mathcal{F}uzzyBM\text{-}algebra$

Definition 3.1

An $\varepsilon - \boldsymbol{Lukasz\ Intuitionistic\ \mathcal{F}uzzy}$ **Set** of an Intuitionistic $\mathcal{F}$uzzy set $H = (\alpha_H, \beta_H)$ in $\mathfrak{G}$ is of the form,
$L_H^\varepsilon = \{(p, \alpha_{L_H^\varepsilon}, \beta_{L_H^\varepsilon})|\, p \in \mathfrak{G}\}$,
where $\alpha_{L_H^\varepsilon}: \mathfrak{G} \to [0,1]$, $p \mapsto max\{0, \alpha_H(p) + \varepsilon - 1\}$ denote the degree of membership　　and $\beta_{L_H^\varepsilon}: \mathfrak{G} \to [0,1]$,
$p \mapsto min\{\beta_H(p) + \varepsilon, 1\}$ denote the degree of non-membership respectively.

Definition 3.2

An ε-Lukasz Intuitionistic $\mathcal{F}uzzy$ set L_H^ε in $\mathfrak{G}$ is called an $\boldsymbol{\varepsilon\text{-}}$ **LukaszIntuitionistic $\mathcal{F}uzzy$ subalgebra** of $BM\text{-}algebra\mathfrak{G}$
if it satisfies
$(LFS_1)[p/u_a], [q/u_b] \in \alpha_{L_H^\varepsilon} \Rightarrow [(p*q)/min\{u_a, u_b\}] \in \alpha_{L_H^\varepsilon}$　　　　　　　　(3.1)
$(LFS_2)[p/v_a], [q/v_b] \in \beta_{L_H^\varepsilon} \Rightarrow [(p*q)/max\{v_a, v_b\}] \in \beta_{L_H^\varepsilon}$　　　　　　　　(3.2)
for all $p, q \in \mathfrak{G}, u_a, u_b \in (0,1]$ and $v_a, v_b \in [0,1)$

Example 3.3

Let $\mathfrak{G} = \{0, h_1, h_2, h_3\}$ be a set with binary "$*$" given by Table 1,

$*$	0	h_1	h_2	h_3
0	0	h_1	h_2	h_3
h_1	h_1	0	0	h_2
h_2	h_2	0	0	h_1
h_3	h_3	h_2	h_1	0

TABLE 1 Cayley table for the binary operation "$*$"
Then $\mathfrak{G}$ is a $BM\text{-}algebra$.
Defining an Intuitionistic $\mathcal{F}uzzy$ set $H = (\alpha_H, \beta_H)$ in $\mathfrak{G}$ as follows:
$\alpha_H: \mathfrak{G} \to [0,1], p \mapsto \begin{cases} 0.86\ if\ p = \{0, h_1\} \\ 0.65\ if\ p = h_2 \\ 0.31\ if\ p = h_3 \end{cases}$ and $\beta_H: \mathfrak{G} \to [0,1], p \mapsto \begin{cases} 0.09\ if\ p = \{0, h_1\} \\ 0.25\ if\ p = h_2 \\ 0.65\ if\ p = h_3 \end{cases}$.

If it is taken that $\varepsilon = 0.62$, then the Lukasz Intuitionistic $\mathcal{F}uzzy$ set L_H^ε of H in $\mathfrak{G}$ is provided as follows:
$\alpha_{L_H^\varepsilon}: \mathfrak{G} \to [0,1], p \mapsto \begin{cases} 0.48\ if\ p = \{0, h_1\} \\ 0.27\ if\ p = h_2 \\ 0.00\ if\ p = h_3 \end{cases}$ and $\beta_{L_H^\varepsilon}: \mathfrak{G} \to [0,1], p \mapsto \begin{cases} 0.71\ if\ p = \{0, h_1\} \\ 0.87\ if\ p = h_2 \\ 1.00\ if\ p = h_3 \end{cases}$
Typically, it is verified that L_H^ε is a Lukasz Intuitionistic $\mathcal{F}zzy$ subalgebra of $BM\text{-}algebra\mathfrak{G}$.

Theorem 3.4

Every Lukasz Intuitionistic $\mathcal{F}uzzy$ set L_H^ε is a Lukasz Intuitionistic $\mathcal{F}zzy$ subalgebra of$BM\text{-}algebra$ of $\mathfrak{G}$ iff it satisfies:

(i) $\forall\, p, q \in \mathfrak{G}, \alpha_{L_H^\varepsilon}(p*q) \geq min\{\alpha_{L_H^\varepsilon}(p), \alpha_{L_H^\varepsilon}(q)\}$　　　　　　　　(3.3)
(ii) $\forall\, p, q \in \mathfrak{G}, \beta_{L_H^\varepsilon}(p*q) \leq max\{\beta_{L_H^\varepsilon}(p), \beta_{L_H^\varepsilon}(q)\}$　　　　　　　　(3.4)

Proof
Let H be an Intuitionistic $\mathcal{F}uzzy$ set in$BM\text{-}algebra\mathfrak{G}$.

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Assume that L_H^ε is a Lukasiewicz Intuitionistic $\mathcal{F}zzy$ subalgebra of $BM\text{-}algebra\mathfrak{G}$.

Let $p, q \in \mathfrak{G}$ and it is clear that $[p/\alpha_{L_H^\varepsilon}(p)] \in \alpha_{L_H^\varepsilon}$ and $[q/\alpha_{L_H^\varepsilon}(q)] \in \alpha_{L_H^\varepsilon}$ It follows from (3.1) that $[(p * q)/min\{\alpha_{L_H^\varepsilon}(p), \alpha_{L_H^\varepsilon}(q)\}] \in \alpha_{L_H^\varepsilon}$, and hence $\alpha_{L_H^\varepsilon}(p * q) \geq min\{\alpha_{L_H^\varepsilon}(p), \alpha_{L_H^\varepsilon}(q)\}$ for all $p, q \in \mathfrak{G}$. Similarly note that $[p/\beta_{L_H^\varepsilon}(p)] \in \beta_{L_H^\varepsilon}$ and $[q/\beta_{L_H^\varepsilon}(q)] \in \beta_{L_H^\varepsilon}$ for all $p, q \in \mathfrak{G}$. It follows from (3.2) that $[(p * q)/max\{\beta_{L_H^\varepsilon}(p), \beta_{L_H^\varepsilon}(q)\}] \in \beta_{L_H^\varepsilon}$, and hence $\beta_{L_H^\varepsilon}(p * q) \leq max\{\beta_{L_H^\varepsilon}(p), \beta_{L_H^\varepsilon}(q)\}$ for all $p, q \in \mathfrak{G}$. Conversely, suppose that L_H^ε satisfies (3.3) and (3.4). Also let $p, q \in \mathfrak{G}$ and $u_a, u_b \in (0,1]$ be such that $[p/u_a] \in \alpha_{L_H^\varepsilon}$, $[q/u_b] \in \alpha_{L_H^\varepsilon}$. Then $\alpha_{L_H^\varepsilon}(p) \geq u_a$ and $\alpha_{L_H^\varepsilon}(q) \geq u_b$, which imply from (3.3) that

$$\alpha_{L_H^\varepsilon}(p * q) \geq min\{\alpha_{L_H^\varepsilon}(p), \alpha_{L_H^\varepsilon}(q)\} \geq min\{u_a, u_b\}.$$

Thus $[(p * q)/min\{u_a, u_b\}] \in \alpha_{L_H^\varepsilon}$. Similarly, $\beta_{L_H^\varepsilon}(p) \leq v_a$ and $\beta_{L_H^\varepsilon}(q) \leq v_b$,

which imply from (3.4) that

$$\beta_{L_H^\varepsilon}(p * q) \leq max\{\beta_{L_H^\varepsilon}(p), \beta_{L_H^\varepsilon}(q)\} \leq max\{v_a, v_b\}.$$

Thus, $[(p * q)/max\{v_a, v_b\}] \in L_H^\varepsilon$.

Therefore L_H^ε is a Lukasiewicz Intuitionistic $\mathcal{F}zzy$ subalgebra of $BM\text{-}algebra\mathfrak{G}$.

Theorem 3.5

Show that ε-Lukasz Intuitionistic $\mathcal{F}uzzy$ set L_U^ε in $\mathfrak{G}$ is an ε-Lukasz Intuitionistic $\mathcal{F}uzzy$ subalgebra of $BM\text{-}algebra\mathfrak{G}$, if H is an Intuitionistic $\mathcal{F}uzzy$ subalgebra of $\mathfrak{G}$.

Proof

Assume that H is an Intuitionistic $\mathcal{F}uzzy$ subalgebra of $\mathfrak{G}$.

Let $p, q \in \mathfrak{G}$ and $u_a, u_b \in (0,1]$ be such that $[p/u_a] \in \alpha_{L_H^\varepsilon}$, $[q/u_b] \in \alpha_{L_H^\varepsilon}$.

Then $\alpha_{L_H^\varepsilon}(p) \geq u_a$ and $\alpha_{L_H^\varepsilon}(q) \geq u_b$.

Similarly, $v_a, v_b \in [0,1)$ be such that $[p/v_a] \in \beta_{L_H^\varepsilon}$, $[q/v_b] \in \beta_{L_H^\varepsilon}$.

Then $\beta_{L_H^\varepsilon}(p) \leq v_a$ and $\beta_{L_H^\varepsilon}(q) \leq v_b$.

Thus

$$\begin{aligned}
\alpha_{L_H^\varepsilon}(p * q) &= max\{0, \alpha_H(p * q) + \varepsilon - 1\}[\because by\ defn\ (3.1)]\\
&\geq max\{0, min\{\alpha_H(p), \alpha_H(q)\} + \varepsilon - 1\}[\because (3.3)]\\
&= max\{0, min\{\alpha_H(p) + \varepsilon - 1, \alpha_H(q) + \varepsilon - 1\}\}\\
&= min\{max\{0, \alpha_H(p) + \varepsilon - 1\}, max\{0, \alpha_H(q) + \varepsilon - 1\}\}\\
&= min\{\alpha_{L_H^\varepsilon}(p), \alpha_{L_H^\varepsilon}(q)\}[\because by\ defn\ (3.1)]\\
&\geq min\{u_a, u_b\}.
\end{aligned}$$

So, $[(p * q)/min\{u_a, u_b\}] \in \alpha_{L_H^\varepsilon}$.

Similarly,

$$\begin{aligned}
\beta_{L_H^\varepsilon}(p * q) &= min\{\beta_H(p * q) + \varepsilon, 1\}[\because by\ defn\ (3.1)]\\
&\leq min\{max\{\beta_H(p), \beta_H(q)\} + \varepsilon, 1\}[\because (3.4)]\\
&= min\{max\{\beta_H(p) + \varepsilon, \beta_H(q) + \varepsilon\}, 1\}\\
&= max\{min\{\beta_H(p) + \varepsilon, 1\}, min\{\beta_H(q) + \varepsilon, 1\}\}\\
&= max\{\beta_{L_H^\varepsilon}(p), \beta_{L_H^\varepsilon}(q)\}[\because by\ defn(3.1)]\\
&\leq max\{v_a, v_b\}.
\end{aligned}$$

So, $[(p * q)/min\{v_a, v_b\}] \in \beta_{L_H^\varepsilon}$.

Hence L_H^ε is a ε-Lukasiewicz Intuitionistic $\mathcal{F}uzzyBM$-algebra of $\mathfrak{G}$. The following example demonstrates why the converse portion of Theorem 3.5 is false.

Example 3.6

Suppose the set $\mathfrak{G} = \{0, h_1, h_2\}$ be a $BM\text{-}algebra$ and Table 3.2 shows binary operation $" * "$ in $\mathfrak{G}$

$*$	0	h_1	h_2
0	0	h_2	h_1
h_1	h_1	0	h_2
h_2	h_2	h_1	0

TABLE 3.2 Cayley table for the binary operation " $*$ "

Defining an Intuitionistic $\mathcal{F}uzzy$ set $H = (\alpha_H, \beta_H)$ in G as follows:

$$\alpha_H: \mathfrak{G} \to [0,1], p \mapsto \begin{cases} 0.76 \ if \ p = 0 \\ 0.32 \ if \ p = h_1 \ and \ \beta_H: \mathfrak{G} \to [0,1], p \mapsto \begin{cases} 0.16 \ if \ p = 0 \\ 0.65 \ if \ p = h_1. \\ 0.59 \ if \ p = h_2 \end{cases} \\ 0.40 \ if \ p = h_2 \end{cases}$$

Provided that $\varepsilon = 0.41$, then the ε-Lukasz Intuitionistic $\mathcal{F}uzzy$ set $L_H^\varepsilon = (\alpha_{L_H^\varepsilon}, \beta_{L_H^\varepsilon})$ of H in $\mathfrak{G}$ is formed as follows:

$$\alpha_{L_H^\varepsilon}: \mathfrak{G} \to [0,1], p \mapsto \begin{cases} 0.17 \ if \ p = 0 \\ 0.00 \ if \ p = h_1 \ and \ \beta_{L_H^\varepsilon}: \mathfrak{G} \to [0,1], p \mapsto \begin{cases} 0.57 \ if \ p = 0 \\ 1.00 \ if \ p = h_1 \\ 1.00 \ if \ p = h_2 \end{cases} \\ 0.00 \ if \ p = h_2 \end{cases}$$

Typically, it is verified that L_H^ε is an ε-Lukasz Intuitionistic $\mathcal{F}uzzy$ subalgebra of BM-$algebra\mathfrak{G}$. But H is not an Intuitionistic $\mathcal{F}zzy$ subalgebra of $\mathfrak{G}$ because of

$\alpha_H(0 * h_2) = \alpha_H(h_1) = 0.32 \not\geq 0.40 = min\{\alpha_H(0), \alpha_H(h_2)\}$ and

$\qquad \beta_H(0 * h_2) = \beta_H(h_1) = 0.65 \not\leq 0.59 = max\{\alpha_H(0), \alpha_H(h_2)\}$.

CONCLUSION

In Society, Decisions are taken based on incomplete and uncertain insights, such as risk management and financial marketing. The application of BM-algebra within Lukasz Intuitionistic $\mathcal{F}uzzy$ logic operation can improve the robustness of decision-making process using the degree of hesitancy and scepticism. This study give rise to the notion of Lukasz Intuitionistic $\mathcal{F}uzzy$sub algebra along with the investigation some of their properties. In addition to the characterization of Lukasz Intuitionistic $\mathcal{F}uzzy$ subalgebra algebra, the relations of Intuitionistic $\mathcal{F}uzzy$ sub algebra and Lukasz Intuitionistic $\mathcal{F}uzzy$ subalgebra are discussed. Some examples are provided based on those relations. In future, we will construct an algorithm for the improvement of robustness by making use of the ideas and results of this study.

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RESEARCH ARTICLE

Impact of Bio Digested Slurry of Biogas Plant in Vermitechnology

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ABSTRACT

Animal waste can be managed biologically through the process of vermicomposting. The current study provides examples of how to make vermicompost from biogas plants by mixing the leaves litter and *Eisenia festida*. The biogas plant has two crucial functions. Through outlet sludge, it indirectly supports organic farming while also directly supplying energy. For vermicomposting, two distinct types of vermin beds were constructed in the following ratios: 3:1 for leaf litter plus cow dung and 3:1 for leaf litter plus biogas plant slurry. They were given the labels "control" and "test," in that order. After 15 weeks, the vermicompost material was examined for several chemical parameters, and *Phaseolus vulgaris* was used in the pot experiment to assess the material's potential for growth. In the test tank, a drop in pH, organic carbon, and the C: N ratio, as well as an increase in N availability, exchangeable K, and P, were noted in comparison to the control. Vermi compost's final material's C: N ratio fell between 20 to 30 percent, which is considered agronomically acceptable. The application constructed from biogas plant slurry improved root length, shoot length, and number of leaves, according to the results of the pot experiment. In the two treatments, *E. festida* reproduction biology was also observed, and the results revealed outstanding biomass of microbial flora and earthworms in the test tank compared to the control. The findings unequivocally showed that vermin technology might be a viable means of transforming household biogas plant byproducts into certain value-added goods.
Keywords: Vermicompost, vermibed, *P.vulgaris*, bio digested slurry, *E.festida*

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INTRODUCTION

Interest in enhancing overall soil quality through the addition of organic matter has increased as a result of the reduction in soil fertility and productivity brought on by excessive soil erosion, nutrient run-off, and loss of soil organic matter [1]. In natural systems, the addition of organic matter from falling leaf litter and root mortality over time maintains the soil's fertility level and organic structure [2].The conversion of organic wastes, such as sewage sludge, green waste, industrial sludge, urban community wastes, and livestock excreta, to compost or vermicomposting is one of the many techniques that is becoming more and more popular worldwide. This reduces the amount of waste that is added to landfills and the need for artificial fertilizers [3]. It's noteworthy to note that 38 billion metric tons of organic wastes are produced year worldwide by humans, animals, and crops. This trash could be a useful source of organic matter for soils [4]. Vermicompost, a nutrient-rich biofertilizer, may be made from this enormous amount of organic waste that is produced from many sources for use in sustainable and restoration operations [5]. Earthworms and microbes work together to create vermicompost. Earthworms play a crucial role in conditioning the substrate and modifying biological activity, which in turn drives the biochemical breakdown of organic materials by microorganisms [6]. Thus, earthworms were used by farmers in India to create manure in their crops more traditionally and conventionally [7]. In terms of nutrient availability, vermicomposting produces a higher-quality product than regular composting [8]. The Indian government has been encouraging the generation of biogas at the individual and community levels from cow dung and other organic wastes for the past few decades. A high-quality manure that is utilized as a soil conditioner in agricultural areas is the slurry left over from the biogas plant [9]. Because earthworms are biofilters, they can be utilized to increase crop yields and manage cattle dung and biogas plant slurry without causing pollution [10]. Vermicomposting technology can be effective for managing cow manure and biogas plant slurry, according to a literature review [11]. The requirement for food and water is increased due to the world's population growth and increased energy consumption, which promotes the creation of agricultural waste [12]. The community is paying close attention to issues such as excessive chemical fertilizer use, agricultural waste generation, and proper waste disposal techniques [13]. Nonetheless, utilizing agricultural residues combined with vermicompost for biogas technology is a sustainable way to address the needs of energy recovery, reducing pollution and global warming, replacing artificial fertilizers, and providing wholesome food security [14]. Therefore, this study was conducted to determine the effectiveness of vermicompost in promoting plant development utilizing biogas plant slurry and cow manure [15].

MATERIALS AND METHODS

The bioconversion process was carried out with the help of earthworm (*E.festida*) in Biocompoting pits of A.P.C Mahalaxmi College for Women, Thoothukudi, Tamil Nadu, India. The experimental details, materials used, and analytical methods employed for the characterization of the materials are presented below.

Preparation of vermibeds and composting trial
For vermicomposting, two distinct types of vermibed were created in the following ratios: 1:3 (leaf litter + cow dung) and 1:3 (leaf litter + bio-digested slurry). They were labeled as control and test pits. Water was routinely sprayed to regulate the temperature and moisture content. Following three weeks of pre-composting, 250 adult *E. festida* individuals were placed into pits. On the sixty-fifth day, the physio-chemical characteristics of the vermicompost were assessed using conventional techniques.

Germination of *P.vulgaris*
 P. vulgaris was chosen as the field crop to assess plant development using decomposed materials. Two sets of plastic containers were selected, each measuring 45 cm in diameter and 25 cm in depth. There were four containers in each set. The control group's composted materials were used in the first set, and the test compost was added to the pots in the second set. Fifteen seeds were planted in each container.

Earthworm collection

Earthworm *E. festida*, which is used for composting, was acquired from Killikulam Agriculture University in Killikulam, Tamil Nadu, India. On cow manure that had partially decomposed, stock earthworms were raised. The biomass, growth, and reproduction of earthworms are trustworthy markers of the quality of the vermimanure. When comparing the test feedstock group to the control, the largest number of *E.festida* was discovered.

Chemical analysis

A digital pH meter (manufactured by Systronics) was used to determine the pH. The partial-oxidation approach [16] (Hartenstein and Hartenstein 1981) was used to determine the amount of organic carbon. Jackson's (1975) method was used to determine total Hjeldahl nitrogen (TKN). The amount of available phosphorus was measured using the technique outlined by Anderson and Ingram. After the material was extracted using ammonium acetate, exchangeable K was calculated [17].

Statistical Analysis

The average (mean) and standard deviation of all the experimental data were calculated as mean±SD by using Microsoft Excel. Then the N, P&K values were tested by Students't' test analysis of in vermicomposting.

RESULTS AND DISCUSSION

If not handled appropriately, the biogas digesters' slurry turns into a breeding ground for insects that carry disease. Earthworm culture could benefit greatly from the usage of biogas slurry. Figure 1-3 displayed the physico-chemical properties of the "control and test" vermicompost pits. Figures 4 and 5 showed the rate of plant growth and earthworm multiplication, respectively. The vermicompost unit's average temperature was measured and found to be 27°C, falling within 0 and 35° C according to Dominguez and Edwards (2011) classification. According to the humidity result, the unit was moist to wet (85%), falling between 80 and 90 percent for rapid growth. Only after the slurry period were the pH values of the vermicompost taken in all treatments. In the test, the pH dropped in comparison to the control (fig 1). The involvement of microorganisms in the decomposition process during vermicomposting may be the cause of the overall pH reduction. The pH drop was caused by the microbial breakdown that occurs during vermicomposting, which produces CO_2 and organic acids. According to Suther (2009), the final pH range of the vermicomposted material was 7.4±0.01 to 8.0±0.05. In the final compost, the soluble salt concentration (expressed as electric conductivity) was 3.71 mS/cm and 3.00 mS/cm, respectively. Earthworms' intake and subsequent excretion of inorganic chemicals from organic compounds resulted in a high EC in the test.

The total organic carbon has significantly decreased in the treated when compared with the control. A decrease is an indication of enhanced decomposition. The total organic carbon was 18.53% and 21.02%. The significant percentage change indicated that the earthworms accelerated the decomposition of the organic matter. The total nitrogen was 1.46% in the test vermicompost and 1.88% in the control. The C: N ratio in the vermicompost of control is 11:1 and the test is 13:1. The total phosphorus was 0.58% and 0.26%. The total potassium was 0.56% in the test vermicompost and 0.48% in the control. From the results, it was clear that there was a significant increase in NPK values of the test when compared to the control (fig 3). The nitrogen level increased because the earthworms enhanced the nitrogen cycle which attributed to the increased levels of nitrogen in vermicompost [16]. When compared to the control, the test compost showed the highest plant growth on day 20 in terms of shoot length, root length, leaf length, number of leaves, and root length. There are more macro and micronutrients in the test. They were easily assimilated by the plants for growth and development (fig 4). This might be caused by certain of the worms' and their associated bacteria' secretions, which, in addition to other nutrients, function as growth boosters [20]. In the test and control groups, earthworm counts rose to 487 and 396, respectively. The study concludes that cow dung blends and biogas plant sludge promote earthworm proliferation (fig 5). The present investigation indicated that biogas plant slurry and cow dung could be used as raw material in the vermicomposting process. It concluded that biogas plant slurry contributed to increasing NPK, macro, and micronutrients.

Ho: There is significant difference between N,P&K in the control and in the experimental vermicomposting..
Unpaired *t* test results
P value and statistical significance
The two-tailed P value equals 0.5509 By conventional criteria, this difference is considered to be not statistically significant.

Confidence interval
The mean of Group One minus Group Two equals -0.2367
95% confidence interval of this difference: From -1.2470 to 0.7736

Intermediate values used in calculations:
t = 0.6504
df = 4
standard error of difference = 0.364

Review your data

Group	Group one	Group Two
Mean	0.8333	1.0700
SD	0.4562	0.4349
SEM	0.2634	0.2511
N	3	3

Declaration
All authors have read, understood, and have complied as applicable with the statement on "Ethical responsibilities of Authors" as found in the instructions for Authors.

Author Contribution Statement
Jeyanthi kumari   -   Wrote the main manuscript text and project administration
Radhika   -   Project design and administration
Veerabahu   -   Reviewed and edited

Competing interests policy

No, I declare that the authors have no competing interests as defined by Springer, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

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Data Availability
All data sets and statistical report analysis during this study are included in the manuscript.

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Table 1. Students't' test analysis of N,P&K in vermicomposting

Experiment	*N		*P		*K	
	Control	Experimental	Control	Experimental	Control	Experimental
	1.36	1.57	0.58	0.78	0.56	0.86
Total	1.36	1.57	0.58	0.78	0.56	0.86

Figure 1: pH of vermicompost.

Figure 2: EC of vermicompost

Figure 3: Nutrient levels of vermicompost

Figure 4: Plant growth parameters during vermicompost application
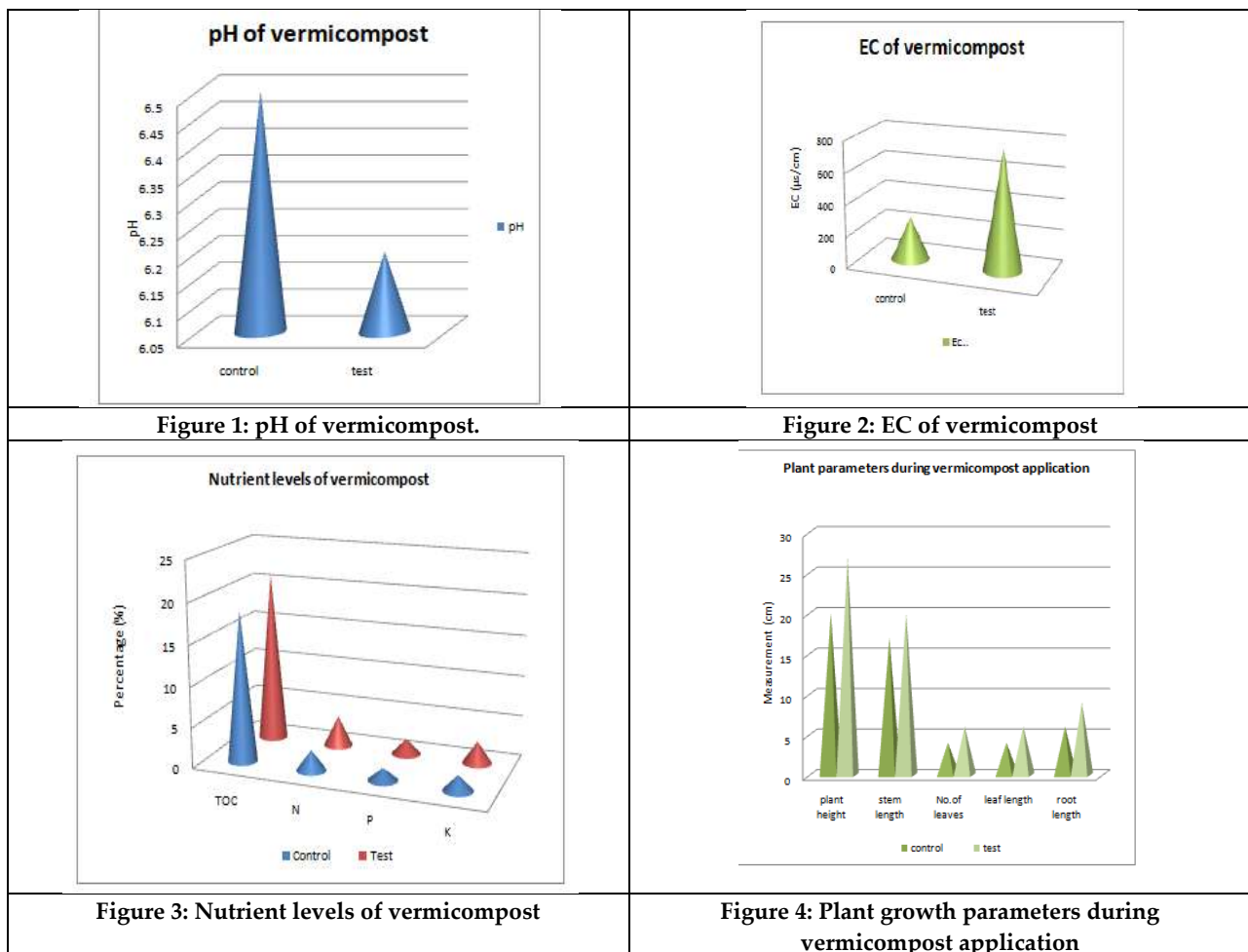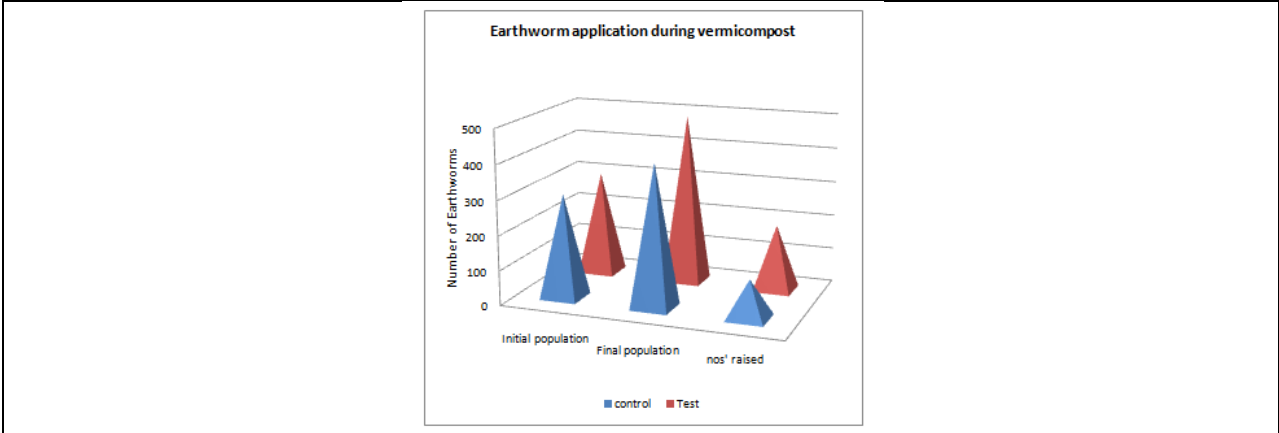
Figure 5: Earthworm multiplication during vermicompost

RESEARCH ARTICLE

Exploring Prime Distance Networks with Gaussian Integers

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ABSTRACT

Prime distance is a measure of the connectivity of a graph based on the concept of prime numbers. The Gaussian prime distance (GPD) graph G is defined as any graph with two relatively prime vertices. The Gaussian neighborhood prime distance (GNPD) graph G along with each vertex v, with neighboring vertices being relatively prime numbers. It is formed by dividing G into n separate Gaussian numbers such that adjacent vertex numbers are relatively prime numbers. The order in the XY plane was structured linearly by means of Gaussian integers to create a spiral structure and demonstrate that certain graph family has a finite Gaussian prime distance with the Gaussian integers.

Keywords: Finite Gaussian Prime distance, Neighborhood Gaussian Prime Distance, Spiral order, Gaussian integers.

INTRODUCTION

Labeling in the realm of graph theory has found application across diverse research domains. For instance, within social network analysis, labeling serves to pinpoint influential nodes or communities. Moreover, in the field of bioinformatics, graph labeling has proven instrumental in scrutinizing protein structures and DNA sequences. The advent of complex numbers and their inherent properties has catalyzed numerous breakthroughs in various disciplines. The impression of prime labeling for graphs was initially formulated by Roger Entringer, gaining prominence with its publication in a work by Tout et al. [1] during the early 1980s. Then, it has evolved into a widely explored subject among scholars, with Gallian [2] serving as a comprehensive resource detailing prime graph results.

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This document introduces the novel concept of neighborhood-prime labeling utilizing Gaussian integers, inspired by the exploration of prime labeling in Gaussian integers. We anticipate that this will emerge as a captivating area of research for academics in the future. Finite Gaussian prime distance graphs and neighborhood prime distance graphs exhibit vertices with significantly prime distances. The vertices in neighborhood graphs are relatively prime, ensuring that each vertex of a graph G can be labeled by n distinct numbers. Various graph families, such as walks, trails, paths, double star trees, caterpillars, spider webs, snake graphs, fans, and others, are recognized for permitting prime distance labeling [3]. In this study, the concept of finite Gaussian prime distance is extended to Gaussian Integers [4], commonly referred to as Gaussian integers. Neighboring vertices of a vertex v in a GNPD graph are relatively prime Gaussian integers. By splitting the GPD graph into discrete Gaussian numbers and making sure that neighboring vertex numbers are substantially prime, the graph is created. To illustrate specific graph families with finite Gaussian prime distance, the ordering of the Gaussian integers in the XY plane is usually arranged linearly, frequently in a spiral pattern. This paper initiates its exploration by delving into the first n Gaussian integers, subsequently turning its focus towards the finite Gaussian prime and neighborhood prime distance graph for Gaussian integers. The ensuing analysis encompasses a presentation of the graphs' outcomes, unveiling their properties and characteristics. These results provide important new information about the distribution and behavior of prime numbers in the Gaussian integer domain. Section 2 delves into the concept of Gaussian integers, elucidating various aspects of their nature. The XY plane spiral order is introduced, preserving numerous known properties observed in the natural number ordering of N. Additional features within this spiral sequence are highlighted in this section. Moving on to Section 3, the paper demonstrates how the spiral ordering lends itself to facilitating prime distance labels [5] with Gaussian integers for certain tree families. Moreover, it explores snake graph families that are amenable to neighborhood prime labeling. An alternative graph is also discussed, showcasing its capacity to accommodate both prime distance and neighborhood prime distance labeling.

GRAPH LABELING WITH GAUSSIAN INTEGERS AS PRIMES

There will be no loops or numerous edges in our graphs. The goal of our study is extended to Gaussian integers in the finite Gaussian prime distance labeling. To establish the concept of the first n Gaussian integers [6], it is necessary to provide a definition for "the first n Gaussian integers." This exploration serves to demonstrate that Gaussian numbers share similar properties with real numbers. Outlined below is our proposed ordering.

Definition 2.1

Using recursive definitions of the Gaussian integers, we can recursively order them in spiral order. As with, the spiral ordering denotes the nth Gaussian integer by τ_n. Equation 1 states that the spiral is ordered from $\tau_1 = 1$ to base on the nth integer in the spiral. See Fig.1 for an illustration. The first 10 Gaussian integers are ordered according to this ordering $1, 1+i, i, -1+i, -1, -1-i, -i, 1-i, 2-i, 2 \ldots \ldots \ldots$

In the spiral ordering, we write $[\tau_k]$ to represent all the kth Gaussian integers.

$$\tau_{k+1} = \begin{cases} \tau_k + i & if \ |\mathrm{Re}(\tau_k)| > |\mathrm{Im}(\tau_k)|, \ \mathrm{Re}(\tau_k) > 0 \ and \ -(\mathrm{Re}(\tau_k)-1) \le \mathrm{Im}(\tau_k) \le (\mathrm{Re}(\tau_k)-1) \\ \tau_k - 1 & if \ |\mathrm{Re}(\tau_k)| \le |\mathrm{Im}(\tau_k)|, \ \mathrm{Im}(\tau_k) > 0 \ and \ -\mathrm{Im}(\tau_k) \le \mathrm{Re}(\tau_k) \le \mathrm{Im}(\tau_k) \\ \tau_k - i & if \ |\mathrm{Re}(\tau_k)| \ge |\mathrm{Im}(\tau_k)|, \ \mathrm{Re}(\tau_k) < 0 \ and \ \mathrm{Re}(\tau_k) < \mathrm{Im}(\tau_k) < -\mathrm{Re}(\tau_k) \\ \tau_k + 1 & if \ |\mathrm{Re}(\tau_k)| \le |\mathrm{Im}(\tau_k)|, \ \mathrm{Im}(\tau_k) < 0 \ and \ \mathrm{Im}(\tau_k) \le \mathrm{Re}(\tau_k) \le -\mathrm{Im}(\tau_k) \end{cases}$$

Gaussian integer spiral ordering leads to finite Gaussian prime distance labeling of other Gaussian integer graphs.

Definition 2.2

Let G be a simple graph. A finite GPD labeling graph of Gaussian integers G is a injective labeling $\varphi : V(G) \to Z[i]$ such that if $uv \in E(G)$, then $\varphi(u)$ and $\varphi(v)$ are relatively prime to each other. So G is called a finite Gaussian prime distance graph if there exists a finite Gaussian prime distance labeling exists. Prime distance labeling requires distinct labels at each vertex of G.

AN OVERVIEW OF SPIRAL ORDERING PROPERTIES

An order of Gaussian spiral is defined here in several pieces. Spiral corners occur when spirals move from one direction to another direction. Spirals have branches when they travel in a straight line north, south, east, or west.
Our first objective is to decide the ordinal numeral of an inconsistent Gaussian whole number, $a + bi$ in the winding request in light of which kind of branch or corners it lies on. Let $O_{GI}(a + bi)$ be used to mean the ordinal numeral of $a + bi$ in the twisting requesting. The points lie on the axes is

On X axis, either $\mathrm{Re}(z) > 0 \, or \, < 0 \, and \, \mathrm{Im}(z) = 0$

On Y axis, either $\mathrm{Im}(z) > 0 \, or \, < 0 \, and \, \mathrm{Re}(z) = 0$

I and III quadrant corners are the Gaussian integers such that their real and imaginary parts are equal and of same in signs. II quadrant corners are having equal real and imaginary part and are of opposite signs. IV quadrant corners are of opposite in signs and $\mathrm{Re}(z) = |\mathrm{Im}(z)| + 1$

Lemma 2.3

Ordinal numerals of four types of points lie on X – axes, and Y-axes and are found as follows:

$$O_{GI}(a + bi) = \begin{cases} 4a^2 - 3a & if \ a > 0 \ and \ b = 0 \\ 4b^2 - b & if \ a = 0 \ and \ b > 0 \\ 4a^2 - a & if \ a < 0 \ and \ b = 0 \\ 4b^2 - 3b & if \ a = 0 \ and \ b < 0 \end{cases}$$

Proof

The ordinal numerals of a GI are the number of points in its path. First, we'll examine the points on the positive side of the X-axis. We started with the very first integer $1 + 0i$, and its ordinal numerals are 1. The second point in the axis is $2 + 0i$, it finally crosses a 3 x 3 grid of points having three columns of three points each, and it may cross another point to reach its ordinal numerals. For our convenience in the calculation, we include point zero and exclude point $2 + 0i$. The third point in the axis is $3 + 0i$, which crosses a grid of five columns of five points each, and it may cross another two points to reach its position. By progressing in this fashion, the point $a + bi, b = 0$ on the positive real axis is crossed by "$2a - 1$" columns of "$2a - 1$" a point each and it may crosses another "$a - 1$" points. It crossed completely $(2a - 1)(2a - 1) + (a - 1) = 4a^2 - 4a + 1 + a - 1 = 4a^2 - 3a$ points. So, its ordinal numerals are $4a^2 - 3a$ Second, we'll look at the points on the positive side of the Y axis. We started with the first point $0+i$ in the Y axis, which ordinal number is 3. The second point in the axis is $0+2i$, from which crosses three columns with four points each and it may cross another two points to reach its place. We use the current y-axis as the point instead of zero as the center point. $0 + 3i$, The Y axis third point crosses five columns of six points each and it may cross another three points. In general, the positive side of Y axis point $0 + bi, b > 0$ is crossed by "2b-1" columns of 2a points each by continuing in this manner.
It entirely crossed $(2b - 1)(2b) + b = 4b^2 - 2b + b = 4b^2 - b$ points. So, their ordinal numerals are $4b^2 - b$
Similarly, we get the indices of the points on the negative sides of the X and Y axes.

Lemma 2.4
Ordinal numerals of the corners lie on the four quadrants are found as follows:

$$O_{GI}(a+bi) = \begin{cases} 4a^2 - 2a & \text{if corners lie in I quadrant} \\ 4a^2 & \text{if corners lie in I quadrant} \\ 4a^2 + 2a & \text{if corners lie in III quadrant} \\ (a-b)^2 & \text{if corners lie in IV quadrant} \end{cases}$$

Proof
First, let's explore the corner points of the first quadrant in the XY plane. Initiating with the initial corner integer 1+i, the second corner point in the first quadrant, 2+2i, spans three rows of four points each. Meanwhile, the third corner point, 3+3i, traverses seven rows, each containing eight points. Progressing systematically, the corner points a+bi in the first quadrant, where a equals b, intersects "2a-1" rows, each with 2a points. This results in a total intersection of $4a^2-2a$ points. Moving on to the second quadrant's corner points, we commence with -1+i, which intersects two columns, each with two points. The second corner point, -2+2i, crosses four columns with four points each, while the third corner point, -3+3i, extends across six columns of six points each. Continuing this pattern, the corner point -a+ai in the second quadrant, with a=b, intersects "2a" columns, each comprising 2a points. This yields a complete intersection of $4a^2$ points. Next, we turn to the third quadrant's corner points. Starting with -1-i, this first corner integer crosses two rows, each containing three points. The second corner point, -2-2i, spans four rows with five points each, and the third corner point, -3-3i, traverses six rows of seven points each. Following the established trend, the corner point -a-ai in the third quadrant, with a=b, intersects "2a" rows, each with 2a+1 points. This results in a total intersection of $4a^2+2a$ points. Finally, examining the corner points of the fourth quadrant, we initiate with the first corner integer, 2-i, which crosses three columns, each comprising three points. The second corner point, 3-2i, spans five columns with five points each, while the third corner point, 4-3i, extends across seven columns of seven points each. In a similar manner, the corner point a+bi in the fourth quadrant, with a>b, is intersected by "(a-b)" columns, each with "(a-b)" points. This leads to a complete intersection of (a-b)(a-b) = $(a-b)^2$ points.

Finite Gaussian Prime Distance Results for Graph Families
Definition 3.1
A lattice graph is a type of graph that represents a structure consisting of points or nodes arranged in a regular, grid-like pattern. It is commonly used in physics and mathematics to model crystal structures and other regular arrangements of particles.

Theorem 3.2
Every grid graph is a finite Gaussian prime distance graph.

Proof
The set of Gaussian integers we are considering here is already on a grid system in the XY plane, and we know of consecutive Gaussian integers in the system that differ by a unit difference and unit distance points having the gcd of 1. Thus, every Lattice graph is a finite Gaussian prime distance graph
Example: A 2x2 grid graph.

$$5 + 3i = (1)(4 + 3i) + (1)$$

$$4 + 3i = (1)(4 + 3i) + (0)$$

$$\text{Thus, gcd}(4 + 3i, 5 + 3i) = 1$$

Similarly,

$$4 + 3i = (1)\,(4 + 2i) + (i)$$
$$4 + 2i = (i)\,(2 - 4i) + (0)$$
$$Thus, \gcd\,(4 + 3i, 4 + 2i) = i$$

$$5 + 3i = (1)\,(4 + 2i) + (1 + i)$$
$$4 + 2i = (1 + i)\,(3 - i) + (0)$$
$$Thus, \gcd\,(5 + 3i, 4 + 2i) = 1 + i$$

Theorem 3.3
Every path graph is a finite Gaussian prime distance graph.

Proof
A square grid graph is a particular kind of graph that has edges joining adjacent vertices and vertices arranged in a s quare grid pattern.We can say that the square grid graph is a composition of multiple path graphs if we assume of the vertical and horizontal lines of the grid as path graphs, which implies that they enhance the property of finite prime distance. It therefore proves.

Definition 3.4
Grid graphs are bipartite, meaning that all edges have its end points in two different vertex sets.

Theorem 3.5
Bipartite graphs admit finite Gaussian prime distance labeling.

Proof
If we color the vertices of the grid graphs in a checkerboard fashion, it can be verified easily. (Fig 4)

Definition 3.6[6]
The star S_{2n} with central point v_0 and leaves through v_{2n}, with an edge connecting each subsequent pair of vertices v_{2k-1} and v_{2k} where $1 \le k \le n$, is the Dutch windmill graph D_n or friendship graph. As a result, D_n has n copies of C_3 joined at v_0 [7]. D_5 is seen in Figure 5.

Theorem 3.7
Any Dutch windmill graph $D_n, n > 1$ admits a finite Gaussian prime distance labeling.

Proof
The Dutch windmill graph is a simple graph consisting of a central vertex v_0, and n blades, each containing m vertices[8], where every vertex in the ith blade is adjacent to v_0 and to the equivalent vertex in the (i+1)[th] blade. Let us start with vertex $v_0 = \alpha + \beta i, v_0 \in Z[i]$, the center vertex of the Dutch windmill graph [9]. Assign a vertex value in the blade neighboring to v_0 such that $v_0 \ and \ v_i$ are relatively prime Gaussian integers [10, 11].
Hence, every adjacent vertex in the Dutch windmill graph is relatively prime and admits a finite prime distance.

Theorem 3.8

Any star graph S_n, $n > 1$ is a finite Gaussian prime distance graph.

Proof

If we start with a star graph, we have one central vertex connected to several peripheral vertices. Labeling the central vertex v_0 with $\alpha + \beta i \in Z[i]$ and labeling all other peripheral vertices with the Gaussian integers relatively prime [12] to v_0. Hence, every adjacent vertex in the star graph is relatively prime and admits a finite prime distance.

Definition 3.9

The (n, r, s)-double star tree, where n, r, s be integers with $r \leq s$ then $DS_{n,r,s}$, is the graph with $V(DS_{n,r,s}) = \{v_1, \ldots, v_n, v_{n+1}, \ldots, v_{n+r-1}, v_{n+r}, \ldots, v_{n+r+s-2}\}$, and
$E(DS_{n,r,s}) = \{v_j v_{j+1}: 1 \leq j \leq n-1, v_1 v_{n+j}: 1 \leq j \leq r-1, v_n v_{n+r+j}: 0 \leq j \leq s-2\}$

Theorem 3.10

Any (n, r, s) −double star tree admits a finite Gaussian prime distance labeling.[13]

Proof

A path graph is characterized by a linear sequence of vertices, where each vertex is connected to its adjacent ones. In contrast, a star graph features a central vertex linked to all other vertices. In a double star tree, there exists a path of distance end to end with end vertices and v_1 and v_2 serving as the middle vertices for stars having r and s vertices. Theorems 3.3 and 3.8 assert that both path graphs and star graphs have a finite Gaussian prime distance, categorizing them as finite Gaussian distance graphs.

Definition 3.11

A tree with at least one vertex with a degree of three and all other vertices with degrees of one or two is called a spider graph. (Fig.8)

Theorem 3.12

Any spider tree admits finite Gaussian prime distance labeling.

Proof

Let T be a spider tree and assume the center vertex v_0 has degree n. Label the any vertex v_k, $1 \leq k \leq n$ with the Gaussian integers relatively prime to v_0 and continue the process to the adjacent vertices of v_k, $1 \leq k \leq n$.

NEIGHBORHOOD PRIME DISTANCE RESULTS FOR GRAPH FAMILIES
Definition 3.13

The neighborhood of a vertex v in Graph G is defined as the set of all vertices in G that are adjacent to v, denoted by the set N(v).

Definition 3.14

Consider a graph G = (V(G), E(G)) with n vertices. If, for every vertex v ∈ V(G) with degree greater than 1 (deg(v) > 1), the greatest common divisor of the set {f(u): u ∈ N(v)} is equal to 1, then the function f: V(G) → Z[i] is referred to as a neighborhood-prime labeling[14].

Definition 3.15

A triangular cactus is a linked graph that only consists of triangles as its building blocks.

Remark

A prime graph may or may not also be a neighborhood-prime graph and vice versa [15]. This independence between the words "prime graphs" and "neighborhood-prime graphs" refers to their flexibility.

Theorem 3.16

Every path graph P_n admits neighborhood prime labeling.

Proof

Let v_i be any Gaussian integer in P_n where $v_i = \alpha + \beta i \in Z[i]$. Already we say that every grid graph (Theorem 3.2) and every path P_n (Theorem 3.3) admits finite prime labeling. If we take the neighborhood of v_i as v_{i-1} and v_{i+1} belongs to the set$\{(\alpha - 1) + \beta i, (\alpha + 1) + \beta i, \alpha + (\beta - 1)i, \alpha + (\beta + 1)i\}$, Clearly, v_i, v_{i-1} and v_{i+1} are relatively prime to each other.

Theorem 3.17

Every triangular cactus graph is a neighborhood prime labeling graph.

Proof

Identifying a path as the cactus graph's basis is the first step in proving the theorem. According to Theorem 3.16, the path that is derived from the grid graph allows for neighborhood prime labeling [16]. Since their differences in the path alternative are *2i*, it follows that their gcd is *-i*. Gaussian integers are relatively prime in this case. Thus every triangular cactus graph admits neighborhood prime labeling. [Fig.9]

CONCLUSION

The study of Gaussian prime distance and Gaussian neighborhood prime distance graphs has provided a unique perspective on graph connectivity, combining the principles of number theory with the intricate structures of graph theory. The Gaussian neighborhood prime distance graph, with vertices representing Gaussian numbers and edges connecting vertices with relatively prime numbers, presents a visually compelling spiral structure that showcases the beauty of interconnectedness and underlying mathematical principles. The delineation of a finite Gaussian prime distance within this graph family reinforces the potential for finite patterns in graph theory. This exploration deepened our understanding of graph structures and underscored the versatility of mathematical concepts in diverse fields. The study of Gaussian prime distance graphs and their variants contributed to the rich tapestry of mathematical research and exemplified the beauty that emerges when seemingly disparate concepts converge.

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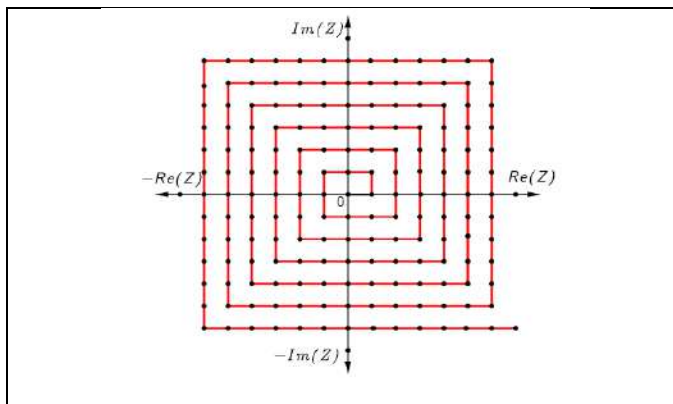
| **Fig.1. The spiral order of Gaussian Integers** | **Fig.2. The 2x2 grid graph** |
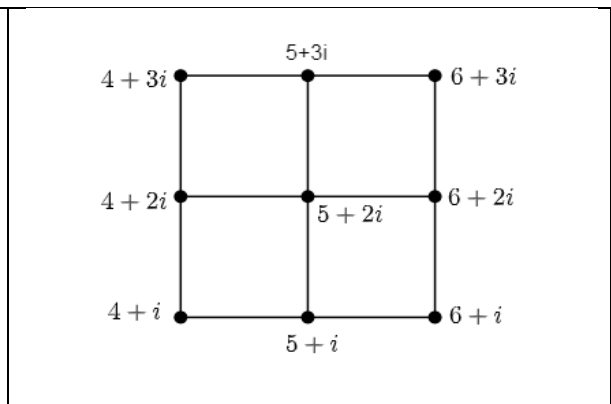
Fig.3.The path P_{n+1} graph

Fig.4. A 4 x 4 Grid graph as a $B_{8,8}$ bipartite graph

Fig.5.The Dutch windmill graph D₅

Fig.6. The star graph

Fig.6.The (n,r,s)-Double star tree

Fig.7.Tha Gaussian prime distance spider graph

Fig 9. Triangular Cactus Graph with 13 vertices

RESEARCH ARTICLE

A Narrative Review of Dexamethasone in Anaesthesia Practice

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ABSTRACT

Strong synthetic glucocorticoids like dexamethasone are increasingly used in many medical specialities, including anaesthesia. Its antiemetic, immunosuppressive, and anti-inflammatory qualities make it a useful perioperative care adjunct. This narrative review aims to provide an overview of the available data on the application of dexamethasone in anaesthesia practice. We review its pharmacokinetics, mechanisms of action, and clinical uses, including how it helps minimize pain and inflammation, lessen airway oedema, and prevent postoperative nausea and vomiting. We also discuss the possible side effects and controversy related to its use, including immune suppression and hyperglycaemia. We also highlight new directions in research and recent advancements in the use of dexamethasone to improve perioperative outcomes. Dexamethasone is a useful tool in anaesthesiologists' toolbox, but cautious application and understanding of its potentialrisks are essential for safe and effective perioperative management.

Keywords: dexamethasone, anaesthesia, perioperative care, antiemetic, anti-inflammatory, immunosuppressive

INTRODUCTION

Due to its many different pharmacological characteristics, the powerful synthetic glucocorticoid dexamethasone has attracted a lot of interest in the field of anaesthesia. Dexamethasone was first identified as having anti-inflammatory and immunosuppressive properties, but its use in perioperative settings has expanded to include anaesthesia. Its ability to lessen inflammation, lower postoperative nausea and vomiting (PONV), and possibly improve postoperative analgesia is the reason for its widespread use [1]. Dexamethasone has become a useful addition to anaesthesia protocols in recent years due to its capacity to control the stress response during surgery, improve hemodynamic stability, and help patients recover more smoothly. Dextamethasone's pleiotropic effects have prompted its investigation in a variety of surgical specialities, from neurosurgery to orthopaedic procedures, among others [2]. This narrative review aims to present a thorough summary of the available data regarding the perioperative administration of dexamethasone in anaesthesia practice. Through the integration of results from observational studies, meta-analyses, and clinical trials, we aim to clarify the medication's safety profile, efficacy, ideal dosage schedules, and possible directions for future investigation [3]. This review aims to provide insights into the complex role of dexamethasone in perioperative care by critically analyzing the body of existing literature and addressing its effects on outcomes like immune function, wound healing, glycemic control, and surgical site infections. We will also look at new developments, debates, and paths forward for the use of dexamethasone in anaesthesia management procedures [4]. Anesthesiologists, perioperative teams, and healthcare professionals need to comprehend the changing landscape of dexamethasone utilization in anaesthesia practice. Given its potential to improve patient care, optimize perioperative outcomes, and refine anaesthesia strategies, anesthesiologists, perioperative teams, and other healthcare providers must comprehend the changing landscape of dexamethasone utilization in anaesthesia practice [5].

Mechanism of Dexamethasone

Administration of Dexamethasone
|
Binds to glucocorticoid receptors (GR) in the cytoplasm
|
Formation of GR-Dexamethasone Complex
|
Translocation of the complex into the nucleus
|
Binding of complex to DNA (GREs) in promoter regions of target genes
|
Activation or repression of gene transcription
|
Anti-inflammatory effects and immunosuppressive effects
|
Reduction of inflammation and Immune responses in the body
|
Clinical effects: reduction in swelling, inflammation, immune responses, and associated symptoms
|
Overall improvement in patient condition

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Dexamethasone in Postoperative Nausea and Vomiting

In perioperative care, postoperative nausea and vomiting (PONV) continue to pose major challenges. It is associated with increased healthcare costs, delayed recovery, and patient discomfort. Many pharmaceuticals have been used to reduce PONV, and because of its antiemetic qualities, dexamethasone has become a promising adjunct [6]. Synthetic glucocorticoids such as dexamethasone have anti-inflammatory and immunosuppressive properties, but they are not the only ways in which they help manage PONV. Dexamethasone has been the subject of numerous studies that have examined its safety and effectiveness in lowering the incidence and severity of post-operative nerve injury (PONV) in a variety of surgical populations [7]. The purpose of this review is to present a thorough summary of the available data on the application of dexamethasone in the treatment of PONV. By critically analyzing meta-analyses, systematic reviews, and randomized controlled trials, Our objective is to assess the effectiveness of dexamethasone in treating and preventing PONV, as well as how well it works in comparison to other antiemetic medications [8]. In addition, the safety profile of dexamethasone will be covered in this review along with its implications for managing PONV, taking into account possible side effects like hyperglycemia, immunosuppression, and difficulties with wound healing. The best time to administer dexamethasone, dose-response relationships, and patient-specific factors affecting its safety and effectiveness will all receive particular consideration [9]. Perioperative healthcare providers must comprehend the role of dexamethasone in PONV management to better tailor multimodal antiemetic strategies and enhance patient outcomes. Through a comprehensive analysis of the existing literature, our review seeks to support clinical judgment and encourage additional investigation to enhance PONV prevention and therapy approaches [10].

Role in Prospective Pain

Inflammation, nerve injury, or direct tissue damage are the causes of postoperative pain. Of these, acute inflammation brought on by tissue damage is the main contributing factor. By blocking peripheral phospholipase and thereby lowering cyclooxygenase and lipoxygenase, dexamethasone reduces pain. Several reactions, including inflammatory, metabolic, hormonal, and immune responses, are triggered as soon as a surgical incision is made. Dextamethasone's anti-inflammatory and immunosuppressive properties may reduce these responses, demonstrating the drug's role in pain management [11].

Dose and Administration of Dexamethasone

Depending on the type of surgery, the patient, and the intended results, several variables can affect the best dose and timing of dexamethasone administration in the context of different perioperative applications, such as pain management and the prevention of postoperative nausea and vomiting (PONV)[12]. Nonetheless, based on the information at hand, a few broad recommendations, and widely accepted regimens have been developed:

Prevention of postoperative nausea and vomiting (PONV):
- To lower the frequency and severity of PONV, dexamethasone is commonly used as a preventive antiemetic medication.
- The usual intravenous dose is between 4 and 10 milligrams. Although the exact timing of administration varies, common practices include: - Giving dexamethasone at the time of induction of anesthesia.
- Giving dexamethasone to the patient after the procedure, before their awakening from anesthesia.
- Giving high-risk patients or procedures dexamethasone at both the beginning and the end of the surgical procedure. Research indicates that most of the time, a single dose of dexamethasone is sufficient for PONV prophylaxis; however, in cases of prolonged surgery or high-risk patients, additional doses may need to be considered [13].

Pain Management: - Dexamethasone can also be used to lessen the need for opioids and improve postoperative pain control.
- For this purpose, intravenous administration of a dose of 4 to 8 mg is typically advised.
- Although the exact timing of administration varies, common practices include: - Giving dexamethasone at the onset of anesthesia to prevent inflammation and pain.

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- Giving dexamethasone to help with postoperative pain management following surgery.
- Adding dexamethasone to multimodal analgesic regimens or regional anesthesia techniques may help improve pain management and decrease opioid-related side effects [14].

Other Perioperative Uses

Dexamethasone can also be applied in other perioperative situations, like lowering airway edema, avoiding stridor after extubation, and speeding up recuperation following specific surgical procedures. For these applications, the dosage and schedule of administration ought to be customized according to particular clinical circumstances and patient requirements [15]. Healthcare professionals should take patient comorbidities, drug interactions, and possible side effects into account when deciding on the right dosage and schedule for dexamethasone administration. Optimizing perioperative management strategies can also be achieved by adhering to the most recent evidence-based recommendations and consulting institutional guidelines [16].

Role of Dexamethasone in Neuromuscular Block

Synthetic glucocorticoids like dexamethasone have been studied for their possible effects on neuromuscular function and how they affect neuromuscular blocking agents (NMBAs) in different clinical settings. Although dexamethasone is best known for its anti-inflammatory and immunosuppressive qualities, its impact on neuromuscular transmission has drawn interest in the field of anesthesia [17]. The function of dexamethasone in the neuromuscular block is summarized as follows:

Strengthening of Neuromuscular Blockade

- Research indicates that dexamethasone may strengthen the effects of non-muscular blockade agents (NMBAs), resulting in a longer period of neuromuscular blockade and possibly influencing the extent and length of muscle relaxation during surgery.
- By improving neuromuscular blockade, dexamethasone may improve operating conditions, ease surgical exposure, and lessen the need for volatile anesthetics. These effects could have an impact on intraoperative management [19].

Diminished Neuromuscular Blockade Reversal:

- Research suggests that dexamethasone may postpone the restoration of neuromuscular function after reversal medications, like sugammadex or neostigmine, are administered.
- To guarantee sufficient recovery of respiratory function and muscle strength, modifications to postoperative monitoring and extubation protocols may be necessary due to the delayed reversal of neuromuscular blockade by dexamethasone [20].

Possible Mechanisms

- Although the exact processes underlying dexamethasone's effects on neuromuscular transmission are unclear, they could include interactions with neuromuscular junction receptors, changes in muscle membrane excitability, or modulation of neurotransmitter release.
- Dexamethasone's complex interactions with neuromuscular signaling pathways may be attributed to its broad pharmacological profile, which includes effects such as anti-inflammatory and metabolic [21].

Clinical Implications and Considerations

- When using dexamethasone in perioperative management strategies, healthcare providers should be aware of the possible effects it may have on neuromuscular function.
- Optimizing patient outcomes and reducing the possibility of side effects require tailored dosing schedules and close observation of neuromuscular function [22].

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When using dexamethasone in anesthesia practice, healthcare providers should be aware of its potential impact on perioperative neuromuscular function, even though more research is required to clarify the exact mechanisms and clinical implications of this medication's effects on the neuromuscular blockade[21,22].

Role of Dexamethasone in Shievering

Postoperative shivering can have a major impact on patient care, so treating and preventing it should be a top priority. Increased oxygen consumption, increased carbon dioxide production, or sympathetic stimulation can all result from shivering. Dexamethasone reduces shivering by lowering the difference in temperature between the skin and the body's core. The effects of shivering were compared between dexamethasone and pethidine in a randomized double-blind study. According to the study's findings, dexamethasone outperformed pethidine in preventing postoperative shivering[23]. However, in patients undergoing transurethral prostatectomy under spinal anesthesia, there was no discernible difference in the incidence of shivering between intrathecal pethidine and intrathecal dexamethasone[24].

Concerns Associated with Dexamethasone Usage

Issues with dexamethasone use in anesthetic practice include poor wound healing, hyperglycemia, and an increased risk of infection. Dexamethasone taken alone does not appear to raise the risk of infection or slow the healing of wounds. Furthermore, there is no proof that a single dexamethasone dosage will cause hyperglycemia. The most recent trial confirming dexamethasone's safety is the PADDI trial [25].

Role of Dexamethasone in Quality of Recovery

Dexamethasone is an effective tool for enhancing the standard of recovery following surgery. It improves patient comfort and satisfaction by lowering pain, decreasing inflammation, and preventing postoperative nausea and vomiting (PONV). Furthermore, by lowering the chance of complications like hypersensitivity reactions and airway edema, its immunomodulatory qualities may aid in quicker recoveries. But it's important to dose carefully and take possible side effects into account. Healthcare providers must work together to make decisions to maximize benefits and minimize risks. To improve the quality of recovery, more research is required to define its role and create standardized protocols for its application [26].

Mechanism of Action

Dexamethasone most likely works as an anti-inflammatory through both nongenomic and genomic mechanisms. Postoperative pain results from tissue injury and inflammation caused by surgical procedures. The strong anti-inflammatory qualities of corticosteroids like dexamethasone lessen these effects. The processes include lowering the concentration of bradykinin in tissues, stabilizing neuronal membranes, and inhibiting the cyclooxygenase and lipoxygenase pathways. Moreover, dexamethasone inhibits the release of neuropeptides following tissue damage from nerve endings [27].

CONCLUSION

To sum up, dexamethasone has a variety of uses in the field of anesthesia and is advantageous in a range of clinical situations. Its versatility makes it a useful adjunct in perioperative management, from reducing pain and inflammation to mitigating postoperative nausea and vomiting. Its immunomodulatory properties may also be useful in reducing side effects like hypersensitivity reactions and airway edema. Potential negative effects, however, must be carefully considered, especially in more susceptible patient populations [28]. To maximize patient outcomes while lowering risks, anesthesiologists, surgeons, and other healthcare professionals must collaborate when making decisions. To clarify its exact mechanisms of action and improve dosage schedules for particular surgical procedures, more research is necessary [29].

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RESEARCH ARTICLE

Navigating the Digital Frontier: Past and Recent Information Technology Trends, Risks and Challenges

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ABSTRACT

The banking industry has played a significant role in the economic progression of a country since time immemorial, especially in terms of preserving capital and granting credit to both people and enterprises. The banking concern in India has experienced an evolutionary change, particularly in the last two decades. The quality of the assets, technology, and laws have all changed substantially. Branchless banking enabled by modern and contactless technologies has replaced traditional physical banking, which required client walk-ins and in-person interactions. Digitization in the financial sector has revolutionised the banking landscape. Therefore, the foremost purpose of this paper is to explore the various approaches in the banking sector as digitization resulted in paradigm change from traditional banking processes to digital operations using new technologies. It can be concluded that banking can be reformed and redesigned through technological advancements and will continue to drive the economy forward by integrating various financial sector components. This paper serves as a learning guide to the future researchers as it provides a comprehensive outlook of the various developments the banking sector has undergone over the years.

Keywords: Banking industry, Information Technology, Digitization, Digital banking

INTRODUCTION

Banking industry which is amongst the main pillars of the financial system plays a crucial part in the economic progression of any country. The rapidly evolving economy is bringing with it rapidly evolving technologies, a greater need for expertise in all facets of business, and new ways to provide services to customers, like e-banking (Chandrasekharan & Narayanan, 2019). The business operations of the banking concern have undergone remarkable transformation in the last few years. Following the economic crisis of 2007–2008, financial controllers reinforced

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governance of the banking industry by executing new rules and reinforcing those that already existed (Romanova &Kudinska, 2016). The e-banking revolution is one of the few breakthroughs that has altered the banking industry so swiftly. E-banking has offered banks the potential to cross potential frontiers, amend their entrepreneurial behaviour, and open new possibilities. With the advent of e-banking, real-world banking practices are now more in line with neoclassical economic ideas of how markets operate. Customers are better able to evaluate the services of different banks because of the market's complete transparency (Nitsure, 2003). Furthermore, the advancement of Fintech has boosted the necessity for increased creative banking solutions. As a result of growing competition from nonbank financial entities, banks today have begun to compete outside the realm of traditional financial services (Romanova &Kudinska, 2016). Thus, over a period the banking industry has transformed from a product centric approach to customer centric approach. Internet technologies have a significant potential to profoundly alter banks and the banking sector. Banks are influenced to outline, expand, and operate their own e-banking techniques. The e-banking services and technologies provide the banking industry with an opportunity to fulfil the demands of prospective customers and attract new potential consumers (Angelakopoulos & Mihiotis, 2011). The Banking Regulation Act of 1949 (BR Act), which governs banking, explicitly states the importance of the money-saving industry in India. In accordance with Section 5 (c) of the BR Act, a banking firm is an entity that conducts banking operations in India. Furthermore, according to Section 5(b) of the BR Act, banking is defined as "accepting, with the intent of providing or assuming, from the people, repayable with interest or generally, and withdrawal, with check, draft, order, or otherwise" (Abhijit Roy, 2012). The Indian banking sector is currently experiencing an IT revolution.

To keep up with the top global competitors who offer a broad range of sophisticated services, Indian banks are evolving and becoming more powerful by investing heavily in digital technologies. A quickly expanding digital community is being created at the same time by current innovations and prospective banking developments in India. The significance of complete Indian banking automation is rising due to a mix of competitive and regulatory factors (Chittabbai et al., 2015). Dhanwani (2014) opines that information technology has reformed and redesigned banking and it will be able to offer more enhanced amenities in the future with further product and process improvements. As a result, the sector is transitioning from a seller's to a buyer's market, which ultimately has an impact on bankers' methods, causing them to switch from traditional banking to convenience banking and mass banking to class banking. Gupta & Shrivastava (2018); Bansal et al., (2022) concludes that communication and business process re-engineering are two different ways that information technology is utilized in banking. Considering the enormous global expansion of financial operations, the information technology transformation has created an environment for addressing the problems the new economy is facing. Kumar & Pavithra (2017) emphasises that due to the newly enhanced and cutting-edge services provided by banks, India's banking industry is advancing along with the rise in its customer base. The country's economic expansion is a sign that the banking industry will expand as well. Priyanka (2020); Sujatha et al., (2017) states that the development of the economy is greatly aided by technological advancements in banking. The "next level of banking" is now operational in the Indian financial sector.

The banking industry is certain to experience transformation as a result of ICT innovation combined with the cashless economy vision. Yadav (2019); Gupta et al., (2017) opines that banks are anticipated to have considerable expansion in the years ahead. Banks can implement universally accepted accounting methods, improve risk management systems, and increase openness and transparency due to innovation and IT systems utilized in the banking industry. The analysis outlines the ways in which information technology has impacted the Indian banking industry, including its advancements, transformations, and possible future developments. A possible research gap that the assessment highlights is the need for a more thorough examination of the challenges and risks connected to the banking sector's growing use of information technology. In particular, the assessment emphasizes the benefits, like improved services, economic growth, and expansion, but it skips over any potential negative effects or difficulties banks may encounter as a result of this technological revolution. Hence the main objective of the paper is to explore the past approaches of the Indian banking system and to explore the recent trends that have taken banking in India to an advanced level. This paper serves as a learning guide to the future researchers as it provides a comprehensive outlook of the various developments the banking sector has undergone over the years.

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METHODOLOGY

The study uses secondary data in the form of research articles published in various databases, newspaper articles and government websites.

OBJECTIVES

The main aim of this study is:

1. To analyse the banking approaches in the past.
2. To explore the recent approaches in the Indian banking system.
3. To explore the various challenges and risks that banks encounter for being reliant on information technology.

DISCUSSIONS

History of the Indian banking industry

Indian banks are the country's first generation of financial facilitators. Due to its unique geographic and socioeconomic features, the Indian banking industry stands apart from the rest of the global financial system (Bhosale, 2015). The Indian banking system can be categorised into three periods namely, pre-independence (1786 – 1947), post-independence (1947 – 1991) and liberalisations period (1991 – till date). The Bank of Hindustan, which had its headquarters in Kolkata and was founded in 1770, was the first bank of India. However, this bank was a failure and stopped operations in 1832. A number of other banks were formed in India after the Bank of Hindustan such as The general bank of India (1786-1791), Oudh commercial Bank (1881-1958), Bank of Bengal (BoBe) (1809), Bank of Bombay (BoB) (1840), Bank of Madras (BoM) (1843). The BoBe, the BoB, and the BoM were three banks that the East India company founded during the British era of rule in India and known as presidential banks. In 1921, these three banks were ultimately combined into a single institution known as the Imperial Bank of India (IBI). The IBI was later nationalised in 1955 and renamed as the State Bank of India (SBI), which is presently the biggest public sector bank. On the advice of the Hilton Young Commission, RBI was established on April 1st, 1935. All the main banks during independence were autonomous, which raised issues as rural population still depended on financiers for funding. The administration decided to nationalise the banks to confront this issue.

These banks were nationalised in accordance with the Regulation Act of 1949, while the RBI was nationalised the same year. SBI was founded in 1955, and 14 additional institutions were nationalised between 1969 and 1991. The 14 banks that were nationalised in 1969 included Allahabad Bank, Bank of India, Bank of Baroda, Bank of Maharashtra, Central Bank of India, Canara Bank, Dena Bank, Indian overseas Bank, Indian Bank, Punjab national Bank, Syndicate Bank, Union Bank of India, United Bank, and Uco Bank. These banks had national deposits that totalled more than 50 crores. Six additional banks were nationalised in the year 1980. These institutions included Vijaya Bank, Punjab & Sindh Bank, New Bank of India, Oriental Bank of Commerce, Andhra Bank and Corporation bank. State Bank of India subsequently merged with some of the banks, including State Bank of Patiala, State Bank of Hyderabad, State Bank of Bikaner & Jaipur, State Bank of Mysore, State Bank of Travancore, State Bank of Saurashtra, and State Bank of Indore, in 2017. The banks needed to be regularly monitored and regulated during the liberalisation phase. The government decided to establish a commission under the chairmanship of Shri. M Narasimhan to oversee the major developments in the Indian banking sector to provide consistency and profitability to the nationalised Public Sector Banks. The introduction of private sector banks in India was the biggest advancement. Global Trust Bank, ICICI Bank, HDFC Bank, Axis Bank, Bank of Punjab, IndusInd Bank, Centurion Bank, IDBI Bank, Times Bank, and Development Credit Bank were some of the financial institutions. Other measures taken included establishing foreign bank branches in India, introducing payments banks in response to technological and banking advancements, allowing small finance banks to open branches throughout India, and progressing a significant portion of Indian banking online with internet banking (Kumar, 2021).

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Banking innovations in the past

Society For Worldwide Interbank Financial Telecommunications (Swift)

SWIFT was founded as an intergovernmental organization in May 1973 and currently has 239 affiliated organizations from 15 different nations. The headquarters is in Brussels. The RBI, along with 27 other public sector banks and 8 foreign banks, became members of SWIFT in 1977. SWIFT offers a quick, safe, dependable, and affordable way to send financial messages across the globe. SWIFT was upgraded in the 1980s to accommodate the increase in message volume; this form is known as SWIFT-II. Indian banks are connected to the SWIFT-II network. A reputable international means of advanced message transportation is SWIFT. This kind of money transfer is reliable, safe, and cost-effective. Additionally, this network makes it convenient for messages about fixed deposits, interest payments, inflow-outflow statements, foreign currency, etc. to be transferred. This is offered 365 days a year, around-the-clock (Kumar & Pavithra, 2017).

Automated Teller Machine (ATM)

It is a type of electronic device that a consumer uses to deposit, withdraw, and perform other financial transactions (Deolalkar, 1998). The ATM facility is accessible 24/7. This card bears the customer's name. The magnetically recorded data on this card can be accessed by the device. Each cardholder receives a personal identification number (PIN) that is kept confidential. The customer must insert his card in the machine's slot and follow the instructions to withdraw the money (Indian Banking, 2004).

Electronic Clearing Service (ECS)

A committee was established by the RBI in 1994 to examine the electronic clearing service as well as the mechanization of banks. The committee suggested in its report that all business bodies and government institutions should have access to electronic clearing services and credit clearing facilities for processing frequent small-value payments including dividends, interest, refunds, salaries, pensions, and commissions. The committee also suggested that pre-authorized debits for payments of utility bills, insurance premiums, and instalments to leasing and financing businesses be made through the Electronic Clearing Service-Debit clearing (Kumar & Karthik, 2013).

Telebanking

Another technological advancement that provided customers the facility of 24-hour banking was telebanking (Lakshmi et al., 2009). Telebanking relies on the voice recognition capability found on a bank's system and provides the caller with an appropriate response. The user can check the transaction details whenever he/she calls the bank (Lakshmi et al., 2010). In this method, a modem is used for linking the bank's computers to a telephone line. Some banks also utilize telephone answering machines; however, these are only used for a few limited activities (Venkataganesan et al., 2016).

Chip card

The bank issues a specific kind of credit card to each of its customers that bears their name, code, and other information. The customer account's credit balance is magnetically recorded on the card. These magnetic dots may be read by the computer (Kanniga& Sundararajan, 2013). From the moment a customer uses the card, the credit amount reflected on it starts to decline. The cardholder is required to put cash into his account before making any additional card purchases. Once more, the credit amount is written on the card using a magnetic method (Venkatesh & Ramachandran, 2014).

Internet Banking

The ability to do monetary transactions online through a bank's website is known as internet banking (Suganthi & Senthilkumar, 2015). It is a method of using a computer to access accounts and basic details about bank's offerings while being at the comfort of home (Thooyamani et al., 2014). While in the conventional banking system a customer had to visit the bank branch physically for cash withdrawals, cash deposits, account statement requests and so on

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(Nivethitha & Brindha, 2014). All these types of transactions can now be performed by anyone using the bank's website and a computer. These transactions employ advanced multi-layered security framework, including firewalls and filters, and are encrypted (Mathew & Brindha, 2014).

Recent trends in banking
In India, banking has undergone significant developments. Banking has been at the forefront of advancements brought about by the newest technology and swift actions taken by the industry and the administrators, from the cash withdrawals at counters to now 24X7 accessibility of all bank services, to Fintech's redefining payments and loans. Banks have changed from being a place to store cash to a platform for financial services. They provide for practically all a person's direct and indirect requirements by providing them with financial goods or services that improve their quality of life. The industry has advanced farther and more quickly during the last two years. Banks are increasingly concentrating on experience-driven, platform-based banking, utilizing the bigger ecosystem, for the routine financial services experience to transition to a totally virtual environment. The prospects of digital banking in India have effectively gained an entirely novel aspect because of Covid-19. The usage of digital technology in India grew rapidly during the pandemic.   Transition was facilitated at the local level by the introduction of new digital engagement from other financial firms (Bank of Baroda, 2022).

Digitisation
Digitizing processes and reinventing digital technologies are today's top strategic banking priorities as banks aim to increase efficiency and modernize their infrastructure across the board. Processes like customer onboarding have already seen a change from paper-based to digital onboarding. Today's customers, however, look for customized service designs that are interesting and in line with what Internet businesses are delivering. To meet the customer's expectation, banks must therefore speed up the digitisation process. It will result in fundamental process changes that will lower costs, increase employee productivity, and facilitate smooth customer interactions.

Growth of banking as a service (BaaS) Model
As banks permit other partners to utilize their core infrastructure, which includes technology and regulatory licenses, to expand their products and services to a larger market, the idea is emerging as a game-changer for many of them. Banks profit greatly from this since downstream organizations like FinTechs, NBFCs, NEO Banks, and others use their services to access novel markets and clientele. With the use of BaaS, banks can act as a market for financial products due to their regulatory arbitrage.

Modernising payments
The backbone of the Indian economy is its payment and settlement systems. The pandemic has been crucial for the digital payments sector specifically since it has ushered in new advances, which have been supported by regulatory assistance, technological breakthroughs, and industrial transformation. This expansion has largely been facilitated by UPI. However, upgrading the infrastructure to support digital payments is necessary to create a strong payments ecosystem. Due to the expanding adoption of e-commerce and the growing number of physical acceptance points, Cards—namely credit, debit, and prepaid—are currently one of the reliable drivers to the expansion of digital payments.

The proliferation of Super apps
The days of using an app to access a specific service are long gone. For instance, many apps that initially served a single purpose have evolved to offer a variety of services in order to increase their portion of the user's pocket. For its consumers to be able to utilize their apps for all their daily requirements, banks must put in a lot of work and money. In order to anticipate what the user will need next, banks will need to rethink their customer journeys and point of encounter, leveraging data to inform logical recommendations and ideas. These are all essential elements of how banks can increase their users' wallet shares. Fintech's are helpful partners in the transition from a single-use case

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interface to a daily use app since they not only operate as integrators of such complementary services but also have a keen understanding of how to use data to create a truly wonderful customer experience.

Collaboration with FinTech

The future lies in partnership-based growth in a disruptive environment. Due to historical issues and a complicated decision-making process, banks are less adaptable and sensitive to shifting market conditions. For instance, many banks struggle to expand their card business despite possessing lucrative retail franchisees. Banks need the ability to introduce card schemes that are tailored for a consumer with all the characteristics that such a customer demands because cards (including credit, debit, and other types) are significant income generators. On the contrary, FinTech's are designed to be incredibly adaptable and sensitive to markets. Currently, banks and fintech companies work together to open accounts, manage balances, carry out transfers, invest in savings products, and provide access to prepaid/multi-currency instruments as well as on-demand short- and long-term credit products. They can support banks in expanding their clientele, broadening the market for financial services, particularly lending, and boosting GDP. Overall, this can lead to reduced transaction and acquisition costs, faster processing times due to digitization, the use of multiple media like mobile, and increased consumption among consumers, particularly young people through influencing their choices (BFSI, 2022). According to the RBI, the banking institutions in India are well-funded and subject to tight regulations. India has much superior monetary and economic standing than any other country in the world. Recently, cutting-edge banking methods like payments and small finance banks have been established. India has recently focused on enlarging the reach of its banking system through several programs, including the Pradhan Mantri Jan Dhan Yojana and Post Payment Banks. Such initiatives have notably accelerated financial inclusion in India and quickened the country's credit cycle along with extensive banking sector reforms including neo-banking, digital payments, the expansion of Indian NBFCs, and fintech. The Immediate Payment Service (IMPS), the only payment method ranked at level five in the Faster Payments Innovation Index (FPII), has experienced the fastest growth in its digital payments' infrastructure among the 25 nations. In recent years, India's Unified Payments Interface (UPI) has functioned to broaden its universal reach and transformed real-time payments (Indian Brand Equity Foundation, 2023).

Risks, challenges and potential vulnerabilities associated with the integration of IT in the banking sector

The integration and significant dependence on information technology (IT) in the changing terrain of modern banking has created numerous opportunities and breakthroughs. But there are challenges and dangers along this path to transformation. A number of risks, difficulties, and vulnerabilities arise when banks digitize their operations more and more; these need to be carefully considered and strategically mitigated. As researchers like Kumar et al., (2021) indicate, the field of cybersecurity becomes increasingly important due to dangers ranging from sophisticated cyber-attacks to data breaches. There are numerous operational concerns, including the possibility of interruptions, outages, and difficulties during data migration while implementing new IT systems (Acharya et al., 2019). The complex world of regulatory compliance is explored by He et al., (2020), who highlight the legal repercussions that may arise and the delicate balancing acts that must be performed in order to adjust to rapidly changing technology landscapes. The intricate obstacles that banks have in navigating this digital frontier include vendor and supply chain risks, customer privacy issues, the threat of technological obsolescence, and the human element in IT security. In order to maintain the advantages of technological integration and strengthen the resilience of the banking industry, it is critical that banks have a thorough awareness of the risks and challenges associated with the rapidly changing financial technology landscape.

Cybersecurity risks

A major risk for the banking industry is cybersecurity. Banks are susceptible to a range of cyberthreats, including malware, phishing, and hacking (Kumar et al., 2021). The likelihood of cyberattacks and data theft has increased as banks depend more and more on digital channels for consumer communications and transactional processes.

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Operational challenges

The deployment of new IT systems may encounter operational issues that result in service delivery interruptions, system outages, and challenges with data migration management (Acharya et al., 2019). The general effectiveness and dependability of banking operations may be impacted by these difficulties.

Regulatory compliance and legal risks

The banking industry is subject to stringent regulatory systems. Technology advancements may make compliance more difficult, and breaching regulations may have legal repercussions (He et al., 2020). To minimize legal concerns, IT systems must be in compliance with regulations.

Customer privacy concerns

The gathering and processing of large volumes of consumer data by banks for tailored services raises the possibility of privacy violations. Consumer mistrust of financial institutions might be worsened by anxieties about data privacy and possible exploitation of personal information (Kshetri, 2020).

Vendor and supply chain risks

Banks frequently depend on outside suppliers for IT solutions. Because of this reliance, there are dangers related to these suppliers' security policies. Significant risks can arise from problems like supply chain vulnerabilities and relying on outside parties for essential services (Schneier, 2021).

Technology obsolescence

Existing IT infrastructure may become outdated as a result of rapid technological improvements. According to Mohanty et al., (2016), banks may encounter difficulties in keeping up with the rapid advancement of technology and may encounter difficulties in upgrading their legacy systems.

Human factor risks

Mistakes committed by employees, deliberate wrongdoing, or ignorance of cybersecurity procedures can all be serious hazards. Internal risks could be caused by inadequate programs for awareness and training (Safa et al., 2019).

Financial fraud and identity theft

A greater dependence on digital transactions puts banks and their clients at risk of identity theft and financial fraud. Cybercriminals could take advantage of flaws in online systems to commit fraud (Jang-Jaccard et al., 2019).

CONCLUSION

A phenomenal talent pool is driving the banking and financial technology change in India. Innovation in digital banking will open possibilities for client inclusion if there is a willingness to adapt, parallel effort on the part of the government, and close monitoring by the RBI. The size and complexity of the Indian banking system will continue to increase as it drives the nation's economy forward and integrates various financial sector components. It follows logically that both domestic dynamics caused by continued returns and international trends in the financial sectors will affect how Indian banking develops in the future. With the aid of information technology, banking has been reformed and reengineered, and it is certain that, as product and process advancements continue, individuals will receive enhanced amenities from banks in the future. On a whole, banks must use a diverse and proactive approach to overcome the risks and difficulties associated with the integration of information technology. Strong cybersecurity measures must be put in place, operational difficulties must be addressed with careful planning and phased implementation, and regulatory compliance must be seen as a chance for creativity. Clear communication with

clients about data protection, robust vendor due diligence, and a commitment to continual innovation can jointly mitigate possible weaknesses. Establishing a robust and customer-focused digital banking ecosystem is facilitated by industry collaboration, alliances with cybersecurity specialists, and the integration of cutting-edge technology like artificial intelligence. Banks can ensure the security of their operations and position themselves for long-term success in the changing financial landscape by adopting these measures and navigating the challenges of technology integration.

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RESEARCH ARTICLE

Analyzing Various Performance Metrics Working upon Transfer Learning Approach for Object Detection from Fruit Images

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ABSTRACT

A computer vision approach, which helps in locating various elements in an image/video can be called as object detection. Various CNN models can be built for processing the input, with efficient accuracy score. In this paper, an approach of Deep Learning, known as Transfer Learning is used for measuring the performance of various pre-trained models for detecting objects from fruit images. Fruits360 dataset is used for testing and training the pretrained models. Performance metrics of various pretrained models like VGG16, VGG19, MobilenetV2, GoogleNet, InceptionV3, ResNet18, ResNet50, DenseNet121 and Alexnet are evaluated and compared using Fruits360 dataset for object detection.

Keywords: Object Detection, Performance Metrics, Pretrained Models, Fruits360 dataset, Transfer Learning

INTRODUCTION

Computer vision has been recognized as one of the most important applications of Deep Learning concepts, which has its primary focus on extracting the metadata of the image or video input to the convolutional neural network. This extraction is possible with the help of certain detection techniques like detecting objects from the image/video, motion detection, cluster based detection, detection based on features like color, shape, etc.[1][3] In this paper, one of

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the techniques of metadata extraction, i.e. object detection is used to detect the objects from the images. This approach can be implemented by creating a convolutional neural network and providing the set of training images as an input to it, or by using the concept of Transfer Learning, which gives the provision of using the predefined CNN models, and hence one doesn't need to create a CNN model from the scratch [2]. The concept of Transfer Learning improves the performance of object detection application by reducing the training and testing time of the model while the larger datasets are provided for input to the neural networks. Also, unlike common CNN models, the models defined by the Transfer Learning approach, also known as Pretrained Models, doesn't require the training and testing dataset to be mutually dependent on one another.[2]As discussed, the transfer learning approach for object detection, using various pre-trained models is used in this work. The models used are namely VGG16, VGG16, VGG19, MobilenetV2, GoogleNet, InceptionV3, ResNet18, ResNet50, DenseNet121 and Alexnet. These models are trained using Fruits360 dataset [4], which contains 131 classes of fruits, with 90,483 sample images [5], out of which 67692 images (one fruit or vegetable per image) are used for training and 22688 images (one fruit or vegetable per image) are used for testing [4]. In this paper, various performance metrics like training and validation accuracy, Kohen's Kappa Value, F1 Score, Precision Score, Recall, etc.[6] have been evaluated to compare the pre trained models mentioned above. In the present work, the values of the parameters used to evaluate the performance of the pretrained models, apart from those mentioned above, have been kept fixed for each and every model. For instance, the number of classes in the dataset is 131, batch size for training the model is 128, number of epochs for training the pretrained model is 5, learning rate for the model is set to 0.01 and the mean and standard deviation values set to [0.485, 0.456, 0.406] and [0.229, 0.224, 0.225] respectively.

Pretrained Models

Using pretrained models in the deep learning applications has been considered one of the dominant approach in the transfer learning methodology. This approach is useful in advancing the model performances where there is a presence of subsequent amount of noise in the input dataset. [7]. Some of the applications of pretrained models include: Natural Language Processing, Computer Vision, Content Creation and Virtual Assistants [7]. The VGG16 model is the simplest of all the models available in Keras Library. The architecture is divided into two parts- Convolution Base which is being developed from a sequence of connecting layers, also known as MaxPooling2D and convolution layers, i.e. Conv2D. The other part of the architecture is the classifiers are densely connected and situated at the latter part of the network. This architecture is found suitable for classification problems used in image processing. The important point to note about this architecture is that the outputs produced by this model is based on the tested dataset of image classes on which the model was trained.[13]VGG19 is CNN model which has 19 layers in its architecture. This pre-trained model is capable of classifying the images belonging to almost 1000 categories, which is the result of its training over millions of images from the ImageNet dataset[12]. The 19 layers of this model consists of 16 convolutional layers and three layers which are fully connected [14]. The GoogleNet architecture has been considered to be the first application of the modern neural networks architectures, which uses the Inception model, and isdoes not consist only sequential convolution as well as pooling layers. There are around 7 million parameters in this architecture.[15].The presence of inception modules, this architecture becomes complex structurally, and also utilizes more memory and power. This might also result in increase of memorization.[16].

Resnet18 and Resnet50 are collectively a part of a transfer learning approach known as Residual Network. This network is more deeper than the normal artificial neural networks. Hence, it increases the accuracy and eases the training of the architecture.[17]. The residual networks come in may variants, based on the number of layers it consists, viz. 18 layer, 34 layer, 50 layer, 101 layer, 152 layer. The Densenet121 architecture inculcates the coupling of each layer in a feed forward manner. Suppose there are X layers in the model, then the number of direct connections will be $X(X+1)/2$. The model merges the output features with the input features, and hence, it becomes important for each layer to gain the collective knowledge of its previous layers.[18] .This architecture is best suitable for the models of the neural networks where it is necessary to reduce the gradient problem, keeping the minimum number of parameters, and feature reusability.The only drawback of this architecture is the excessive usage of memory due to the concatenation of the tensors. For InceptionV3 architecture, there is a sequence of layers which are used to divide and bunch the relationship statistics of the last layer with high connections. These bunches are used to shape the

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units of the past layer. It has been defined previously that every unit from the former layer will be compared with some portion of the input image and then the bunch of these units would be assembled together into filter banks. [18]. The MobileNet architecture is being designed considering the convolutions that can be separated on the basis of the depth of the network architecture. This results in a lightweight deep convolution network that shrinks the overall size of the network and as a result, reduces the computation time for training and validation. This architecture has its core applications in detecting objects from images, face detection algorithms, classification and other computer vision applications.[19]. The last pretrained model used, AlexNet, is able to handle multiple GPUs , and the network is designed to handle larger images of the dimensions 224x224x3. It has a capacity to train 62 million parameters in total.[20].

Comparison of the pretrained models

The performance of the above mentioned pretrained models was measured using the metrics like Training and Validation Accuracy/Loss to train the model, Accuracy, Precision, Recall, F measure, Coheran's Kappa value, discussed in this section.

Training and Validation Accuracy

The model was provided the Fruits360 dataset to classify the fruit images, belonging to 131 predefined classes. The number of epochs to be processed were limited to 5, and the learning rate set to 0.01. From this, we had tried to obtain the training accuracy, as well as validation accuracy, depicted in the following:

Accuracy

To evaluate any deep learning model, it is necessary to get the number of correct and incorrect predictions/classifications. This may be classified into True Positive (i.e. predicted and actual values are same and positive), False Positive (predicted values are positive but the actual outcomes are negative), False Negative (predicted values are negative but the actual outcomes be positive), and True Negative (both the predicted as well as actual values are negative). For any pre-trained model used for classification of images, the accuracy of the model can be observed by dividing the total number of correct classifications by the total number of classifications possible. From the above description of the possible classifications, we can obtain Accuracy of the model using the following formula:[6]

$MODEL\ ACCURACY = \frac{TP+TN}{TP+FP+FN+TN}$ ……………………………………………….(1)

In this work, the observed accuracies of all the pretrained models used are as depicted in the following chart:

Precision

The precision parameter of a pretrained model gives the proportion of the classification values which are actually true positive. This value indicates how reliable a model is to classify the correct class of interest. The value of precision can be obtained using the following equation: [6]

$PRECISION = \frac{TP}{TP+FP}$ ……………………………………………………(2)

The following graph depicts the precision values of the pretrained models used:

Recall

This metric gives the observed values of true positive cases with respect to the total positive cases. For example, in our dataset, the proportion of the total objects detected as kiwi which were classified correctly is defined by Recall. One can calculate the recall value using the formula:

$RECALL = \frac{TP}{TP+FN}$ …………...……………………………………………(3)

The following graph shows the observed values of recall for the pretrained models used.

F-Measure

This gives the harmonic mean of the precision and recall values, which is calculated as

$F\ MEASURE = \frac{2 X PRESCISION X RECALL}{PRECISION\ + RECALL}$ ………………………………………….(4)

Cohen's Kappa

It may happen in certain cases that both True Positive as well as True Negative values may happen together coincidentally. This causes the accuracy value to rise drastically, but ideally this should not happen. The Cohen's Kappa value is calculated as below:

Kappa Value (k) $= \frac{P(a) - P(p_r)}{1 - P(p_r)}$ …………………………………………(7)

P(a)=proportion of observed argument between actual and predicted in overall dataset

$= \frac{TP + TN}{TP + FP + FN + TN}$

$P(p_r)=$ Proportion of expected agreement between actual and predicted data both in case of class interest as well as the other classes.

$= \frac{TP + FP}{TP + FP + FN + TN} X \frac{TP + FN}{TP + FP + FN + TN} X \frac{TN + FN}{TP + FP + FN + TN} X \frac{TN + FP}{TP + FP + FN + TN}$

Observing the values obtained for the above mentioned performance metrics, we can summarize the observations in the following table:

CONCLUSION

This paper observed the performance of the pretrained models used for object detection using the Fruits360 dataset. The performance metrics for measuring the same has been described in detail. From the observations, we can say that AlexNet Model gave the maximum accuracy for object detection in lesser amount of time taken, as compared to the other pretrained models. DesnseNet and GoogleNet had near about 95% accuracies respectively, which can also be considered remarkable, but DenseNet took more amount of time than AlexNet and GoogleNet both. ResNet also had 95% accuracy but took the maximum training time. Hence, observing all the performance metrics, AlexNet model was found to be the most efficient pretrained model for object detection.

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Table 1: Final Observations for Performance metrics of pretrained models

Models -> Metrics ↓	VGG16	VGG19	GoogleNet	ResNet18	ResNet50	InceptionV3	MobileNetV2	DenseNet121	AlexNet
Training Accuracy	72%	69%	88%	91%	91%	99%	98.18%	98.18%	89%
Validation Accuracy	91%	88%	95%	95%	95%	98.8%	95.72%	95.72%	82%
Accuracy	91%	88.4%	94.8%	95.3%	94.7%	94.3%	93.47%	97.32%	99.20%
Precision	81%	90%	96%	96%	96%	94.6%	94.6%	97.6%	88%
Recall	67%	88%	95%	95%	95%	94%	93.40%	97.30%	82%
F Measure	67%	88%	95%	95%	95%	94%	93%	97%	80%
Cohen's Kappa	66.3%	87.9%	94.8%	95.16%	94.8%	93.9%	93%	97.3%	81.45%

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Fig. 1: Comparing the training accuracy and validation accuracy of the pretrained models

Fig. 2: Comparing the accuracies of the pretrained models used

Fig. 3: Comparing the Precision values of the pretrained models used

Fig. 4: Observed values of recall for the pretrained models used

Fig. 5: Observed Values for F-Measure for the pretrained models used

Fig 6: Observed Kohen's Kappa Values

RESEARCH ARTICLE

Plithogenic Cognitive Maps with Extended Plithogenic Sociogram Approach in Decision Making

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ABSTRACT

Plithogenic Cognitive Maps (PCM) are attribute centric, robust and flexible decision-making models that facilitate in investigating the relational impacts between the factors of the study. PCM models are a generalized form of cognitive maps discussed with various representations of sets. This paper introduces an alternate decision approach to PCM integrating with Extended PlithogenicSociogram (EPSo). In this newly designed integrated approach, both the dominant and the recessive attributes are considered to make comprehensive decisions. The proposed blended approach is advantageous as it facilitates to study the extent of the relational impacts between the factors subjected to significant attributes of the factors. This method also assists to determine the most influential factor which will benefit the decision-makers to strategize and devise suitable policies and framework as further course of action. The efficacy of the model is illustrated by applying to make decisions on the factors promoting green industries.

Keywords: Plithogenic Cognitive Maps, PlithogenicSociogram, Green Industries

INTRODUCTION

Plithogenic theory is purely attribute based and it is considered to be the generalization of all types of set representations The inclusive nature of Plithogenic sets of the form (P,a,V,d,c) has drawn the attention of researchers to develop Plithogenic based decision models. This quintuple Plithogenic sets is more concerned on the dominant attribute values subjected to each of the attributes. A decision instant which is primarily concerned over the

significant attributes values facilitates in accepting the ideal alternatives. However, it is equally essential to consider the recessive attribute values also to make decisions on eliminating the alternatives. Sudha et al [1] discussed the notion of Extended Plithogenic sets (EPS) which includes the concept of recessive attributive values. The extended version of Plithogenic sets is a seven tuple of the form (P, a, V, dD,cD,dR,cR) where d, the degree of appurtenance and c, the degree of contradiction considered with respect to both the dominant and recessive attributive values. Researchers have developed several Plithogenic based decision models, however, the models based on extended Plithogenic sets are very limited in literature. A few decision models integrating Extended Plithogenic sets with Plithogenicsociogram, Plithogenic multi-criteria decision making and Plithogenic cognitive maps are constructed. Plithogenic Cognitive Maps are developed to study the interrelational impacts between the factors using Plithogenic theory. The PCM models developed by Martin and Smarandache [2]are more generalized in nature to accommodate any kind of representations. Researchers have formulated many Plithogenic based PCM models such as New Plithogenic sub cognitive maps, Induced Plithogenic Cognitive Maps, Plithogenıc Combined Disjoınt Block Fuzzy Cognitive Maps, PCM with Linguistic Contradiction Degree Representations. PCM models are also applied in several domains of medical, spiritual intelligence and many other. Martin and Smarandache[9] jointly worked on the theoretical arguments of PlithogenicSociogram. Sudha et al [1] discussed PlithogenicSociogram with extended Plithogenic sets and evolved the notion of Extended Plithogenic Sociogram. The decision approach based on EPS is applied as an alternative to Plithogenic based multi-criteria decision making. PlithogenicSociogram is integrated with Plithogenic Cognitive Maps to devise a novel decision-making method. Plithogenic Cognitive Map models basically investigate the interrelational impacts between the factors of the decision problem and the integrated Plithogenicsociogram based Plithogenic Cognitive Map approach facilitates in identifying the most influential factors. Based on this integrated approach, in this research work, a similar kind of blended decision approach is formulated with extended PlithogenicSociogram. The efficacy of the proposed hybrid approach is measured by applying to find the most influential factor contributing to the promotion of green industries. On investigating the need of such a hybrid model, the following research gaps are identified,

(i)   The PCM model in general facilitates only in determining the interrelational impacts between the factors of the study

(ii)   PCM based PlithogenicSociogram decision model helps in identifying the most influential factor using the interrelationships only with respect to the dominant attribute values. However, the above-mentioned decision models do not consider the recessive attribute values and this lacks the holistic approach of making optimal decisions. This has motivated the authors to develop a more holistic model by including both the dominant and recessive attribute values. The remaining contents of the paper are presented in the following sections. The methodology of the integrated approach is presented in section 2. The application of the proposed approach is discussed in section 3. The results are discussed in section 4 and the concluding remarks with future directions are presented in section 5.

Methodology of Integrated Approach of PCM and EPSo

This section presents the steps followed in the newly introduced integrated approach of PCM and EPSo.

Step 1: The problem definition is the first step in which the problem to be resolved is considered with therelated core factors say F1,F2,..Fm (Attributes) and the sub-factors (Attribute values) say F11,F12,….F1j, F21,F22,…,F2k, ……, Fm1,Fm2,…Fmy. The decisive factors day D1,D2,..,Dn whose interrelational impacts are to be investigated are also determined together with the choices the of dominant and recessive attribute values.

Step 2: Based on the domain experts, the proximity between the decisive factors or the associational impacts between the factors are determined with respect to the dominant attribute values pertaining to each of the attributes. Let us consider an expert E1 using the representations of the form {D2((F1j)(dβj),F2k(dβk),… Fmy(dβy)), D3((F1j)(dαj),F2k(dαk),… Fmy(dαy)), … Dn((F1j)(dμj),F2k(dμk),… Fmy(dμy))} to state the decisive factors such as D2, D3,..Dn having proximal relation with the decisive factor say D1 with respect to the dominant attribute values. The values dβj, dβk,.. dβy are the degrees of appurtenance stating the proximal relationship between the decisive factors.

Step 3: The above step is repeated with respect to the recessive attribute values to determine the deviations between the decisive factors. In this case, the degrees of appurtenance state the deviance in relationship between the decisive factors.

Step 4 : The Evaluation matrix with respect to each of the dominant attribute value and recessive attribute value is formulated to and the combined evaluation matrix is also determined by considering the weight of the attribute values (both dominant and recessive) and the weightage given to the experts.

Step 5 : The Plithogenic amicability degree with respect to dominant attribute value say tD_{gh}, is calculated using $\frac{2}{tD_{gh}} = \frac{1}{fD_{gh}} + \frac{1}{fD_{hg}}$ and the Plithogenic non-amicability degree with respect to recessive attribute value say tR_{gh}, is calculated using $\frac{2}{tR_{gh}} = \frac{1}{fR_{gh}} + \frac{1}{fR_{hg}}$, Where fD_{gh} presumes the associational impact between the factors g and h and fD_{hg} represents the associational impact between the factors h and g in proximal sense, also, fR_{gh} presumes the deviational impact between the factors g and h and fR_{hg} represents the deviational impact between the factors h and g in deviance sense. The values say tD12 with respect to dominant attribute value and tR12 with respect to the recessive attribute value determines the range of values stating the extent of associational impacts.

Step 6 : The most influential factor shall be determined with respect to the dominant attribute value using $\frac{\sum_h tD_{gh}}{\sum_g \sum_h tD_{gh}}$. The extent of diminishing the possibilities of ranking the influential factors shall be determined with respect to the recessive attribute values using $\frac{\sum_h tR_{gh}}{\sum_g \sum_h tR_{gh}}$.

Step 7: The final ranking of the factors is determined by finding the differences between the score values with respect to the associational and deviational impacts considering equal and unequal weightages.

Application of the Integrated Approach in Decision making on Promoting Green industries
In this section, the novel integrated approach proposed in section 2 is applied to make decisions on the factors influencing the promotion of green industries.

Problem Definition
Industrial sectors are mostly contributing to the economic growth of every nation and equally contributing to the environmental deprivation. The onset of several industries has been drawing the end of the natural resources and puts the future generation to a large disarray. It is quite inevitable for the industrial sectors to minimize their production as such course of actions will certainly affect the functioning of the populace resulting in shortages. This is the vantage point where the industries are compelled to be eco-friendly and this is the origin point of Green Industries. In the context of Green industries, the industrial sectors are expected to practice green initiatives in all its activities of pre-production, production and post production. But, how does these industries shall promote green environment or the sustainable environment. What are the aspects should these industries consider in promoting eco-sustainability? Which action-based initiative shall be concentrated more or which factor shall be implemented based on their flexibility? These are some of the practical problems faced by the industrial sectors on promoting green industries. To resolve this, the proposed approach is applied as follows

Literature review on the attributes of Green industries
The green industries are the need of the hour and the attributes or the characteristics of the green industries are to be identified to decide the decisive factors. The following table 1 presents the state of art with respect to some characteristics of green industries and they are determined as the core attributes.
The above table clearly explicates that the environmental researchers have strongly favoured the above-mentioned characteristics of green industries and henceforth they are considered in the further modelling procedure.

Expert's Opinion on Attributes, Attribute Values, Decisive Factors, Dominant and Recessive Attribute Values.
The experts chosen from the environmental domain have given their expertise in making initial decisions on the following:

Decision on Attributes

The attributes considered for modelling are presented in Table 2 and they are determined with the assistance of expert's opinion and the literature review of the work mentioned in Table 1.

Decision on Sub Attribute Values

Since the model is embracing the theory of Plithogeny, the sub attribute values of each of the attribute is determined and presented in Table 3.

Decision on the Decisive Factors proposed for promoting Green Industries

The following factors are considered as the decisive factors based on the Expert's opinion and the intention is to find the most influential factor.

F1: Establishing collaboration with the stakeholders to evolve green practices

F2: Integrating eco-friendly technologies to create carbon neutral communities

F3: Formulating policies and strategies backing renewable energy and sustainable practices

F4: Exercising corporate social responsibility endeavours.

F5: Developing products with eco-consciousness and societal concerns

Decision on Dominant and Recessive Sub Attribute Values

The dominant and recessive sub attribute values are decided based on the opinion of the experts and it is presented in Table 4.

Determination of the Influential Decisive Factor using the integrated approach

Case (i) Proximity Between the Factors with respect to the Dominant Attribute Values

The expert's opinions are considered in determining the factors proximal to one another based on the dominant sub attribute values and are presented in Table 5.

The Evaluation matrices Mi, (i = 1,2..5) for each of the dominant sub attribute values are presented in Table 6.

Case (i a) Sub Attribute Values with Equal Weightage. In this case, the sub attribute values are assumed equal weightages of 0.2 each and the combined evaluation matrix is computed using step 4 and it is presented in Table 7. The amicability degree is determined using the step 5 and it is sketched out in Table 8. The respective score values of the decisive factors with respect to equal sub attribute weightages are presented in Table 9

Case (i b) Sub Attribute Values with Unequal Weightage

In this case the sub attribute values are assumed different weightage values based on the expert's opinion. (AT11 = 0.1, AT21 = 0.2, AT31 = 0.3, AT41 = 0.2, AT51 = 0.2)

The amicability degree is computed as follows and it is presented in Table 11. The respective score values of the decisive factors with respect to unequal sub attribute weightages are presented in Table 12

Case (ii) Deviance Between the Factors with respect to the Recessive Attribute Values

The expert's opinions are considered in determining the factors deviant to one another based on the recessive sub attribute values and are presented in Table 13.

The Evaluation matrices Ni, (i = 1,2..5) for each of the recessive sub attribute values are presented in Table 14.

Case (i a) Sub Attribute Values with Equal Weightage

In this case, the sub attribute values are assumed equal weightages of 0.2 each and the combined evaluation matrix is computed using step 4 as in Table 15. The non-amicability degree is determined using the step 5 and it is presented in Table 16. The respective score values of the decisive factors with respect to equal sub attribute weightages are presented in Table 17

Case (i b) Sub Attribute Values with Unequal Weightage

In this case the sub attribute values are assumed different weightage values based on the expert's opinion. (AT13 = 0.2, AT23 = 0.3, AT33 = 0.2, AT43 = 0.1, AT53 = 0.2).The combined evaluation matrix is presented in Table 18.

The non-amicability degree is computed as follows and it is presented in Table 19. The respective score values of the decisive factors with respect to unequal sub attribute weightages are presented in Table 20. The ranking of the factors is determined by finding the difference in the score values obtained with respect to both dominant and recessive attribute values. The final ranking of the factors under two cases of equal and unequal weightages are presented in Table 21.

Comparative Analysis
This section compares the efficacy of the proposed approach of Plithogenic Cognitive Maps with Extended PlithogenicSociogram with the extended plithogenic cognitive maps. The former ranks the factors considering both the associational and deviational impacts whereas the latter represents the associational impacts between the factors with respect to both dominant and recessive attribute values. The extended plithogenic cognitive analysis of the factors is determined as follows:

Formulation of Plithogenic Connection Matrix
The Plithogenic connection matrix is developed which state the expected associational impacts between the factors in terms of fuzzy values and it is presented in Table 22.

Contradiction degrees of the Factors with respect to the Dominant and Recessive Attribute Values
The impact between the factors is determined using the contradiction degree presented in Table 23
The associational impacts between the factors are determined using the approach discussed by Angel et al and the results are presented in Table24

Inferences
The rankings of the factors presented in Table 13 facilitates in identifying the most crucial factor in promoting the green industries. The rankings obtained with respect to equal and unequal weightages of the attribute values result in an almost similar manner. It is evident that the factor F1 is more significant and it is more influential amidst other factors in both the cases of equal and unequal weightages. Moreover, the inter associational impacts are presented in Table 15 which shows the relational impacts between these factors with respect to each of the dominant and recessive attribute values. This will facilitate the decision makers to identify the influence of each of the factors with respect to specific attribute values. However, the Extended Plithogenic cognitive map approach assists only in determining the associational impacts between the factors but not in identifying the influential factor. This is resolved with the integrated approach proposed in this work. The amicability and non-amicability degrees with respect to the attribute values states the relational impacts and the ranking of the factors identifies the influential factor.

CONCLUSION

This research work presents a hybrid decision making method integrating Plithogenic cognitive approach with extended Plithogenicsociogram approach. The proposed approach facilitates in identifying the influential factor in addition to the relational impacts between the factors. The validity of the decision-making model is determined by applying it to the context of finding the most influential factor that the business people or the policy makers shall implement to promote green industries. This integrated model shall be further developed and extended by embracing different kinds of Plithogenic representations.

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Table 1. State of Art of the Characteristics of Green Attributes

Characteristics of Green Industries	Authors & Year
Resources Utilization	Evan.,2014 [11], Park.,2015 [13], Susanto et al.,2023 [12], Yadav et al.,2024 [14]
Carbon Neutrality	Gang.,2023 [15], Yang et al., 2023 [17], Xu et al.,2024 [16]
Sustainable Technology Interface	Roy et al.,2017 [19], Luo et al.,2019 [21], Patil.,2022 [18], Zhao et al.,2022 [20].
Waste Management	Ashok.,2010 [23], Sartz et al.,2017 [22], Jarnerud et al., 2021 [24], Banerjee et al.,2021 [25],Ahmmed et al., [26]
Environmental Conservation	Ho.,2014 [28], Dhull and Narwal.,2017 [29], Xu et al., 2021 [30], Zhou et al., 2023 [27]

Table 2. Description of the Attributes

Attributes of Green Industries	Description
Resources Utilization (AT1)	Optimal utility if the resources
Carbon Neutrality (AT2)	Minimization of carbon emissions
Sustainable Technology Interface (AT3)	Use of eco-friendly technology in production
Waste Management (AT4)	Management of different types of wastes
Environmental Conservation (AT5)	Preservation of natural resources and biodiversity

Table 3. Attribute Values

Attributes	Sub Attribute Values		
Resources Utilization (AT1)	High Efficiency (AT11)	Intermediate Efficiency (AT12)	Low Efficiency (AT13)
Carbon Neutrality (AT2)	Minimal Emissions (AT21)	Moderate Emissions (AT22)	High Emissions (AT23)
Sustainable Technology Interface (AT3)	Advanced (AT31)	Basic (AT32)	Non-basic (AT33)
Waste Management (AT4)	Effective (AT41)	Average (AT42)	Ineffective (AT43)
Environmental Conservation (AT5)	Strong (AT51)	Medium (AT52)	Weak (AT53)

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Table 4:Dominant and Recessive Sub Attribute Values

Attributes	Dominant Attribute Values	Recessive Attribute Values
Resources Utilization (AT1)	High Efficiency (AT11)	Low Efficiency (AT13)
Carbon Neutrality (AT2)	Minimal Emissions (AT21)	High Emissions (AT23)
Sustainable Technology Interface (AT3)	Advanced (AT31)	Non-basic (AT33)
Waste Management (AT4)	Effective (AT41)	Ineffective (AT43)
Environmental Conservation (AT5)	Strong (AT51)	Weak (AT53)

Table 5:Associational Impacts between the Factors based on Dominant Sub Attribute Values

Strategies	Proximal Choice-Making over Sustainability based on Dominant Sub Attribute Values	
	Expert-I	Expert-II
F1	F2(AT11(0.3), AT21(0.5), AT31(0.7), AT41(0.3), AT51(0.8)), F5(AT11(0.5), AT21(0.7), AT31(0.2), AT41(0.8), AT51(0.5))	F4(AT11(0.5), AT21(0.8), AT31(0.7), AT41(0.3), AT51(0.8)), F5(AT11(0.5), AT21(0.3), AT31(0.5), AT41(0.8), AT51(0.7))
F2	F3(AT11(0.7), AT21(0.3), AT31(0.5), AT41(0.5), AT51(0.2)), F4(AT11(0.3), AT21(0.5), AT31(0.8), AT41(0.7), AT51(0.5))	F1(AT11(0.5), AT21(0.7), AT31(0.8), AT41(0.5), AT51(0.2)), F5(AT11(0.8), AT21(0.3), AT31(0.7), AT41(0.5), AT51(0.8))
F3	F2(AT11(0.3), AT21(0.8), AT31(0.5), AT41(0.7), AT51(0.2)), F4(AT11(0.7), AT21(0.8), AT31(0.5), AT41(0.7), AT51(0.3)), F5(AT11(0.5), AT21(0.7), AT31(0.5), AT41(0.3), AT51(0.8))	F1(AT11(0.5), AT21(0.7), AT31(0.3), AT41(0.8), AT51(0.5)), F2(AT11(0.8), AT21(0.3), AT31(0.5), AT41(0.8), AT51(0.2))
F4	F1(AT11(0.7), AT21(0.5), AT31(0.3), AT41(0.5), AT51(0.7)), F2(AT11(0.8), AT21(0.5), AT31(0.7), AT41(0.3), AT51(0.2))	F3(AT11(0.2), AT21(0.5), AT31(0.5), AT41(0.8), AT51(0.3)), F5(AT11(0.5), AT21(0.7), AT31(0.5), AT41(0.3), AT51(0.5))
F5	F1(AT11(0.5), AT21(0.3), AT31(0.7), AT41(0.8), AT51(0.2)), F3(AT11(0.8), AT21(0.5), AT31(0.3), AT41(0.7), AT51(0.8))	F2(AT11(0.5), AT21(0.3), AT31(0.5), AT41(0.3), AT51(0.7)), F3(AT11(0.7), AT21(0.8), AT31(0.5), AT41(0.5), AT51(0.7)), F4(AT11(0.3), AT21(0.2), AT31(0.7), AT41(0.5), AT51(0.5)),

Table 6: Evaluation Matrices with respect to Dominant Sub Attribute Values

Matrix	Dominant Sub Attribute Values	Evaluation Matrix					
M1	AT11		F1	F2	F3	F4	F5
		F1	0	0.15	0	0.25	0.5
		F2	0.25	0	0.35	0.15	0.4
		F3	0.25	0.55	0	0.35	0.25
		F4	0.35	0.4	0.1	0	0.25
		F5	0.25	0.25	0.75	0.15	0
M2	AT21		F1	F2	F3	F4	F5
		F1	0	0.25	0	0.4	0.5

			F1	F2	F3	F4	F5
		F2	0.35	0	0.15	0.25	0.15
		F3	0.35	0.55	0	0.4	0.35
		F4	0.25	0.25	0.25	0	0.35
		F5	0.15	0.15	0.65	0.1	0
			F1	F2	F3	F4	F5
		F1	0	0.35	0	0.35	0.25
		F2	0.4	0	0.25	0.4	0.35
M3	AT31	F3	0.15	0.5	0	0.25	0.25
		F4	0.15	0.35	0.25	0	0.25
		F5	0.35	0.25	0.4	0.35	0
			F1	F2	F3	F4	F5
		F1	0	0.15	0	0.15	0.1
		F2	0.25	0	0.25	0.35	0.25
M4	AT41	F3	0.4	0.75	0	0.35	0.15
		F4	0.25	0.15	0.4	0	0.15
		F5	0.4	0.15	0.6	0.25	0
			F1	F2	F3	F4	F5
		F1	0	0.4	0	0.4	0.6
		F2	0.1	0	0.1	0.25	0.4
M5	AT51	F3	0.25	0.2	0	0.15	0.4
		F4	0.35	0.1	0.15	0	0.25
		F5	0.1	0.35	0.75	0.25	0

Table 7:Combined Evaluation Matrix

	F1	**F2**	**F3**	**F4**	**F5**
F1	0	0.26	0	0.31	0.39
F2	0.27	0	0.22	0.28	0.31
F3	0.28	0.51	0	0.3	0.28
F4	0.27	0.25	0.23	0	0.25
F5	0.25	0.23	0.63	0.22	0

Table 8: Amicability degree between the Factors

	F1	F2	F3	F4	F5
F1	0	0.2649	0	0.2886	0.3047
F2	0.2649	0	0.3074	0.2642	0.2641
F3	0	0.3074	0	0.2604	0.3877
F4	0.2886	0.2642	0.2604	0	0.2340
F5	0.3047	0.2641	0.3877	0.2340	0

Table 9: Ranking of the Decisive Factors based on Equal Weightages

Factors	ScoreValue
F1	0.16658
F2	0.21362
F3	0.18546
F4	0.20326
F5	0.23108

Table 10: Combined Evaluation Matrix

	F1	F2	F3	F4	F5
F1	0	0.28	0	0.32	0.365
F2	0.285	0	0.21	0.305	0.305
F3	0.27	0.505	0	0.29	0.28
F4	0.25	0.245	0.245	0	0.25
F5	0.225	0.23	0.595	0.24	0

Table 11 : Amicability Degree Between the Factors

	F1	F2	F3	F4	F5
F1	0	0.2825	0	0.2807	0.2784
F2	0.2825	0	0.2966	0.2717	0.2622
F3	0	0.2966	0	0.2656	0.3808
F4	0.2807	0.2717	0.2656	0	0.2449
F5	0.2784	0.2622	0.3808	0.2449	0

Table 12: Ranking of the Decisive Factors based on Unequal Weightages

Factors	ScoreValue
F1	0.16415
F2	0.21710
F3	0.18394
F4	0.20732
F5	0.22749

Table 13: Deviant Impacts between the Factors based on Dominant Sub Attribute Values

Strategies	DeviantChoice-MakingoverSustainabilitybasedonRecessiveAttributeValues	
	Expert-I	Expert-II
F1	F3(AT13(0.5), AT23(0.7), AT33(0.5), AT43(0.3), AT53(0.5), F4(AT13(0.7), AT23(0.5), AT33(0.2), AT43(0.3), AT53(0.8))	F2(AT13(0.3), AT23(0.8), AT33(0.5), AT43(0.8), AT53(0.5)), F4(AT13(0.5), AT23(0.7), AT33(0.5), AT43(0.3), AT53(0.7))
F2	F1(AT13(0.2), AT23(0.8), AT33(0.7), AT43(0.5), AT53(0.5)), F5(AT13(0.5), AT23(0.3), AT33(0.7), AT43(0.8), AT53(0.8))	F3(AT13(0.7), AT23(0.5), AT33(0.2), AT43(0.3), AT53(0.5)), F4(AT13(0.5), AT23(0.3), AT33(0.2), AT43(0.7), AT53(0.8))
F3	F1(AT13(0.5), AT23(0.3), AT33(0.7), AT43(0.8), AT53(0.5)), F2(AT13(0.2), AT23(0.3), AT33(0.5), AT43(0.7), AT53(0.8)), F5(AT13(0.7), AT23(0.8), AT33(0.3), AT43(0.5), AT53(0.7))	F4(AT13(0.5), AT23(0.8), AT33(0.7), AT43(0.2), AT53(0.3)), F5(AT13(0.5), AT23(0.3), AT33(0.8), AT43(0.7), AT53(0.5))
F4	F3(AT13(0.8), AT23(0.7), AT33(0.3), AT43(0.5), AT53(0.7)), F5(AT13(0.3), AT23(0.5), AT33(0.8), AT43(0.5), AT53(0.3))	F1(AT13(0.3), AT23(0.8), AT33(0.7), AT43(0.2), AT53(0.8)), F2(AT13(0.5), AT23(0.7), AT33(0.8), AT43(0.5), AT53(0.3)), F5(AT13(0.2), AT23(0.7), AT33(0.8), AT43(0.5), AT53(0.3))
F5	F2(AT13(0.8), AT23(0.8), AT33(0.7), AT43(0.3), AT53(0.5)), F4(AT13(0.2), AT23(0.5), AT33(0.5), AT43(0.8), AT53(0.2))	F3(AT13(0.8), AT23(0.5), AT33(0.3), AT43(0.5), AT53(0.7)), F4(AT13(0.8), AT23(0.5), AT33(0.3), AT43(0.7), AT53(0.5)),

Table 14: Evaluation Matrices with respect to Recessive Sub Attribute Values

Matrix	Recessive Sub Attribute Values	Evaluation Matrix					
			F1	F2	F3	F4	F5
N1	AT13	F1	0	0.15	0.25	0.6	0
		F2	0.1	0	0.35	0.25	0.25
		F3	0.25	0.1	0	0.25	0.6
		F4	0.15	0.25	0.4	0	0.25
		F5	0	0.4	0.4	0.5	0

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N2	AT23		F1	F2	F3	F4	F5
		F1	0	0.4	0.35	0.6	0
		F2	0.4	0	0.25	0.15	0.15
		F3	0.15	0.15	0	0.4	0.55
		F4	0.4	0.35	0.35	0	0.6
		F5	0	0.4	0.25	0.5	0
N3	AT33		F1	F2	F3	F4	F5
		F1	0	0.25	0.25	0.35	0
		F2	0.35	0	0.1	0.1	0.35
		F3	0.35	0.25	0	0.35	0.55
		F4	0.35	0.4	0.15	0	0.8
		F5	0	0.35	0.15	0.4	0
N4	AT43		F1	F2	F3	F4	F5
		F1	0	0.4	0.15	0.3	0
		F2	0.25	0	0.15	0.35	0.4
		F3	0.4	0.35	0	0.1	0.6
		F4	0.1	0.25	0.25	0	0.5
		F5	0	0.15	0.25	0.75	0
N5	AT53		F1	F2	F3	F4	F5
		F1	0	0.25	0.25	0.75	0
		F2	0.25	0	0.25	0.4	0.4
		F3	0.25	0.4	0	0.15	0.6
		F4	0.4	0.15	0.35	0	0.3
		F5	0	0.25	0.35	0.35	0

Table 15 : Combined Evaluation Matrix

	F1	F2	F3	F4	F5
F1	0	0.29	0.25	0.52	0
F2	0.27	0	0.22	0.25	0.31
F3	0.28	0.25	0	0.25	0.58
F4	0.28	0.28	0.3	0	0.49

F5	0	0.31	0.28	0.5	0

Table 16: Non-Amicability Degree Between the Factors

	F1	F2	F3	F4	F5
F1	0	0.2796	0.2642	0.3640	0
F2	0.2796	0	0.2340	0.2642	0.3100
F3	0.2642	0.2340	0	0.2727	0.3777
F4	0.3640	0.2642	0.2727	0	0.4949
F5	0	0.3100	0.3777	0.4949	0

Table 17: Ranking of the Decisive Factors based on Equal Weightages

Factors	ScoreValue
F1	0.15863
F2	0.19009
F3	0.20071
F4	0.24391
F5	0.20666

Table 18: Combined Evaluation Matrix

	F1	F2	F3	F4	F5
F1	0	0.29	0.27	0.55	0
F2	0.285	0	0.23	0.23	0.285
F3	0.255	0.23	0	0.2425	0.575
F4	0.31	0.29	0.31	0	0.5
F5	0	0.335	0.28	0.475	0

Table 19: Non-amicability Degree Between the Factors

	F1	F2	F3	F4	F5
F1	0	0.2875	0.2623	0.3965	0
F2	0.2875	0	0.2300	0.2565	0.3080
F3	0.2623	0.2300	0	0.2721	0.3766
F4	0.3965	0.2565	0.2721	0	0.4872

| F5 | 0 | 0.3080 | 0.3766 | 0.4872 | 0 |

Table 20: Ranking of the Decisive Factors based on Unequal Weightages

Factors	ScoreValue
F1	0.16447
F2	0.18806
F3	0.19832
F4	0.24548
F5	0.20367

Table 21. Final Ranking of the Factors

Factors	Score values		Ranking of the Factors	
	Equal Weightages	Unequal Weightages	Equal Weightages	Unequal Weightages
F1	0.00795	0.00032	1	1
F2	0.02353	0.02904	3	4
F3	0.01525	0.01438	2	2
F4	0.04065	0.03816	5	5
F5	0.02442	0.02382	4	3

Table 22. Plithogenic Connection Matrix

	F1	F2	F3	F4	F5
F1	0	0.3	0.5	0.8	0.5
F2	0.5	0	0.3	0.3	0.3
F3	0.8	0.7	0	0.2	0.7
F4	0.8	0.2	0.8	0	0.8
F5	0.3	0.5	0.3	0.7	0

Table 23: Contradiction Degrees of the Factors

Factors	Dominant Attribute Values					Recessive Attribute Values				
	AT11	AT21	AT31	AT41	AT51	AT13	AT23	AT33	AT43	AT53
F1	0.5	0.7	0.7	0.2	0.8	0.7	0.3	0.2	0.5	0.8
F2	0.7	0.5	0.5	0.5	0.2	0.5	0.2	0.5	0.7	0.5
F3	0.2	0.3	0.8	0.3	0.8	0.8	0.8	0.3	0.8	0.7
F4	0.5	0.7	0.5	0.7	0.3	0.5	0.5	0.2	0.5	0.3
F5	0.8	0.2	0.3	0.5	0.3	0.3	0.7	0.7	0.3	0.2

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Table 24: Associational Impacts Between the Factors with respect to both Dominant and Recessive Attribute Values

ON Position of Vectors	Dominant Attribute Values	F1	F2	F3	F4	F5	Recessive Attribute Values	F1	F2	F3	F4	F5
(1 0 0 0 0)	AT11	1	0.82	0.77	0.9	0.93	AT13	1	0.82	0.93	0.9	0.8
	AT21	1	0.76	0.82	0.94	0.8	AT23	1	0.72	0.93	0.9	0.9
	AT31	1	0.82	0.93	0.9	0.8	AT33	1	0.73	0.76	0.84	0.88
	AT41	1	0.76	0.82	0.94	0.87	AT43	1	0.88	0.93	0.9	0.8
	AT51	1	0.71	0.92	0.86	0.77	AT53	1	0.8	0.89	0.86	0.74
(0 1 0 0 0)	AT11	0.8	1	0.7	0.8	0.9	AT13	0.91	1	0.91	0.85	0.77
	AT21	0.9	1	0.8	0.9	0.77	AT23	0.79	1	0.89	0.8	0.86
	AT31	0.91	1	0.91	0.86	0.77	AT33	0.6	1	0.64	0.64	0.8
	AT41	0.72	1	0.76	0.83	0.82	AT43	0.85	1	0.9	0.82	0.75
	AT51	0.93	1	0.9	0.82	0.74	AT53	0.92	1	0.86	0.81	0.7
(0 0 1 0 0)	AT11	0.9	0.91	1	0.85	0.94	AT13	0.94	0.85	1	0.87	0.79
	AT21	0.94	0.85	1	0.92	0.79	AT23	0.86	0.76	1	0.83	0.91
	AT31	0.94	0.85	1	0.87	0.79	AT33	0.84	0.85	1	0.73	0.91
	AT41	0.84	0.85	1	0.88	0.85	AT43	0.9	0.91	1	0.85	0.79
	AT51	0.96	0.76	1	0.84	0.79	AT53	0.96	0.85	1	0.84	0.76
(0 0 0 1 0)	AT11	0.9	0.84	0.84	1	0.96	AT13	0.94	0.83	0.96	1	0.86
	AT21	0.94	0.78	0.86	1	0.84	AT23	0.86	0.74	0.96	1	0.94
	AT31	0.94	0.83	0.96	1	0.86	AT33	0.84	0.78	0.86	1	0.94
	AT41	0.84	0.78	0.86	1	0.9	AT43	0.9	0.89	0.96	1	0.86
	AT51	0.96	0.74	0.96	1	0.86	AT53	0.96	0.82	0.94	1	0.84
(0 0 0 0 1)	AT11	0.83	0.85	0.74	0.85	1	AT13	0.91	0.81	0.91	0.86	1
	AT21	0.91	0.75	0.8	0.91	1	AT23	0.8	0.7	0.91	0.95	1
	AT31	0.91	0.81	0.92	0.86	1	AT33	0.68	0.75	0.71	0.76	1
	AT41	0.78	0.75	0.8	0.91	1	AT43	0.86	0.87	0.91	0.85	1
	AT51	0.93	0.7	0.9	0.82	1	AT53	0.92	0.79	0.87	0.81	1

RESEARCH ARTICLE

Dental Caries and Periodontal Disease – Nutrition and Oral Health

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ABSTRACT

Oral health is important for overall health of the body. We are what we eat. We should be aware of the nutrition and balanced diet we take. Numerous oral health disease are a result of lack of knowledge, care and poor diet. Diet should be rich in micro as well as macro nutrients. In this article we have discussed various factors associated with the common oral diseases. It's causes and role of nutrition. The role of sugars in dental caries is well known but still it's prevention is not controlled due to it's multifactorial behaviour. Periodontal diseases which are accumulated over the years and present late in life has many risk factors which are discussed at length.

Keywords: Oral Health, Sugars, Caries, Periodontitis, xerostomia, Nutrition

INTRODUCTION

Oral health depends on the same nutritional factors as the overall bodily health. It includes routine maintenance, a healthy non sedentary lifestyle and nutritional food. Healthy nutrition influence the progression and development of oral diseases and conditions such as enamel erosion, gingivitis, periodontal disease and dental caries.1 Impact of nutrition on oral health-

CARIES
The standard classification of sugars by Committee on Medical Aspects of Food Policy (COMA) is based on the location of sugar molecule within the food or drink.

Total sugars
Intrinsic Sugar: Sugar molecules inside the cell e.g. fresh fruit & vegetables.
Extrinsic Sugar: Sugar molecules outside the cell. This is of two types

MILK SUGARS
E.g. lactose in dairy products.

NON-MILK EXTRINSIC SUGARS (NMES)
e.g. table sugar, confectionery, honey fruit juice. According to Rugg Gunn 1993 NMES are highly cariogenic. Milk extrinsic sugars are virtually non cariogenic. Non- sugar sweeteners are non cariogenic. According to the recommendations on diet and caries the amount of NMES must be reduced and should be taken with meals in less frequency. Consumption of intrinsic sugars such as fresh fruits, vegetables, should be increased to 5 pieces/ portion of fruit or vegetable / day. According to Department of Health 1989; WHO 1990 the energy provided by Non milk extrinsic sugar (NMES) should not exceed 10% of total energy in diet.2 Various types of sugars available in eatable products

Coupling Sugar
When a mixture of starch & sucrose are allowed to act upon by enzyme cyclodextrin glucosyltransferase, derived from Bacillus megaterium, a mixture of glycosylsucrose, maltosylsucrose, monosaccharide & oligosaccharides is formed which is termed coupling sugar. The acid production by fermentation of this sugar is much less than obtained with glucose & sucrose. Very little insoluble glucans are produced for adherence of S mutans.

Sucrose
it is a non reducing disaccharide. It has a positive optical rotation & can be readily hydrolyzed. Sucrose being fermentable resists bacterial decomposition at higher concentrations. Sugar cane & sugar beet are the main industrial sources of sucrose. Sucrose serves in the formation of insoluble extracellular polysaccharides & enhances plaque formation & microbial aggregation on tooth surface. The adhesion of S. mutans is promoted by the glucans which is the most important determinant of virulence of them on smooth surface.

Invert sugar
The resulting mixture of glucose & fructose is known as invert sugar which has a negative optical rotation. It is slightly sweeter than sucrose.3 Plaque pH

Stephans curve
Robert Stephans 1940 was the first person to demonstrate changes in plaque pH after every consumption of food items which was responsible for demineralization procedure. In his experiments he demonstrated that after a rinse with sucrose solution (10 ml of 10% sucrose solution for 10 seconds). The mixed bacteria in dental plaque are responsible for uptake of sucrose and acid production and rapid drop in pH. pH in the range of 5-5.5 was termed critical pH as at this pH the saliva stops to get saturated with mineral such as calcium and phosphates. Initially there is drop in the plaque pH and it takes almost 20 minutes for the pH to attain its resting value. Depending upon the other factors influencing the drop in pH such as microbial composition of plaque, the type of carbohydrate consumed and rate of diffusion of substrate in plaque it may take even longer 40 minutes for the plaque to achieve the resting pH.20

Buffering System
The buffering agents are bicarbonates, the phosphates and the protein buffer systems. Bicarbonates are most important because it can buffer rapidly by losing carbon dioxide. Its pK is close to that encountered in plaque & therefore it is more effective. As flow rate increases bicarbonate concentration increases dramatically whereas phosphate falls slightly. After removal of bicarbonate by a current of CO_2-free air at pH 5, the buffering capacity of saliva is markedly reduced. Sialin is an argenine peptide which rapidly clears glucose from plaque, increases base

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formation and increases pH. The human saliva are supersaturated with calcium and phosphates which is mediated by salivary proteins egstatherin, the acidic Prolin rich proteins, cystatins and histatinshistatins. 3,4

Trace elements
Zinc
Zinc helps in arresting demineralization of tooth LYNCH RJ. Studies indicate role of zinc in prevention of dental caries UCKARDES .Lower level of zinc systemically was associated with high caries prevalence ATASOY, however few studies do not support the utility of zinc in the prevention of dental caries.5, 6,7

Strontium
The deficiency of strontium may help form caries. The role of strontium in preventing dental caries was much studied in 1970s and 80s but till date the results of studies are inconclusive.8, 9

Iron
Iron interferes with the sucrose metabolism of streptococcus mutans thus reducing the production of extracellular polysaccharides and inhibits enzyme glucosyl transferase. 10

Saliva
Saliva is a mixture of major and minor salivary glands secretions. Saliva contains inorganic molecules such as electrolytes, mucin, immunoglobulins and various enzymes. Salivary antioxidant system is made of peroxidase, catalase, superoxide dismutase glutathione, peroxidase and small molecules, uric acid, Vitamin E & C. Immunoglobulins acts as defence against bacteria, viruses, fungi and promotes mucosal healing and enzymes. Antioxidants are helpful in prevention and progression of dental caries.15,16,There is a possible connection between dental caries & mucin(MUC1 & MUC5B) in saliva.17The main oral innate defence factors are the peroxidase systems,Lysozyme,Lactoferrin and histatins. they limit bacterial or fungal growth, intereference with glucose metabolism of bacterias, promote aggregation and elimination of bacteria.11

Lactoferrin
Iron binding basic protein.Tends to bind and limit the amount of free iron which is essential for microbial growth, this salivary protein is an active host defense mechanism.

Igs
They could bind to salivary pellicle blocking glucan-induced irreversible adherence or they could agglutinate bacteria. IgGs opsonize bacteria permitting phagocytosis by polymorphonuclear leukocytes or possibly macrophages.

Lysozyme
Small highly positive enzyme- catalyzes the degradation of the negatively charged peptidoglycan matrix of microbial cell wall. Binds to hydroxyapetite and maintains its activity after binding. Strong ionic interactions with bacterial cell walls and with the mucin in saliva.

Lactoperoxidase
Kills microorganisms- catalyzing the hydrogen peroxide mediated oxidation of a variety of substances in the microbes. High affinity for enamel surface and it forms an important defense mechanism limiting early microbial colonization of tooth surfaces. 12,11

Fluoride dentifrices
Tinanoff N 2005 in a CDE program in Chennai in 2005 pointed out the fluoridated dentifrices as the single most important factor for the global decline of caries. Downer reviewed caries prevalence in UK in the 20 yrs from 1973-93 and observed a 53% reduction of caries experience in 5 yr old children. He attributed this to the widespread use of

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fluoridated dentifrices. Brown regarded widespread use of fluoridated tooth pastes in reduction of dental caries prevalence in NZ. Changing levels of dental caries experience (DMFT) among 12-year-olds in developed and developing countries

Increased dental awareness

As stated by the joint working group of FDI and WHO in 1985, the increased dental awareness and the organized oral health education programmes may be few of the most probable reasons for dental caries decline. Adoption of preventive approach by the practitioner. The criteria for filling the teeth have changed over time with the advent of Minimal Intervention Dentistry (MI), smart restorative materials, Nanotechnology, etc. Increased use of professionally applied fluorides. Advent of sealants and preventive resin restorations in the routine dental practice.

NUTRITIONAL RISK FACTORS FOR PERIODONTITIS

Nutritional factors

vitamin deficiency, protein deficiency, starvation: Refined carbohydrate
Leads to Scorbutic, Rachitic, non-detergent diet gingivitis. Vitamin C deficiency leads to bleeding gums. Gastrointestinal disorders, syphilis, nephritis, liver disease, tuberculosis show signs in the mouth.

Physical disabilities

physical disabilities makes a person affected with it with lower neuromotor skills and thus poor maintenance of oral hygiene and thus rendering him more prone to gingival and periodontal disease.

Xerostomia

Xerostomia will lead to retention as well as lower clearance of food particle from mouth and reduced ability of natural oral clearance of food by the action of tongue, lips and cheeks thus increased chances of periodontitis.13
Drug induced disorders: Dilantin sodium used in treatment of epilepsy leads to gingival inflammation & enlargement. Chronic bismuth intoxication shows ulcerative gingivostomatitis.

Psychological or emotional factors

In such conditions a person is high strung and due to emotional upheaval salivary changes such as xerostomia or excess salivation can occur, lack of proper personal care can lead to poor oral hygiene and hence periodontitis or altered gingival conditions. Psychological factors has important role in necrotizing ulcerative gingivitis. Psychosomatic disorders exert their effect on periodontitis by the development of habits that are injurious to the periodontium.14

Metabolic conditions

pregnancy, puberty, menopause: Endocrine adjustments takes place during this time. There is generalized tissue enlargement with discoloration. Bleeding and mulberry like swelling and papillae become bulbous. There is adverse effect on periodontal structure during the course of pregnancy.

Endocrinal disturbances

diabetes mellitus, hyperparathyroidism and hyperthyroidism: The glucose level of saliva and blood in diabetic patients is more than normal which has the potential to alter the microflora towards more pathogenic bacterias. Due to polymorphonuclear leucocytes deficiencies in diabetes which results in impaired chemotaxis, defective phagocytosis thus making the diabetic individual more susceptible to periodontal infection. Most of the studies show statistically significant relationship between severe gingival inflammation and loss of attachment in diabetic group as compared to normal individuals which is more when there is increase in glucose level. Periodontal disease in diabetics presents with very severe gingival inflammation, deep periodontal pockets, rapid bone loss, frequent periodontal abscesses, greater loss of attachment, increased bleeding on probing and increased tooth mobility. 15

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1,25(OH)2D3 has an important role in maintaining calcium and phosphate level in blood. Its deficiency leads to increased secretion of parathyroid hormone leading to rickets and osteomalacia. In Mice, vitamin D receptor (VDR)-mediated induction of osteoblast RANKL may account for enhanced bone resorption. Osteoporosis results in lowered density in jaw bones leading to altered trabecular bone pattern and rapid alveolar bone resorption followed by invasion of periodontal pathogens. Periodontal infection increases the systemic release of proinflammatory cytokines, which accelerate systemic bone resorption. Hypopitutarism exhibits with crowding of teeth, enlarged gingiva, delayed resorption of deciduous teeth, delayed formation and eruption of teeth. Hyperpitutarism exhibits spacing of lower teeth-jaw size. Thus people with poor metabolic control have higher frequency of gingivitis and periodontitis.16

Hematologic disorders
There is occurrence of hemorrhagic gingival overgrowth with or without necrosis as a common early manifestation of acute leukemia. Chemotherapy associated with bone marrow transplantation also adversely affect gingival health. Immune system disorder: leukocyte disorder, antibody disorders, HIV infection, persons on immunosuppressive drugs: Bacterial infections acts as a stimulus for systemic acute phase response resulting in increased production of acute phase proteins like C Reactive protein(CRP), macroglobulin and Serum amyloid. The bacterial endotoxins also stimulate the local host inflammatory mediators which finally results in serum antibody response to bacteria. Thus if the immune system is compromised it will be a risk factor for developing periodontitis. HIV infected patients exhibit Kaposi's sarcoma, necrotizing ulcerative gingivitis, necrotizing ulcerative stomatitis, necrotizing ulcerative periodontitis which results in inflammation and enlargement of gingiva.17

Stress
stress, depression and anxiety are considered potential risk factors to affect periodontal condition as these factors are risk indicators to take up health impairing habits such as smoking, tobacoo chewing, alcoholism, poor oral hygiene status and the pathophysiological factors that lead to higher glucocorticoid and catecholamine level which affects the immunological profile thus making the individual susceptible to periodontitis.10 stress related habits such as pencil biting are detrimental to periodontal health.17

Obesity
stress has been marked as a potential risk factor for uptaking unhealthy lifestyle which includes uptake of unhealthy food habits such as refined carbohydrates, fast food, which promotes plaque retention and thus periodontal and gingival diseases.18

Cardiovascular disorders
There is increase in C-reactive proteins and fibrinogen in periodontitis. Furthermore there is an increase in level of systemic markers of inflammation such as C-reactive protein and IL-6 in cardiovascular disease. Bacteremia from periodontitis and dental disease is known to be the primary cause of infective endocarditis.SALIVA: several inorganic and organic factors in saliva are important for bacteria and their products in oral environment. Saliva like GCF contains antibodies that are reactive with indigenous oral bacterial species. Salivary enzymes such as hyaluronidase , lipase, beta-glucuronidase, chondroitin sulfatase are present in increased concentrations in periodontal disease. Proteolytic enzymes in the saliva are generated by both host and oral bacteria which are contributors to the initiation and progression of periodontal disease.To combat these enzymes saliva contains antiproteases that inhibit cystine proteases such as cathepsins and antileucoproteases. Saliva contains coagulation factors that hastens blood coagulation and protects wound from bacterial invasion. Saliva exerts a major role in plaque initiation, maturation and metabolism. Calculus formation, periodontal disease and caries are dependent on salivary flow. An increase in inflammatory gingival disease, rapid tooth destruction are a consequence of decrease salivary gland secretion.19

CONCLUSION

Oral health is a gateway to overall health. Mouth is the entry point which decides what a person will become as the adage goes we are what we eat. Oral diseases are preventable if proper lifestyle is adapted. A few changes in eating habits can save oral and overall health.

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RESEARCH ARTICLE

On Distance Pair Mean Labeling of Graphs

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ABSTRACT

Let p and q denote respectively the number of vertices and edges of a finite, simple and undirected G. A graph G with p vertices and q edges is called a *mean graph* if it is possible to label the vertices $x \in v$ with distinct elements $f(x)$ from $0,1,2,\dots,q$ in such a way that when each edge $e = uv$ is labeled with $\frac{f(u)+f(v)}{2}$ if $f(u) + f(v)$ is even and $\frac{f(u)+f(v)+1}{2}$ if $f(u) + f(v)$ is odd, then the resulting edge labels are distinct f is called a *mean labeling* of G. A graph which admits mean labeling is called a *mean graph*. An injective map $f: V(G) \to \{\pm1, \pm2, \pm3, \dots, \pm p\}$ is said to be *pair mean labeling* if the induced edge function $f_{em}: E(G) \to Z\{0\}$ defined by

$$f_e(uv) = \begin{cases} \frac{f(u)+f(v)}{2} & \text{if } f(u) + f(v) \text{ is even} \\ \frac{f(u)+f(v)+1}{2} & \text{if } f(u) + f(v) \text{ is odd} \end{cases}$$

is one-one $f_{em}(V(G))$ is either of the form $\left\{\pm k_1, \pm k_2, \pm k_3, \dots, \pm k_{\frac{q}{2}}\right\}$ or $\left\{\pm k_1, \pm k_2, \pm k_3, \dots, \pm k_{\frac{q-1}{2}}\right\} \cup \left\{k_{\frac{q+1}{2}}\right\}$ according as q is even or odd.. A graph with a pair mean labeling defined on it is called a *pair mean graph.* Motivated by the above two works, we introduce here a new pair mean labeling called distance pair mean labeling.

Keywords: Mean labeling**,** Pair mean labeling, DPML, comb graph, ladder graph, star graph.
2010 Mathematics Subject Classification: 05C78.

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INTRODUCTION

The concept of mean labeling was introduced by R. Ponraj[4] and investigated the existence of such labeling on path, cycle, complete graph K_n for $n \leq 3$, the triangular snake and some more special graphs and also proved that the complete graph K_n and complete bipartite graph $K_{1,n}$ for $n \geq 3$ are not mean graph. Inspired by the labeling, R. Ponraj[5] defined and discussed the concept of pair mean labeling and studied $P_n, C_n, n > 3$, admit pair mean labeling. Also proved the complete graph is a pair mean graph iff $n \leq 2$. The Cartesian product $G \times H$ of two graphs G and H is a graph such that the vertex set of $G \times H$ is the Cartesian product $V(G) \times V(H)$ and two vertices (u, v) and (u', v') are adjacent in $G \times H$ iff either $u = u'$ and v is adjacent to v' in H or $v = v'$ and u is adjacent to u' in G. The ladder graph L_n is defined by $L_n = P_n \times K_2$ where P_n is a path with n vertices and x denotes the Cartesian product and K_2 is a complete graph with two-vertices. The corona $G_1 \odot G_2$ of two graphs G_1 and G_2 defined as the graph by taking one copy of G_1 (with P_1 vertices) and P_1 copies of G_2 and then joining the ith vertex of G_1 to all the vertices in the ith copy of G_1. The comb graph is represented by $P_n \odot K_1$ where P_n is a path graph with $(n-1)$ edges and n vertices. The graph is constructed by connecting each vertex in the path with a pendant edge. There are 2n vertices and 2n-1 edges in the comb graph.

Distance pair mean labeling of a graph G

Definition 2.1. An injective map $f: V(G) \to \{\pm 1, \pm 2, \pm 3, \ldots, \pm p\}$ is said to be distance pair mean labeling, if the induced vertex weight function $w(v): V(G) \to Z \setminus \{0\}$ defined by $w(v) = \left\lceil \dfrac{\sum\limits_{u \in N(v)} f(v)}{|N(v)|} \right\rceil \neq 0$ is one-one, where

$N(v) = \{u \epsilon V: uv \epsilon E\}$ is the open neighborhood of v and $w(V(G))$ is either of the form $\left\{\pm k_1, \pm k_2, \pm k_3, \ldots, \pm k_{\frac{p}{2}}\right\}$ or $\left\{\pm k_1, \pm k_2, \pm k_3, \ldots, \pm k_{\frac{p-1}{2}}\right\} \cup \left\{k_{\frac{p+1}{2}}\right\}$ according as p is even or odd. A graph which admits distance pair mean labeling is called a distance pair mean graph or just a DPML graph.

Example2.2

    An example for a distance pair mean graph of C_5 is given below. Here, the vertex labels are in *usual font* and weight are in *bold font.*
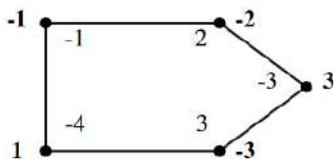
Figure:1 C_5 is distance pair mean graph.

Observation 2.3. If G contains two vertices u and v such that $N(u) = N(v)$, then G is not a distance pair mean graph. For, Let $u, v \epsilon V(G)$ and $N(u) = N(v)$. Then $w(u) = w(v)$. Hence G is not a distance pair mean graph. The following figure shows the P_3 and C_4 are not distance pair mean graphs.

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From this observation, we can conclude that the *star graph*, denoted by $K_{\{1,n\}}$, is not a distance pair mean graph.

Main Results

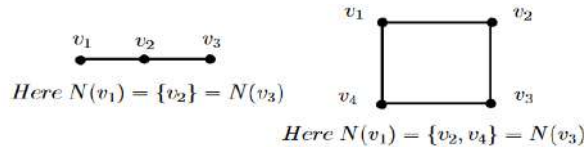**Theorem 2.1.1.** Anypath P_n is distance pair mean graph for $n \neq 3$.

Proof.

Let $V = \{v_1, v_2, \ldots, v_n\}$ be the vertex set of P_n.

By definition, P_2 is obviously a distance pair mean graph and P_3 is not a distance pair mean graph by observation **2.3.**

Take $n \geq 4$. We consider the following two cases:

Case(i): n is even.

For $n \geq 4$, define the labeling $f: V(P_n) \to \{\pm1, \pm2, \ldots, \pm n\}$ by

$$f(v_1) = -1; f(v_2) = 2; f(v_i) = \begin{cases} -\left\lceil \dfrac{i+2}{2} \right\rceil, & \text{if } i \geq 3 \text{ and } i \text{ is odd} \\ \dfrac{i+2}{2}, & \text{if } i \geq 4 \text{ and } i \text{ is even} \end{cases}$$

The induced vertex weights labeling are

$$w(v_i) = \begin{cases} \left\lceil \dfrac{i+2}{2} \right\rceil, & \text{if } i \text{ is odd} \\ -\left(\dfrac{i+2}{2}\right), & \text{if } i \text{ is even} \end{cases} \Rightarrow w(v_i) = -w(v_{i+1}), \text{for all } i = 1,2,\ldots,n.$$

Hence, f is a distance pair mean labeling of P_n, if n is even.

Case(ii): n is odd.

Define the labeling $f: V(P_n) \to \{\pm1, \pm2, \ldots, \pm n\}$ by

$$f(v_1) = 1 = -f(v_2), and \ f(v_3) = 2,$$

$$f(v_i) = -\left\lceil \dfrac{i+1}{2} \right\rceil = -f(v_{i+1}), if \ i \geq 4 \text{ and } i \text{ is even.}$$

The induced vertex weights labeling are $w(v_1) = -1$

$$w(v_i) = \begin{cases} \dfrac{i+2}{2}, & \text{if } i \text{ is even} \\ -\left\lceil \dfrac{i}{2} \right\rceil, & \text{if } i \text{ is odd} \end{cases}$$

Clearly f is a distance pair mean labeling of P_n, if n is odd.

Hence P_n is distance pair mean graph for $n \neq 3$.

Theorem 2.1.2. Anycycle C_n is distance pair mean graph if $n \geq 5$.

Proof.

Let $V = \{v_1, v_2, \ldots, v_n\}$ be the vertex set of C_n. Consider the following two cases:

Case(i). n is even and $n \geq 6$.

Consider the following two subcases.

Subcase (i). $n = 4m + 2$, where $m = 1,2,3,\ldots$

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Define $f: V(C_{4m+2}) \to \{\pm 1, \pm 2, \ldots, \pm n\}$ by

$$f(v_i) = \begin{cases} i, & if \ i = 1,3,5,\ldots,n-1 \\ -(i-1), & if \ i = 2,4,\ldots,n \end{cases}$$

The induced vertex weight labeling are

$$w(v_i) = \begin{cases} -(i-1), & if \ i = 3,5,\ldots,n-1 \\ i, & if \ i = 2,4,\ldots,n-2 \end{cases}$$

Hence f is a distance pair mean labeling of C_{4m+2}, if $m \geq 6$

Subcase (ii). $n = 4m$ and $m \geq 2$

Figure:2 C_8 is a distance pair mean graph.

If $m = 2$, clearly from the above labeling C_8 is a distance pair mean graph.

If $m \geq 3$, we define $f: V(C_{4m}) \to \{\pm 1, \pm 2, \ldots, \pm n\}$ by

$$f(v_i) = \begin{cases} i+1, & if \ i = 1,3,5,\ldots,2m-1 \\ -i, & if \ i = 2,4,6,\ldots,2m \end{cases}$$

$$f(v_{n-i}) = \begin{cases} n - \left(\dfrac{i+1}{2}\right), & if \ i = 1,3,5,\ldots,2m-3 \\ -\left(n - \dfrac{i}{2}\right), & if \ i = 2,4,6,\ldots,2m-2 \end{cases}$$

$f(v_n) = -n, f(v_{2m+1}) = 3m.$

Then induced vertex weight labeling are

$$w(v_i) = \begin{cases} i+1, & if \ i = 2,4,6,\ldots,2m-2 \\ -i, & if \ i = 3,5,7,\ldots,2m-1 \end{cases}$$

$$w(v_{n-i}) = \begin{cases} n - \left(\dfrac{i}{2}\right), & if \ i = 2,4,6,\ldots,2m-2 \\ -\left(n - \left(\dfrac{i+1}{2}\right)\right), & if \ i = 1,3,5,7,\ldots,2m-3 \end{cases}$$

$w(v_1) = -(2m+1) = -w(v_n); w(v_{2m}) = \left\lceil \dfrac{5m}{2} \right\rceil = -w(v_{2m+1}).$

Hence f is a distance pair mean labeling of C_{4m}, if $m \geq 2$.

Case (ii). n is odd and $n \geq 5$.
We consider the following two subcases.

Subcase (i). $n = 4m + 1$, where $m \geq 1$.
If $m = 1$, clearly from the figure 1, C_5 is a distance pair mean graph.
If $m \geq 2$, we define $f: V(C_{4m+1}) \to \{\pm 1, \pm 2, \ldots, \pm n\}$ by

$$f(v_1) = 1, f(v_2) = -2, f(v_3) = 2$$

$$f(v_i) = \begin{cases} -(i-1), & if \ i = 4,6,\ldots,\dfrac{n-1}{2} \\ i-2, & if \ i = 5,7,\ldots,\dfrac{n+1}{2} \end{cases}$$

$$f\left(v_{\frac{n+1}{2}+i}\right) = \begin{cases} \dfrac{n+1}{2} + (i-1), & if \ i = 1,3,5,\ldots,\dfrac{n-3}{2} \\ -\left[\dfrac{n+1}{2} + (i-2)\right], & if \ i = 2,4,\ldots,\dfrac{n-1}{2} \end{cases}$$

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Then induced vertex weight labeling are

$$w(v_1) = -\left(\frac{n-1}{2}\right) = -w(v_n),$$

$$w(v_2) = 2 = -w(v_3), w(v_4) = 3,$$

$$w\left(v_{\frac{n+1}{2}}\right) = 1 = -w\left(v_{\frac{n+1}{2}+1}\right),$$

$$w(v_i) = i - 1 = -w(v_{i+1}), \text{for } i = 5,7,\dots,\frac{n-1}{2}$$

$$w\left(v_{\frac{n+1}{2}+i+1}\right) = \frac{n+1}{2} + i = -w\left(v_{\frac{n+1}{2}+i+2}\right), i = 1,3,5,\dots,\frac{n-7}{2}$$

Hence f is distance pair mean labeling of C_{4m+1}.
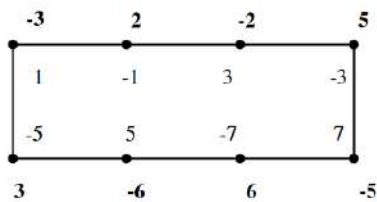
Subcase (ii).$n = 4m + 3$ and $m \geq 1$.
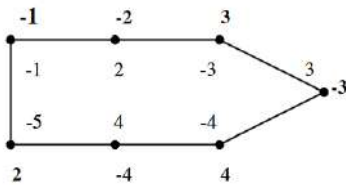
Figure:3 C_7 is a distance pair mean graph.

If $m = 1$, clearly from the above labeling C_7 is a distance pair mean graph.
If $m > 1$, we define $f: V(C_{4m+3}) \to \{\pm 1, \pm 2, \dots, \pm n\}$ by

$$f(v_1) = 1, f(v_2) = -2 = -f(v_3)$$

$$f(v_i) = -(i-1); i = 4,6,\dots,\frac{n-3}{2}$$

$$f(v_i) = (i-2); i = 5,7,\dots,\frac{n-1}{2}$$

$$f\left(v_{\frac{n-1}{2}+i}\right) = \frac{n-1}{2} + i - 1; i = 1,3,\dots,\frac{n-1}{2}$$

$$f\left(v_{\frac{n-1}{2}+i}\right) = -\left(\frac{n-1}{2} + i - 2\right); i = 2,4,\dots,\frac{n+1}{2}$$

Then induced vertex weight labeling are

$$w(v_1) = -\left(\frac{n-1}{2}\right) = -w(v_n), w(v_2) = 2 = -w(v_3), w(v_4) = 3,$$

$$w(v_i) = -(i-1) = -w(v_{i+1}), i = 5,7,9,\dots,\frac{n-5}{2},$$

$$w\left(v_{\frac{n-1}{2}}\right) = 1 = -w\left(v_{\frac{n+1}{2}}\right)$$

$$w\left(v_{\frac{n+1}{2}+i}\right) = \frac{n+1}{2} + i - 1 = -w\left(v_{\frac{n+1}{2}+i+1}\right), i = 1,3,5,\dots,\frac{n-5}{2}.$$

Thus f admits distance pair mean labeling and hence C_n is a distance pair mean graph for $n \geq 5$.

Theorem 2.1.3. The Ladder graph $P_n \times P_2$ is distance pair mean graph for $n \geq 3$.

Proof.
Let $V(L_n) = \{u_i, v_i : 1 \leq i \leq n\}$;
$E(L_n) = \{u_i u_{i+1}, v_i v_{i+1} : 1 \leq i \leq n-1\} \cup \{u_i v_i : 1 \leq i \leq n\}$.
Define $f: V(L_n) \to \{\pm 1, \pm 2, \dots, \pm n\}$ by
For $1 \leq i \leq n$,

$$f(u_i) = -f(v_i) = \begin{cases} 2i, & \text{if } i \text{ is odd} \\ -2i, & \text{if } i \text{ is even} \end{cases}$$

Then the induced vertex weight labeling are as follow:
$w(u_1) = -3 = -w(v_1)$
For $1 \leq i \leq n$,

$$w(u_i) = -w(v_i) = \begin{cases} 2i, & if\ i\ is\ even\ and\ i \neq 1, n \\ -2i, & if\ i\ is\ odd\ and\ i \neq 1, n \end{cases}$$

$$w(u_n) = -w(v_n) = \begin{cases} -(2n-1), & if\ i\ is\ odd \\ 2n-1, & if\ i\ is\ even \end{cases}$$

$$\Rightarrow w(u_i) = -w(v_i)\ for\ all\ i.$$

Thus f admits distance pair mean labeling and hence, $P_n \times P_2$ is a distance pair mean graph.

Theorem 2.1.4. Any comb graph $P_n \odot K_1$ is distance pair mean graph if $n \geq 3$.

Proof. Let G be a comb $P_n \odot K_1$ obtained from the path $v_1, v_2, \ldots, v_n$ by joining a vertex u_i to v_i for each $i = 1,2, \ldots, n$. Then G is of order $2n$ and size $2n - 1$.

We consider the following two cases:

Case(i). n is odd.

Define $f : V(G) \rightarrow \{\pm 1, \pm 2, \ldots, \pm 2n\}$ by

$$f(u_i) = \begin{cases} i, & if\ i\ is\ odd \\ -i, & if\ i\ is\ even \end{cases}$$

$$f(v_i) = \begin{cases} -i, & if\ i\ is\ odd\ and\ i < n \\ i, & if\ i\ is\ even\ and\ i < n \\ -(n+1), & if\ i = n \end{cases}$$

Case(ii). n is even**.**

Define $f : V(G) \rightarrow \{\pm 1, \pm 2, \ldots, \pm 2n\}$ by

$$f(u_i) = -f(v_i) = \begin{cases} i, & if\ i\ is\ odd \\ -i, & if\ i\ is\ even \end{cases}$$

In both cases the weight of the vertices are

$$w(u_i) = -w(v_i) = \begin{cases} -i, & if\ i\ is\ odd \\ i, & if\ i\ is\ even \end{cases}$$

Thus f admits distance pair mean labeling and hence $P_n \odot K_1$ is distance pair mean graph.

RESULTS AND DISCUSSIONS

Investigation of mean labeling on graph families are given in [4]. Pair mean labeling has been defined by R. Ponraj, J. Vijaya Xavier Parthipan in 2011 and studied the labeling on certain graph such as path, complete graph, star graph, complete bipartite graph and $P_n \odot 2K_1$. And also the one-one map f admits pair sum labeling iff it is pair mean labeling has been observed. Further for a pair mean labeling, any two adjacent vertices of G never have the labels of the form $x, -x$ and $x, -x - 1$ has been observed. The various results on various mean labeling[7,8] and pair sum labeling[3,6] motivated us to extend the concept and define the DPML and characterize the labeling for some graph families.

CONCLUSION

In this paper the distance pair mean labeling of a simple undirected graph is defined and contributed some results by investigating distance pair mean labeling on certain families of graphs such as path, cycle, comb, ladder and observed that the star graph is not a DPML graph.

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RESEARCH ARTICLE

Unveiling Educational Transformation: Innovative Holistic Assessment for a Distinctive Learning Journey

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ABSTRACT

In the quest for educational excellence, this paper presents a pioneering approach to student evaluation. This paper explores the paradigm shift from traditional assessment methods to a comprehensive, learner-centered framework that recognizes the multifaceted nature of student development. The proposed holistic assessment model integrates cognitive, emotional, and social competencies, offering a more accurate reflection of a student's learning journey. The research underscores the limitations of conventional testing, advocating for assessments that encapsulate the full spectrum of educational experiences. By incorporating diverse evaluation tools, including portfolios, peer reviews, and self-assessments, the model fosters an environment where feedback is constructive and learning is personalized. The paper also delves into the challenges of implementing such a transformative system, including teacher training, curriculum adaptation, and stakeholder acceptance. It presents case studies of successful integrations of holistic assessment in various educational settings, highlighting the positive outcomes on student engagement and achievement. Finally, the paper proposes strategies for scaling this innovative assessment approach, emphasizing the role of policy reform and community involvement. It calls for a collective effort to redefine success in education, ensuring that every learner embarks on a distinctive journey that prepares them for the complexities of the modern world.

Keywords: Holistic Evaluation, 360-degree Holistic Assessment, Education, Evaluation Tools

Parinka Sharma and Baliya

INTRODUCTION

Historically, education has often relied on standardized tests and narrowly defined metrics to assess student performance. While these assessments have their merits, they often fail to capture the full spectrum of students' abilities and potential. Innovative holistic assessment, however, takes a broader view, encompassing not only academic achievements but also personal growth, social-emotional development, creativity, critical thinking, and collaborative skills. Holistic assessment recognizes that every learner is unique, with diverse strengths, interests, and learning styles. It seeks to provide a more comprehensive and nuanced understanding of student progress, enabling educators to tailor instruction and support to individual needs. By moving beyond one-size-fits-all evaluations, holistic assessment celebrates the richness of student diversity and promotes inclusive learning environments.

By embracing innovative holistic assessment, educators unlock new possibilities for nurturing well-rounded individuals poised for success in the 21st century. A distinctive learning journey emerges—one that is characterized by:

- Personalized Growth: Students receive personalized support and feedback tailored to their unique needs and aspirations, fostering a sense of agency and empowerment.
- Cultivation of Lifelong Learners: Holistic assessment cultivates a culture of continuous learning and growth, instilling in students the value of lifelong learning beyond formal education.
- Preparation for the Future: By developing a comprehensive skill set and a growth mindset, students are better prepared to navigate complex challenges and seize opportunities in an increasingly interconnected global society.

Concept of Holistic Education

Beyond the fundamentals of academics, the notion of holistic education aims to educate the whole person. Many educational institutions understand that providing pupils with a solid foundation in a core curriculum is not enough. This method is learner-centered. a thorough method of teaching in which instructors work to meet students' intellectual, social, emotional, and ethical requirements through an integrated learning environment. Positive school climates and attending to kids' academic and non-academic needs are prioritized. The curriculum would incorporate, among other "traditional" disciplines, dancing, games, role play, stage performances, painting, photography, and debates. This method is oriented toward play-based learning. In addition to learning how to take lessons from their local and global communities, students are also taught to reflect on their actions and how they affect those communities. Instructors make an effort to get students involved in projects that use critical thinking abilities to solve practical issues. A developing child'smoral, physical, spiritual, emotional and psychological qualities are nurtured through the holistic education method. Personalized learning experiences that take into account a kid's abilities and emotions are essential to addressing the full child. Students can make use of their skills in a supportive learning atmosphere where lessons are taught. A holistic learning culture may be established via the use of a variety of techniques and tactics. (Dutta, 2022).

RESEARCH OBJECTIVES

- To study the role of technology in facilitating 360-degree holistic assessment and its integration into the curriculum.
- To explore the different tools used in 360-degree holistic assessment in a teaching-learning environment.
- To propose a framework for the continuous improvement of the teaching-learning climate through iterative feedback and assessment cycles.

NEP 2020's Holistic Approach

The National Education Policy (NEP) 2020 in India emphasizes the importance of holistic development and assessment of students. The policy proposes a shift towards a more comprehensive and continuous evaluation

system, moving away from rote learning and high-pressure exams. Regarding the concept of "360-degree holistic evaluation," the NEP 2020 emphasizes the following principles:

1. **Comprehensive Assessment**: The policy advocates for a shift from summative assessment (focused on end-of-year exams) to formative assessment (which includes a range of tools like quizzes, projects, and activities throughout the academic year). This approach aims to provide a more comprehensive understanding of a student's progress.
2. **Multi-dimensional Evaluation**: The NEP emphasizes assessing students not only on academic achievements but also on their skills, interests, attitudes, and values. This multi-dimensional evaluation is intended to capture a student's overall development.
3. **Life Skills and Values Assessment**: The policy suggests incorporating assessments that measure life skills such as critical thinking, creativity, communication, collaboration, ethical reasoning, and digital literacy. Additionally, it emphasizes the assessment of values like empathy, respect, and responsibility.
4. **Flexible Board Exams**: NEP 2020 suggests reforms in board examinations to test core competencies rather than memorized facts, providing students with flexibility in choosing subjects and the mode of examination.
5. **Technology Integration**: The policy encourages the use of technology for assessment, including adaptive testing methods that adjust to a student's level and style of learning.
6. **Continuous Professional Development**: NEP 2020 emphasizes the need for continuous professional development of teachers to ensure the effective implementation of holistic evaluation practices. Thus, the NEP 2020 promotes a shift towards a more holistic, continuous, and multi-dimensional assessment system that aims to foster overall development in students beyond academic achievements. This approach aligns with the intention to nurture well-rounded individuals capable of thriving in various aspects of life.

Concept of 360-Degree Evaluation

In NEP 2020, 360-degree evaluation is a novel technique for assessing each learner's progress and distinctiveness across all domains of learning. It includes feedback from a variety of sources, including self, peers, instructors, and parents. It aspires to give a holistic, multifaceted, and comprehensive report card that represents each student's strengths, areas for progress, and interests. The report card will also highlight students' accomplishments in other co-curricular and extra-curricular activities such as athletics, arts, social service, and so on. Rather than ranking or labeling students, the goal of this assessment is to support their learning and development. 360-degree feedback is a procedure that collects comments from teachers, peers, supervisors, and parents as well as a self-evaluation by the students themselves. It is also referred to as multi-source feedback or multi-source assessment. The participants are encouraged to continue studying thanks to the efficient 360-degree feedback. They may become better learners simply by hearing feedback, but this transformation must occur internally. It is crucial to first "unfreeze" the participant's self-view in order to encourage improvement or behavioural change. The greatest method to break the self-view out of its ice is to give the participant factual information from several angles and to urge them to be open to receiving criticism. 360 Degree Holistic Assessment of students is a new approach to evaluating the learning and development of students in different domains and contexts. It is based on the idea that students can benefit from receiving feedback from multiple sources, such as themselves, their peers, their teachers, and their parents. This way, they can get a comprehensive and holistic view of their strengths, weaknesses, opportunities, and challenges. According to the National Education Policy 2020, 360 Degree Holistic Assessment is one of the key features of assessment reform in India. It aims to shift the focus of assessment from certification to improvement in learning and to test higher-order skills such as analysis, critical thinking, and conceptual clarity. It also involves using a Holistic Report Card (HRC) that reflects the progress and uniqueness of each child in the cognitive, affective, and psychomotor domains. The HRC will also provide valuable information to teachers and parents on how to support each child in and out of the classroom(NEP, 2020). The new report cards are going to be "a holistic, 360-degree, multidimensional report that reflects in great detail the progress and the uniqueness of each learner in the cognitive, affective, and psychomotor domains". The progress report will contain self-assessment, peer assessment, and instructor evaluations.

Benefits of 360 Degree Holistic Assessment

- It helps students to become more aware of their own learning process and goals and to develop self-regulation and metacognition skills.
- It encourages students to collaborate with their peers and learn from each other's perspectives and experiences.
- It provides teachers with a rich and diverse data source to monitor student learning and adjust their teaching strategies accordingly.
- It fosters a culture of continuous feedback and improvement among all stakeholders involved in student learning.
- It reduces the stress and anxiety associated with high-stakes examinations and promotes a more positive attitude towards learning (Extramarks, 2023).

Difference Between Traditional Assessment Techniques & 360-Degree Holistic Assessment

- Traditional assessment techniques measure students' knowledge and understanding, while 360-degree evaluation measures each learner's development and individuality across all learning domains. These are some of the primary contrasts.
- Unlike 360-degree evaluations, which incorporate feedback from a variety of sources, including peers, teachers, parents, and self, traditional assessment techniques rely on feedback from a single source, typically the teacher.
- Unlike 360-degree evaluation, which uses a variety of informal tools including portfolios, projects, and observations, traditional assessment methods use standardized and formal tools like tests, quizzes, and essays.
- While 360-degree evaluations are utilized for learning and growth, traditional assessment methods are employed for grading and reporting.

Different Domains Assessed in 360-Degree Holistic Assessment

These domains are interrelated and influence each other in the learning process. Therefore, 360 Degree Holistic Assessment aims to capture the holistic and multidimensional nature of student learning and development. The different domains are assessed using various methods and tools that are aligned with the learning outcomes and competencies of each domain. Some of the methods and tools are:

- **Self-assessment:** This method involves students reflecting on their own learning process and goals, and evaluating their own performance and progress in different domains. Self-assessment can be done using tools such as checklists, rubrics, journals, portfolios, etc. Self-assessment helps students develop self-regulation and meta cognition skills, and to identify their strengths and areas for improvement.
- **Peer assessment:** This method involves students giving and receiving feedback from their classmates on their work and behavior in different domains. Peer assessment can be done using tools such as peer review, peer editing, peer feedback, etc. Peer assessment helps students to collaborate with their peers and learn from each other's perspectives and experiences.
- **Teacher assessment:** This method involves teachers observing, monitoring, and evaluating students' performance and progress in different domains. Teacher assessment can be done using tools such as quizzes, tests, assignments, projects, observations, interviews, etc. Teacher assessment helps teachers provide timely and constructive feedback to students and to adjust their teaching strategies accordingly.
- **Parent assessment:** This method involves parents or guardians providing feedback on their children's learning and development in different domains. Parent assessment can be done using tools such as parent-teacher meetings, parent surveys, parent reports, etc. Parent assessment helps parents to be actively involved in their children's holistic education and development, and to support them in and out of the classroom. These methods and tools are used in a balanced and integrated way to create a 360-degree holistic report card that reflects the progress and uniqueness of each child in the cognitive, affective, socio-emotional, and psychomotor domains. The report card is descriptive and analytical rather than numerical and provides valuable information to teachers and parents on how to support each child.

Tools Used In 360 Degree Holistic Assessment Are
This table provides an overview of various tools used in 360 Degree Holistic Assessment for students in education, covering aspects related to data collection, academic progress, social-emotional development, skill development, technology integration, feedback/reflection, collaboration, and data analysis. These tools are essential for assessing students comprehensively and supporting their overall growth and learning experiences. The description of these tools is given below:

Data Collection
- **Surveys**: Surveys can be designed to gather feedback from students about their learning experiences, interests, and challenges.
- **Interviews**: One-on-one interviews with students can provide in-depth insights into their perceptions, strengths, and areas for improvement.
- **Observations**: Teachers and assessors can observe students in various learning settings to assess their behavior, engagement, and interaction with peers.

Academic Progress
- **Portfolios**: Students compile portfolios showcasing their work, achievements, and reflections over time to demonstrate academic progress.
- **Projects**: Project-based assessments allow students to demonstrate their knowledge, skills, and creativity through extended assignments.
- **Exams/Assessments**: Traditional exams and assessments measure students' understanding and mastery of academic content.

Social-Emotional Development
- **Self-Assessment Tools**: Tools like self-assessment questionnaires or reflections help students evaluate their own social-emotional skills and growth.
- **Peer Feedback**: Peer assessment encourages students to provide feedback to each other on teamwork, communication, and social skills.

Skill Development
- **Rubrics**: Rubrics outline specific criteria for assessing student performance across various skills and competencies.
- **Performance Assessments**: Assessments that require students to demonstrate skills through presentations, simulations, or practical tasks.
- **Skill Inventories**: Inventories assess students' skills and abilities in areas like problem-solving, critical thinking, and creativity.

Technology Tools
- **Online Platforms**: Learning management systems (LMS) and assessment tools provide digital platforms for administering and managing assessments.
- **Interactive Apps**: Apps and tools that facilitate interactive learning experiences, quizzes, and simulations to assess student understanding.

Feedback and Reflection Tools
- **Feedback Forms**: Structured forms or templates for providing and receiving feedback on academic work or projects.
- **Reflection Journals**: Journals where students record their reflections on their learning progress, challenges, and achievements.

Collaboration Tools

- **Collaborative Platforms**: Using online collaboration tools like Google Workspace or Microsoft Teams to facilitate group projects, peer collaboration, and shared document editing.

Data Analysis Tools

- **Data Analytics Software**: Analyzing assessment data using tools like Microsoft Excel or Google Sheets to identify trends, student performance patterns, and areas needing intervention or improvement. These tools are integrated into the educational process to create a comprehensive picture of students' academic performance, social-emotional development, and overall growth. They enable educators to tailor instruction and support based on individual student needs and promote a holistic approach to student assessment and development.

Role of Technology in 360-Degree Holistic Assessment

Technology plays an important role in 360-degree holistic Assessment, as it can facilitate the collection, analysis, and reporting of data from multiple sources and domains. Technology can also enhance the quality, efficiency, and accessibility of assessment tools and methods. Some of the ways that technology can support 360 Degree Holistic Assessment are:

➢ Technology can enable the use of appropriate and flexible software that allows and enables children to work at their own pace, with personalized and adaptive curricula that leverage each child's strengths and interests.

➢ Technology can help create an ecosystem for appropriate assessment and certification, by providing online platforms, digital portfolios, e-certificates, etc. that can document and showcase the learning and development of each child in different domains.

➢ Technology can assist teachers in designing and implementing various assessment tools and methods, such as quizzes, tests, assignments, projects, observations, interviews, etc. that can test higher-order skills and competencies of students in the cognitive domain.

➢ Technology can empower students to engage in self-assessment and peer assessment, by using tools such as checklists, rubrics, journals, feedback forms, etc. that can help them reflect on their own learning process and goals, and provide constructive feedback to their classmates in the affective and socio-emotional domains.

➢ Technology can enable parents to be actively involved in their children's holistic education and development, by using tools such as parent-teacher meetings, parent surveys, parent reports, etc. that can provide them with valuable information on how to support their children in and out of the classroom in the psychomotor domain.

➢ Technology can integrate with artificial intelligence and machine learning algorithms that can enhance data analysis, improve accuracy, and provide even more valuable insights for individuals and organizations. Technology can thus play a vital role in transforming the culture of assessment from certification to improvement in learning, and from summative to formative and competency-based. Technology can also help create a 360-degree holistic report card that reflects the progress and uniqueness of each child in the cognitive, affective, socio-emotional, and psychomotor domains(Recruitment, 2022).

PARAKH for Holistic Evaluation

PARAKH, which stands for Performance Assessment, Review, and Analysis of Knowledge for Holistic Development, is India's first national assessment regulator established by the NCERT. It was set up to align with the National Education Policy (NEP) 2020, focusing on four key areas:

1. Capacity Development in Competency-Based Assessment: PARAKH aims to bridge gaps in competency-based learning and teaching through initiatives like Project Vidyasagar, which involves workshops to disseminate learning competencies at various educational levels.

2. Large-Scale Achievement Survey: It conducts large-scale surveys to monitor and assess the educational standards of the country. For instance, an assessment covering approximately 8.5 million learners across grades 3, 6, and 9 was conducted to gauge competencies in foundational literacy and numeracy, language, and mathematics.

3. Equivalence of School Boards: PARAKH works towards examination reforms and equivalence across all school boards in India. This includes developing recommendations and conducting workshops to collect data for analysis and report preparation.
4. Holistic Progress Cards: These are designed for foundational, preparatory, middle, and secondary stages to provide a comprehensive view of a student's progress. PARAKH's approach to assessment is competency-based, focusing on the development and demonstration of skills, knowledge, and abilities rather than solely relying on traditional standardized testing. This regulator plays a crucial role in setting norms, standards, and guidelines for student assessment and evaluation across all recognized school boards in the country. With PARAKH, education will progressively shift toward a more scientific methodology. It would take care of academic requirements such as a child's cognitive growth and social and physical awareness. The efficient method of assessment and evaluation for the comprehensive, growth of the kids will undoubtedly improve the country's future, and the PARAKH will be implemented successfully to make this happen (Sharma & Baliya, 2023).

CONCLUSIONS

In conclusion, the research on evolving teaching-learning climate through 360-degree holistic assessment highlights the transformative potential of comprehensive evaluation methods in education. This study has underscored the importance of moving beyond traditional assessment practices towards a more inclusive, multifaceted approach that considers various dimensions of student development and teacher effectiveness. Through a thorough analysis of the literature and empirical findings, it is evident that embracing 360-degree assessment can foster a supportive and dynamic learning environment. By incorporating feedback from diverse stakeholders including students, peers, and supervisors, educators can gain valuable insights into their teaching methods and areas for improvement. Similarly, students benefit from a more personalized and well-rounded educational experience that nurtures their holistic growth. Moreover, the research underscores the need for educational institutions to adapt and evolve in response to changing pedagogical demands and student expectations. The implementation of 360-degree assessment requires institutional commitment and investment in professional development to ensure its successful integration into teaching practices. In essence, this study advocates for a paradigm shift towards continuous improvement and student-centered learning approaches facilitated by comprehensive assessment frameworks. By embracing the principles of 360-degree assessment, educators can create a more inclusive, engaging, and effective teaching-learning climate that better prepares students for the challenges of the modern world. This research serves as a catalyst for further exploration and implementation of innovative assessment strategies aimed at enhancing educational outcomes and fostering a culture of lifelong learning.

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Table 1: Tools Used In 360 Degree Holistic Assessment Are

Category	Tools Used
Data Collection	Surveys, Interviews, Observations
Academic Progress	Portfolios, Projects, Exams/Assessments
Social-Emotional	Self-Assessment Tools, Peer Feedback
Skill Development	Rubrics, Performance Assessments, Skill Inventories
Technology Tools	Online Platforms, Interactive Apps
Feedback/Reflection	Feedback Forms, Reflection Journals
Collaboration Tools	Collaborative Platforms
Data Analysis Tools	Data Analytics Software

| **Figure 1: Concept of Holistic Education** | **Figure 2: Concept of 360-Degree Evaluation** |
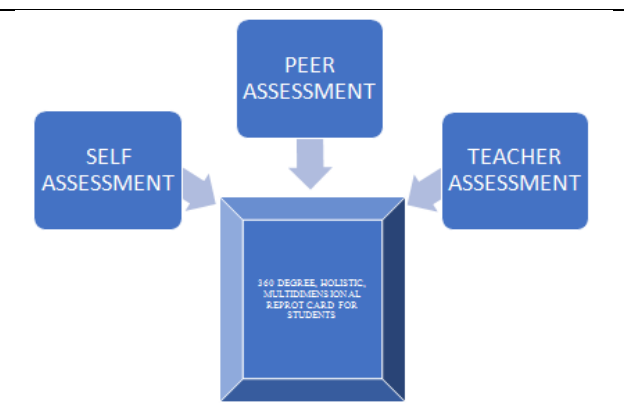
Parinka Sharma and Baliya

Figure 3: Different Domains Assessed in 360-Degree Holistic Assessment

Advancing Chromatographic Analysis: The Role of Quantitative Structure - Retention Relationship (QSRR) in Compound Retention Time Prediction

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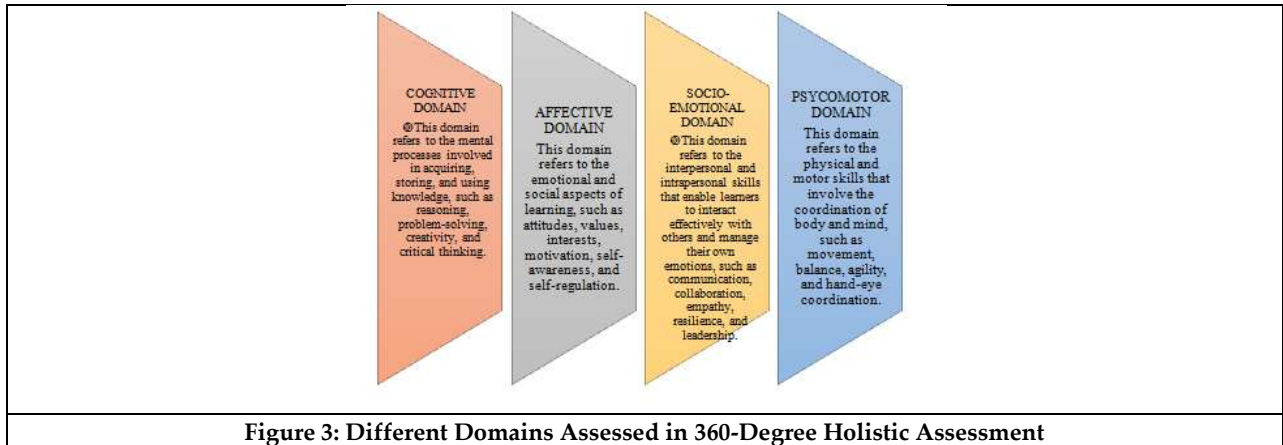[3]Student, Department of Pharmaceutical Chemistry, Raghavendra Institute of Pharmaceutical Education and Research (RIPER), Ananthapuramu, Andhra Pradesh, India.

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ABSTRACT

Retention time (RT) prediction stands as a cornerstone in analytical chemistry, pivotal for upholding the accuracy of identification and quantification while streamlining method development. In this review paper, we delve into the intricate realm of the Quantitative Structure-Retention Relationship (QSRR) technique, an invaluable tool for forecasting retention times (RTs) in chromatography. By examining the historical progression and amalgamation of diverse statistical and computational methodologies, we elucidate the pivotal role these approaches have played in various pharmaceutical applications, encompassing quality control and drug discovery among other critical sectors of the industry.Drawing upon the rich tapestry of QSRR applications, we uncover its multifaceted utility in pharmaceutical endeavors, showcasing its efficacy in drug development and quality assurance. QSRR, with its systematic framework, orchestrates a symbiotic relationship between chemical structures and chromatographic behavior, establishing mathematical correlations that underpin precise RT predictions.The evolution of QSRR owes much to the synergy of statistical and computational techniques, harnessing their prowess to achieve extraordinary precision in RT prognostication. Through meticulous analysis and synthesis, this review underscores the transformative impact of QSRR on the pharmaceutical landscape, paving the way for enhanced efficiency and accuracy in analytical methodologies.

Keywords: Retention time prediction, Quantitative Structure-Retention Relationship, Pharmaceutical analysis, Chromatography, Statistical and computational techniques.

Harini Rachamallu *et al.,*

INTRODUCTION

Analytical chemistry stands as a cornerstone within various industries, including pharmaceuticals, food, biotechnology, and forensics, where its primary focus lies in the precise identification and quantification of substances, as well as the intricate analysis of complex compound mixtures[1]. Its significance resonates across diverse sectors, aiding in determining the purity and quantity of chemical entities amidst compound mixtures found in realms like natural products, clinical chemistry, and forensic science [2] A plethora of techniques and instruments are employed by analytical chemists to accomplish these tasks effectively. Among the most prominent are UV-visible spectroscopy, Infrared (IR) Spectroscopy, Nuclear Magnetic Resonance (NMR), Mass Spectrometry, and various Chromatography techniques such as Gas Chromatography (GC), Liquid Chromatography (LC), and High-Pressure Liquid Chromatography (HPLC). These instruments serve as pillars in the analytical arsenal, each offering unique capabilities tailored to different analytical challenges [3]. The selection of equipment is a critical decision influenced by several factors, including the specific analytical objectives, the characteristics of the sample under investigation, and the requisite sensitivity and accuracy demanded by the analysis. From elucidating the molecular structure of a pharmaceutical compound to identifying trace evidence in forensic investigations, analytical chemistry tools are indispensable in unraveling the complexities of chemical composition and behavior. As technology advances, so too does the breadth and depth of analytical methodologies, ensuring that analytical chemists remain at the forefront of scientific inquiry and innovation [4].A key aspect of analytical chemistry is the estimation of RTs, which plays a crucial role in the separation of analytes and their subsequent identification. QSRR is a powerful tool that links the chemical structure of analytes to their RTs, allowing for predictive modeling and optimization in various analytical techniques [5]. This review offers an in-depth overview of QSRR in retention time (RT) estimation, focusing on applications in gas chromatography (GC), liquid chromatography (LC), and related techniques[6-8]. It covers QSRR principles, model development, influencing factors, challenges, and future prospects. Software like ChemDraw, MarvinSketch, and RDKit are used for chemical structure drawing, while tools like Dragon and PaDEL compute molecular descriptors. QSRR models are developed using statistical methods in R, Python (scikit-learn, TensorFlow), MATLAB, and JMP. Cheminformatics libraries like RDKit, Open Babel, and ChemPy aid in model development using algorithms like linear regression, SVMs, and neural networks[9,10].

Scope and objectives of QSRR in Chromatography
Chromatography's versatile, precise, and highly sensitive capabilities enable researchers to analyze complex mixtures, optimize methods, and achieve precise separations across a wide range of compounds[11]. This makes chromatography an essential tool in scientific research, quality control, and numerous industrial applications, as illustrated in Figure 1. Its ability to dissect intricate compositions with high accuracy and reliability underscores its critical role in advancing both scientific discovery and practical applications across multiple fields.

Predictive Capability
QSR Renables the anticipation of retention durations for compounds based on their chemical structure. This predictive power is instrumental in identifying and quantifying individual components within complex mixtures, a common challenge in chromatographic analysis [12].

Method Optimization
QSRR models play a pivotal role in optimizing chromatographic methods. Understanding how structural variations in analytes influence RTs allows researchers to fine-tune chromatographic settings for enhanced separation, resolution, and analytical efficiency [13].

Reduced Expenses and Time
QSRR models offer a cost-effective and time-efficient approach to method development in chromatography. By providing insights into the relationship between molecular structure and chromatographic behavior, these models minimize the need for extensive experimental trials to identify optimal conditions [14]. This not only conserves

resources but also accelerates the pace of research and development in industries reliant on chromatographic analysis.

Environmental Analysis

QSRR in chromatography plays a vital role in predicting the behavior of pollutants and contaminants in complex environmental samples such as water. By extrapolating RT data, QSRR models aid in assessing environmental risks and ensuring regulatory compliance [15]. This capability is indispensable for monitoring and mitigating the impact of contaminants on ecosystems and human health.

Structural Clarification

QSRR facilitates the elucidation of unknown substance structures by comparing expected RTs times with experimental data. By leveraging computational tools to correlate retention behavior with molecular properties, researchers can make informed hypotheses about the chemical structure of unidentified analytes [16]. This contributes to the comprehensive characterization of complex mixtures and accelerates the process of compound identification.

Understanding Molecular Interactions

QSRR sheds light on the intricate molecular interactions occurring between analytes and chromatographic phases. By elucidating the mechanisms underlying separation processes, QSRR enhances our understanding of chromatographic phenomena and guides the development of novel separation techniques [17]. This fundamental knowledge paves the way for innovation in chromatography, enabling the design of more efficient and selective analytical methods.

Adaptability to Diverse Chromatographic Methods

QSRR can be applied across various chromatographic techniques including GC, TLC, and HPLC. This versatility underscores the utility of QSRR in diverse analytical scenarios, making it a valuable tool for researchers across different fields and industries [18].

Quality Assurance and Control

QSRR enhances quality assurance in industrial and medicinal settings by predicting retention times (RTs) under varying conditions, ensuring consistency in chromatographic analyses and safeguarding product integrity [19]. It aids in seamless method transfer between labs or equipment by minimizing validation efforts and promoting standardization [20]. By integrating computational chemistry for molecular descriptor calculations, QSRR strengthens predictive models, improving accuracy and providing deeper insights into chromatographic behavior across analytical platforms [21].

Factors influencing RT

RT refers to the duration a solute spends traversing through a chromatographic column, influenced by various parameters associated with both the mobile and stationary phases [22]. Alternatively, it can be defined as the duration between the injection of a sample combination and the appearance of its peak in the chromatogram. Several factors impact RT, including stationary phase, temperature, column length, analyte properties, mobile phase composition, flow rate, etc shown in Figure 2.

Stationary Phase

The choice of stationary phase significantly affects RT in chromatography. Different stationary phases interact with analytes distinctively, leading to varying RTs [23-25].Here are examples of different stationary phases and their effects on RT.

Silica Gel

Widely used in normal-phase chromatography, silica gel is a polar stationary phase that strongly retains polar analytes, resulting in longer retention times (RTs).

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C18 (Octadecylsilane)
A common reversed-phase stationary phase with hydrophobic alkyl chains. C18 columns retain non-polar analytes strongly, allowing polar analytes to elute faster compared to silica gel columns.

Cyano (CN)
Moderately polar, cyano stationary phases provide intermediate retention for both polar and non-polar analytes, offering distinct selectivity influenced by specific functional groups.

Amide
Polar stationary phases with carbonyl groups that interact via hydrogen bonding, extending RTs for polar compounds like carbohydrates and amino acids.

Chiral Stationary Phases (CSPs)
Designed for separating enantiomers, CSPs contain chiral selectors like cyclodextrins that influence RTs based on analyte stereochemistry.

Ion Exchange Resins
Charged stationary phases used in ion chromatography separate analytes by charge properties, with RTs dependent on mobile phase pH and ionic strength.

Size-Exclusion Columns
These separate analytes by size, where larger molecules elute quickly, bypassing pores, while smaller molecules infiltrate the beads, prolonging RTs.

Mobile Phase
Components of the mobile phase, such as solvent polarity, play a crucial role in RT. Adjustment of mobile phase composition alters analyte-stationary phase interactions, consequently affecting RT. Various mobile phases and their effects on RT

Aqueous Mobile Phases
Water
A fundamental constituent of aqueous mobile phases in chromatography, water's innate polarity fosters interactions with polar analytes. Consequently, polar analytes tend to exhibit prolonged RTs in aqueous environments. [25-27]

Buffer Solutions
Buffer solutions, such as phosphate or ammonium acetate buffers, are frequently employed to regulate pH in chromatography. These buffers wield the power to modulate analyte interactions with the stationary phase, thereby influencing RTs based on pH-dependent properties.

Organic Mobile Phases
Methanol
A prevalent organic solvent in chromatography, methanol offers distinct selectivity owing to its lower polarity compared to water. Consequently, non-polar analytes may experience abbreviated RTs when subjected to methanol-based mobile phases.

Acetonitrile
Another widely utilized organic solvent, acetonitrile presents intermediate polarity and offers differential selectivity compared to methanol or water. RTs of analytes may fluctuate depending on the composition of acetonitrile in the mobile phase.

Mixed Mobile Phases

Water-Methanol Mixtures
Blending water with methanol in varying ratios enables precise tuning of solvent polarity. Mobile phases with higher methanol content tend to favor non-polar analytes, leading to reduced RTs, while those skewed towards higher water content favor polar analytes, resulting in elongated RTs.

Water-Acetonitrile Mixtures:
Analogous to water-methanol mixtures, adjusting the ratio of water to acetonitrile allows for modulation of solvent polarity and selectivity. Mobile phases with elevated acetonitrile content may expedite elution of non-polar analytes, whereas those with a higher water content may protract RTs for polar analytes.

Ionic Mobile Phases
Incorporating salts like sodium chloride or ammonium sulfate into the mobile phase can modulate the ionic strength, thereby influencing analyte retention. Ionic interactions between analytes and the stationary phase are augmented or perturbed by the presence of salts, thereby exerting a pronounced effect on RTs.

pH-Modified Mobile Phases
Manipulating the pH of the mobile phase using acids (e.g., formic acid) or bases (e.g., ammonium hydroxide) facilitates alterations in analyte ionization and polarity. This transformative adjustment can significantly impact RTs, particularly for ionizable compounds.

Column Temperature in Chromatography
Column temperature plays a crucial role in chromatography by influencing analyte interactions with the stationary and mobile phases. Understanding its effects allows for optimizing chromatographic conditions and improving separation efficiency and retention time (RT) control[28,29].

Gas Chromatography (GC)
In GC, temperature increases enhance analyte volatility and vapor pressure, reducing RTs. Higher temperatures expedite the analysis of volatile organic compounds (VOCs) by shortening elution times[30].

Liquid Chromatography (LC)
In reversed-phase LC (RPLC), increased temperatures reduce hydrophobic interactions, decreasing RTs for non-polar analytes. In normal-phase LC (NPLC), higher temperatures improve analyte solubility in the mobile phase, weakening interactions with the stationary phase and lengthening RTs for polar compounds[31,32].

Size-Exclusion Chromatography (SEC)
Temperature influences macromolecule mobility in SEC. Higher temperatures increase the mobility of large molecules, shortening RTs, as seen in protein separations.

Ion Chromatography (IC)
Temperature affects ion mobility and ionization in IC. Elevated temperatures enhance ion mobility, reducing RTs and speeding up the analysis of inorganic ions [33].

Chiral Chromatography
Temperature changes influence the enantio selectivity of chiral stationary phases (CSPs). Adjusting temperature alters interactions with enantiomers, impacting RTs and enantiomer resolution[34,35].

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Analyte Properties

The size, chemical structure, and polarity of analytes play a pivotal role in determining RT in chromatography. Generally, more polar analytes demonstrate shorter RTs in reverse-phase chromatography. Molecular properties significantly impact retention times (RTs) in chromatography. Larger molecules typically exhibit longer RTs due to increased interactions with the stationary phase, while in size exclusion chromatography (SEC), they experience prolonged RTs by being excluded from stationary phase pores.[36] Complex chemical structures, like aromatic compounds, engage in π-π interactions, extending RTs in reversed-phase liquid chromatography (RPLC). Polarity and hydrophobicity influence RTs based on interactions with stationary phases in normal-phase (NPLC) and RPLC, respectively.[37] Additionally, ionization state affects RTs depending on mobile phase pH, while functional groups, especially in chiral analytes, determine RTs through stereochemical interactions.[38]

Flow Rate

The flow rate in chromatography directly influences retention time (RT). Higher flow rates result in shorter RTs due to reduced interaction time with the stationary phase, while lower flow rates prolong RTs by increasing analyte interaction. Optimizing flow rates balances analysis speed with adequate separation and resolution, ensuring reliable results.[39]

Pressure

In HPLC, pressure significantly affects RT and overall performance. Higher pressure enhances column efficiency and mass transfer, leading to shorter RTs. However, excessive pressure may compromise column stability and resolution. Proper pressure management is crucial for achieving accurate, reproducible outcomes.[28,35,40]

Column Length

Longer columns increase analyte interaction with the stationary phase, extending RT and improving resolution, albeit with longer analysis times and higher costs. Balancing column length with RT, resolution, and efficiency is key to optimizing chromatographic performance.

Analyte Concentration

Higher analyte concentrations typically extend RT due to intensified interaction with the stationary phase. Variations in concentration can affect peak shape, detection sensitivity, and quantification accuracy, influencing overall chromatographic results.[41]

Significance of predicting RT

Predicting RT is a crucial task in analytical chemistry, offering several advantages that enhance efficiency and accuracy in identification and quantification processes.

Technique Development Facilitation

Predicted RT aids in technique development by assisting in the selection of optimal stationary phases, mobile phases, and column temperatures for chromatographic separations. [42]

Identification Capability

Each compound exhibits a distinct RT, enabling the identification of unknown compounds by comparing their RTs with those of known standards. [43]

Quality Control Assurance

Comparison of RTs between test and standard samples facilitates quality control, aiding in the detection of contamination, impurities, and adulteration in various fields. [44]

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Sample Identification
RT comparison between known and unknown samples allows for easy identification of unknown compounds, utilizing known RTs as benchmarks for detection.[44]

Cost Savings
Predicting RTs leads to increased accuracy and reduced trial and error, resulting in cost savings by minimizing unnecessary experimentation and analysis. [45]

Time Efficiency
Prediction of RTs contributes to shorter chromatographic analysis durations, thereby reducing the overall duration of the analytical process. [46] While the benefits of RT prediction are substantial, achieving them requires adherence to complex procedures and strategies rooted in principles of chromatography. Various approaches and techniques, including statistical and computational methods utilizing precise datasets, have been extensively employed by researchers to forecast RT accurately.

Quantitative Structure-Retention Relationship (QSRR)
Quantitative Structure-Retention Relationship (QSRR) is a predictive approach used to estimate compound retention times (RTs) in chromatographic systems based on structural and physicochemical data. [47]. This review explores QSRR principles, methodologies, and recent advancements, focusing on data sources, model development strategies, and applications in analytical chemistry. Additionally, it addresses challenges and future prospects, emphasizing QSRR's significance in predicting RTs and enhancing chromatographic analyses.

Theoretical foundation
The theoretical foundation of QSRR lies in the principle that a compound's retention time (RT) is determined by its chemical structure and physicochemical properties. This relationship can be mathematically represented as: tR = f(Structure, Physicochemical Properties), where tR is the RT. "Structure" includes molecular descriptors like chemical formula, connectivity, and molecular weight, while "Physicochemical Properties" cover polarity, hydrophobicity, and acid-base characteristics. QSRR models quantitatively link these factors to RT using statistical methods, machine learning, or quantum chemical calculations.

Descriptors and Molecular Representation
An integral facet of QSRR lies in the meticulous selection of pertinent molecular descriptors and the accurate representation of chemical structures. Descriptors serve as numerical representations of chemical attributes, adept at capturing both the structural intricacies and physicochemical properties of compounds such as size, shape, polarity, electronic properties, and other pertinent characteristics.[48] These descriptors play a crucial role in various fields including computational chemistry, cheminformatics, and drug discovery, facilitating investigations such as QSAR, QSPR, and QSRR[23,49] shown in Figure 3.By mathematically capturing the essence of chemical compounds, molecular descriptors essentially create molecular fingerprints, providing deeper understanding of their characteristics and functions. They are particularly invaluable in disciplines like material science and pharmaceutical research. In recent times, molecular fingerprints have garnered attention due to their efficacy in encoding the presence or absence of specific substructures within a molecule. These fingerprints facilitate the efficient management of extensive datasets and facilitate the development of robust machine learning modelsand enhances the efficiency and precision of analyses in diverse scientific endeavors.

Zero-dimensional (Topological) molecular descriptors
Zero-dimensional (0D) molecular descriptors constitute a foundational class of descriptors that offer essential molecular information independent of spatial arrangement or connectivity. Although they appear simplistic in contrast to higher-dimensional descriptors, they yield valuable insights into fundamental properties critical across chemical and biological domains. Nonetheless, their simplicity inherently imposes limitations on the breadth and depth of information they convey when compared to descriptors of higher dimensions. [50]

Molecular Formula and Atom Information

The molecular formula provides the elemental composition of a molecule, indicating the types and numbers of atoms present. Atom information includes the identification and counting of different atom types (e.g., carbon, hydrogen, oxygen) and their connectivity. Bond information involves the types of chemical bonds (e.g., single, double, triple) connecting atoms.

Ionization Potential

This descriptor measures the energy required to extract an electron from a molecule or atom, reflecting its stability and reactivity.

Electronic Charge Distribution

Describes the distribution of electrons within the molecule, providing insights into its electronic structure and reactivity.

Constitutional Descriptors

These descriptors are based on the chemical makeup of the molecule, providing fundamental information about its composition like molecular weight, number of atoms, and rotatable bonds etc.

These foundational information about molecules, essential for various applications such as drug design, chemical synthesis, and property prediction. While they offer simplicity and ease of computation, they may lack the detailed structural information provided by higher-dimensional descriptors.

One dimensional (1D) molecular descriptors

One-dimensional molecular descriptors characterize structural fragments such as fingerprints, functional groups, and substituents, offering key insights into molecular structure.[48] Molecular fingerprints, widely used in similarity searches and virtual screening, are binary or hashed representations indicating the presence or absence of specific substructures. Chemical fingerprints encode structural substructures, [51] while circular fingerprints capture circular substructures around atoms for detailed representation. These descriptors are valuable tools in drug discovery, chem. informatics, and computational chemistry, providing concise numerical representations of molecular structure for efficient analysis and prediction of molecular properties and behaviors.[52]

Two dimensional (2D) molecular descriptors

Two-dimensional molecular descriptors provide key insights into molecular structure and properties essential for predicting retention times (RTs) in QSRR. These descriptors, calculated from a molecule's 2D representation, capture connectivity, functional groups, and topological indices. Common descriptors include molecular volume, shape indices, atom and bond counts, and topological measures like the Wiener and Zagreb indices. Molecular volume, reflecting atom spatial distribution, informs on size, reactivity, and solubility, impacting chromatographic behavior. This approach is valuable in fields like analytical chemistry, pharmaceuticals, and biochemistry, where chromatography is crucial for compound analysis and separation. [53]

Three-dimensional (3D) molecular descriptors

3D molecular descriptors are crucial for predicting retention times (RTs) in chromatography by capturing the spatial arrangement of atoms. These descriptors model interactions between analytes and the stationary phase, improving RT accuracy. Chirality descriptors are essential in chiral separations, reflecting how stereochemistry affects retention behavior, critical in pharmaceutical analysis for enantiomeric purity. Additionally, 3D pharmacophores highlight key spatial features influencing molecular interactions, aiding RT predictions. By identifying structural elements for effective binding, pharmacophore descriptors support designing optimized chromatographic methods for specific analytes, enhancing separation efficiency and analytical performance. [52, 54]

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Four-dimensional (4D) molecular descriptors

4D molecular descriptors enhance QSRR models for predicting retention times (RTs) by offering deeper insights into molecular properties and interactions. Beyond traditional 1D, 2D, and 3D descriptors, 4D descriptors incorporate time-dependent properties and environmental variations, capturing dynamic molecular behavior. This comprehensive portrayal improves RT predictions by considering factors like molecular dynamics and temporal changes that influence chromatographic separations. Integrating 4D descriptors into QSRR models increases accuracy and reliability, driving advancements in pharmaceuticals, environmental science, and chemical analysis by enabling more precise chromatographic analyses and better method optimization. [52,54]

Modeling Statistics

Following the selection of relevant descriptors, a variety of statistical and machine learning models are employed to establish the quantitative relationship between these descriptors and RT.50 Regression analysis serves as a pivotal tool in elucidating the link between descriptors and specific molecular characteristics or behaviors. By employing regression analysis, we can discern the contributions of individual descriptors to the property of interest, unveiling their relative importance and influence. This analytical approach finds applications across diverse sectors such as drug discovery, materials science, and chemical engineering, shedding light on fundamental factors governing molecular behavior. [55]

Linear Regression Models

Linear regression models, including simple linear regression and regression with multiple linear variables, form the cornerstone of regression analysis. In simple linear regression, the relationship between two variables is represented as a linear combination of descriptors and corresponding coefficients. Regression with multiple linear variables expands upon this basic framework by incorporating multiple descriptors simultaneously. [56] Previous research has demonstrated the effectiveness of combining genetic algorithms with multiple linear regression for handling both constrained and unconstrained problems. [57]

Nonlinear Regression Models

Nonlinear regression techniques, such as polynomial regression and spline regression, enable the modeling of nonlinear relationships by incorporating polynomial terms or piecewise polynomials for the descriptor. [58] Kernel regression further extends this capability by leveraging kernel functions to capture intricate nonlinear relationships by transforming data into a higher-dimensional space.

Machine Learning Models

Machine learning models offer powerful tools for capturing complex relationships between descriptors and RT. Support Vector Machines (SVMs) identify hyperplanes that maximize the margin between data points, effectively capturing intricate relationships. [59]. Ensemble techniques, such as Random Forest, are particularly adept at capturing complex relationships between descriptors. Deep learning models, such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), [60] with multiple layers, excel at depicting intricate, nonlinear functions and can be adapted for QSRR tasks.[61] Additionally, methods like K-Nearest Neighbors (KNN) and Gradient Boosting, including Light GBM and XG Boost, demonstrate exceptional prediction accuracy and are frequently employed for QSRR tasks, especially in processing high-dimensional descriptor spaces and capturing complex patterns in data. [62]

Chemometric Approaches

Chemometrics, a multidisciplinary field combining statistics, mathematics, and chemistry, offers invaluable techniques for modeling and processing chemical data in QSRR. [63]

Principal Component Analysis (PCA)

PCA reduces the dimensionality of the dataset by transforming descriptors into a new set of uncorrelated variables known as principal components. This facilitates data visualization and highlights significant structural elements. [64]

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Partial Least Squares (PLS)

PLS combines multiple linear regression and PCA, identifying latent variables that capture the most variance in RT and descriptors. It is especially useful in cases with multicollinearity and many descriptors [65]. Integrating regression analysis, machine learning, and chemometric approaches in QSRR provides a robust framework for predicting RT, advancing research, and discovering compounds with desired properties.

QSRR Model Evaluation

Performance Metrics

Performance metrics are fundamental tools for evaluating the efficacy and precision of QSRR models developed for prognosticating RT in chromatographic methods. [66] Widely utilized metrics encompass

Root Mean Square Error (RMSE)

RMSE gauges the root of the average squared deviation between predicted and observed RTs. Reduced RMSE values signify enhanced model performance.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}$$

Where n denotes the number of observations, y_i represents the observed RT, and $\hat{y}_i$ signifies the predicted RT.

Coefficient of Determination (R²)

R^2 delineates the ratio of the variance in RT elucidated by the model. Augmented R^2 values, nearing unity, indicate superior model fit to the data. [67]

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

Where $\tilde{y}$ denotes the mean of observed RTs.

Cross-validated Coefficient of Determination (Q²)

Q^2 assesses the predictive capability of the model via cross-validation. Elevated Q^2 values connote enhanced predictive performance. [67]

$$Q^2 = 1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

Where $\hat{y}_i$ represents the predicted RT from cross-validation.

Mean Absolute Percentage Error (MAPE)

MAPE delineates prediction errors as a percentage of observed values, offering insight into the relative precision of the model.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - \hat{y}_i}{y_i}\right| \times 100\%$$

These metrics serve as indispensable benchmarks for scrutinizing the fidelity and efficacy of QSRR models, ensuring their applicability and reliability in chromatographic method prediction and refinement.

Bias-Variance Trade-off

The bias-variance trade-off is critical in QSRR model development. High bias results in underfitting, oversimplifying the RT prediction, while high variance leads to overfitting and poor generalization. Balancing both requires choosing the right model complexity. Techniques like cross-validation and regularization help mitigate overfitting by penalizing overly complex models[68].

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Model Robustness and Reliability

Ensuring QSRR model robustness and reliability is crucial for accurate RT predictions in chromatography [69]. Techniques like cross-validation, bootstrapping, and external validation with independent datasets assess model performance and generalization [70]. Validating predictions against varied experimental conditions, including column types and temperatures, ensures consistency and accuracy across diverse scenarios.

Overfitting and Underfitting Assessment

Overfitting and underfitting are key challenges in QSRR model development. Overfitting occurs when a model captures noise in the training data, leading to poor performance on new data, often due to excessive complexity or inadequate regularization. Underfitting happens when a model fails to capture the data's underlying patterns, resulting in low accuracy. Cross-validation helps identify these issues by comparing performance on training and validation sets. High training accuracy with low validation accuracy suggests overfitting, while poor performance on both indicates underfitting. Regularization methods like ridge and lasso regression help mitigate overfitting by penalizing excessive complexity, improving model generalizability.

Interpretability of the Model

Interpretability is crucial in QSRR models for RT prediction, as it allows researchers to understand how molecular descriptors influence retention behavior. This insight aids in optimizing compounds and designing effective chromatographic methods. Linear regression models like multiple linear regression (MLR) and partial least squares (PLS) regression are inherently interpretable, providing clear coefficients that show the impact of each descriptor on RT. Advanced techniques such as feature importance analysis also help identify key descriptors, even in complex models [71]. Prioritizing interpretability enhances the practical utility of QSRR models, fostering trust and enabling better decision-making in chromatographic research.

DISCUSSIONS

Analytical chemistry serves as a cornerstone across various industries, from pharmaceuticals to forensics, providing invaluable insights into the identification and quantification of substances. Within this domain, QSRR stands out as a powerful tool, particularly in chromatography, aiding in the precise estimation of RTs (RT) of compounds. By establishing a mathematical correlation between the chemical composition of compounds and their RTs, QSRR enables predictive modeling and optimization in chromatographic techniques such as gas chromatography (GC) and liquid chromatography (LC). The scope of QSRR in chromatography is vast and multifaceted, offering numerous benefits across different analytical challenges. One of its primary advantages lies in its predictive capability, allowing for the anticipation of RTs for compounds based on their chemical structure. This predictive power is instrumental in identifying and quantifying individual components within complex mixtures, facilitating method optimization and reducing expenses and time associated with method development. Furthermore, QSRR plays a crucial role in environmental analysis by aiding in the prediction of pollutant behavior and structural clarification of unknown substances. The theoretical foundation of QSRR is rooted in the intricate relationship between a compound's chemical structure, physicochemical properties, and its RT. By leveraging molecular descriptors to mathematically represent these factors, QSRR models provide a quantitative framework for understanding and predicting RTs. These descriptors, ranging from zero-dimensional to four-dimensional representations, capture essential structural and physicochemical characteristics of compounds, essential for accurate RT predictions. Modeling statistics, including linear regression models, nonlinear regression models, machine learning models, and chemometric approaches, are employed to establish the quantitative relationship between descriptors and RT. These models undergo rigorous evaluation using performance metrics such as Root Mean Square Error (RMSE), Coefficient of Determination (R^2), Cross-validated Coefficient of Determination (Q^2), and Mean Absolute Percentage Error (MAPE). Additionally, the bias-variance trade-off, model robustness and reliability, overfitting and underfitting assessment, and interpretability of the model are critical considerations in QSRR model development.

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CONCLUSION

QSRR holds immense potential in advancing chromatographic analysis by providing a systematic approach to predict RTs based on compound structure and physicochemical properties. Its application spans across various industries, offering cost-effective and time-efficient solutions for method optimization, environmental analysis, structural elucidation, and quality assurance. As technology continues to evolve, QSRR remains at the forefront of analytical chemistry, driving innovation and pushing the boundaries of scientific inquiry.

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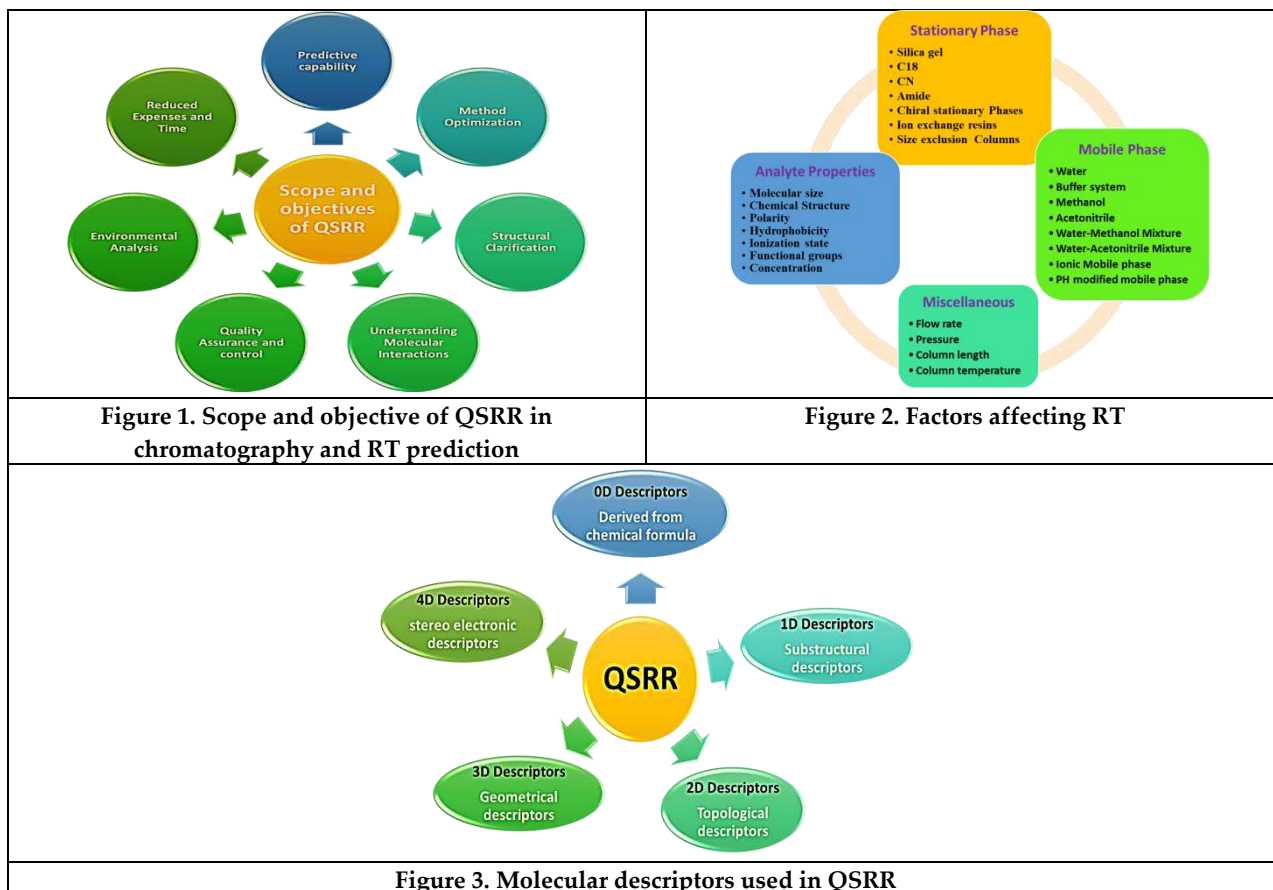
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Figure 1. Scope and objective of QSRR in chromatography and RT prediction

Figure 2. Factors affecting RT

Figure 3. Molecular descriptors used in QSRR

RESEARCH ARTICLE

Third-Order Optical Nonlinearities and Optical Limiting in 1-Naphthol Picrate: A Z-Scan Approach

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ABSTRACT

1-Naphthol picrate has been synthesized and characterized, and its third-order nonlinear optical properties were investigated via Z-scan studies. It demonstrates reverse saturable absorption, as indicated by a positive absorption coefficient β, which is of the order 10^{-12} m/W. Closed aperture data indicate positive refractive nonlinearity due to self-focusing, with nonlinear refractive index n_2, third-order susceptibility $\chi^{(3)}$ and second-order hyperpolarizability γ in the order of 10^{-19} m²/W, 10^{-13} esu and 10^{-34} esu respectively. Additionally, it exhibits an optical limiting property with a threshold of 18.66J/cm². Optical limiting is crucial for protecting sensitive optical sensors and human eyes from damage caused by intense laser beams. Therefore, 1-naphthol picrate is highly recommended for optical limiting applications due to its effective third-order nonlinear optical properties and low threshold for limiting.

Keywords: Z Scan, Third-Order Nonlinear Optical (NLO) Properties, Optical Limiting

INTRODUCTION

Nonlinear optics plays a crucial role in modern photonics, encompassing various phenomena such as second-order and third-order nonlinearities [1-3]. Among these, third-order nonlinearities are particularly important due to their ability to facilitate processes like third-harmonic generation, self-phase modulation, and the optical Kerr effect, which

are essential for manipulating light in advanced optical systems[4-5]. These third-order effects enable precise control over light propagation, phase, and intensity, allowing for the development of sophisticated optical devices such as all-optical switches, modulators, and signal processors. Additionally, third-order nonlinearities are pivotal in creating new frequencies of light through processes like four-wave mixing, expanding the versatility and functionality of optical technologies [6-8]. The significance of third-order nonlinearities extends to their crucial role in optical limiting, where they protect sensitive equipment and human vision from high-intensity laser beams, ensuring safety and reliability in various applications [9-10].In today's era of rapidly advancing laser technologies, optical limiting is increasingly relevant for safeguarding delicate optical sensors and human eyes from accidental exposure to high-power laser pulses. This protection is vital not only in industrial and scientific research settings but also in consumer electronics and medical devices, where the prevalence of laser use continues to grow. Organic molecules with aromatic rings are highly promising for third-order nonlinear optical applications due to their exceptional nonlinearity, high tolerance to optical damage, and rapid electronic response [11-12]. Among these, picric acid derivatives stand out as compelling candidates, owing to their readily accessible charge transfer interactions, which confer strong nonlinear optical (NLO) activity [13-15]. Despite the potential of picrates, 1-naphthol picrate remains relatively unexplored regarding its nonlinear optical behavior. Therefore, this study aims to conduct a comprehensive investigation into the third-order nonlinear optical responses and optical limiting properties of 1-naphthol picrate through z-scan studies.

MATERIALS AND METHODS

The reagents used for the synthesis were of AR grade. Solvents were purified and dried according to standard procedures. 1-Naphthol and picric acid were purchased from Merck and used without further purification. Purity of the product was checked by TLC and melting point determination (BUCHI, B540). Characterization was done using FT-IR (Bruker Alpha-E FT IR).

Synthesis of 1-Naphthol Picrate
1-Naphthol Picratewas synthesized by slow evaporation of methanolic solution containing equimolar amount of 1-naphthol and picric acid. Solution of equimolar amounts of naphthol and picric acid in Methanol were prepared separately. After mixing the two solutions, the resultant solution is stirred well. Within two days, bright yellow crystals of 1-naphthol picrate were formed. The obtained crystalline material mixed with methanol and allowed to evaporate at room temperature. Good morphological yellow-coloured crystals were grown within one week.Purity was checked by TLC and melting point determination. Melting point for the title compound is obtained as 191.1˚(Methanol).

Z-scan Studies
The Z-scan technique holds significant relevance for investigating third-order nonlinear optical properties and optical limiting characteristics due to its ability to accurately measure nonlinear absorption, nonlinear refraction, and third-order nonlinear optical susceptibility. By traversing the sample along the focal point of a lens, the technique provides insights into the material's response to intense light, distinguishing between reverse saturable absorption and saturable absorption mechanisms. This thorough characterization enables the identification of materials with desirable optical limiting properties, crucial for the development of effective laser safety measures and advanced photonic devices [16-17]. The open aperture Z-scan technique involves measuring the transmission of a sample while keeping the aperture fully open, allowing the entire beam to pass through the sample. This setup is useful for investigating nonlinear absorption processes such as reverse saturable absorption (RSA), where the intensity-dependent transmission is observed due to nonlinear absorption mechanisms within the material [18].In contrast, the closed aperture Z-scan technique involves partially blocking the beam using an aperture, allowing only a fraction of the beam to pass through the sample. This configuration is employed to study nonlinear refraction effects such as self-focusing or self-defocusing, where changes in the beam's phase and focal length occur due to nonlinearities in the refractive index of the material[19].In summary, open aperture Z-scan measures nonlinear absorption processes,

while closed aperture Z-scan assesses nonlinear refraction effects, providing complementary information about the third-order nonlinear optical properties of the material. Indeed, for a molecule to effectively exhibit optical limiting properties, it must possess both reverse saturable absorption behavior and positive nonlinear refractive properties. Reverse saturable absorption (RSA) allows the material to absorb more light as the intensity increases, effectively limiting the transmission of high-intensity light through the medium. Additionally, positive nonlinear refractive properties indicate that the material exhibits self-focusing behavior, where the refractive index increases with increasing light intensity, leading to the defocusing of intense light and thereby contributing to optical limiting capabilities. Together, these characteristics enable the molecule to efficiently mitigate the effects of high-intensity light, making it suitable for optical limiting applications in various fields such as laser safety and photonics. Z-scan measurement was carried out using Q-switched Nd-YAG laser having 5 ns pulses at a repletion rate of 10 Hz giving second harmonic at 532 nm. The laser beam was focused by a lens of 10 cm focal length. In this technique sample is mounted on the translation stage and translating the sample between +Z and –Z position along Z-direction. The radius of the beam waist ω_0 was calculated to be 35μm. The Rayleigh length, was calculated as 7.42 mm, is greater than the thickness of the sample cuvette (1mm), an essential requirement for Z-scan experiments. The third- order nonlinear refractive index n_2 and nonlinear absorption coefficient β, third order NLO susceptibility $\chi^{(3)}$, second hyperpolarizability γ(third order effect) of 1-naphthol picrate in acetone having 0.5 mM concentration and intensity at 1.08 GW/cm2 were evaluated by closed and open aperture Z-scan techniques.

RESULTS AND DISCUSSIONS

Characterization using FT-IR

FT- IR spectrum of 1-naphthol picrate is given in Figure 1.The O-H stretching vibrations are sensitive to hydrogen bonding. The non-hydrogen-bonded or free hydroxyl group absorbs strongly in the 3600–3550 cm^{-1} region, whereas the existence of an intermolecular hydrogen bond can lower the O-H stretching wave number to the 3550–3200 cm^{-1} region with the increase in IR intensity. The O-H stretching vibration appears as a weak band in IR at 3120 cm-1 which reveals the presence of intramolecular hydrogen bonding and a strong band corresponds to the OH vibration. The characteristic infrared absorption wavenumbers of carbonyl group in cyclic ketones are present. The C=O stretching mode can be easily identified from IR spectra and because of the degree of conjugation, the strength and polarizations are increased. The carbonyl stretching vibrations in ketones are expected in the region 1715–1680 cm^{-1}. Peaks around 1300-1500 cm^{-1} are attributed to aromatic C=C stretching vibrations, characteristic of the naphthalene ring in 1-naphthol. Furthermore, peaks in the region of 1000-1200 cm^{-1} indicate the presence of C-O stretching vibrations, likely originating from the ether linkage in the molecule.

Third Order Nonlinear Optical Studies of 1-Naphthol Picrate
Open Aperture (OA) Z-Scan Plot

Nonlinear absorption characteristics of 1-naphthol picrate have been obtained from open aperture Z-scan plot. Figure 2 shows the open aperture (OA) Z-scan curve of 1-naphthol picrate at 0.5 mM concentration in acetone and 1.08 GW/cm2 intensity. The obtained OA curve shows decrease in transmittance (a dip) as the sample passes through the focal point of the lens (z = 0). This dip occurs because the absorption increases with the light intensity at the focus, resulting in less transmitted light. It is the characteristic feature of reverse saturation behavior where the material absorbs more light as the light intensity increases. Hence the absorption coefficient β is positive. A material with reverse saturable absorption property shows increase in absorption when increase in laser intensity. From the following curve, it is clear that open aperture plot of 1-naphthol Picrate shows excellent agreement with theoretical fit.

Closed Aperture (CA) Z-Scan Plot

Closed Aperture (CA) Z-Scan Plot of 1-naphthol picrate at 0.5 mM concentration in acetone and 1.08 GW/cm2 intensity have been recorded and is shown in Figure 3.In the closed aperture Z-scan data of 1-naphthol picrate, the presence of a valley followed by a peak in the normalized transmittance curve indicates positive nonlinear refraction.

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This pattern signifies that as the sample approaches the focal point (z = 0), the refractive index increases with light intensity, causing the beam to focus more tightly. This self-focusing effect leads to a reduction in transmittance (valley) because the beam becomes more concentrated within the aperture. As the sample moves past the focus, the beam diverges, resulting in an increase in transmittance (peak). This characteristic valley-peak sequence is a clear indicator of positive nonlinear refractive behavior, confirming the self-focusing nature of 1-naphthol picrate.

The normalized transmittance T(z) is given by

$$T\left(z,\Delta\phi_0\right) = 1 - \frac{4\Delta\phi_0 x}{(x^2+9)(x^2+1)}$$ ---------------- **(1)**

Where, $\Delta\phi_0$ is the on axis nonlinear phase shift and x is z/z_0. The nonlinear refractive index n_2 and real part of third-order nonlinear susceptibility, Re $\chi^{(3)}$ were calculated by the following relations[20].

$$n_2 = \frac{\Delta\phi_0 \lambda}{2\pi I_0 L_{eff}}$$ ---------------- **(2)**

$$\mathrm{Re}\,\chi^{(3)} = 10^{-4}\frac{\varepsilon_0 n_0^2 c^2}{\pi} n_2$$ ---------------- **(3)**

The imaginary part of the third order susceptibility (Im$\chi^{(3)}$) was calculated from β through the relation

$$\mathrm{Im}\,\chi^{(3)} = 10^{-2}\frac{\varepsilon_0 n_0^2 c^2 \lambda}{4\pi^2}\beta$$ ---------------- **(4)**

Where, ε_0 is the permittivity of free space, c is the velocity of light in vacuum and n_0 is the linear refractive index.

The third-order nonlinear susceptibility, $\chi^{(3)}$ was calculated from the relation

$$\chi^{(3)} = \left[(\mathrm{Re}\,\chi^{(3)})^2 + (\mathrm{Im}\,\chi^{(3)})^2\right]^{1/2}$$ ---------------- **(5)**

The second order hyperpolarizability, γ of the sample is related to the third-order susceptibility through the equation

$$\gamma = \frac{\chi^{(3)}}{\left[\frac{1}{3}\left(n_0^2+2\right)\right]^4 N}$$ ---------------- **(6)**

Where, N is the molecular number density in cm^{-3}.

The third order nonlinear refractive index n_2, nonlinear absorption coefficient β, third order NLO susceptibility $\chi^{(3)}$ and second order hyperpolarizability γ of 1-naphthol picrate in acetone having 0.5 mM concentration and intensity at 1.08 GW/cm^2 were evaluated by the measurements of closed and open aperture Z-scan techniques and are enlisted in Table 1.The values presented in Table 1 highlight key nonlinear optical properties of the material under study, which have significant implications for various applications in photonics and optoelectronics. The nonlinear absorption coefficient β (m/W) is of the order of 10^{-12}. This coefficient indicates the material's ability to absorb light in an intensity-dependent manner, which is crucial for applications such as optical limiting and the protection of sensitive optical components from high-intensity light. The nonlinear refractive index n_2 is of the order of 10^{-19} m^2/W which measures the intensity dependent change in the refractive index. This property is essential for applications in all-optical switching, modulation, and the development of advanced photonic devices that leverage light. Additionally,

the third-order susceptibility $\chi^{(3)}$ and second-order hyperpolarizability γ are of the order of 10^{-13} esu and 10^{-34} esu, respectively. $\chi^{(3)}$ is a fundamental parameter describing the third-order nonlinear response of the material, indicating its ability to interact with high-intensity light in a non-linear fashion. γ further elucidates the strength of the nonlinear interaction, providing insights into the efficiency of various nonlinear optical processes within the material. These parameters collectively underscore the material's potential for integration into advanced optical systems, enabling innovations in optical limiting, signal processing, and other photonic applications.

Optical Limiting Properties of 1-NaphtholPicrate
Figure 4 illustrates the optical limiting curve of 1-naphthol picrate, where the normalized transmission is plotted against the input power for a 0.5 mM solution. At a threshold value of 18.66 J/cm², a self-focusing effect occurs, significantly reducing the beam intensity that reaches the detector. This self-focusing effect causes a notable decrease in the transmittance recorded by the detector. The importance of this behavior lies in its application potential for optical limiting devices, which are essential for safeguarding sensitive optical sensors and human eyes from high-intensity light sources. The ability of 1-naphthol picrate to clamp transmitted intensity through self-focusing makes it a promising material for developing advanced optical limiters, ensuring protection against laser-induced damage.

CONCLUSION

1-Naphthol picrate has been synthesized and characterized and found to be third order NLO active from Z-scan study. The Z-scan technique reveals its reverse saturation behavior, characterized by a positive absorption coefficient β of the order 10^{-12} m/W. This behavior is crucial for optical limiting, which protects sensitive optical sensors from damage by intense light pulses. The positive nonlinear refractive index n_2 of the order 10^{-19} m²/W, indicates self-focusing properties, essential for beam control in optical systems. The third-order nonlinear optical susceptibility $\chi^{(3)}$ and the second-order hyperpolarizability γ are of the order of 10^{-13} esu and 10^{-34} esu, respectively, confirm the picrate's strong nonlinear response. The optical limiting threshold of 18.66 J/cm² indicates its effectiveness in limiting high-intensity light, ensuring its applicability in protecting optical devices. These properties underscore 1-naphthol picrate's potential in optical limiting applications, where controlling light intensity is crucial for device safety and performance.

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Table 1. Third-Order Nonlinear Optical Parameters of1- Naphthol Picrate

β (x10⁻¹²) (m/W)	n_2 (x10⁻¹⁹) (m²/W)	Re $\chi^{(3)}$ (x10⁻¹³) (esu)	Im $\chi^{(3)}$ (x10⁻¹³) (esu)	$\chi^{(3)}$ (x10⁻¹³) (esu)	γ (x 10⁻³⁴ esu)
6.5716	6.0780	4.4322	1.5054	4.6808	8.9172
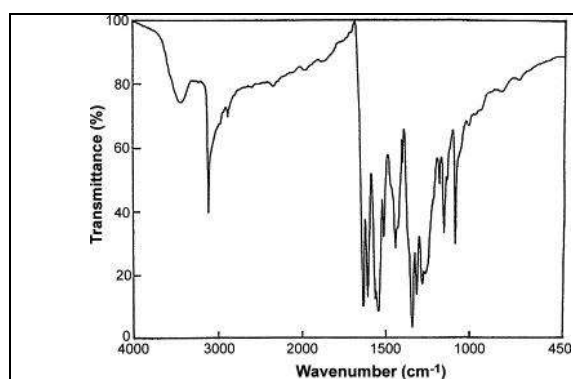
| **Figure 1. FT-IR Spectrum of 1-Naphthol Picrate** | **Figure 2. Open Aperture (OA) Z-Scan Plot of1-Naphthol Picrate** |
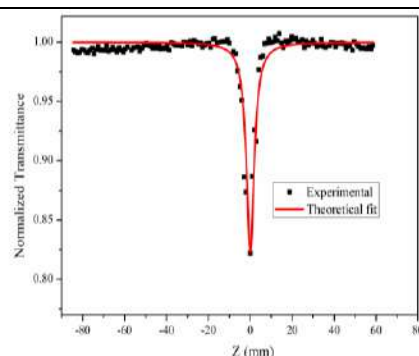
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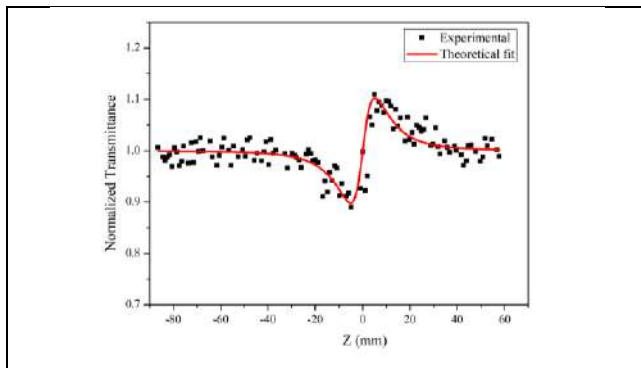
Figure 3. Closed Aperture (CA) Z-Scan Plot of 1-Naphthol Picrate	**Figure 4. Optical limiting curve of 1-Naphthol Picrate**
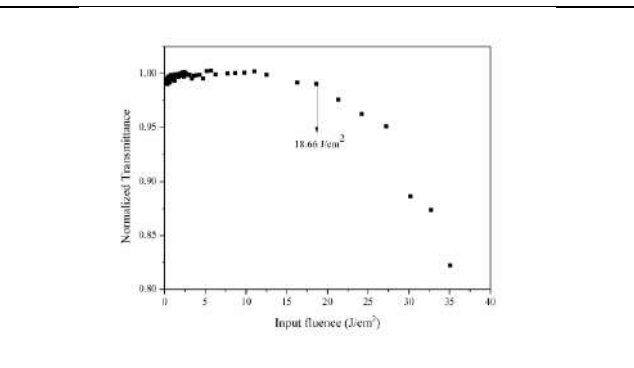
RESEARCH ARTICLE

Assessing the Technical Efficiency of Sorghum Farmers in Namakkal District

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ABSTRACT

Sorghum is a versatile grain with promising agricultural, industrial, and nutritional applications. Sorghum production in India stands at 8.71 million tonnes. It is grown on 4.01 lakh hectares in Tamil Nadu, with a yield of 612 kg/ha. The output is 4.6 lakh tonnes. Technical efficiency of sorghum farmers in Namakkal district, with a focus on factors influencing productivity. A study was carried out in Namakkal district to investigate the technical efficiency of sorghum production as well as the constraints that sorghum farmers face. The study included a sample of 120 respondents chosen at random and analyzed using stochastic frontier analysis and the garret ranking technique. This study concluded the efficiency level of sorghum production in a selected study area and investigated the problems encountered by sorghum farmers. The mean technical efficiency of the study area obtained 0.82. Because selected variables like seed, plant protection measures, chemical fertilizer, irrigation and machinery usage are high significant at positive nature.

Keywords: Productivity, Stochastic frontier production, Technical Efficiency, Constraints, Garret Ranking.

INTRODUCTION

Sorghum a drought-tolerant crop grown by small farmers in rainy regions. Sorghum is a popular food among high-income individuals due to its high nutritional value. Efficient production is systems benefit agricultural growth, nutritional security, and rural livelihoods in countries such as India and Nigeria, where sorghum is a major crop [1]. Improving the use of existing technologies by all households, rather than introducing new technology, can increase sorghum output. Smallholder households growing sorghum lack technical efficiency, which can be improved by addressing important policy variables that impact their level of technical inefficiency [2]. The extension support system should work towards awareness building in terms of improving economic and technical efficiency of inputs [3]. Comparing Technical efficiency and productivity across farming systems, methods, and locations, including periurban and rural areas [4]. Consider the profitability, employment generation, and technical efficiency of various cropping systems, rather than a single enterprise. There is a growing emphasis on doubling farmers' income and eliminating hunger. Farming systems have the potential to reduce production risks, increase profitability, optimize resource utilization, and generate sustainable income in today's agricultural policy context [5]. The marginal value productivity analysis revealed that all variables, except farm yard manure, were used inefficiently in sorghum farms. Maize farms used all variables inefficiently. Farmers of sorghum and maize faced significant challenges such as pest and disease outbreaks, high labor costs, lack of value-added awareness, and limited processing options [6]. Sorghum production by smallholder farmers in the county is inefficient in terms of resource utilization [7]. Sorghum is a high-yield crop in the area under investigation. In this focus the current study which examines technical efficiency and production constraints faced by the sorghum farmers based on the study area.

MATERIALS AND METHODOLOGY

Tamil Nadu offers a plethora of studies. The area under cultivation of sorghum crop ranks first in Namakkal district in overall Tamil Nadu [8]. A predetermined interview schedule was used to collect primary data. The data for the 120 sample farmers respondents was collected using the random sampling method. In this section, I examined the technical efficiency of frontier stochastic production function analysis, as well as the constraints that sorghum farmers face when using the Garrett Ranking Technique.

Technical Efficiency

The stochastic frontier production function for estimating farm level technical efficiency is specified as

$$Y_i = f(X_i \beta) + e_i \qquad\qquad \text{......................... (1)}$$

Here i is the nth observations, Y_i is output, X_i is denotes the actual input vector of production function and β is the vector of parameters of production function and e is the error term is divided of two elements, that is

$$e_i = V_i - U_i \qquad\qquad \text{................. (2)}$$

Here, V_i is the symmetric disturbances assumed to be identical, independently and normally distributed as $N(0, \sigma_{vi}^2)$ given the stochastic structure of the frontier. Next U_i is a one side error term that is independent of V_i and is normally distributed as $(0, \sigma_{ui}^2)$. The farm specific technical efficiency is defined in terms of observed output (Y_i) to the corresponding frontier output (Y^*_i) using the available technology derived which is defined as follows:

$$TE_i = \frac{Y_i}{Y_i} = \frac{E\left(Y_i / u_i \, X_i\right)}{E\left(Y_i / u_i = 0, \ X_i\right)}$$

$$= E\left[exp^{-U_i / e_i}\right] \qquad\qquad \text{.............................(3)}$$

In measuring the technical efficiency this study assumed that yield of sorghum production (Kg) is dependent on farm size (ha), quantity of seeds (kg), labor (man day), plant production measures (lit), chemical fertilizer (kg), irrigation (no.) and machinery usage (hr). The stochastic model was specified as,

$$\ln(Y) = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + V_i - U_i \qquad \text{..................... (4)}$$

Where,

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Y = sorghum yield

X_1 = farm size (ha)

X_2 = quantity of seeds (kg)

X_3 = labor (man day)

X_4 = plant production measures (lit)

X_5 = chemical fertilizer (kg)

X_6 = irrigation (no.)

X_7 = machinery usage (hr)

β_0 = constant

$\beta_0 - \beta_7$ = Coefficient of independent variable $X_1 - X_7$

v_i = random error team which is assumed to be independent and normally distributed as N $(0, \delta^2)$

u_i = technical inefficiency which is assumed to be independent and a truncated normal distribution at zero with mean μ_i and variance δ^2_u, N (μ_i, δ^2_u)

Garret Ranking Technique

Garret ranking technique is widely used to rank the qualitative judgements and opinion about a phenomenon. The technique was used to rank the reason for constraints faced by sorghum farmers. The respondents were asked to rank the factors or problems and the ranks were converted into percent position using following formula.

$$\text{Percent Position} = \frac{100\,(R_{ij} - 0.5)}{N_{ij}}$$

Where,

R_{ij} – Rank given for the ith attribute by the jth individual

N_{ij} – number of items ranked by j^{th} individuals

RESULTS AND DISCUSSIONS

MLE estimators of stochastic frontier function of sorghum farmers

The technical efficiency of sorghum farmers was estimated by using the stochastic frontier production function. The Maximum Likelihood Estimates (MLE) of the parameters of Cobb-Douglas stochastic frontier function were obtained and using maximum likelihood procedures through FRONTIER 4.1 package and the results are presented in Table 1. The variance of parameters γ and σ^2 were 0.99 and 0.082 in sorghum production. The sigma squared denoted that the goodness fit and correctness of the distribution form assumed for the composite error team while the gamma indicated that systematic influence was un-explained by the production and also, the mean technical efficiency was estimated at 82 percent. It represents the estimated coefficient of seed, plant protection measures, chemical fertilizer, irrigation and machinery usage were influenced positively and significantly. Labor was negatively significant. The estimated coefficient of the seed and plant protection measures was positive and significant with the value of 0.5155 and 0.1224 in respectively, implied that one percent increases in the expenditure on seed and plant protection measures would increase sorghum yield by 0.51 per cent and 0.12 per cent in respectively. The coefficient of the chemical fertilizer and machinery usage was positive and significant with the value of 0.6811 and 0.5638 in respectively, implied that one percent increases in the chemical fertilizer and mechanization would increase the yield by 0.68 per cent and 0.56 per cent in respectively. The estimated coefficient of the irrigation was positive and significant with the value of 0.0273, implied that one percent increases the no. of irrigations it could influence the yield at 0.02 per cent.

Level of efficiency in farmers

Table 2. represent the technical efficiency ranges from 0.98 to 0.50 with a mean efficiency of 0.82. For the average efficiency to achieve the technical efficiency level of most efficient farmers could only bring about a 16.32 percent increase in production. The least efficient farmers can increase their production by 43.2 percent to achieve the required technical efficiency of the most efficient farmers. Among the farmers, 35 percent efficient level. Mostly we

can see that 66.67 per cent sample respondent of sorghum farmers which shows the efficiency level is above 80 per cent.

Production constraints faced by the sorghum farmers

Table 3. represent that the problem faced by the user respondents of the sorghum farmers used to Garret ranking tool and analyzed to given the ranking of that problems. Lack of high-quality seeds were in first ranked and that garret mean score is 57.7. Lack of capital is a second rank of that garret mean score is 47. Irrigation problems is an occupied third rank of the respondents and it state the score on 41.01. Price fluctuations is a fourth rank of the respondents and it state the score is 38.31. Inadequate transport is a fifth rank of the respondents and it is state that the score is 29.96.

CONCLUSION

The study concluded that the technical efficiency level of sorghum farmers and constraints faced by the sorghum farmers in the research area. Independent variables in quantity of seed, plant protection measures, chemical fertilizers, irrigation and machinery usage were found to influence the production of sorghum positively and significantly. Farmers increasing one percent quantities of raw materials would increase the co-efficient of output. To maintain proper collaboration with nearby farmers to overcome the constraints. It provides valuable insights for policy makers and adaptation of new technologies to increase the sorghum productivity.

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Table 1. MLE estimators of stochastic frontier function of sorghum farmers

S. No.	Variables	Parameters	Coefficient	Standard Error	T value
1	Constant	β_0	7.2582***	0.8656	8.3851
2	Farm Size (ha)	β_1	0.2496	0.2765	0.9028
3	Quantity of Seed (Kg)	β_2	0.5155***	0.1745	2.9542
4	Labour (man days)	β_3	-0.1670	0.6452	-0.2589
5	Plant Protection Measures (lit)	β_4	0.1224***	0.0345	3.5479
6	Chemical Fertilizer (kg)	β_5	0.6811**	0.3052	2.2318
7	Irrigation (no)	β_6	0.0273*	0.0158	1.7307
8	Machinery Usage (hrs)	β_7	0.5638**	0.2561	2.2013
9	Sigma - Square	σ	0.0820	0.0110	
10	Gamma	γ	0.9907	0.0128	
11	Log-Likelihood		0.2671		
12	LR		0.2402		
13	Mean Technical Efficiency		0.82		
14	Number of observations		120		

(Note *, ** and *** denote significance at 10, 5 and 1 per cent levels, respectively)

Table 2. Level of Technical Efficiency Level in Sorghum Farmers

Level of Efficiency	No	Percentage
50-59	3	5
60-69	6	10
70-79	11	18.3
80-89	21	35
90-99	19	31.7
Total	60	100
Mean efficiency	0.82	
Minimum efficiency	0.50	
Maximum efficiency	0.98	

Table 3. Production Constraints faced by the sorghum farmers

S. No.	Constraints	Mean Score	Rank
1	Lack of high-quality seeds	57.7	I
2	Lack of capital	47.00	II
3	Irrigation problems	41.01	III
4	Price fluctuations	38.31	IV
5	Inadequate transport	29.96	V

RESEARCH ARTICLE

The Power of Investing in Early Education: Transforming Literacy and Numeracy Skills for Future Success

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ABSTRACT

The existing literature has revealed that the children who have enriching early educational experience will utilize future experiences more efficiently. The previous studies have further highlighted that investing in early years will create a strong foundation for higher education. The children success in higher education greatly relies on the attainment of foundational skills such as literacy and numeracy in the early years of life. Therefore, there is a great need to provide early financial support to the children for the subsequent attainment of higher educational success. The present study explores the pivotal role of early financial support in fostering higher educational success, shedding light on the varied aspects that shape the learning pathway of the children. Recognizing that financial barriers can significantly impede educational opportunities, this research inquire into the multifaceted ways in which securing essential features, such as scholarships, grants, and financial aid, plays a decisive role in fostering academic achievement. Drawing on a comprehensive review of existing literature, empirical studies, and case analyses, the research investigates the impact of early financial support on students' access to quality education, persistence in academic pursuits, and eventual graduation rates. It elucidates the varied patterns between socio-economic factors, financial accessibility, and educational outcomes, emphasizing the potential long-term consequences of insufficient early financial support on individual academic orientation. Furthermore, this research explores the exquisite effects of financial support on diverse student populations, including underrepresented minorities, first-generation college students, and those facing additional socio-economic challenges. By understanding the critical connection between early financial support and higher educational success, this study offers insights that can inform policy development, intervention strategies, and the allocation of resources, ultimately working towards fostering an inclusive and supportive educational system for all students.

Keywords: Early Investment, Financial Accessibility, Financial Barriers, Foundational skills, Financial Support, Higher Education

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INTRODUCTION

The formative years of a child's education serve as the bedrock upon which the edifice of their academic journey is constructed. The journey from early learning to higher education is a continuum (Aunola, 2004) where the seeds of success are sown in the fertile soil of early educational experiences. Early learning experiences are instrumental in cultivating foundational skills such as literacy and numeracy, fostering a love for learning, and preparing students for the challenges and rigors of higher education (Slaby et.al., 2005). These experiences further help children adapt to a structured learning environment, setting the stage for a smooth transition to formal schooling (Slaby et.al., 2005). This preparation contributes to a positive attitude towards learning and academic success in the later years. The research studies also indicate that the quality early education impacts the adulthood, influencing educational attainment, employment opportunities, and even physical and mental health outcomes (The State of Global Learning Poverty report: 2022). National Scientific Council for the Developing Child (2012) has further highlighted that sound early educational experiences enhance children Foundational literacy and numeracy skills, alleviates the risk of drop-out and failures and consequently leads to a higher educational success. (Slaby et.al., 2005) has also stated that quality early education helps the individuals to accomplish more academically in higher grades. Moreover, early learning serves as the incubator for language acquisition and communication skills cultivated in the early years (The State of Global Learning Poverty Report: 2022). These skills are the keystones of higher education success, where effective reading, writing, and communication form the backbone of academic engagement.

Beyond academics, early learning environments play a pivotal role in socialization and emotional development (The report on state of foundational literacy and numeracy, 2023 and Braak et al., (2022). The interpersonal skills and emotional intelligence nurtured during these formative years are integral for navigating the collaborative and diverse landscapes of higher education. Students who emerge from quality early learning experiences are often better equipped to build meaningful relationships, collaborate with peers, and handle the social complexities inherent in advanced academic settings (Henningham, 2014). Furthermore, children who receive quality early education are more likely to stay in school, graduate, and pursue higher education. This sets the stage for better career opportunities and increased economic mobility in the long run. Therefore, investing in the early years of children's education is crucial and has long-lasting positive effects on their overall development and moreover it provides higher returns in future (Bhalotra & Zamora, 2006 and Lloyd et al., 2000). Investing in early childhood education can lead to cost savings in the long run (Rolnick & Grunewald, 2007). Studies have shown that children who receive quality early education are less likely to require remedial education, special education services, or encounter behavioral issues that may result in costly interventions (Rolnick & Grunewald, 2007). Several studies have further highlighted the significant economic benefits associated with investing in early childhood education (Karoly, 2016). Position Paper on Early Childhood Education, 2006 and Heckman, 2006 have highlighted that high-quality early childhood education enhances cognitive and social development, preparing children for success in school and later in the workforce which consequently contributes to economic productivity and innovation.

Additionally, the existing studies has also highlighted the positive ripple effects of early education on society, as a highly educated workforce is essential for innovation, productivity, and economic growth (report on tracking Progress on Foundational Learning: Findings From The Rapid 2023 Analysis). There is a critical connection between early financial support and higher educational success underscores the profound influence that financial resources wield on a student's academic journey. The ability to access resources and support in the early stages of education can significantly impact a student's trajectory, shaping their educational experiences and setting the stage for higher learning achievements. This connection highlights the importance of recognizing and addressing financial barriers at the onset of a student's educational pathway, paving the way for a more equitable and empowering educational system. This paper highlights the connection between early financial support and higher educational success and the ways in which financial investments during a student's formative years can serve as catalysts for academic excellence, laying the groundwork for a future enriched by educational opportunities and achievement.

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Objectives of the Study

The objectives of the study are delineated as follows:

- To explore the long term impact of insufficient financial support provided during the early years of children's education.
- To highlight the positive impact of adequate financial support provided during the early years of children's education.
- To understand the significance of early financial support for underrepresented minorities, first-generation college students, and individuals facing socio-economic challenges.
- To highlight various strategies that educational stakeholders can employ to offer financial support to children's in their early years, ensuring their success in subsequent educational stages.

Long term Impact of Insufficient Early Financial Support

Insufficient early financial support can have profound and lasting consequences on an individual's academic trajectory

Difficulty in Meeting Basic Needs

Insufficient early financial support can create a ripple effect, hindering the ability to cover basic needs. Difficulty in meeting basic needs during early childhood education can have lasting effects on higher education. Moreover, lack of access to proper nutrition, healthcare, and a supportive environment can hinder cognitive development, impacting academic readiness (Kobayashi, 2021). This early disadvantage may lead to academic challenges in later years, potentially limiting opportunities for higher education due to gaps in foundational knowledge and skills. Therefore, it is significant to address the basic needs during early childhood for laying a solid educational foundation and fostering future academic success.

Educational Attainment Gap

Insufficient early financial support can perpetuate an educational attainment gap, limiting opportunities for those facing economic challenges. Limited financial support may hinder access to quality educational resources, tutoring, and extracurricular activities, leading to a potential gap in educational attainment. This disadvantage often persists, contributing to a gap in foundational skills, confidence, and readiness for further education (Duncan & Magnuson, 2011). This early setback can create a lasting impact on educational attainment, widening the disparity between those with and without adequate support (centre for education statistics and evaluation, 2001). Thus, it is important to address these disparities for fostering a more equitable education system.

Psychological Impact

Insufficient early financial support can create stress and limit opportunities, impacting one's overall well-being. Financial instability during the formative years of education can contribute to long-term stress and anxiety, impacting mental health and overall well-being (The report on state of foundational literacy and numeracy, 2023 and report on tracking Progress on Foundational Learning: Findings from the Rapid 2023 Analysis). This may lead to lower academic achievement and self-esteem, impacting future career prospects. Therefore, seeking support from related organisations and developing financial literacy among parents can help to alleviate from these challenges.

Lowered Aspirations and Confidence

Insufficient financial support in early years of child education may lead to lowered aspirations and reduced confidence in one's ability to succeed in higher education and career pursuits. Lower aspirations and confidence may stem from limited resources and opportunities. When children experience a lack of opportunities and resources, they may develop a sense of inadequacy or lower self esteem. Kobayashi (2021) has highlighted that children who receive high quality learning in their early are more likely to have higher educational and career aspirations later in life. Adequate resources and encouragement are vital for fostering positive future outlook.

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Potential Dropout Risk

Insufficient early financial support can force students to juggle work and studies, impacting academic performance. This may lead to increased stress, fatigue, and a higher likelihood of dropping out due to the inability to meet both financial and academic demands. Moreover, as student's progress through the education system with these disadvantages, they may find it increasingly challenging to meet the academic expectations of higher education. In extreme cases, financial strain may lead to the inability to continue education, resulting in dropping out of higher academic programs (The report on state of foundational literacy and numeracy, 2023). In summary, insufficient financial support in early childhood education creates a domino effect, impacting various aspects of a child's development and setting the stage for potential challenges in higher education. Addressing these financial disparities is crucial for fostering an environment that promotes equal opportunities and sets the stage for lifelong success.

Impact of Adequate Early Financial Support on an Individuals Academic Trajectory

Early financial support can have a significant impact on mainly students' access to quality education, persistence in academic pursuits, and eventual graduation rates

Access to Quality Education

Financial support provides students with the means to access quality education, including enrolment in reputable institutions, access to well-qualified faculty, state-of-the-art facilities, and up-to-date educational resources. Quality education at the elementary level builds a strong foundation for future academic success (The report on state of foundational literacy and numeracy,2023). Financial support in early years can ensure a stable environment for a child's development, covering basic needs such as nutrition, healthcare and a conducive living space. This support fosters overall development, laying a strong foundation for their educational journey.

Enhanced Persistence in Academic Pursuits

Early financial support can positively impact academic persistence by alleviating financial barriers that might otherwise hinder a student's educational journey. It reduces the likelihood of students dropping out due to financial constraints (Kumar et al., 2023). Moreover, students who receive early financial assistance are more likely to persist in their academic pursuits, even when facing challenges, as they have the necessary resources to overcome obstacles. Early financial support not only removes financial hurdles but also enriches the overall academic experience, promoting persistence and dedication to educational goals.

Improved Graduation Rates

Early financial support contributes to higher graduation rates by reducing financial barriers and allowing students to focus on their studies without excessive financial stress. Students who have the financial means to navigate their academic journey are more likely to complete their programs successfully and graduate. Furthermore, improved graduation rates are often linked to early intervention programs, mentorship, and tailored academic support, ensuring students receive the assistance they need to overcome challenges and successfully complete their degrees (Kumar et al., 2023).

Strengthen the Foundational skills

Early childhood is a critical period of cognitive development, where children are particularly receptive to learning experiences. Quality early education programs provide enriching environments that stimulate intellectual curiosity and encourage exploration, fostering the development of essential language and mathematical concepts (Slaby et.al., 2005) . Moreover, early education investment supports the recruitment and retention of qualified educators who are trained to implement evidence-based instructional strategies tailored to the diverse needs of young learners. By investing in early education, societies can ensure that all children, regardless of socioeconomic background, have equitable access to the resources and support necessary to build a strong educational foundation, setting them on a pathway towards academic achievement and future success. In summary, early financial support has a cascading effect on various aspects of a student's educational journey, from initial access to quality education to successful graduation and beyond. It plays a crucial role in shaping the trajectory of students' academic and professional lives.

Furthermore, this can benefit the diverse student population including underrepresented minorities, first-generation college students, and individuals facing socio-economic challenges.

Significance of Early Financial Support for Diverse Student Population
Early financial support plays a crucial role in shaping the educational trajectories of underrepresented minorities, first-generation college students, and individuals facing socio-economic challenges

Underrepresented Minorities
Early financial support plays a pivotal role in shaping the educational trajectories of underrepresented minorities. For many individuals from these groups, financial barriers pose formidable obstacles to accessing higher education. When provided with early financial support, such as scholarships, grants, or subsidized educational programs, underrepresented minorities experience increased opportunities for academic advancement. This support not only addresses immediate financial needs but also fosters a sense of belonging and equity within the educational system. It enables individuals to pursue higher education without the burden of overwhelming financial constraints, empowering them to focus on their studies and engage more fully in extracurricular activities. Additionally, early financial assistance often contributes to building a supportive community, as it sends a message of inclusivity and investment in the success of underrepresented minorities. Overall, early financial support is a catalyst for breaking down systemic barriers, promoting diversity in academia, and empowering underrepresented minorities to thrive in their educational pursuits.

First-Generation College Students and Individuals facing Socio-Economic Challenges
Early financial support plays a pivotal role in shaping the academic trajectories of first-generation college students and those facing socio-economic challenges. For individuals who are the first in their families to pursue higher education, financial assistance can be a transformative factor. It not only addresses the economic barriers that may hinder their access to college but also establishes a foundation for academic success. By alleviating the burden of tuition, textbooks, and other educational expenses, early financial support empowers first-generation students to focus on their studies, fostering a sense of belonging in the academic environment. Additionally, it provides a pathway for these students to explore extracurricular activities, internships, or research opportunities that might otherwise be financially out of reach. Similarly, for students facing socio-economic challenges, early financial support becomes a lifeline, enabling them to overcome obstacles and pursue education without compromising their basic needs. This support not only enhances their academic persistence but also contributes to breaking the cycle of generational educational disparities, opening doors to broader opportunities. In essence, early financial support for first-generation college students and those facing socio-economic challenges is instrumental in creating an equitable educational landscape, offering them the resources and encouragement needed to thrive academically.

Strategies that Educational Stakeholders can Employ to offer Financial Support to Children's in their Early Years
Educational stakeholders, including governments, schools, communities, and non-profit organizations, play a crucial role in providing financial support to children in their early years to ensure their success in later educational stages. Here are several strategies and initiatives that can be implemented:

Early Learning Grants
The early learning grants doesn't only means providing free education to the children but it also means allocating funds for teacher training, professional development, curriculum development, and facility improvements. Furthermore, for covering the basic needs of children in their initial years, a system of child allowances or grants should be implemented that provide direct financial assistance to families based on the number of children they have. This can help cover basic needs and create a foundation for a child's development.

Early Intervention Services
Early childhood interventions focus on building essential skills, fostering a love for learning, and enhancing school readiness, setting the stage for future academic achievements. The educational stakeholders should invest in early

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intervention services for children with developmental delays or special needs, ensuring they receive the necessary support and resources from an early age. Early intervention programs in early childhood education play a crucial role in ensuring higher education success by laying a strong foundation for cognitive, social and emotional development. These programs help to identify and address developmental delays or challenges early on, promoting a positive learning trajectory.

Parental Education and Support Programs
The educational stakeholders should develop programs that educate parents about the importance of early childhood education and provide support in navigating educational resources. Empowered parents can create a more conducive learning environment for their children (Kobayashi, 2021). These programs should aim to provide parents with knowledge and skills to create a positive learning environment. They should be encouraged to do long-term financial planning and should be provided incentives for consistent contributions. Additionally, they should be informed about the compounding effect of starting early and the ability to cover future educational costs. The programs should be organized to provide clear information to parents on savings and investment options, showcasing potential returns and the security they offer and share success stories of individuals who have benefitted from such programs, making it relatable for parents. Additionally, offer resources or workshops to enhance financial literacy, making them more confident in committing to long-term savings for their children's education.

Long-Term Savings and Investment Programs
The educational planners and stakeholders should introduce savings and investment programs for families, allowing them to set aside funds for their child's future education. They should be encouraged to do long-term financial planning and should be provided incentives for consistent contributions. Additionally, they should be informed about the compounding effect of starting early and the ability to cover future educational costs. The programs should be organized to provide clear information to parents on savings and investment options, showcasing potential returns and the security they offer and share success stories of individuals who have benefitted from such programs, making it relatable for parents. Additionally, offer resources or workshops to enhance financial literacy, making them more confident in committing to long-term savings for their children's education.

Healthcare Support
Healthcare support in early childhood education is crucial as it lays the foundation for a child's overall well-being and can significantly impact their later success in higher education. Moreover, a healthy child is more likely to attend school regularly. Regular health check-ups and prompt medical attention contribute to reduced absenteeism (Health policy snapshot, 2016). Health check-ups on regular basis ensure that any health-related barriers are identified and addressed promptly for supporting children learning. The educational stakeholders should ensure access to affordable healthcare for children, covering preventive care, vaccinations, and medical treatments. They should implement programs to address nutrition and well-child checkups. Investing in health care support for early childhood education can have long-term economic benefits by reducing health-related barriers to learning, leading to a more skilled and productive individuals.

CONCLUSION

In conclusion, the research undertaken in this paper sheds light on the pivotal role that early financial support plays in shaping the educational trajectories and, consequently, the futures of individuals. The critical connection between early financial assistance and higher educational success is evident through a comprehensive analysis of various factors, including access to resources, academic performance, and long-term outcomes. Our paper underscore the significance of fostering a supportive financial environment from the early stages of education, as it has the potential to break down barriers and pave the way for academic achievement. The present study highlights a direct correlation between adequate financial support and increased access to educational opportunities, leading to improved academic performance and, ultimately, higher educational success. Furthermore, this research study emphasizes the

need for policymakers, educators, and stakeholders to recognize the long-term impact of early financial support on an individual's educational journey. Moreover, the research underscores the need for collaborative efforts among stakeholders to design and implement effective financial support mechanisms. Initiatives such as scholarships, grants, and targeted financial aid programs are essential tools in ensuring that students have the resources they need to pursue higher education without the burden of financial constraints. By investing in initiatives that ensure equitable access to resources, scholarships, and financial aid, society can contribute to breaking the cycle of educational disparities and empower individuals to reach their full potential. As we navigate the complex landscape of education and the challenges that students face, it is crucial to acknowledge the role of financial support as a catalyst for securing brighter futures. By prioritizing and expanding efforts to provide early financial assistance, we can collectively contribute to a more inclusive and equitable educational system, fostering a generation of individuals poised for success in higher education and beyond. In securing futures through targeted financial support, we pave the way for a society that thrives on the principles of equal opportunity, achievement, and the realization of individual potential.
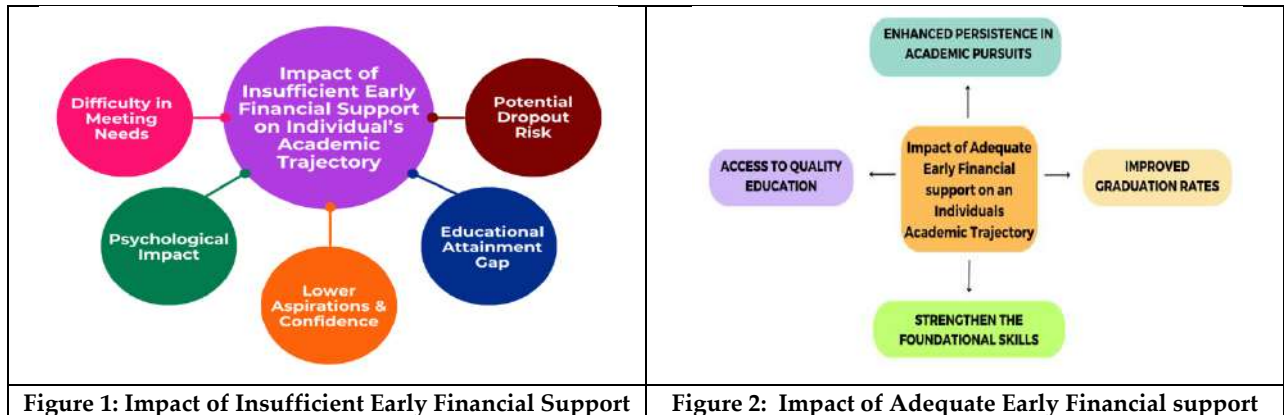
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Figure 1: Impact of Insufficient Early Financial Support	Figure 2: Impact of Adequate Early Financial support

RESEARCH ARTICLE

A Study on Solving Fuzzy Transportation Problems using MATLAB Code for the North-West Corner Method

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ABSTRACT

This research paper presents a comprehensive investigation into solving fuzzy transportation problems using MATLAB. The fuzzy transportation problem is an extension of classical transportation problems, where the demand and supply values are uncertain and represented by fuzzy numbers. Fuzzy set theory offers a robust framework to model and analyze such uncertain systems. In this study, we investigate the application of fuzzy set theory to the transportation problem, specifically focusing on the Northwest Corner (NWC) method, which is a widely used technique for initializing the transportation matrix. We propose a fuzzy version of the NWC method and develop a MATLAB code to solve fuzzy transportation problems. The MATLAB implementation allows us to explore various scenarios and analyze the impact of uncertainty on transportation decisions.

Keywords: Fuzzy set theory, Transportation problem, Northwest Corner method, MATLAB, Uncertainty, Optimization.

INTRODUCTION

The transportation problem is a classical optimization problem that arises in various domains, including supply chain management, logistics, and distribution planning. Its primary objective is to determine the most cost-effective

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way to transport goods from suppliers to consumers, given the available supply, demand, and transportation costs. Traditional formulations of the transportation problem assume precise and deterministic data, which may not accurately reflect real-world conditions characterized by uncertainty and imprecision. Fuzzy set theory, introduced by Zadeh, provides a mathematical framework for modeling and handling uncertainty, vagueness, and ambiguity in decision-making processes. By allowing elements to belong to a set to a degree between 0 and 1, fuzzy set theory enables the representation of vague or imprecise information more accurately. In recent years, there has been growing interest in applying fuzzy set theory to optimization problems, including the transportation problem, to address the limitations of traditional approaches. The Northwest Corner (NWC) method is a heuristic approach commonly used to initialize the transportation matrix in classical transportation problems. It starts by allocating shipments from the northwest corner of the transportation matrix and then iteratively adjusts the allocations until all supply and demand constraints are satisfied. While the NWC method is straightforward and easy to implement, its deterministic nature may not be suitable for scenarios where data uncertainty is prevalent.In this study, we propose a fuzzy version of the NWC method to address the limitations of traditional approaches in handling uncertain transportation data. We develop a MATLAB code to implement the fuzzy NWC method and conduct a comparative analysis to evaluate its performance against conventional techniques.

Mathematical Formulation

The fuzzy transportation problem deals with finding the optimal allocation of goods from multiple sources to multiple destinations, considering uncertain or vague parameters such as demand, supply, and transportation costs. The traditional transportation problem assumes crisp (precise) values for these parameters, whereas the fuzzy transportation problem allows for fuzzy sets to represent these parameters.

Existing Method for finding optimal solution

Step 1: In the cell located in the upper left (north-west) corner of the transportation table, the initial assignment is made. It allots the highest amount that can be. In other words,$x_{11} = \min\{a_1, b_1\}$.

Case (i): Put $x_{11} = a_1$, reduce b_1 by a_1, and go vertically to the second row (that is, to the cell (2,1) cross out the first row if $\min\{a_1, b_1\} = a_1$.

Case (ii): Put $x_{11} = b_1$, reduce a_1 by b_1, and proceed horizontally right (i.e., to the cell (1,2) cross out the first column if $\min\{a_1, b_1\} = b_1$.

Case (iii): Put $x_{11} = a_1 = b_1$ and proceed diagonally to the cell (2,2) cross off the first row and the first column if $\min\{a_1, b_1\} = a_1 = b_1$.

Step 2: Continue the process until all rim specifications have been met.

CONCLUSION

In this study, we have presented a comprehensive analysis of solving fuzzy transportation problems using the Northwest Corner method and MATLAB code. Our findings highlight the advantages of incorporating fuzzy set theory into transportation optimization, particularly in handling uncertain data. The proposed fuzzy NWC method offers a promising approach to address real-world challenges in logistics and supply chain management, where uncertainty is prevalent. Future research directions may include extending the methodology to other optimization problems and integrating advanced fuzzy techniques for improved performance.

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M-file

This MATLAB code is for a 3x3 matrix, where the input values are triangular fuzzy integers that are defuzzified using the "centroid" method after being triangulated using "trimf."
(Dr. A. Rajkumar, 2024)

```matlab
cost_matrix = [3 4 6; 7 2 9; 8 5 1]; % Cost matrix
supply = [10 20 30]; % Supply constraints
demand = [25 15 20]; % Demand constraints
% Initialize variables
   [m, n] = size(cost_matrix);
   X = zeros(m, n);
   i = 1;
   j = 1;

% While there are still supplies and demands left
while i <= m && j <= n

% Calculate the amount to transport
     amount = min(supply(i), demand(j));


% Update the transportation matrix
X(i, j) = amount;



% Update supply and demand
     supply(i) = supply(i) - amount;
     demand(j) = demand(j) - amount;


% Move to the next row or column depending on whether supply or demand is exhausted
if supply(i) == 0
       i = i + 1;
end
if demand(j) == 0
       j = j + 1;
end
end


% Calculate the total cost
disp("Transportation Matrix:");
       disp(cost_matrix);
disp("Allocated Transportation Matrix:");
       disp(X);
   cost = sum(sum(X .* cost_matrix));
disp("Total Cost:");
     disp(cost);
```

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Output of this M-File:

>> northwest_corner

Transportation Matrix:

       3   4   6
       7   2   9
       8   5   1

Allocated Transportation Matrix:

      10   0   0
      15   5   0
       0   10   20

Total Cost: 215

RESEARCH ARTICLE

Validity of St.George's Respiratory Questionnaire in Bronchogenic Carcinoma

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ABSTRACT

This study aims to evaluate the concurrent validity of the St. George's Respiratory Questionnaire (SGRQ) by comparing it with the Chronic Respiratory Questionnaire (CRQ) and the Medical Outcomes Study Short Form 36 (SF-36), which are considered gold standard measures for assessing health-related quality of life (HRQoL) in patients with lung cancer—a condition characterized by respiratory diseases with airflow limitation. A cross-sectional study design was employed. The correlation between the domains of the SGRQ and CRQ was assessed, as well as the correlation between the SGRQ and SF-36. The analysis revealed a high to moderate correlation between the SGRQ and CRQ domains ($r = -0.826$, $p < 0.05$) and a moderate correlation between the SGRQ and SF-36 domains ($r = -0.697$, $p < 0.05$). The SGRQ, a disease-specific questionnaire, showed a strong alignment with the CRQ, while demonstrating moderate correlation with the generic SF-36. The findings suggest that the SGRQ is a valid tool for assessing HRQoL in lung cancer patients, with excellent concurrent validity when compared to the CRQ and moderate validity relative to the SF-36. This supports the use of the SGRQ in clinical settings to effectively measure HRQoL in this population.

Keywords: Bronchogenic carcinoma, Chronic Respiratory Questionnaire, Health-Related Quality of Life, Lung Cancer, St. George Respiratory Questionnaire,

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INTRODUCTION

Lung cancer (LC), also known as bronchogenic carcinoma, is the leading cause of cancer-related deaths globally (Leiter et al., 2023). In 2020, it was the most commonly reported cancer, with an estimated 2.2 million new cases and 1.8 million deaths worldwide (Leiter et al., 2023).In Bharat, lung cancer represented 11.4% of all cancer cases and caused 18% of cancer-related deaths in 2020 (Mathur et al., 2022). The estimated number of cancer cases in Bharat for 2022 was 1,461,427, with a crude incidence rate of 100.4 per 100,000 people (Sathishkumar et al., 2023). Lung cancer arises from tumors in the lung parenchyma or bronchi (Street et al., 2023) and includes any cancer originating from the airways. Common symptoms are dyspnea, cough, wheezing, blood-stained sputum, and hoarseness (Ralston et al., 2018).Dyspnea is a prevalent and distressing symptom among lung cancer patients, affecting about 80% of individuals and significantly impairing their quality of life. It can limit physical endurance and make daily activities increasingly difficult (American Cancer Society, 2004). Quality of life (QoL) is a measure of overall physical and social well-being as perceived by individuals or groups. Health-related quality of life (HRQoL) assessments typically include physical, emotional, and social dimensions, with some also considering cognitive aspects. Although HRQoL tools are used in various settings, a specific instrument for lung cancer patients has not been validated (Sell et al., 1992).The St. George's Respiratory Questionnaire (SGRQ) is designed to assess health status in patients with chronic airflow limitations and has been validated for diseases such as COPD, cystic fibrosis, bronchial asthma, bronchiectasis, and pulmonary tuberculosis (Carolyn et al., 1997). However, its use in lung cancer patients has not been studied. The SGRQ comprises three components: "symptoms," "activity," and "impacts." The Chronic Respiratory Questionnaire (CRQ) evaluates physical and emotional function through four dimensions: dyspnea, fatigue, emotion, and mastery. The Medical Outcomes Study Short Form 36 (SF-36) is a general HRQoL tool used to evaluate various chronic conditions, demonstrating strong validity and reliability.Despite the SGRQ's established effectiveness in respiratory diseases, it has not yet been used to assess HRQoL in lung cancer patients. This study aims to determine the concurrent validity of the SGRQ in evaluating HRQoL in this population, in comparison with the CRQ and SF-36.

AIMS AND OBJECTIVES
Aim
To determine the concurrent validity of SGRQ in the LC population.

METHODOLOGY

Study Design
Cross-sectional study design

Source of data
The participants with LC in this study were recruited from the following hospital
- Vinus Institute Of Physiotherapy, Gandhinagar
- Vidhyadeep Institute of Physiotherapy, Kim Permission for the ethical clearance was obtained from the Institutional ethical clearance committee of Madhav University, Sirohi-Rajsthan and above mentioned respective centres.

Sampling Technique
Since the study was done on LC patients subjects were chosen based on the selectivity criteria. Hence purposive sampling was done.

Sample Size
A total 59 number of cancer subjects were selected for the study. Out of 59 subjects 34 were included in the study as 17 subjects were not willing to participate and 8 did not meet the inclusion criteria.

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Criteria for selection
Inclusion Criteria
- Patient with histopathological diagnose daslung cancer.
- Age more than eighteen years.

Exclusion criteria
Subject with history of
- Psychiatric disorders.
- Neurological impairments.
- Muscula dystrophies.
- Cognitive impairments.
- Medically unstable.

PROCEDURE
The participants who fulfilled the inclusion& Exclusion criteria were explained to sign an informed consent form approved by the institution. Pre-participation data was taken for each subject beforethe study which included Name, Age, Sex, Socioeconomic status, Concurrent disease, and Type of LC. Subjects were asked to fill out the questionnaire which was designed to measure their level of health-related quality of life by using SGRQ, CRQ and SF-36 respectively. The participants, who did not know how to read and write, were explained about the questionnaire in their mother tongue and response was noted by the person interviewing.

Data Recording and Tabulation
Data was collected in hard copies of all questionnaires, and then the data for SGRQ was entered in the SGRQ Microsoft Excel-based calculator as recommended by the developer, while for the CRQ the scoring was done on a 7-point Likert scale higher the score better the quality of life as suggested by developer and for SF – 36 the same MicrosoftExcel-based calculator as recommended by the developer.

Statistical Analysis
Basic characteristics of the subject's age, gender, height, weight and BMI were analyzed by Descriptive statistics. The concurrent validity of SGRQ with CRQ and SF-36 was validated with Spearman's correlation test. Statistical analysis was done by using SPSS Version 14.0.

RESULT

Table 1 shows the descriptive statistics i.e. mean and Standard Deviation of SGRQ, CRQ and SF-36 score(x = 54.25 SD = 17.68, x= 75.23 SD =18.35 and x = 46.55 SD = 18.76 respectively). Table 2describes the descriptive statistics for subject age and all the domains of SGRQ,CRQ andSF-

DISCUSSIONS

The assessment of lung function alone does not fully capture the complex impact of lung cancer (LC) on patients, necessitating the use of quality-of-life (QoL) questionnaires to provide a more comprehensive evaluation. Health-related quality of life (HRQoL) measures are essential for capturing both the personal and social aspects of a patient's experience. The integration of HRQoL assessments in clinical research has grown significantly over the past two decades, reflecting advancements in the development of psychometrically robust tools to evaluate a range of health conditions (Chan et al., 2002). In this study, we found a strong correlation (r = -0.826, p<0.05) between the St. George's Respiratory Questionnaire (SGRQ) and the Chronic Respiratory Questionnaire (CRQ), and a moderate correlation (r = -0.697, p<0.05) between the SGRQ and the Medical Outcomes Short Form 36 (SF-36). This variation can be attributed to SF-36 being a generic HRQoL questionnaire, whereas CRQ is specifically designed for chronic respiratory diseases.

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Previous research by Molken et al. demonstrated a good correlation (r = -0.725, p<0.001) between the SGRQ and CRQ, consistent with our findings (r = -0.826, p<0.001). This underscores the strong alignment between the total scores of both questionnaires and their respective domain scores (Wilson et al., 1997). Our study also revealed a moderate to strong significant correlation between the SGRQ domains and the CRQ total score (p<0.05), corroborating findings from earlier studies. Furthermore, our results align with prior research indicating moderate to high correlations between SGRQ and SF-36 across different health conditions. Notably, SGRQ scores were more strongly associated with the Physical Component Summary (PCS) of the SF-36 than with the Mental Component Summary (MCS). This is likely due to the fact that the Impacts component of SGRQ shares similarities with the PCS and MCS components of SF-36, highlighting the overlap in measuring physical and emotional impacts (Roberts et al., 1993). The moderate significant correlation observed between the SGRQ domains and the SF-36 total score (p<0.05) suggests that the SGRQ is a valid instrument for assessing HRQoL in respiratory diseases, comparable to the CRQ. The SGRQ encompasses a broader range of HRQoL aspects compared to the CRQ, offering a more detailed understanding of the disease's impact on patients' daily lives. This comprehensive assessment is particularly valuable in clinical trials, as it facilitates the evaluation of treatment benefits, side effects, and costs. Moreover, the SGRQ is available in 48 languages, including 11 Indian languages, enhancing its applicability for assessing HRQoL in diverse populations. In contrast, the CRQ is available in only 8 languages, with no Indian languages included, making the SGRQ a more suitable tool for use in Indian contexts.

LIMITATIONS
- Smaller sample size.
- To precisely know HRQOL, and how longits impact remains longitudinal study should bed one.

FURTHER RECOMMENDATIONS
- Further research should be focused on specific types of local language-adapted questionnaires.
- Further research should be done with Cancer cancer-specific questionnaire along with the HRQOL questionnaire.
- The SGR Q emerges as an excellent discriminative and a good evaluative instrument for LC subjects, and its use should be encouraged in the routine assessment of patient's health status.
- Psychometric properties of the Questionnaire should be done in Lung cancer.

CONCLUSION

This study establishes that the St. George's Respiratory Questionnaire (SGRQ) is a valid and reliable tool for assessing health-related quality of life (HRQoL) in patients with lung cancer. Our findings demonstrate a strong concurrent validity of the SGRQ when compared with the Chronic Respiratory Questionnaire (CRQ) (r = -0.826, p<0.05) and a moderate correlation with the Medical Outcomes Short Form 36 (SF-36) (r = -0.697, p<0.05). These results indicate that the SGRQ effectively captures key dimensions of HRQoL related to respiratory symptoms, activity limitations, and impacts, comparable to established measures like the CRQ and SF-36. The high correlation between SGRQ and CRQ underscores the SGRQ's robustness as a disease-specific instrument for evaluating respiratory health. Additionally, the moderate correlation with SF-36 highlights its relevance in assessing broader HRQoL aspects, particularly the physical component. The SGRQ's broad linguistic availability, including in several Indian languages, enhances its applicability in diverse populations and settings, making it a valuable tool for both clinical practice and research. In summary, the SGRQ provides a comprehensive and nuanced assessment of HRQoL in lung cancer patients, offering insights that extend beyond traditional lung function metrics. Its effectiveness in capturing the multifaceted impact of lung cancer on patients' daily lives supports its use in clinical trials and routine evaluations, contributing to more informed treatment decisions and improved patient care.

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Table 1: Descriptive data of total scores of SGRQ, CRQ and SF-36

	Mean	Standard Deviation
TotalSGRQ	54.2544	17.68
Total CRQ	75.2353	18.35
TotalSF-36	46.5588	18.76

Table 2: Descriptive data of Domains of SGRQ,CRQ and SF-36.

		Mean	Standard Deviation
SGRQ	Symptoms	65.5368	17.09
	Activity	59.0712	20.11
	Impact	47.6065	18.63
CRQ	Dyspnea	20.8235	4.69
	Fatigue	14.9706	3.97
	Emotional Functioning	25.2941	6.96
	Mastery	14.5588	4.11
	Physical functioning	52.5000	20.53
	Role-Physical	36.0294	29.63
	Bodily-Pain	42.0294	18.60
	Genera lHealth	39.5000	15.95
	Physical Health Component Score	42.8235	18.32

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SF-36	Vitality	44.5588	17.89
	Social Function	52.0294	21.17
	Role Emotional	50.9706	36.08
	Mental Health	55.0588	19.39
	Mental Health Component Score	48.2941	18.46

Table 3: Correlations between the SGRQ domains and the CRQ

SGRQ Domains	CRQ Domains	Correlation(r)	Significance(p)
Symptoms	Dyspnea	-0.396*	0.020
	Fatigue	-0.596**	0.0001
	Emotional function	-0.719**	0.0001
	Mastery	-0.751***	0.0001
Activity	Dyspnea	-0.570**	0.0001
	Fatigue	-0.495*	0.0003
	Emotional function	-0.691**	0.0001
	Mastery	-0.619**	0.0001
Impacts	Dyspnea	-0.609**	0.0001
	Fatigue	-0.460*	0.0006
	Emotional function	-0.711**	0.0001
	Mastery	-0.641**	0.0001
Total Score	Dysnea	-0.601**	0.0001
	Fatigue	-0.528**	0.001
	Emotional function	-0.757*	0.0001
	Mastery	-0.699**	0.0001

***= high correlation **=moderate correlation *=low correlation. Table 3 shows a correlation between domains of SGRQ and CRQ

Table 4: Correlations between the SGRQ domains and the SF-36.

SGRQ Domains	SF- 36 Domains	Correlation (r)	Significance (p)
Symptoms	PCSscore	-0.669**	0.0001
	MCSscore	-0.541**	0.001
Activity	PCSscore	-0.676**	0.0001
	MCSscore	-0.586**	0.0001
Impacts	PCSscore	-0.662**	0.0001
	MCSscore	-0.636**	0.0001
TotalScore	PCSscore	-0.716**	0.0001
	MCSscore	-0.646**	0.0001

***=high correlation**=moderate correlation*=low correlation.

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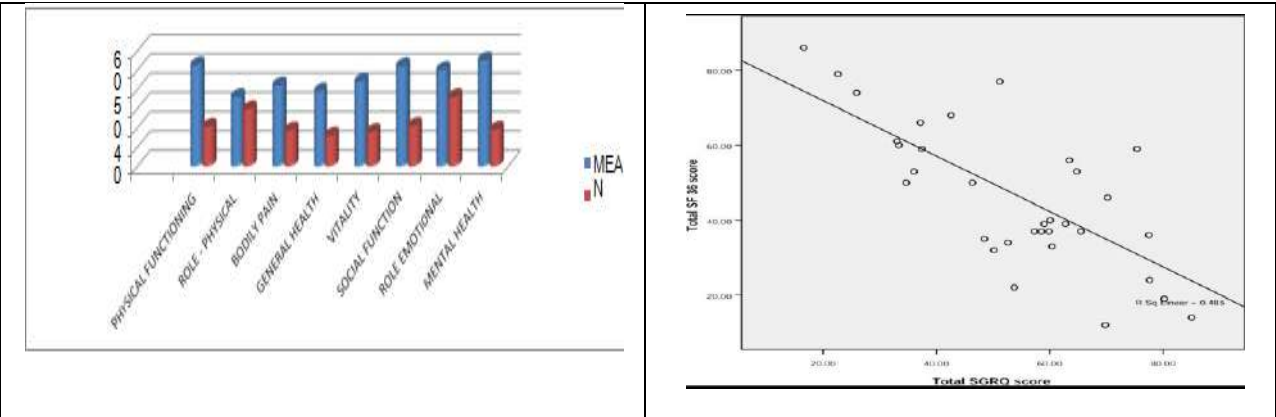
Fig.1:Shows descriptive data of Domains of SF-36	Fig. 2: Shows correlation between total score of SGRQ and total score of CRQ
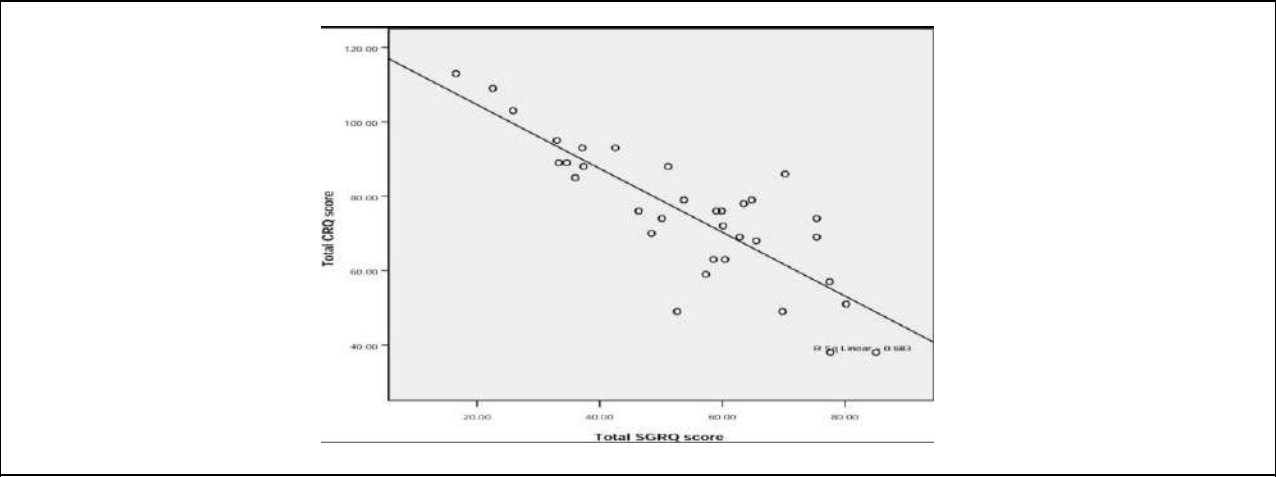
Fig. 3: Shows the correlation between the total score of SGRQ and the total score of SF-36

RESEARCH ARTICLE

Green Synthesis of Metal Oxide Nanoparticles and their Applications for Reducing Water Pollutants with Special Reference to Heavy Metals

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ABSTRACT

Increased globalization and industrialization over the last few decades have undoubtedly boosted the global economy and led us towards development but have contributed to a huge upsurge in environmental pollution. The discharge of industrial wastewater flooded with various pollutants like heavy metals, organic pollutants, pharmaceuticals, textile dyes, and other contaminants into surface water bodies has considerably depleted the groundwater quality, raising several concerns over the usage of such polluted water for animal and human usage. This has fueled the research to look for safer alternatives to ameliorate the groundwater quality, restoring it to a level fit for human and animal consumption. In this regard, the field of phyto-nanotechnology, involving the usage of biosynthesized green nanoparticles for removal of wastewater toxicants appears to be a promising tool, owing to the non-toxic and biodegradable nature of the biosynthesized nanoparticles. The current review summarizes the recent studies conducted in the last few years, showcasing the usage of green nanoparticles in amelioration of wastewater quality by heavy metals removal and other wastewater pollutants.

Keywords: Phyto-nanotechnology, green nanoparticles, heavy metals, wastewater bioremediation

INTRODUCTION

The last few decades have witnessed the implementation of an increasing number of nanomaterials for ameliorating the environmental quality by alleviating the problems associated with the deteriorating quality of soil as well as groundwater due to the noxious toxicants infiltrating them. However, one crucial aspect that needs to be considered while utilizing the agents to ameliorate the environmental quality is that the so-called "ameliorative agents" do not end up becoming pollutants themselves. Therefore, this concern has been dealt with by the usage of biodegradable materials ameliorative agents for restoration of environmental quality owing to their inability to persist in the environment and eco-friendly nature. Nanomaterials are an excellent choice when it comes to usage in various applications owing to their exceptional physic-chemical properties in the form of a high surface area to volume ratio, which makes it amenable to nanoengineers by introducing several functional groups on their surface. Furthermore, several other attributes associated with green nanomaterials include [1] their non-toxic nature and biodegradability, low economic cost associated with manufacture and maintenance, target specific nature, and potential to recover, and recyclable nature. All these benefits outweigh the demerits associated with the use of metallic nanoparticles such as high recovery cost, toxicity problems associated with byproducts of metallic nanoparticles, and implementation of a special fabrication process coupled with limited stability. Keeping in mind the above-stated facts, it is asserted that a thorough understanding of the biosynthesis process along with optimization of the performance and usage of material platforms are some of the points that need to be kept in mind while biosynthesizing nanomaterials. The usage of different plant extracts as capping agents for the biosynthesis of green nanomaterials has given rise to an altogether new branch of science, termed Phyto-nanotechnology. Phyto-nanotechnology can be best defined as an approach to phytochemical mediated synthesis of metallic nanomaterials to address several existing environmental issues [2]. Several other sources such as different bacteria and fungi are also being used at an increasing scale for the greensynthesis of nanoparticles owing to the availability of several phytochemicals in them. However, the current review article only talks about the applications of plant-synthesized green nanomaterials and their applications in wastewater remediation.

TYPES OF TOXIC EFFLUENTS PRESENT IN WASTEWATER
Heavy Metals
Heavy metals such as Ni, Zn, Co, Cd, Cu, Fe, Cr, Pb, Cr, Hg, and Mn may enter the water bodies from effluents released from several industries such as mining waste, natural gas, plastic, coal, dye, vehicular emissions, and several other anthropogenic activities. Exposure to heavy metals present in water may lead to innumerable deleterious effects on plants, animals, and humans. Exposure of aquatic animals to heavy metals may lead to retarded growth and development, alteration in feeding as well as swimming patterns, and induction of oxidative stress owing to the production of ROS, which may have detrimental effects on DNA, proteins, and other organs of aquatic animals. Certain heavy metals such as Arsenic may lead to fish death due to asphyxiation, and alteration in the number of B and T cells, thus making the aquatic animals immune compromised and susceptible to infections. Consumption of heavy metal-contaminated water has been visualized to induce several detrimental effects in humans including irritation of the lining of lungs and stomach, decreased erythrocyte production, reproductive disability, and other fatal consequences. Exposure of plants to heavy metal-contaminated water has been seen to trigger a whole cascade of malicious events, evident in the form of increased oxidative stress, decreased photosynthetic efficiency, inhibition of plant signaling leading to compromised plant immunity and several other fatal consequences [3].

Dyes
Anionic and Cationic dyes used in various industries such as paper mills, textile industry, plastic industry, leather industry, food, printing, and pharmaceutical industries are major sources of water pollution. Nearly 15% of the dyes used for coloring the fabrics are discharged into water bodies after being used up. Discharge of these dyes triggers a series of malicious events in the water bodies including augmentation of turbidity of the water bodies, an increase in turbidity further curtails the penetration of sunlight and a consequent reduction in photosynthetic efficiency of aquatic plants, an increase in lipid peroxidation activity, necrosis, chlorosis, and impaired root system in aquatic

plants, decrease in dissolved oxygen content of water, leading to increased BOD and COD. Exposure to several textile dyes has been observed to trigger several haemotoxic and genotoxic traits in aquatic animals, evident in the form of RBC lysis, increased mortality, alteration in shape and size, decreased amount of carbohydrates, lipids, and proteins, alteration in enzyme activity, decreased haemoglobin, impaired liver activity, respiratory distress, kidney dysfunction and several other debilitating metabolic disorders [4].

Organic pollutants
Organic pollutants present in the water bodies include fertilizers, phenols, pesticides, pharmaceuticals, biphenyls, hydrocarbons, and other waste products. Discharge of organic pollutant-laden water may disturb the ecological balance in several ways such as Nitrogen and phosphorus present in fertilizers may lead to algal bloom and lead to eutrophication in water bodies, Exposure to pesticides may trigger several genotoxic and cytotoxic effects in aquatic animals, The presence of biodegradable organic pollutants may deplete the oxygen content of the water bodies and may cause eutrophication and the presence of pharmaceutical products such as antibiotics in wastewater may lead to the selection of antibiotic-resistant bacterial strains, followed by their proliferation, leading to the emergence of drug-resistant strains[5].

Pathogens
The effluents released from hospitals, medical laboratories, and municipal wastes may be rich in many potentially harmful pathogenic organisms such as *E. coli, Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa, Salmonella typhi, Vibrio cholera, Enterobacter aerogenes,* and several other harmful pathogens. Exposure to pathogen-containing water may lead to the spread of infections and other outbreaks of communicable diseases in the community [6].

PROCESSES USED FOR WASTEWATER TREATMENT
For the treatment of wastewater conventional and non-conventional approaches have been used. Conventional approaches include the use of activated carbon, activated sludge process and microalgae reactor, while non-conventional methods include constructed wetlands and membrane bioreactors. Besides these two methods, chemical (coagulation, ozonation, advanced oxidation process, photocatalysis) and physical processes (microfiltration/ultrafiltration, nanofiltration, and reverse osmosis) are also being used for the treatment of wastewater. Currently, scientists are taking an interest in developing strategies for adsorption-based water treatment which includes the use of various nanomaterials, composites with activated carbon, activated hydrochar, biochar, activated carbon, metal-organic framework, organic soils, zeolites, carbon nanotubes, graphene and mesoporous nanocomposite of polymer and clay.

INTRODUCTION TO GREEN NANOPARTICLES, THEIR SYNTHESIS AND THEIR APPLICATIONS
Green synthesis of nanoparticles using plant extracts is carried out by mixing the plant extracts with the optimum concentration of desired metal ions to be incorporated in the nanoparticle. The ions ofmetal are further reduced and stabilized by several phytochemicals that are there in the plants that include secondary metabolites such as alkaloids, phenolics, terpenes, flavonoids, and other secondary metabolites. This is followed by filtration of the obtained nanoparticle and a series of other processing steps. The shape and size of synthesized nanoparticle can be manipulated at various steps by optimizing the concentration of the plant extracts. The green nanoparticles synthesized from plant extracts can be used for a number of applications such as:

Agriculture and Environment
The biosynthesized nanoparticles can be used for the alleviation of environmental pollutants and bioremediation of polluted soil and wastewater.

Biomedical
The green biosynthesized nanoparticles have been used for several biomedical applications such as immunotherapy, regenerative medicine, antibacterial, antifungal, and anticancer properties, wound healing, and bio-sensing.

Besides these, these are also used in Food science and technology, the cosmetic and textile industry, and the electronics industry. The current review discusses the usage of nanoparticles for environmental bioremediation by their usage in the removal of heavy metals from contaminated wastewater. This is achieved by exploiting the ability of green nanoparticles to act as super-adsorbents to adsorb contaminants from water. The green biosynthesized nanoparticles possess extremely large surface area to volume ratio along with the presence of several functional groups, specified pore size and surface as well as short diffusion distance. All these attributes contribute to the usage of green nanoparticles as potential bio adsorbents capable of adsorbing heavy metals that are found in polluted water [7],[8]. The nanoparticles biosynthesis and their use in the removal of heavy metals from wastewater is shown in the figure 1.

REMOVAL OF HEAVY METALS FROM WATER USING GREEN SYNTHESIZED NANOPARTICLES
Effluents released from different industries and research labs are rich in heavy metals and their release into the wastewater causes heavy metal accumulation invarious forms of water reservoirs. Increased buildup of these obnoxious heavy metals into the ecosystem has been a menacing problem for scientists, in response to which a number of approaches have been used to alleviate this heavy metal accumulation. Generally, heavy metals like copper, lead, chromium, iron, and cadmium are the major toxicants that are present in the water bodies. The studies enlisted in the section underneath as well as Table 1 highlight research studies to ameliorate the effect of heavy metal accumulation in wastewater using green nanomaterials. A recent study by [9] showed the biosynthesis of ZnO green nanoparticles from leaf extract of *Zizyphus jujuba* using microwave irradiation, followed by the characterization of the synthesized nanoparticles and further demonstrated the unparalleled efficacy of the green nanoparticles to eliminate Pb from wastewater. Furthermore, the researchers also highlighted the crucial role of various physic-chemical parameters such as the mass of synthesized ZnONPs, pH of the solution, contact time, ionic strength of the solution, and temperature in determining the absorption efficacy of the nanoparticles to adsorb heavy metals from wastewater. In yet another study by [10], the researchers synthesized silver nanoparticles using leaf extract of *Prosopis juliflora,* followed by characterization of the biosynthesized nanoparticles by FTIR, SEM, and XRD. Furthermore, the biosynthesized silver nanoparticles were demonstrated to exhibit potent cleansing action in the removal of several obnoxious pollutants from wastewater including *E coli*, heavy metals as well as Rose bengal dye (Table 2). Another study by [11] demonstrated thebiosynthesis of silver nanoparticles from an agro-industrial byproduct, walnut husk. Furthermore, the synthesized nanoparticles were characterized using different biochemical techniques followed by a demonstration of the ability of the green silver nanoparticles to ameliorate the quality of petroleum wastewater by removing several heavy metal toxicants including Pb. Cr and Cd.

Another recent study by [12] showed the green biosynthesis of silver nanoparticles using leaf extract of *Piliostigma thonningii* followed by characterization of the biosynthesized nanoparticles using FTIR, XRD, UV-visible spectroscopy, Zetasizer, and TEM techniques. Furthermore, the researchers demonstrated the ability of silver nanoparticles to eliminate heavy metal toxicants from laboratory-simulated wastewater, with the best adsorptive performance of the nanoparticles at pH of 6.5, temperature 65°C, 1.25 mM of silver nitrate, and 5 ml of plant extract. The researchers further proceeded to demonstrate the safety of the biosynthesized nanoparticles by orally administering the nanoparticles to experimental laboratory rats and showing a lack of any adverse histopathological alterations in the rats in response to nanoparticle exposure. A recent study by [13] showed the biosynthesis of silver nanoparticles using leaf extract of *Ficus Benjamina* followed by characterization of the synthesized nanoparticles using FTIR, UV-visible spectroscopy, and SEM. Furthermore, the researchers demonstrated excellent efficacy of the synthesized nanoparticles to eliminate cadmium from wastewater; with increased efficacy of the nanoparticles with an increase in the concentration of the biosynthesized adsorbent nanoparticles, increase in pH from 1 to 6 and increase in contact duration between the wastewater and the biosynthesized nanoparticles. In a study conducted by [14], the researchers showcased the green biosynthesis of silver nanoparticles from the seed extract of *Moringa oleifera.* Furthermore, the researchers demonstrated excellent efficacy of the biosynthesized nanoparticles in eliminating different types of pollutants in wastewater including both gram-negative and gram-positive bacterial strains (*Staphylococcus aureus, , Salmonella enterica typhimurium, Escherichia coli*and *Pseudomonas aeruginosa)*, organic dyes (methylene blue, orange red and 4-nitrophenol) as well as Pb heavy metal, therefore unveiling the powerful

antimicrobial as well as disinfecting ability of the biosynthesized nanoparticles in the cleansing of effluents released from dyeing units. A recent study by [15] demonstrated the biosynthesis of iron nanoparticles from green tea extract, followed by the characterization of the nanoparticles using XRD, TEM, and UV-Visible spectroscopy and showcasing the unparalleled efficacy of the biosynthesized iron nanoparticles to eliminate Cr contamination from wastewater.
A recent study by [16] demonstrated the biosynthesis of green iron nanoparticles from the leaf extract of the barberry plant followed by the characterization of the nanoparticles using XRD, TEM, and UV-visible spectroscopy.

Thereafter, the researchers showcased the ability of the biosynthesized nanoparticles to remove the heavy metals pollutants (Cr) from industrial wastewater. Another study by [17] showcased the biosynthesis of green zero-valent iron nanoparticles from aqueous tea extract followed by characterization of the nanoparticles using XRD, HRTEM, FESEM zeta-sizer, BET surface area, and UV-visible spectroscopy. Furthermore, the researchers highlighted the microbicidal activity of the synthesized nanoparticles and their ability to eliminate Cu metal ions from polluted industrial effluent. In addition to this, the researchers also highlighted the crucial role of several physicochemical parameters such as pH of the solution, dose of the adsorbent nanoparticle, and concentration of the contaminant in controlling the efficacy of the biosynthesized nanoparticles. A study by [18] showcased the biosynthesis of titanium dioxide nanoparticles from lemon peel extract, followed by SEM analysis and EDS mapping of the biosynthesized nanoparticles. In addition to this, the researchers also showcased the ability of the biosynthesized titanium dioxide nanoparticles to eliminate nickel ions from industrial wastewater. [19] demonstrated the green biosynthesis of bimetallic FeNi nanoparticles from straw waste followed by a demonstration of the excellent ability of the biosynthesized nanoparticles to ameliorate the quality of industrial effluents by removal of Cr heavy metal contamination. A series of studies by [20], [21], and [22] showcased the green biosynthesis of bimetallic FeNi nanoparticles, palladium nanoparticles, and zirconium hydroxide nanoparticles from green tea extract, rice residue and plant extract of *Konjac glucomannan.* Furthermore, the efficacy of these nanoparticles to ameliorate the quality of industrial effluents by eliminating heavy metal pollution in the form of Sb, As, and Cr was demonstrated in the studies by [20],[21] and [22] respectively.

CONCLUSION

The discovery of nanoparticles has revolutionized the entire field of science and technology, however, there are several concerns surrounding the use of synthetic nanoparticles as they are known to exhibit malicious effects on the environment as well as other components of the ecosystem. This has contributed to increased impetus in the biosynthesis of green nanoparticles using plants and other sources, which are biodegradable, non-hazardous, and relatively safe to use with increased efficacy in comparison to their bulk counterparts. The current review sheds light on the recent studies showing the usage of green nanoparticles in environmental bioremediation by removal of pollutants, particularly heavy metals from wastewater released from various industries and other domestic as well as municipal units. The current field of phyto-nanotechnology to ameliorate environmental pollution by performing wastewater remediation using phyto-nanoparticles appears to show promising results. Nevertheless, several concerns need to be addressed before the full-fledged usage of green nanoparticles for wastewater bioremediation, monitoring the influence of physic-chemical attributes such as pH, solvent concentration, temperature, and reaction time in controlling the shape and size of the biosynthesized green nanoparticles. Green synthesis of nanoparticles has only been performed at the laboratory level so far; therefore, performing this humongous task at the industrial level while also controlling the physico-chemical attributes of the biosynthesized nanoparticles would be a daunting task.In-depth research is needed to study the mechanism of action of green nanoparticles before using them at the commercial level.Despite these concerns and issues, the biosynthesis of green nanoparticles for environmental bioremediation appears to showcase promising results in a sustainable way.

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Table 1: Methods used for the treatment of wastewater

S. No.	Name of approach	Methods/materials used
1	Conventional	Biological Activated Carbon, Microalgae Reactor, Activated Sludge Process
2	Non-conventional	Constructed Wetlands, Membrane Bioreactors
3	Chemical	Coagulation, Ozonation, Advanced Oxidation Process, Photocatalysis
4	Physical	Microfiltration/Ultrafiltration, Nanofiltration, Reverse Osmosis
5	Adsorption-based water treatment	Nanomaterials, Composites with Activated Carbon, Activated Hydrochar, Biochar, Activated Carbon, Metal-Organic Framework, Organic Soils, Zeolites, Carbon Nanotubes, Graphene and Mesoporous Nanocomposite of Polymer and Clay

Table 2: Green Synthesis of various Nanomaterials and their Application

Name of plant used	Biomaterial	Name of nanoparticle	Size of nanoparticle	Contaminant removed	Reference
Zizyphus jujuba	Leaf extract	ZnO	20 nm	Pb	[9]
Prosopis juliflora	Leaf extract	AgNPs	30 nm	*E coli*, Heavy metal, Rose bengal dye	[10]
Juglans	Husk extract	AgNPs	46.2 nm	Pb, Cr, Cu	[11]
Piliostigma thonningii	Leaf extract	AgNPs	70-114 nm	Cu	[12]
Ficus benjamina	Leaf extract	AgNPs	60-105 nm	Cd	[13]
Moringa oleifera	Seed extract	AgNPs	9.4 nm	Pb	[14]
Simarouba glauca	Leaf extract	FeNPs	9 nm	Pb	[15]
Green tea	Leaf extract	FeNPs	--	Cr	[16]
Barberry plant	Leaf extract	GnZVI	20-40 nm	Cr	[16]
Black tea	Powder extract	FeNPs	6.1 to 10.6 nm	Cu	[17]
Lemon	Peel extract	Titanium dioxide NPs	22 to 54 nm	Ni	[18]
--	Straw waste	Fe/Ni NPs		Cr	[19]
Green tea	Leaf extract	Fe/Ni NPs	20-80 nm	Sb	[20]
--	Rice residue	Zirconium hydroxide NPs	--	As	[22]
Konjac glucomannan	Plant extract	Pd NPs	6.48 nm	Cr	[21]

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Sida rhombifolia	Leaf extract	Silver-doped nanoparticles of zinc and copper	--	*Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Streptococcus mutans,* and *Staphylococcus aureus*	[23]
Orange	Peel extract	Zinc-FeONPs	30 nm	*Escherichia coli*	[24]
Sugar and rice plant	Bagasse and rice husk	CuNPs	--	*E. coli*	[25]
Madhuca longifolia	Plant extract	CuO	--	*E. coli BL21 DE3 Gram-negative, S. aureus Gram-positive,* and *B. subtilis Gram-positive*	[26]
Phyllanthus pinnatus	Stem extract	AgNPs	>100 nm	*V. cholera, S. flexneri, P. aeruginosa, M. smegmatis, P. vulgaris, B. subtilis*	[27]
Asparagus racemosus	Root extract	AgNPs	10-17 nm	*Escherichia coli, Staphylococcus aureus, Bacillus subtilis, Klebsiella pneumonia, Pseudomonas fluorescens, Aeromonas hydrophila, Edwardsiella tarda, Flavobacterium branchiophilum,* and *Yersinia rukeri*	[28]
Pergularia daemia	Leaf extract	AgNPs	30-45 nm	*Escherichia coli*	[29]
Citrus paradisi	Peel extract	Ag-MgO	16.44 nm	*Klebsiella pneumonia and Escherichia coli*	[30]
Jujube	Fruit extract	AgNPs	25-35 nm	*E. coli and K.pneumoniae as Gram-negative bacteria* and *S. aureus as Gram-positive bacteria*	[31]
Z. officinale	Ginger extract	FeONPs	5.10 nm	*Escherichia coli*	[32]
Pomegranate	Peel extract	Titanium dioxide NPs	92.8 nm	*Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa*	[33]
Syzygium Cumini	Leaf extract	--	10-12.55 nm	Methylene blue dye	[34]
Ziziphus jujuba	Fruit extract	ZnONPs	20-37 nm	Methylene blue (MB) Eriochrome black T (ECBT)	[35]
Cyanometra ramiflora	Leaf extract	--	13.3 nm	Rhodamine B dye	[36]
M. burkeana	Plant extract	Zinc ferrite nanoparticles	25 nm	Methylene blue and sulfisoxazole	[37]
Psidium guajava	Leaf extract	Zinc ferrite nanoparticles	--	Congo red and methylene blue	[38]
Azadirachta indica	Leaf extract	--	21.6 nm	Methylene blue	[34]
Mimosa pigra	Leaf extract	--	17.5 nm	Methylene blue, hydrogen peroxide	[39]
Acalypha hispida	Plant extract	--	23 nm	Methylene blue, methyl orange, 4-NP, 2,4-DNPH	[40]
Chlorophytum comosum	Leaf extract	Iron oxide NPs	100 nm	Methyl orange dye	[41]
Artocarpus heterophyllus p	Peel extract	--	33 nm	Fuchsin basic dye	[42]
Daphne merezeum	Leaf extract	Iron oxide NPs	9.2 nm	Methyl orange dye	[43]
Peltophorum pterocarpum	Leaf extract	--	16.99 nm	Methylene blue dye	[44]
Punica granatum	Seed extract	Iron oxide NPs	5.54 nm	Congo red (CR) and bromophenol blue (BPB)	[45]

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Punica granatum	Peel extract	Iron oxide NPs/AgNPs	27 nm	Aniline blue (AB) dye	[46]
Convolvulus fruticosus	Flower extract	AuNPs	35 nm	Basic violet 10 (BV10) Basic blue 9 (BB9) Acid red 51 (AR51)	[47]
Alpinia nigra	Leaf extract	--	21.52 nm	Methyl orange dye	[48]
Fraxinus chinensis Roxb	Leaf extract	Phytogenic magnetic nanoparticles (PMNPs)	--	Malachite green (MG)	[49]
Tilia leaves	Leaf extract	--	0.34–1.27 nm	Ibuprofen (Ibu), naproxen (Nap), and diclofenac (Dic)	[50]
Aglaia elaeagnoidea C	Flower extract	Copper nitrate NPs	20–45 nm	4-Nitrophenol	[51]
Terminalia bellerica	Kernel extract	--	32 nm	4-Nitrophenol	[52]
Citrus maxima	Peel extract	--	4 – 11 nm	4-Nitrophenol	[53]
Moringa oleifera	Leaf extract	Fe O3 4 NPs	14.34 nm	Levofloxacin	[54]
Lawsonia inermis	Seed extract	Au-Ag NPs	15-35 nm	4-Nitrophenol	[55]
Aloe barbadensis, Azadirachta indica, Coriandrum sativum	Leaf extract	AgNPs	--	Naphthalene decontamination	[56]
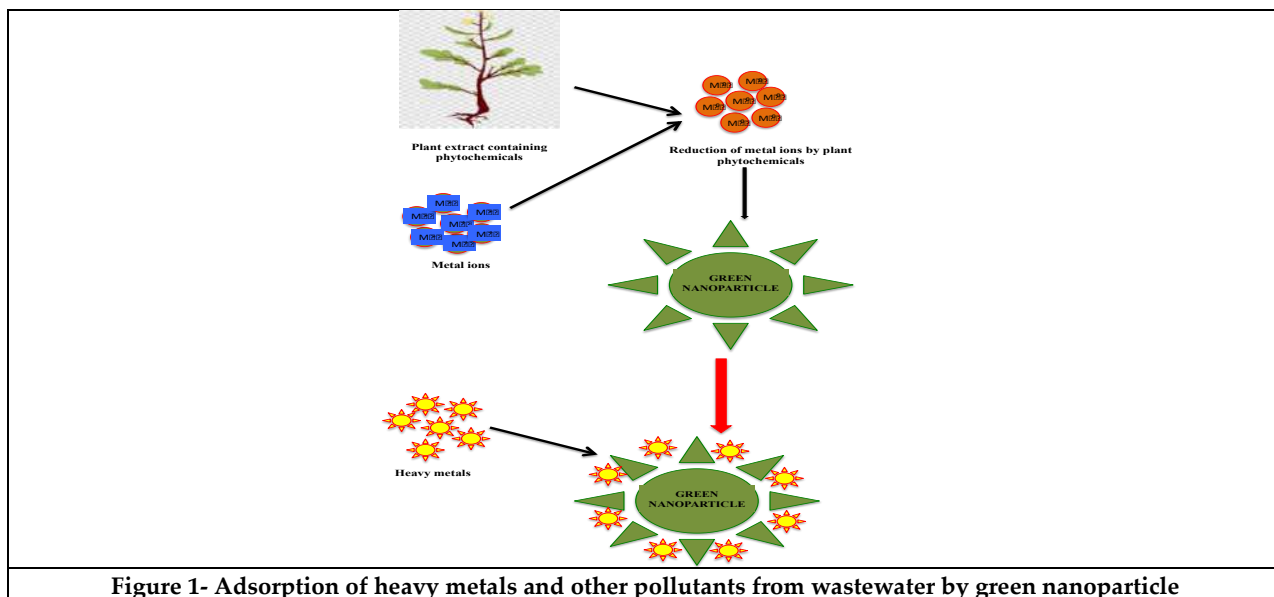
Figure 1- Adsorption of heavy metals and other pollutants from wastewater by green nanoparticle

RESEARCH ARTICLE

Assessing Heavy Metal Influence on Antioxidant Activities Across *Glycine max* L. Cultivars

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ABSTRACT

Due to the increased environmental pollution in recent times, the contamination of the food chain by heavy metals is a plausible concern. The aim of this research was to investigate how heavy metal contamination affects the antioxidant capabilities of three different *Glycine max* L. cultivars (JS:335, JS:80-21 and JS:75-46). The study evaluated various antioxidant parameters such as total antioxidant capacity, ferrous reducing antioxidant capacity, DPPH radical scavenging activity and hydroxyl radical scavenging activity after harvesting. Results indicate that exposure to normal concentrations of lead (Pb) and chromium (Cr) did not produce visible toxic effects in *Glycine max* L. plants. However, at higher concentrations (200mlKg^{-1}), both Pb and Cr caused a significant decrease in antioxidant activities across all parameters except for the ferrous reduction assay. These findings highlight the negative impact of elevated heavy metal concentrations on antioxidant activities in soybeans. Consequently, there's a need for strategies to mitigate heavy metal toxicity in agricultural soils. Additionally, further investigation into the molecular mechanisms underlying heavy metal toxicity in plants is warranted.

Keywords: Heavy metal, chromium, lead, Glycine max, JS:335, JS:80-21 and JS:75-46

INTRODUCTION

"Heavy metals" refers to metals and metalloids with a density exceeding 5 g/cm3, a term commonly used to describe these elements. While some of them serve as micronutrients, they also pose environmental risks as pollutants. Over recent centuries, human actions have resulted in the pollution of land and water with heavy metals (Nagajyoti *et al*., 2010).The escalating issue of environmental pollution due to heavy metals is a significant concern. Factors such as

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rapid urbanization, industrialization, unsustainable agricultural methods, combustion of fossil fuels, and extensive mining activities are primarily responsible for the substantial release of heavy metals into the environment. This contamination severely affects water, air, and soil quality(Li, *et al.*, 2019).The proliferation of heavy metal contamination poses a significant threat to both the environment and food security. This is largely due to the rapid advancements in agriculture and industry, as well as the disruption of natural ecosystems caused by the substantial growth in the global population (Sarwar *et al.*,2016).Heavy metals infiltrate the agricultural ecosystem through both natural means and human activities. Several studies suggest that, in comparison to human-induced activities, the contribution of natural sources to heavy metal presence in the environment is typically minimal (Dixit *et al.*,., 2015).Chromium, positioned in group VI B of the periodic table as a transition metal, exhibits various oxidation states, with the trivalent and hexavalent forms being the most stable and commonly encountered. Despite being the 7th most abundant element on Earth and the 21st in the crustal rock, chromium has become a significant pollutant of air, soil, and water due to its extensive use in leather tanning, pigment production, electroplating, and alloy manufacturing. It is classified as a hazardous heavy metal due to its detrimental effects, which include membrane damage, alterations in organelle structure, disruptions in metabolic processes, and inhibition of growth (Vazquez,1987). Chromium has been shown to promote the generation of free radicals (FR) and reactive oxygen species (ROS) like superoxide radicals (O2), hydrogen peroxide (H2O2), and hydroxyl radicals (OH). This can occur through direct electron transfer involving metal cations or as a result of chromium-mediated interference with metabolic reactions(Stohs and Bagchi, 1995). The presence of these radicals leads to oxidative damage to biomolecules such as lipids, proteins, and nucleic acids (Kanazawa *et al.*, 2000).Lead, a hazardous heavy metal pollutant in the environment, arises from multiple sources including lead ore mining and smelting, coal combustion, emissions from storage battery industries, vehicle exhausts, metal plating and finishing processes, fertilizers, pesticides, and additives in pigments and gasoline (Eick *et al.*,1999).

To counteract oxidative damage, plants possess an antioxidant defense system consisting of enzymes such as catalase, peroxidases , and superoxide dismutases, along with non-enzymatic components including alpha-tocopherol, ascorbate, and reduced glutathione. These elements work together to eliminate, neutralize, and scavenge reactive oxygen species (Shah *et al.,* 2001).Food intake has been recognized as the primary source of metal exposure in humans (Alam, *et al.*, 2003). Furthermore, research on the transference of heavy metals from soil to crops (Lavado, 2006) has indicated that soybeans have the potential to accumulate higher levels of potentially harmful elements compared to other crops. Soybean (*Glycine max*) is globally recognized as one of the most extensively cultivated crops and serves as a crucial protein source. Argentina stands out as a significant producer of the genetically modified Roundup Ready variety of *Glycine max* L. with soybean being its foremost crop in terms of production volume (INTA). The considerable demand for soybean has led to its cultivation in areas adjacent to busy roads with heavy vehicular traffic and in regions near human activities such as industrial manufacturing (Rodriguez, *et al.,* 2011). Currently, there is a shortage of toxicological studies regarding the food safety of soybeans cultivated near industrial areas (Murakami2009, Zheng *et al.*, 2007). Therefore, the objectives of this study were: (i) to determine the impact of heavy metal contamination on antioxidant activities of three different varieties of *Glycine max* L.

MATERIALS AND METHODS

Plant material and experimental setup
Certified seeds of three cultivars i.e. JS:335, JS:80-21, and JS:75-46 of *Glycine max* L. varieties were bought from MFP PARC (Vindhya Herbals) in Barkhera Pathani, Bhopal, Madhya Pradesh, India. The experiment took place in pots at the Department of Botany, Government Motilal Vigyan Mahavidyalaya, Bhopal, from 2021 to 2022.The soil was dried naturally and then combined with vermicompost and sand. Each plastic pot was filled with around 4 kg of this soil mixture, following the method outlined by (Kumar et al., 1993). Solution of Four different concentrations i.e., 50 ml, 100 ml, 150 ml and 200 ml Kg^{-1}(01mM/ml concentration) of two heavy metals Lead (II) nitrate and Potassium dichromate was sprayed and mixing continuous to homogenize properly. Three pots were filled with soil without treatment and labeled as control. Seeds were surface sterilized with 0.1% HgCl$_2$ for two minutes, then washed with

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distilled water twice and air dried. Seeds were sown at 2-3cm depth in pots and watering was done once every two days. All experimental pots were placed outdoor for growing.

Determination of Total Antioxidant Capacity (TAC)

This experiment was performed by following the method of (Prieto *et al.*,1999) with some modifications. A crude sample of 0.5 ml was combined with 3 ml of a reaction mixture (0.6 M sulphuric acid, 28 mM sodium phosphate and 1% ammonium molybdate)in a test tube and left to react at 95°C for 10 minutes. Afterward, the absorbance was gauged at 695 nm using a spectrophotometer against both a blank and catechin as a standard at room temperature. Higher absorbance in the sample mixture compared to the standard and blank indicated a heightened overall antioxidant capacity.$\text{TAC} = \frac{Ac - As}{Ac} \times 100$

Ferrous Reducing Antioxidant Capacity Assay

The ferrous reducing antioxidant capacity was evaluated following the methodology described by Oyaizu 1986. 0.25 ml of the sample along with standard solutions at various concentrations were mixed with 0.625 ml of 0.2 M potassium buffer and 0.625 ml of 1% potassium ferricyanide (K3Fe(CN)6) solution into test tubes. Afterwards, the reaction mixture was allowed to incubate at 50°C for 20 minutes to ensure completion of the reaction. Subsequently, 0.625 ml of 10% trichloroacetic acid (TCA) was introduced, followed by centrifugation at 3000 rpm for 10 minutes. Following centrifugation, 1.8 ml of the supernatant was transferred to a test tube. To this, 1.8 ml of distilled water and 0.36 ml of 0.1% ferric chloride (FeCl3) were added. The absorbance of the resulting solution was measured at 700 nm using a spectrophotometer against both a standard and a blank. A higher absorbance of the sample mixture compared to the standard and blank indicated an increased reducing capacity: % Inhibition $= \frac{Ac - As}{Ac} \times 100$

DPPH Radical Scavenging Assay

The assay test was conducted following the procedure outlined in (Choi *et al.*,2000) and (Desmarchelier *et al.*, 1997). Reaction mixtures (2.4ml of 0.1mM DPPH in methanol and sample/standard (butylated hydroxytoluene) were vortexes and incubated in dark at room temperature for 30minutes. Absorbance was measured at 817nm using a spectrophotometer. The percentage of DPPH was determined as follows:% Inhibition $= \frac{Ac - As}{Ac} \times 100$

Hydroxyl Radical Scavenging Activity

This was determined using the procedure outlined in (Klein *et al.*, 1981).Reaction mixture: 1ml of Fe-EDTA solution, 0.5ml of 0.018% EDTA, 1ml of 0.85% DMSO and 0.5ml of 22% ascorbic acid were added in a test tube. This was act as blank. Similar mixture was made for different sample concentration and standard by adding 0.5 ml of samples or standard. The reaction mixture tubes were tightly capped and heated at 85°C for 15 minutes in a water bath. After cooling to room temperature, the tubes were uncapped, and 0.5 ml of ice-cold 17.5% TCA was added to each tube. Then, 3 ml of Nash reagent (prepared by mixing 7.5gm of ammonium acetate, 300 μl of glacial acetic acid, and 200 μl of acetyl acetone and making up to 100 ml) was added to all tubes and incubated at room temperature for 15 minutes. Absorbance was measured at 412 nm using aa UV-spectrophotometer. The percentage of hydroxyl radical scavenging activity (% HRSA) was calculated using the following equation: % HRSA $= \frac{Ac - As}{Ac} \times 100$

Data analysis

Data were analyzed statistically by analysis of variance (ANOVA) using SPSS 16.0 software. The values are mean (±SE) of treatments (n=3) at P<0.05 significant level. The least significant difference (LSD) was calculated for mean separation for significant differences among treatments at p < 0.05 levels.

RESULTS

The effect of different concentrations of Heavy metals (Lead and Chromium) on Antioxidant activities of three Cultivars i.e JS: 335, JS: 80-21 and JS:75-46 of *Glycine max* L.as shown in table 1. The treatments were categorized as

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follows: A = JS: 335; B = JS: 80-21; C = JS: 75-46; L = Pb; C = Cr. Additionally, numerical values were assigned to represent volume: 1 = 50 ml; 2 = 100 ml; 3 = 150 ml; 4 = 200 ml. The abbreviation "Ctrl" stands for Control.

JS:335 Cultivar

Total antioxidant capacity (mg E AA/g dw), Ferrous reducing antioxidant capacity assay (μmol Fe2+/g FM), DPPH radical scavenging assay (% inhibition) and Hydroxyl radical scavenging activity (% inhibition) were performed on leaf extracts of *Glycine max* L. treated with two different heavy metals i.e. Pb and Cr in four concentrations, i.e. 50 ml, 100 ml, 150 ml and 200 mlKg^{-1} with control. Maximum reduction of Total antioxidant capacity, DPPH radical scavenging activity, Hydroxyl radical scavenging activity parameters was observed in 200ml Kg^{-1}concentration in both pb and cr treated plants whereas minimum reduction was observed at lowest concentration i.e 50 ml Kg^{-1}when compared to control group. At the highest concentrations, there is an observed rise in ferrous reducing antioxidant activity.

JS:80-21 Cultivar

Leaf extracts were subjected to various antioxidant assays after treatment with two different heavy metals, Pb and Cr, at four concentrations, alongside a control group. The maximum reduction in total antioxidant capacity, DPPH radical scavenging activity, and hydroxyl radical scavenging activity was observed at the highest concentration (200 ml Kg^{-1}) for both Pb and Cr treatments, while the minimum reduction was noted at the lowest concentration (50 ml Kg-1) compared to the control group. Additionally, an increase in ferrous reducing antioxidant activity was observed at the highest concentrations.

JS:75-46 Cultivar

Highest reduction in total antioxidant capacity, DPPH radical scavenging activity, and hydroxyl radical scavenging activity was observed at the concentration of 200 ml Kg-1 for both Pb and Cr treatments, while the lowest reduction was observed at the lowest concentration (50 ml Kg^{-1}) compared to the control group. Additionally, an increase in ferrous reducing antioxidant activity was observed at the highest concentrations.

Comparative influence of lead and chromium on antioxidant Potential of different cultivars of Glycine max L.
Total Antioxidant Capacity

The study investigated the impact of varying doses (50ml, 100ml, 150ml, 200mlKg^{-1}) of lead and chromium on the total antioxidant capacity of different cultivars of *Glycine max* L. compared to a control group after harvesting. The highest decrease in total antioxidant capacity was noted in the JS:80-21 cultivar at the highest dose (200mlKg^{-1}) of lead treatment, while the lowest reduction was observed in the JS:75-46 cultivar at the same dose. Conversely, in chromium treatment, the maximum decrease in total antioxidant capacity occurred at the 200ml dose in the JS:75-46 variety, while the minimum reduction was seen at the 200ml concentration in the JS:335 variety compared to the control, as illustrated in Figure 4.

Ferrous reducing antioxidant capacity assay

In higher concentrations (i.e., 200ml) of both lead and chromium, the Ferrous reducing antioxidant capacity showed an increase. The greatest enhancement was observed in the JS:335 variety, followed by JS:75-46 and JS:80-21, compared to the control, as illustrated in the figure 5.

DPPH radical scavenging assay

At higher concentrations (200ml) of lead and chromium treatment, the DPPH radical scavenging activity exhibited a decrease. The most significant reduction was observed in the JS:80-21 variety, while the smallest decrease was noted in the JS:75-46 variety compared to the control, as depicted in the figure 6.

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Hydroxyl radical scavenging activity

The greatest decrease in hydroxyl radical scavenging activity occurred at the 200ml concentration in JS:80-21 cultivar, followed by JS:75-46 and JS:335, in both lead and chromium treated plants compared to the control group as shown in fig 7.

DISCUSSIONS

Heavy metals pose both immediate and long-term health risks to humans and various organisms. Plants act as a conduit for heavy metal accumulation, which can then be transferred to humans through the food chain. These metals in soil can impede plant growth and development by disrupting the absorption and movement of essential nutrients (Massoud *et al*., 2018; Kaya *et al*., 2022). Research indicates that *Glycine max* L., commonly known as soybean, has the capacity to accumulate heavy metals (Bojinova *et al*.,., 1994). A study by Reddy and Dunn (1984) investigated soybean plants and observed the accumulation of heavy metals such as Cd, As, Cr, and Zn in various plant parts. In this research, three varieties of *Glycine max* L. (JS:335, JS:80-21, JS:75-46) were subjected to treatments with different concentrations of lead and chromium. The effects of these heavy metal treatments on antioxidant parameters were investigated, including Total Antioxidant CapacityFerro,us reducing antioxidant capacity, DPPH radical scavenging activity, and Hydroxyl radical scavenging activity. The data presented in Table 1 indicates that following exposure to lead and chromium at concentrations of 50ml, 100ml, 150ml, and 200ml, there was a notable decrease in the antioxidant activities of the *Glycine max*L. plants compared to the control group. The harmful effects of heavy metals on plants stem from an imbalance between the productions of reactive oxygen species (ROS) and antioxidants within plant cells. Exposure to heavy metals can lead to heightened ROS production, including superoxide anion (O_2), hydroxyl radical (OH), and H_2O_2, resulting in oxidative stress (Devi and Prasad, 2005; Pradedova *et al*., 2011). Heavy metals, such as chromium (Cr), are particularly notorious for inducing oxidative stress in plants. Studies have indicated that elevated levels of Cr can disrupt antioxidant activities in response to Cr stress (Adhikari *et al*.,2020). In the current investigation, the total antioxidant capacity, DPPH radical scavenging assay, and Hydroxyl radical scavenging activity exhibited significant reductions at higher doses of heavy metals, while Ferrous reducing antioxidant capacity increased. Consequently, the study's findings suggest that escalating concentrations of supplementary elements lead to diminished antioxidant activities.

CONCLUSION

Our findings indicate that Cr and Pb have distinct impacts on various parameters of our experimental plants. Significant variations in the concentrations of Cr and Pb were found to affect antioxidant activities differently. Both Pb and Cr led to a notable decrease in antioxidant activities across all parameters except for the ferrous reducing antioxidant capacity assay. Among the tested varieties, JS:335 showed the least reduction, while JS:80-21 displayed the highest reduction in all parameters. Pb treatment exhibited greater toxicity compared to Cr treatment. Given the escalating issue of Pb and Cr accumulation in agricultural soils, it is imperative to devise strategies and mechanisms to mitigate their toxicity in crops. Further exploration of molecular mechanisms is necessary to understand the signaling pathways of heavy metal toxicity exhibited by treated plants.

Declaration of Competing Interest

The author declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Table 1: Results

Cultivars	Treatment	Doses	Total antioxidant capacity (TAC) (mg E AA/g dw)	Ferrous reducing antioxidant capacity assay (μmol Fe2+/g FM)	DPPH radical scavenging assay (% inhibition)	Hydroxyl radical scavenging activity (% inhibition)
JS:335	Control	ACtrl	1.30±0.02	27.53±0.66	66.00±1.46	72.00±1.45
	Lead (Pb)	AL1	1.16±0.02	32.42±0.55	50.23±0.87	53.26±0.95
		AL2	1.00±0.02	35.64±0.59	48.56±1.22	51.49±0.94
		AL3	0.96±0.01	37.12±0.87	46.65±0.58	50.24±0.77
		AL4	0.64±0.01	38.54±0.59	42.23±0.73	48.75±0.89
	Chromium (Cr)	AC1	1.20±0.02	30.23±0.61	55.23±0.96	57.86±1.24
		AC2	1.12±0.02	31.15±0.55	53.14±0.92	56.85±1.03
		AC3	1.01±0.03	33.56±0.57	50.14±0.88	54.62±1.23
		AC4	0.98±0.02	34.40±0.59	48.52±0.84	53.28±1.18
JS:80-21	Control	BCtrl	1.22±0.05	25.61±0.94	61.42±1.48	66.59±2.81
	Lead (Pb)	BL1	1.07±0.04	29.86±1.30	46.54±1.11	49.12±2.00
		BL2	0.95±0.04	34.15±1.41	46.25±0.94	46.89±2.18
		BL3	0.88±0.02	34.16±0.45	43.26±0.85	45.61±1.10
		BL4	0.61±0.01	35.41±0.68	38.51±0.17	44.95±0.77

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|						
	Chromium (Cr)	BC1	1.11±0.04	27.89±0.72	50.24±0.91	51.35±1.75
		BC2	1.02±0.04	28.65±0.52	48.69±0.70	51.37±1.91
		BC3	0.95±0.04	30.56±0.69	46.27±1.02	49.89±2.04
		BC4	0.94±0.03	31.26±0.75	44.59±0.69	48.97±1.48
JS:75-46	Control	CCtrl	1.23±0.02	26.53±0.99	63.25±1.28	67.45±1.36
	Lead (Pb)	CL1	1.09±0.02	30.24±1.20	47.58±0.73	50.13±1.44
		CL2	0.98±0.02	33.65±1.24	46.57±0.73	48.35±0.84
		CL3	0.91±0.01	35.41±0.85	46.21±0.68	47.62±0.70
		CL4	0.85±0.02	36.42±0.56	45.61±0.90	46.12±0.97
	Chromium (Cr)	CC1	1.13±0.03	29.65±0.60	54.67±1.40	56.23±1.42
		CC2	1.07±0.01	30.45±0.60	52.11±0.58	55.09±0.85
		CC3	0.97±0.02	31.98±0.55	49.56±1.03	53.12±1.4
		CC4	0.94±0.02	33.32±0.57	47.17±1.04	51.64±1.14
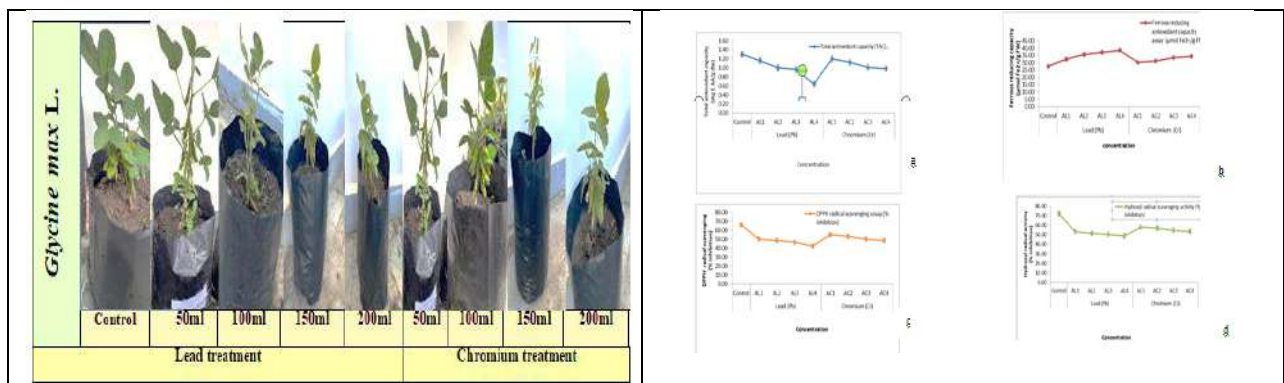
Fig 1: *Glycine max* L. treated with different concentrations of chromium and lead

Fig.1 (A, B,C & D): The impact of varying doses of Pb and Cr on total antioxidant capacity, Ferrous reducing antioxidant capacity assay, DPPH radical scavenging assay, Hydroxyl radical scavenging activity of JS:335 cultivar of *Glycine max* L. in comparison to control. .The obtained values were analyzed by using one-way analysis of variance (ANOVA)-using SPSS 16.0 software.The data presented as treatments mean ±SE (n=3) at P<0.05 significant level.

Fig.2 (A, B, C & D): Figure demonstrates the impact of varying doses of Pb and Cr on total antioxidant capacity, Ferrous reducing antioxidant capacity assay,

Fig.3 (A, B, C & D): Figure demonstrates the impact of varying doses of Pb and Cr on total antioxidant capacity, Ferrous reducing antioxidant capacity assay,

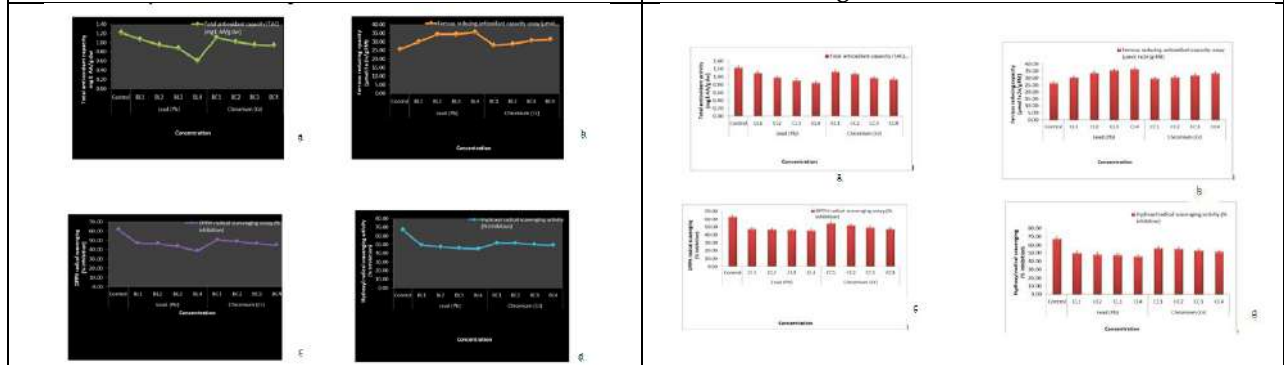|	
DPPH radical scavenging assay, Hydroxyl radical scavenging activity of JS:80-21 cultivar of *Glycine max* L. in comparison to control. The obtained values were analyzed by using one-way analysis of variance (ANOVA)-using SPSS 16.0 software. The data presented as treatments mean ±SE (n=3) at P<0.05 significant level.	DPPH radical scavenging assay, Hydroxyl radical scavenging activity of JS:75-46 cultivar of *Glycine max* L. in comparison to control. The obtained values were analyzed by using one-way analysis of variance (ANOVA)-using SPSS 16.0 software. The data presented as treatments mean ±SE (n=3) at P<0.05 significant level.
Fig.4: Effect of different concentrations of heavy metals (Pb & Cr) on total antioxidant capacity of three different cultivars (JS:335, JS:80-21, JS:75-46) of *Glycine max* L. in comparison to control. The obtained values were analyzed by using one-way analysis of variance (ANOVA)-using SPSS 16.0 software. The data presented as treatments mean ±SE (n=3) at P<0.05 significant level.	**Fig.5:** Effect of different concentrations of heavy metals (Pb & Cr) on Ferrous reducing antioxidant capacity assay of three different cultivars (JS:335, JS:80-21, JS:75-46) of *Glycine max* L. in comparison to control. The obtained values were analyzed by using one-way analysis of variance (ANOVA)-using SPSS 16.0 software. The data presented as treatments mean ±SE (n=3) at P<0.05 significant level.
Fig.6: Effect of different concentrations of heavy metals (Pb & Cr) on DPPH radical scavenging assay of three different cultivars (JS:335, JS:80-21, JS:75-46) of *Glycine max* L. in comparison to control. The obtained values were analyzed by using one-way analysis of variance (ANOVA)-using SPSS 16.0 software. The data presented as treatments mean ±SE (n=3) at P<0.05 significant level.	**Fig.7:** Effect of different concentrations of heavy metals (Pb & Cr) on Hydroxyl radical scavenging activity of three different cultivars (JS:335, JS:80-21, JS:75-46) of *Glycine max* L. in comparison to control. The obtained values were analyzed by using one-way analysis of variance (ANOVA)-using SPSS 16.0 software. The data presented as treatments mean ±SE (n=3) at P<0.05 significant level.

RESEARCH ARTICLE

Efficacy of Phytoremediation potential of *Azolla pinnata* L. using Different Types of Wastewater

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ABSTRACT

Azolla serves as a biofilter during wastewater treatment. Phytoremediation using *Azollapinnata* is ecologically sound and economically viable and it is an attractive alternative to the current cleanup methods. The effluent after phytoremediation is suitable for reuse and recycle along with a yield of *Azollapinnata.* This yield can be used to increase productivity. Hence the present study was planned to study the Phytoremediation potential of *Azollapinnata* with diary, municipal and domestic wastewater. Microbial population was also determined. This effluents after phytoremediation can be used for irrigation and agricultural purposes .The physicochemical parameters of wastewater were analyzed before and after treatment with *Azollapinnata*. Compared to dairy, municipal waste water Phytoremediation of domestic wastewater with *Azolla* decreased the pH from 7.8 to 7 to and the colour of the liquid waste was changed from greyish black to brown colour. The turbidity (0.04NTU),electrical conductivity (0.30dsm-1), COD (0.31mg/L, Nitrogen (0.56ppm) and   Phosphorus(69.7ppm) content was decreased respectively. Heavy metals like Cadmium (Cd)1.76 mg/l, Lead (Pb)0.21 mg/l, and Zinc 14.46 mg/lare potentially hazardous in combined or elemental forms. Heavy metals are profoundly solvent in the aquatic environments and accordingly they can be retained effectively by living organisms. Therefore the further study has remedial approach to treat wastewater for irrigation purposes in developing countries.

Keywords: *Azollapinnata* , Phytoremediation, pH ,COD, BOD , Nitrogen, Phosphorus

INTRODUCTION

Wastewater is water generated after the use of freshwater, raw water, drinking or saline water in a variety of deliberate applications or processes Frankin *et al*., (2016) One more meaning of waste water is "Utilized water from any mix of duman business or developing works out, surface flood storms water, and any sewer inflow interruption". (Tiley *et al*. 2014) in everyday usage, wastewater is commonly a synonym for sewage (also called sewerage, domestic wastewater, or municipal wastewater, which is wastewater that is produced by a community of people. *Azolla Azolla* is a free drifting new water plant having a place with the family *Azollaceae* and request Pteridophyta. It is a typical bio-manure in rice crop. It develops in relationship with the blue-green. *Anabaenaazollae*, is considered to be the most promising because of the case of cultivation, high productivity and good nutritive value (Singh *et al*., 1978, The higher crude protein content above 20%) furthermore, presence of fundamental amino acids (high lysine content),vitamin A precursor beta-carotene, vitamin B^{12} and minerals like Iron calcium, phosphorous, potassium and magnesium made *Azolla* valuable feed supplement for livestock, poultry and fish, rural poultry integrated with in situ *Azolla* cultivation was able to provide sustainable livelihood security as well as income for diversifying the livelihood of the farmers. Therefore the present study was aimed to analyze the Phytoremediation potential of *Azolla*. Lusing different wastewater.

MATERIALS AND METHODS

Collection of wastewater
The source of wastewater were collected from (dairy ,domestic, Municipal) sample was collected from the area of Mannargudi, Thiruvarur district ,Tamil Nadu, ,India, and collected water samples were sealed in air tight polythene containers (5litres capacity)

Sample
Dairy waste water: The colour of dairy wastewater is initially thick white and highly turbid nature.
Domestic waste water: The colour of domestic wastewater is initially greyish black turbid nature.
Municipal waste water: The colour of municipal wastewater is initially blackish and turbid nature.

Analysis of physico-chemical parameters of the water samples before treatment
The collected wastewater was undergoes for the analysis of parameters such as pH, dissolved oxygen, electrical conductivity, nitrogen, phosphorus, oil and grease content.

Determination of pH (Misra,1968)
In a clean conical flask, 20 ml of dairy, domestic, municipal wastewater was taken, and 100ml of distilled water was added for making 1:5 suspensions .It was shaken for one hour at regular intervals. After shaking, the suspension was filtered through Whatmann no.1 filter paper . The pH of the sample was determined using a pH meter.

Dissolved oxygen (Winkler Method, 2021)
The Winkler Strategy is a method used to dissolved oxygen in freshwater frameworks. Dissolved oxygen is used as an indicator of the health of a water body, where higher dissolved oxygen concentrations are correlated with high productivity and little pollution. This test is performed nearby, as deferrals between test assortments and testing might bring about an adjustment in oxygen content.

Estimation of electrical conductivity (Smith and Doran, 1996)
1ml of distilled water was added with 1g of dairy, domestic, municipal wastewater sample was mixed which is a 1:1 suspension. The suspension was filtered using suction. A circular Whatmann no. I filter paper was put in the Buchner funnel, and the filtered paper was moistened with marine water and made sure that it was tightly attached to the bottom of the funnels so that all holes are covered. The vacuum pump was started. The suction was opened, and the

suspension was added to the Buchner funnel. The clear filtrate was transferred into a 50 ml bottle and the conductivity cell was immersed in the solution and the readings were noted.

Estimation of Nitrogen (Subbaiah and Asija, 1956)

The nitrogen was estimated by the dairy ,domestic , Municipal wastewater sample was wrapped in aluminium foil and was put in a kjeldhal flask the catalyst mixture was added and digestion was carried out. The sample was heated on flame for 10- 30 min till charred. The flask was rotated until the natural matter obliteration and tilled grey color solution was obtained. The digested sample was then diluted 10 mi of distilled water and 5 ml in flask. Flask was then heated till the solution boiled. The titration was carried out with 0.1 ml HCL by adding a phenolphthalein indicator. Endpoint purple to pink was noted for calculating the nitrogen content

N-(A-B) 1.4/wt, of the sample

A =ml of the HCL used, B-ml of HCL used for blank

Estimation of Phosphorus (Jackson, 1973)

1ml of wastewater sample taken and 200ml of 0.002 N H_2SO,N H_2SO^4, was added in its mixture was stirred for half an hour. The solution was then filtered through No.1 Whatmann filter paper 42.5 ml Filtrate was taken and 2 ml of ammonium molybdate along with 5 drops of SnCl was added to the total volume of the mixture was made to 100ml with distilled water and absorbance was taken at 690nm standard graph was plotted and reading were extrapolated calculation. %Available phosphorus= mg p/L. of the sample.

Turbidity

Turbidity water becomes fixed, the heavier and bigger suspended particles settle down rapidly and the lighter and finely separated particles settles gradually and even requires months. Ground water is less turbid in light of low speed of water. Turbidity might be useful for controlling development of agnosticisms by not permitting legitimate daylight to water which is important for their development then again it is destructive as the creatures are dealing with to the suspended particles. When water becomes stationary, the heavier and larger suspended particles settle down quickly and the lighter and finely divided particles settles very slowly and even takes months. Ground water is less turbid due to low speed of water. Turbidity may be helpful for controlling growth of paganisms by not allowing proper sunlight to water which is necessary for their growth on the other hand it is harmful as the life forms are dealing with to the suspended particles. The turbidity of the wastewater was analyzed by using spectrometer and difference in turbidity was recorded.

Cultivation of *Azolla* in different wastewater
Collection of *Azolla*

The *Azolla* were collected from agricultural land around Melanatham, Thiruvarur district, Tamil Nadu, India.

Cultivation of *Azollapinnata*

Several methods of *Azollapinnata* production had been explored such as plastic trays, *Azolla* beds, here concert plastic trays was used to cultivate *Azollapinnata* which contains 4 trays and it's was made as bed .It located in shady place , preferably under a tree , with sufficient sunlight should be chosen for cultivation. Direct sunlight should be avoided. Each bed was having the dimensions 2m×2m (4 m 2) with 0.3 m depth. About 1 kg two to three day old cow dung was dissolved in 6litres of water was added into each bed with thorough mixed such that mixture was spread evenly throughout the area .The collected water samples was filled up in the trays .All corners of the tray should be of the same level so that the water level can be kept uniformly .Each bed was inoculated with 5 gm of fresh and pure culture of *azollapinnata* and water was sprinkled over it.pH of the bottom organic matter and top water were tested regularly. After 15-20 day. 1 kg of *azollapinnata* can be harvested from each bed. To avoid nutrient deficiency 20 gm of super phosphate and 1 kg cow dung was mixed once in every month.About 30 percent water was replaced with fresh water once every 15 days to prevent excess nitrogen accumulation. Replacement of water and soil should be followed by fresh inoculation of *Azollapinnata*, once in six months.

Collection and storage of *Azollapinnata*

After 15-20-day *Azollapinnata* multiplied rapidly and filled the beds within 7 days. Every fortnight about 10 *Azollapinnata* samples were collected from beds. Harvested *Azollapinnata* was washed thoroughly in clean water, weighed and dried for 2 to 3 days under shed with the goal that it becomes firm while green variety actually held in the dried *Azolla.* Dried *Azolla* was collected, packed in air tight bags and stored until further use.

Isolation of bacteria from wastewater
Serial dilution technique (Avishai Ben-David 2014)

Microbiological analysis of dairy, domestic, municipal wastewater sample was also carried out to analyse the soil quality. Serial dilution was performed by using the collected sample to isolate the bacteria and fungi .1 gm of soil sample was diluted in the tube containing 9ml of sterile distilled water and mixed thoroughly to make a 1:10 dilution. 1ml of diluted sample was transferred to the next test tube and serially diluted into the series of the test tubes having 9ml of water, sterile pipettes using up 10^7dilution.

Preparation of Sorbitol MacConkey Agar (SagarAryal 2022)

Sorbitol MacConkey Agar 50.03gramsof the powdered was mixed with in 1litre   of purified/distilled or deionized water. Blended completely and heat with regular tumult and bubble for 1 moment to disintegrate the powder totally.Avoid overheating and do not autoclave Leave for cooling to 45-50°C. The medium was poured into petriplates leave plates on the sterile surface until the agar was solidified .The plates were stored in a refrigerator at 2-8°C.

Gram Stain for *E.coli*(Chris Hayhurst 2004)
Gram staining was done by picking colonies from plating technique.

The smear was covered with crystal violet and allowed it to stand for one minute. The smear was flushed again tenderly under regular water. The smear was decolorized with 95% alcohol. The smear was flushed again delicately under regular water. The smear was covered again gently with safranin for one minute. The smear was rinsed again gently under tap water and airs dry it. The smear was first observed, under the low power (10X) objective, and then under oil immersion (100X) objective.

Inoculation of *Azolla* in wastewater

Azollapinnata inoculated with wastewaters such as Dairy, Domestic, Municipal wastewater. Healthy manure *Azollapinnata* plants obtained from the cultivation tanks were rinsed with tap water in order to remove adhering mud particles and epiphytes and used to test for the phytoremediation property. .

Analysis of *Azolla* treated wastewater:

The *Azolla* treated wastewater was undergoes for the parameters such as pH, dissolve oxygen, electrical conductivity, nitrogen, phosphorus, oil and grease content.

Heavymetal analysis in *Azolla* treated wastewater:

The collected water samples were prepared by diluting the respective stock solutions of 6 ppm concentration. Salts of every one of the weighty metals with 6 ppm focuses were combined as one out of 1000 ml refined water, isolated the combination arrangement into two equivalent segments of each having a final volume of 500 ml. An additional beaker with 500 ml freshwater without metals was also set up for comparing the growth rate and characteristics of *Azollapinnata* in comparison with the metal contained habitat. Healthy and developed *Azollapinnata*plants were chosen, washed with refined water, and smudged on channel papers to eliminate disciple water, and 2 g of the water fern were laid on the outer layer of one of the measuring beaker added with metals and the other with fresh water. The third beaker with metals was kept as a control for the experiments. All of them were run for a 9 day period.On the 9th day of the experiments, water samples were filtered with whatmann No.1 filter papers and analyzed by Atomic absorption spectrometer for Zn, Cd, and pb.

RESULTS AND DISCUSSIONS

Phytoremediation is such a strategy where the capacity of plants to get by in dirtied water and to work with contaminations expulsion from the environment is exploited. The main advantage of phytoremediation is that it is very economic and eco friendly method of treatment when compared to other physical and chemical methods of wastewater treatment. The capacity of aquatic plants to fill in supplement rich water and to proficiently eliminate supplements and metals from wastewater make them an appealing choice for coordinating into wastewater treatment plants. Also, they have very high growth rates and hence produce potentially valuable biomass which can be used for the production of a variety of liquid and solid bio fuels. The focus on the use of biomass as an alternative feedstock to fossil fuels is intensifying due to: its role in reducing CO_2 emission (Sreelakshmi *et al.*,2020) Our findings similar with Murali *et al.*, (2022) he was carried to test the *Azolla* (*Azollapinnata*) as bioremediation agent for dairy farm liquid waste and to find out the effect of feeding *Azolla* obtained from bioremediation on growth of Nellore lambs Eighteen Nellore lambs having uniform body weights were selected and randomly divided into 3 groups TD (0% *Azolla*).T (10% Conventional *Azolla),* and T2 (10% Phytoremediation *Azolla* obtained from dairy farm liquid waste) of 6 lambs in each group in a completely randomized design. The exploratory eating diets were proposed to the lambs for a period of 90 days. Bioremediation of dairy farm liquid waste with *Azolla* decreased the pH from 7.96 to 738 and the colour of the liquid waste was changed from greyish black to brown colour.The turbidity, COD, BOD. Nitrogen and Phosphorous substance was diminished to 48.14, 0.74, 0.43, 30.76 and 7.44%, respectively.The present review reasoned that Azolla can be utilized for bioremediation of dairy ranch fluid waste in an eco-friendly manner.

CONCLUSIONS

The present study concluded that *Azolla* can be used for Phytoremediation of domestic wastewater in an eco-friendly manner. Experimental results show that *Azolla* can be used differently for wastewater treatment, such as nutrient remover and heavy metal absorber. But most researchers haven't been forced into real situations and have studied only laboratory scale. Some practical problems will occur in real cases because *Azolla* may not grow well in deep tanks, such as treatment tanks used in wastewater treatment. *Azolla* needs a large surface area for its growth;Providing a large surface area may not be a practical situation in wastewater treatment. This economical wastewater treatment is related with low energy utilization, low capital expense and in certain circumstances, low mechanical innovation prerequisites. Hence this project step forward a lead to mutually beneficial system for treatment of wastewater with a yield of *Azollapinnata*. Further study is to be planned that increase the usage of *Azolla* species as Phytoremediation agent to treat the wastewaters at low cost .

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Table: 1 Physico-chemical parameters of wastewater before treated with *Azollapinnata*

Physicochemical parameters of before treated wastewater	Dairy wastewater	Municipal wastewater	Domestic wastewater
pH	8	9	7.8
Electrical Conductivity (dsm-^{1})	0.46	0.78	0.39
Turbidity (NTU)	0.18	0.22	0.99
Oil and grease content (mg/L)	0.16	0.34	0.13
Nitrogen (ppm)	0.97	1.45	0.82
Phosphorus (ppm)	87.6	98.9	78.4
BOD (mg/L)	26	50	20
COD (mg/L)	36	68	31

Table:2 Heavy metals analysis of *Azollapinnata* before and after treated wastewater

Heavy metal in treated wastewater	Initial days (mg/L)	Final days (mg/L)
Lead (pb)	0.54	0.21
Cadmium(Cd)	1.89	1.76
Zinc	19.34	14.46

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Table: 3 Physico-chemical parameters of *Azolla* treated wastewater

Physicochemical parameters of after *Azolla* treated wastewater	Dairy wastewater	Municipal wastewater	Domestic wastewater
pH	7	8	7
ELECTRICAL CONDUCTIVITY (dsm-^{1})	0.43	0.74	0.30
Turbidity (NTU)	0.16	0.18	0.07
Oil and grease content (mg/L)	0.14	0.28	0.11
Nitrogen (ppm)	77.2	88.7	69.7
Phosphorus (ppm)	0.65	1.39	0.56
BOD (mg/L)	19	28	17.3
COD (mg/L)	29	56	23

RESEARCH ARTICLE

Navigating Competitive Landscapes: A Data-Driven Exploration of Process Innovation in Banking Sector

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ABSTRACT

To be competitive in a time of technological upheaval and shifting consumer tastes, banks must innovate their operations. With a thorough examination of process innovation projects and how they affect competitive advantage, this study seeks to provide empirical understandings of tactics that improve banks' positions in the market. This empirical study explores the relationship that exists between competitive advantage and process innovation in the banking industry. By examining the dynamics of process innovation and its consequences for competitive advantage in the banking sector, this empirical study seeks to close this gap. Through a survey methods approach, we examine the extent and nature of process innovation initiatives adopted by banks, the impact of process innovation on various dimensions of competitive advantage including cost efficiency, service quality, and market share, and the mediating factors influencing this relationship. Leveraging both quantitative and qualitative methods, this study investigates the relationship between process innovation and competitive advantage, shedding light on key drivers, challenges and outcomes. The findings provide actionable insights for banking executives and policymakers aiming to navigate the evolving landscape of financial services.

Keywords: Innovation Process, Consumer preferences, Competitive advantage, Employee empowerment.

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INTRODUCTION

The primary component of the financial system is the banking industry, whose activities have an impact on every facet of the economy (Davies, 1996; Bhosale, 2012). Like other businesses, the banking sector suffers from dynamic conditions, such as intense competition in the financial systems (Khedr, 2008; Kwan, 2010), and it is particularly susceptible to employee malfeasance (Childress, 2014). Compared to other sectors, the banking industry is more prone to instability (Northcott, 2004). Consequently, this industry begins to innovate its administrative system by maintaining moral leadership (Sandra and Johnt, 2015) and knowledge process competence (Bidmeshgipour et al., 2012; Abualloush et al., 2016). The Indian banking sector plays a crucial role in the country's economic development. With a diverse mix of public sector banks, private banks, foreign banks, and cooperative banks, the sector serves the needs of various segments of the economy (Reserve Bank of India, 2021). The regulatory environment, primarily governed by the Reserve Bank of India (RBI), has undergone significant reforms in recent years. Initiatives such as Basel III implementation, asset quality reviews, and the Insolvency and Bankruptcy Code (IBC) have aimed to strengthen the sector's resilience and governance. Digital transformation has been a key focus area for Indian banks, driven by factors such as increasing internet penetration, smartphone adoption, and government initiatives like Digital India. Banks are investing in technology to enhance the customer experience, streamline operations, and offer innovative products and services (Jaiswal & Chaurasia, 2021). Financial inclusion continues to be a priority for the Indian government and regulators. Initiatives like Jan Dhan Yojana, Pradhan Mantri Mudra Yojana, and Payments Banks aim to extend banking services to the unbanked and underbanked population, especially in rural areas (Sengupta & Chakraborty, 2020). The Indian banking sector faces several challenges, including governance issues, NPA (non-performing asset) management, and competition from non-banking entities.

However, it also presents vast opportunities, such as the untapped potential of retail banking, wealth management, and cross-border expansion (Gupta & Chauhan, 2021). In today's rapidly evolving banking landscape, the pursuit of competitive advantage is paramount for financial institutions seeking to thrive amidst fierce market competition. One key avenue through which banks strive to gain an edge is by embracing process innovation – the strategic redesign and optimization of operational processes to enhance efficiency, effectiveness, and customer satisfaction. Process innovation holds promise for banks not only in streamlining internal operations but also in delivering superior services and experiences to customers. However, the precise relationship between process innovation and competitive advantage within the banking sector remains a subject of empirical inquiry. This empirical study sets out to explore the dynamics of process innovation and its impact on competitive advantage in the banking industry. By delving into the extent and nature of process innovation initiatives adopted by banks, this research aims to shed light on the strategies and practices that financial institutions employ to stay ahead in an increasingly digital and customer-centric environment. Moreover, by examining how process innovation influences key dimensions of competitive advantage – such as cost efficiency and employee training – this study seeks to uncover the mechanisms through which innovation translates into tangible benefits for banks. Drawing on theoretical frameworks from innovation management, organizational theory, and strategic management, this study employs a mixed-methods approach to gather and analyze empirical data. Through surveys, interviews, and statistical analysis, we seek to uncover patterns, relationships, and insights that elucidate the complex interplay between process innovation and competitive advantage in banking. The results of this investigation are likely to provide significant insights for banking executives, policymakers, and researcher's alike, providing guidance on how to effectively leverage process innovation to cultivate and sustain competitive advantage in the dynamic and challenging banking landscape.

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REVIEW OF LITERATURE

The conceptual foundation has been developed to specify the topics covered by the literature review such as "employee empowerment", "employee training", "impact of employee empowerment on firm performance" and the "process innovation".

Employee Empowerment

Within the banking sector, employee empowerment has become a key tactic for improving organizational performance and competitiveness. In an organizational environment that is becoming more intricate and dynamic, empowered people are essential for fostering innovation, enhancing customer satisfaction, and accomplishing strategic goals. Recent research has emphasized the significance of employee empowerment within the banking industry, emphasizing its influence on a range of organizational results. For instance, a study conducted by Khan and Ali (2020) discovered that, among banking professionals, employee empowerment has a beneficial impact on work satisfaction, organizational dedication, and performance. Employees that feel valued and invested in their work report increased job satisfaction, which boosts motivation and dedication to company objectives. Furthermore, in the banking industry, enhanced customer happiness and service have been associated with staff empowerment. Empowered bank employees are more likely to provide consumers with individualized and prompt service, which raises customer satisfaction and loyalty, according to a study by Wang and Lo (2021). By giving frontline staff members the freedom to decide for themselves and take initiative, banks may develop a customer-focused culture that encourages customer loyalty and trust. Additionally, it has been demonstrated that employee empowerment improves organizational agility and creativity in the banking industry. According to research by Al-Abdallah and Obeidat (2019), empowered employees are more open to embracing change and adjusting to new procedures and technology, which promotes organizational creativity and agility. Giving staff members the freedom to find and apply creative fixes and process enhancements will give banks a competitive advantage in the quickly changing financial services sector. Notwithstanding the possible advantages of employee empowerment, organizational culture, leadership styles, and support systems must all be carefully considered for it to be implemented successfully in the banking industry. Research has demonstrated how transformational leadership can foster employee empowerment and foster a positive work atmosphere (Rizwan et al., 2021). Transformational leaders cultivate an environment of trust, cooperation, and empowerment inside their organizations by inspiring and motivating staff members to reach their full potential. Employee empowerment is a key driver of organizational success and competitiveness within the banking sector. By empowering employees to make decisions, take initiative, and innovate, banks can enhance job satisfaction, customer service, and organizational performance. However, achieving employee empowerment requires strong leadership, an effective organisational environment, as well as a dedication to innovation and continuous growth.

Employee Training

Employee training is an essential part of human resource development for the banking business. Its goal is to provide employees the competencies, know-how, and abilities they require to perform their jobs effectively and adjust to shifting market conditions. In the banking industry, staff happiness, customer service, and organizational performance are all improved by employee training, as evidenced by recent studies. Several studies have emphasized the importance of ongoing training and development programs in addressing the evolving needs and challenges faced by banking professionals. For instance, research by Ahmad and Ahmad (2021) evaluated the effect of training affecting employee performance within the banking sector; their findings suggest a positive relationship between training effectiveness and employee productivity. Effective training programs not only enhance employees' technical skills and job-related knowledge rather also encourages an environment of ongoing learning and development inside the organisation. Moreover, employee training has been identified as a key driver of customer satisfaction and loyalty in the banking sector. A study by Kumar and Mohanty (2020) revealed that The bank employees with proper training are better able to recognise and meet the demands of their customers, increasing the degree of customer retention and satisfaction. Making investments into development and training of staff members allows banks to

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increase service quality, build customer trust, and gain a competitive advantage in the marketplace. Most recent studies has emphasised the significance of technology-enabled training methods in enhancing learning outcomes and employee engagement in the banking sector. With the advent of digital technologies, banks have increasingly adopted virtual learning facilities, virtual classrooms, and mobile-based training tools to offer training programmes to employees (Al-Kalbani et al., 2021). These technology-enabled training methods offer flexibility, accessibility, and interactivity, enabling employees to acquire new skills and knowledge at their own pace and convenience. However, despite the benefits of employee training, challenges persist in the effective implementation and evaluation of training programs within the banking sector. Research by Al-Habsi et al. (2021) identified various factors that influence the success of training initiatives in banks, including leadership support, organizational culture, and alignment with business objectives. Moreover, measuring the impact of training on organizational performance remains a complex and multifaceted issue, requiring the use of appropriate metrics and evaluation methods. Employee training performs a vital part in enhancing organizational performance, customer service, and employee satisfaction within the banking sector. By making training and development programme investments, banks can empower employees, improve service quality, and gain a competitive edge in the marketplace. However, addressing challenges related to training effectiveness, technology adoption, and performance evaluation is essential for maximizing the benefits of employee training in banking.

Process Innovation

Process innovation has become increasingly important in the banking sector as financial institutions seek to improve efficiency, maintain competitiveness in a market that is changing quickly and improve the customer experience. Recent literature highlights various aspects of process innovation and its implications for banking operations, customer service, and organizational performance. Empirical studies have shown that process innovation can significantly impact various dimensions of competitive advantage in the banking sector. For example, Damanpour (1991) found that banks that invest in process innovation tend to achieve greater cost efficiency, as streamlined processes and automation lead to reduced operational costs and improved resource allocation. Similarly, research has highlighted the role of process innovation in enhancing service quality and customer satisfaction in banks (Dodgson et al., 2005). By leveraging innovative technologies and process improvements, banks can deliver faster, more convenient and personalized services to their customers, thereby strengthening customer relationships and loyalty. Studies have emphasized the role of process innovation in driving efficiency gains and cost reductions within banks. For example, research by Al-Tarawneh and Maqableh (2021) examined the impact of process innovation on operational efficiency in Jordanian banks, finding that innovative process redesign and automation initiatives led to significant improvements in productivity and cost efficiency. By streamlining workflows, reducing manual tasks, and leveraging technology solutions such as "Robotic process automation (RPA)" and "Artificial intelligence (AI)", banks can achieve operational excellence and resource optimization. Process innovation has been shown to have a positive impact on customer experience and satisfaction in the banking sector.

A study by Chang et al. (2020) investigated the relationship between process innovation and customer satisfaction in Taiwanese banks, revealing that innovative service delivery platforms, like "mobile banking apps" and "online account opening platforms", contributed to higher levels of customer satisfaction and loyalty. By simplifying processes, reducing wait times, and offering convenient and personalized services, banks can strengthen their bonds with their valued customers and improve their overall experience with them. The literature has explored the implications of process innovation for regulatory compliance and risk management in banking. With the increasing regulatory scrutiny and complexity facing financial institutions, banks are under pressure to ensure compliance with regulatory requirements while maintaining operational efficiency. Research by Cheng and Xu (2021) examined the impact of process innovation on risk management practices in Chinese banks, highlighting the role of innovative technologies such as block chain and data analytics in enhancing transparency, security, and compliance with regulatory standards. The potential benefits of process innovation, challenges remain in the effective implementation and adoption of innovative processes within banks. Studies have identified organizational barriers, legacy systems, and cultural resistance as key obstacles to successful process innovation initiatives (Loonam et al., 2020). Overcoming these challenges requires strong leadership, a culture of innovation, and investment in employee training and change

management efforts. Process innovation is a critical driver of performance and competitiveness in the banking sector. By embracing innovative processes, leveraging technology solutions, and promoting an environment that values constant growth, banks can increase effectiveness, customer satisfaction, and risk management capabilities. However, addressing organizational barriers and cultural resistance is essential for realizing the full potential of process innovation in banking operations.

Firm Performance

Understanding firm performance in the banking sector is essential for stakeholders ranging from investors to policymakers, as it reflects the financial health, competitiveness, and overall effectiveness of financial institutions. Recent literature has examined various factors influencing firm performance within the banking sector, including financial metrics, strategic management practices, and external market conditions. Financial metrics such as profitability, efficiency, and asset quality are commonly used indicators of firm performance in the banking sector. Research by Khan et al. (2021) investigated the determinants of bank profitability in emerging markets, finding that factors such as capital adequacy, liquidity, and loan quality significantly impact bank profitability. Effective risk management practices, prudent lending policies, and sound capital allocation strategies are crucial for maintaining profitability and sustainability in the banking industry. Strategic management practices play a key role in shaping firm performance and competitiveness in the banking sector. Studies have highlighted the importance of strategic planning, innovation, and market positioning in driving long-term success for banks (Zaidi et al., 2020). Research by Li et al. (2021) investigated the association involving strategic orientation and firm performance in Chinese banks, revealing that banks with a customer-focused strategy and a commitment to innovation tend to outperform their competitors. External market conditions and regulatory environment significantly influence firm performance in the banking sector. For example, research by Gao et al. (2021) examined the impact of regulatory changes on bank performance in the European Union, finding that regulatory reforms such as Basel III and MiFID II have both positive and negative effects on bank profitability and risk-taking behavior. Adapting to regulatory changes, complying with reporting requirements, and managing regulatory risks are essential for banks to maintain performance and meet stakeholders' expectations. Challenges remain in assessing and improving firm performance within the banking sector. Research by Zhang et al. (2021) highlighted the role of corporate governance practices in enhancing firm performance and mitigating agency conflicts in Chinese banks. Effective governance mechanisms, including board independence, executive compensation, and risk oversight, are crucial for aligning managerial incentives with shareholder interests and promoting sustainable performance. The firm performance in the banking sector requires a holistic approach that considers financial metrics, strategic management practices, and external market conditions. By focusing on factors such as profitability, efficiency, strategic orientation, and regulatory compliance, banks can enhance their performance, strengthen their competitive position, and achieve long-term success in a dynamic and challenging industry environment.

Objectives

- To investigate the extent and nature of process innovation initiatives adopted by banks.
- To examine the impact of process innovation on various dimensions of competitive advantage, including employee empowerment and Employee training
- To study the role of Process innovation in mediating the relationship between Employee Empowerment, Employee Training and Firm performance

Hypotheses

H1: There is a significant relationship between Employee Empowerment and Process innovation of the bank
H2: There is a significant relationship between Employee Training and Process innovation of the bank
H3: Process innovation mediates among Employee Empowerment, Employee training and Firm performance

RESEARCH METHODOLOGY

This research work is descriptive. This research aims to collect detailed information on employee empowerment, employee training, process innovation and firm performance of banking sector. For the purposes of this investigation, a descriptive research design was adopted. Primary data was collected using the field survey method and a structured questionnaire that was developed after evaluating pertinent literature. The primary data collection includes questionnaires to determine employee empowerment and training and the firm performance of the firm in the banking sector. The variables of the research study were identified by means of a literature review, which plays a critical role in influencing empowerment, training and process innovation which leads to firm performance. Various statistical tools were employed according to the requirement and suitability. The questionnaire included items related to employee empowerment, employee training, process innovation and firm performance. All the questionnaire items were measured with a Likert scale (ranging from 1= strongly disagree to 5= strongly agree). The data was analysed using appropriate statistical techniques like SPSS and M.S. Excel software. The Structural Equation Modelling (S.E.M.) was used to test the proposed model and hypotheses using PLS-SEM 4.1.0 software for mediation analysis.

Sampling Design

The study has adopted the convenience sampling method. The convenience sampling methodology was adopted since it serves as a highly feasible approach to seek the appropriate source of the target population available to participate in providing the required data for the research. The sample population for this research comprises banking employees' who are working in the selected banks. According to Neuman (2000), for populations larger than 10,000, researchers should collect samples at least 10% of the overall population, and for populations larger than 100,000, researchers should collect samples at least 1%. Accordingly, in this research, it was decided to collect a sample of a total 218 bank employees. Data were collected from the branches of Jammu and Kashmir Bank Ltd. and State Bank of India, Srinagar (J&K).

RESULTS

Data Analysis - Structural Model

The assessment of the structural model involves examining the estimates and conducting hypothesis tests to assess the causal association among endogenous and exogenous variables as depicted in the path diagram. In this process, the model's estimates are compared to the observed data to determine how well the model fits the actual relationships. Hypothesis tests are then used to assess the significance of these relationships, helping to determine if they are statistically meaningful. The goal is to determine whether the proposed causal relationships in the model are supported by the data. Goodness of fit in a global matric that evaluates the complete measurement model efficiency in terms of average communality (Tenenhaus et al, 2005). The models' overall goodness of fit should be the starting point for model evaluation. When the SRMR is below 0.08, the model fits well (Hu & Bentler, 1998). The NFI (Normed Fit Index) can range between 0 & 1. Bentler, (1992) the value close to 0.9 is consider for model fit. For composite model the thresholds for the NFI is still to be determined. Overall, the NFI is still not widely used (Byrne, 2008).

Convergent validity

For assessing convergent validity, three main tests are commonly used: "Cronbach's alpha, reliability, and average variance extracted". In this study, internal reliability was evaluated using Cronbach's alpha, with a value greater than 0.7 indicating strong internal consistency and thus adequate reliability. Table 2 demonstrates that the internal consistency and reliability of this study exceed 0.7, making them suitable for further analysis. Convergent validity requires an average variance extracted greater than 0.5 and standardized factor loadings of all items not less than 0.5. If factor loadings are less than 0.5, it suggests that items contribute more to measurement error than to the variance in the constructs. Every variable in this investigation had an average extracted variance higher than 0.5.

The structural model's overall analysis focuses on the strength of explanatory power, assessed through two criteria: the "coefficient of determination (R-square) and effect size (F-square)". A higher R-square value indicates a stronger explanatory capacity of the construct (Hair et al., 2016). R-square ranges from 0 to 1, with higher values indicating a greater level of explanatory power. Table 6 displays the data, showing strong explanatory power through bootstrapping.

Hypothesis Analysis

Figure 2 illustrates the positive association among Employee Empowerment and Process Innovation (T-value= 9.309 > 1.96, Path coefficient= 0.673, Standard deviation= 0.072, P-value= 0.000 < 0.01) thus supported H1.

As result reveals there is a positive relationship between Employee training and Process Innovation (T-value= 4.353 > 1.96, Path coefficient= 0.315, Standard deviation= 0.072, P-value= 0.000 < 0.01) thus supported H2.

In addition, there is a positive relationship between the quality of Process Innovation and Firm Performance (T-value= 7.397 > 1.96, Path coefficient= 0.945, Standard deviation= 0.012, P-value= 0.000 < 0.01) leading to supported H3.

DISCUSSION

Determinants of Process Innovation: Conducting empirical research to identify and analyze the key determinants that drive process innovation within the banking sector. This could involve exploring variables including technological advancements, market competition, regulatory changes and organizational culture. Impact of Process Innovation on Performance: Investigating the impact of process innovation on various performance metrics within banks, such as efficiency, productivity, customer satisfaction, and profitability. Understanding how different types of process innovations contribute to these outcomes could provide valuable insights for banks aiming to enhance their competitive position. Strategic Responses to Competitive Pressures: Examining how banks strategically respond to competitive pressures through process innovation. This could involve analyzing the strategies adopted by different types of banks (e.g., traditional banks vs. fintech startups) and how these strategies evolve over time in response to changes in the competitive landscape. Role of Data Analytics and Technology: Exploring the role of data analytics, artificial intelligence, and other emerging technologies in driving process innovation within the banking sector. This could involve investigating how banks leverage data-driven insights to identify opportunities for innovation and improve operational efficiency. Cross-Industry Comparisons: Conducting comparative studies to understand how process innovation in the banking sector differs from other industries and how lessons learned from one industry can be applied to another. This could help identify transferable best practices and inform strategic decision-making across different sectors. Overall, the findings provides a foundation for further research on process innovation in the banking sector, offering valuable insights that can be expanded upon and refined through additional empirical analysis and theoretical development.

CONCLUSION

Finally, by applying a data-driven methodology to examine the competitive landscape, our study clarifies the dynamics of process innovation in the banking industry. Our study has revealed important trends and drivers of process innovation, emphasizing the part played by elements including market competition, regulatory changes, and technological improvements. Our results highlight the significance of adopting a strategic approach to counteract competitive pressures and the potential of data analytics and emerging technologies to spur innovation. Furthermore, our research contributes to the broader literature on innovation management and competitive strategy by providing empirical insights into the specific context of the banking industry. By understanding the determinants and outcomes of process innovation in this sector, policymakers and practitioners can make informed decisions to enhance organizational performance and navigate the evolving competitive landscape. However, it is imperative to recognise the limitations of this study, including the dependency on primary data and the potential for measurement

errors. Future research could address these limitations by conducting more extensive both primary and secondary data collection and employing advanced analytical techniques. Additionally, further investigation is warranted to explore the long-term sustainability and effectiveness of process innovations in the banking sector. Overall, our research offers insightful implications for theory and practice and advances our understanding of process innovation in banking. In the pursuit of competitive advantage, we hope that our findings will contribute to strategic decision-making and inspire more study in this field.

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Table 1. Model Fit

Model Fit Analysis	
SRMR	0.073
Chi Square Value	2228.830
NFI	0.697

Table 2. Convergent Validity Tests

Convergent validity			
	Cronbach's Alpha	Reliability	Average Variance Extracted (AVE)
Employee Empowerment	0.943	0.957	0.816
Employee Training	0.932	0.949	0.787
Firm Performance	0.917	0.941	0.801
Process Innovation	0.945	0.957	0.786

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Table 3. Model Strength

Model Strength		
	R-square	R-square adjusted
Firm Performance	0.894	0.893
Process Innovation	0.957	0.950

Table 4. Hypothesis Model

Hypothesis Model		
	T-Value	P-Value
Employee Empowerment > Process Innovation	9.309	0.000
Employee Training > Process Innovation	4.353	0.000
Process Innovation > Firm Performance	7.397	0.000

Table 5. Mediation Analysis

Hypotheses	Independent Variable	Dependent Variable (FP)			
		Direct Effect	Indirect Effect	Total Effect	Decision
EE->PRI->FP	EE	0.068	0.636	0.627	Partial Mediation
ET->PRI -> FP	ET	0.072	0.298	0.307	Partial Mediation

Source: Prepared by researcher

Table 5.1. Mediation Analysis

Hypotheses	Beta	LL	UL	T Value	P Value	Decision
EE->PRI-> FP	0.636	0.041	0.140	9.317	0.000	Accepted
ET-> PRI -> FP	0.298	0.076	0.168	4.328	0.000	Accepted

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Table 5.2. Threshold table for mediation

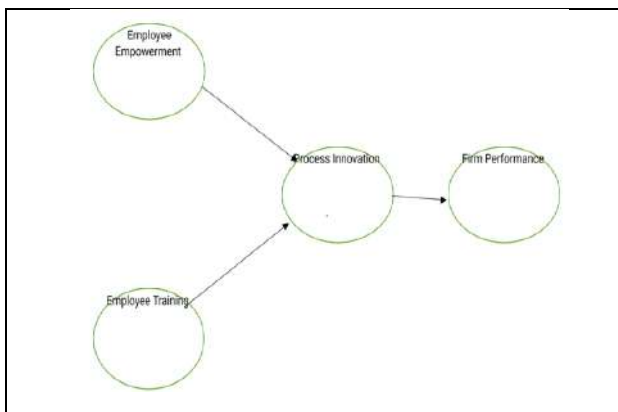| Value	Threshold	Source	Method
P value	Less than 0.05	Hair et al. (2013)	Simple mediation method by Hayes and Preacher (2004)
LL and UL	No zero in between (Both have to be either positive or negative)		
Beta value	At least 0.1		
T value	More than 1.96		

Fig 1. Conceptual Model
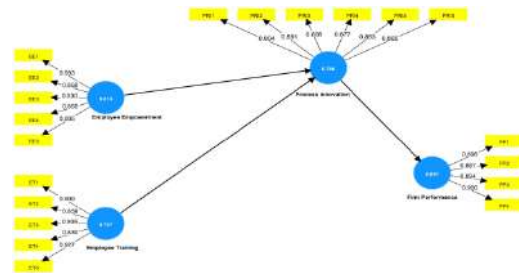**Source: Prepared by researcher**

Fig 2. Construct Model
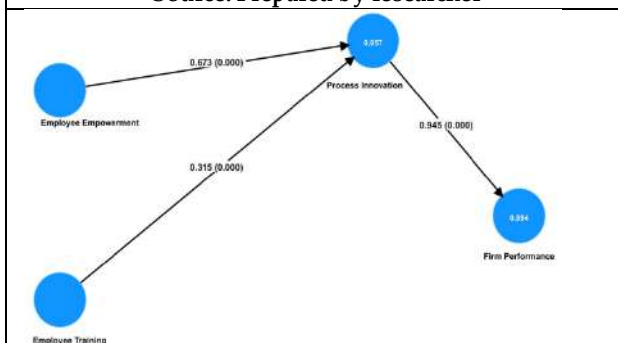**Source: Prepared by researcher**

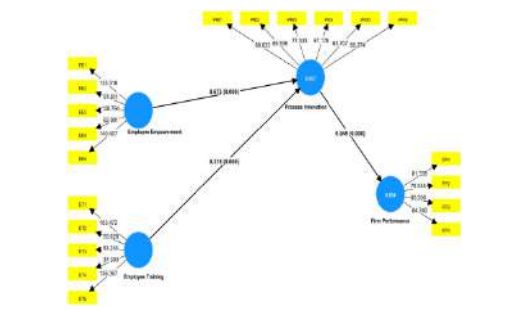**Fig 3. Mediation Model**
Source: Prepared by researcher

Fig. 4 Mediation structural model
Source: Prepared by researcher

RESEARCH ARTICLE

A Cross Sectional Study on Identifying Maternal Risk Factors for NICU (Neonatal Intensive Care Unit) Admission

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ABSTRACT

The increasing prevalence of NICU admissions prompts a critical examination of the antecedent factors originating during the maternal phase of the perinatal period. While advancements in neonatal care have significantly improved survival rates. To comprehensively investigate and identify maternal risk factors associated with the admission of newborns to the Neonatal Intensive Care Unit (NICU). Information of NICU admitted infants was gathered from multiple paediatric hospitals located in different Surat zones, especially those that had Neonatal Intensive Care Units (NICUs).After selection, the following maternal risk factors were evaluated for the infants in accordance with the evaluation form, which also contains the patient's demographic information and maternal risk factors Descriptive analysis of the current study identified that male Neonates (57%) are more than female neonates (43%) with advanced maternal age more than 35 (5.3%), twin pregnancy (9.5%), preeclampsia (11.3%), and peripartum infections (3.5%), history of miscarriage (7%), IVF Pregnancy (8.5%) and oligohydramnios (9.2%) were the predominant maternal risk factors for NICU admission. Additionally gestational diabetes (2.8%), anaemic mother (3.9%), consanguineous marriage (2.5%) are also playing a role for admission in NICU Factors related to being in intensive care found in this study should be understood and interpreted in all of the steps of health services, and interventions should be executed when necessary

Keywords: Prenatal or maternal risk factors, NICU admission

INTRODUCTION

The increasing prevalence of NICU admissions prompts a critical examination of the antecedent factors originating during the maternal phase of the perinatal period. While advancements in neonatal care have significantly improved survival rates. Admission to the neonatal intensive care unit (NICU) is an important parameter for neonatal outcomes, because newborns admitted to NICU are at risk for increased mortality and morbidity[1].There are various indications and risk factors for NICU admission. About 5% to 18% of term neonates are admitted to the NICU every year[2]. However, the risk factors for NICU admission in neonates have not been extensively reviewed. Previously reported risks include gestational age, intrauterine growth restriction, methods of delivery, maternal diabetes, preeclampsia, meconium aspiration syndrome (MAS), and respiratory distress syndrome (RDS)[3-5]. Maternal factors play a pivotal role in shaping the health and well-being of newborns, impacting their susceptibility to adverse outcomes. This cross-sectional study aims to investigate and identify key maternal risk factors that contribute to the increased likelihood of neonatal intensive care unit admissions. By improving prenatal care practices, this research project to improve prenatal care strategies and reduce the incidence of NICU admissions associated with maternal risk factors.

AIM AND OBJECTIVE
To comprehensively investigate and identify maternal risk factors associated with the admission of newborns to the Neonatal Intensive Care Unit (NICU).

METHODOLOGY

We retrospectively reviewed the medical records of patients with 284 mothers and evaluated, maternal factors to analyse the risk for NICU admission. This study was part of a larger neonatal cohort study that enrolled neonates born at Surat, Gujarat.

Study design: cross sectional study
Study Population: Male and Female high risk NICU Infant, from different hospital of different zones of Surat
Sampling: Purposive
Sample size: 284
Source of data: Different Paediatric hospitals with NICU centres from different zones of Surat, visited frequently, from different zones of Surat, India

Inclusion Criteria
1. Infants who admitted In NICU within one month after birth,
2. Both Male and Female NICU Infants

Exclusion Criteria
1. Infant who had a major congenital abnormality such as eg, Hydrocephalus, Spinabifida, Arnold Chiari malformation etc.

Procedure
Following the acquisition of institutional ethical permission, a review of the literature was conducted to identify maternal risk factors. During the data collecting phase, information was gathered from multiple paediatric hospitals located in different Surat zones, especially those that had Neonatal Intensive Care Units (NICUs). Parents were contacted and personally met; they were informed of the study's goal and asked for their written, informed permission. After selection, the following maternal risk factors were evaluated for the infants in accordance with the evaluation form, which also contains the patient's demographic information and maternal risk factors which are in

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details as follows: Demographic data includes Name, gender, Date of Birth, Mothers age, fathers age, mother education and occupation, father age and occupation

Maternal Risk Factors
Maternal and Paternal age (<18 or >35 maternal, >50 Paternal), Any infection during Pregnancy, Seizure, Diabetes, Hypertension/Pre-eclampsia, Anemia, Multiple gestation, IUGR (Intra Uterine Growth Retardation), Radiation exposure, TORCH infection, History ofmiscarriages, Consanguineous marriage, Smoking, Abnormal fetal growth, IVF Pregnancy, Abnormal uterine blood flows, Maternal medications, Oligohydramnios

DATA ANALYSIS
The subsequent step involved performing descriptive analysis of 284 infants' data, by using SPSS 20.0

RESULT
Table-1 Shows that From NICU admitted Neonates male Neonates(57%) are more than female neonates(43%). Table 2 shows Mean of mother's age 28 years and father's age 31 year during pregnancy with minimum age of 17 of mother and 21 of father and maximum age of mother is 46 and fathers age 49. Table 3 and graph 1 shows percentage of maternal risk factors in mothers whose neonates admitted in NICU

DISCUSSIONS

The current study identified that advanced maternal age, twin pregnancy, preeclampsia, and peripartum infections, history of miscarriage, IVF Pregnancy and oligohydramnios were the predominant maternal risk factors for NICU admission. Additionally gestational diabetes, anaemicmother, consanguineous marriage are also playing a role for admission in NICU. In our cross-sectional study on maternal risk factors for NICU admission, a noteworthy observation emerged from the age distribution analysis. Among the participants, three mothers under the age of 18, a recognized high-risk age group, had infants requiring intensive care in the neonatal intensive care unit (NICU). Additionally, the study revealed that 15 mothers aged 35 yearsolder and also mother who had infants admitted to the NICU with maximum age at 46 years Some evidence indicates that advanced maternal age is connected with placental malfunction, which may raise the risk of newborn deaths and stillbirths or exacerbate pre-existing maternal medical conditions. It is also said that age > 35 years and first birth were associated with preterm birth in a previous study in Jordan[6]. Preeclampsia, a condition characterized by hypertension and organ dysfunction during pregnancy, emerged as a substantial risk factor for NICU admission. This emphasizes the critical need for proactive monitoring and management of preeclampsia to mitigate its potential impact on neonatal outcomes.

In our study There are various indications and maternal causes of NICU admission among neonates, the most common of these include hypertension/Preeclampsia, (11.3%) IVFPregnancy, (8.5%) multiplegestation, (9.5%) history of miscarriages (7%) The possibility of staying in intensive care unit is higher for the babies whose mothers have such risky conditions in their pregnancies. These relationships were shown in several studies [7,8] In our study multiple gestation (9.5%) shows high risk factor which matches with other study in which Multiple pregnancies are the most important factor found to be related to intensive care in the USA constitute 14% of neonatal deaths and increase perinatal mortality 10 times[7,9]. we also observed that In Vitro Fertilization (IVF) pregnancies (8.5%) pose a significant risk among maternal factors. This finding is supported by a relevant study, indicating that the increasing prevalence of infertility treatments contributes to higher rates of multiple pregnancies. Consequently, multiple pregnancies are associated with elevated risks such as low birth weight and other complications, leading to an increased need for intensive care. In one of the studies Examining the maternal factors, they found that mothers with a history of five or more previous births are at a higher risk of stillbirth or neonatal death, as well as spontaneous second-trimester abortion or preterm labour. Notably, these risks are further amplified in cases where babies require admission to the Neonatal Intensive Care Unit (NICU). A history of miscarriage has also emerged as a noteworthy factor linked to NICU admissions. This finding prompts further exploration into the potential physiological and

psychological implications of previous pregnancy losses on subsequent neonatal outcomes.The presence of a history of spontaneous second-trimester abortion or preterm labour remains a significant contributing factor to these outcomes.[10] Conditions such as urinary infection and preeclampsia are also the factors resulting in prematurity.[11,12]

We found case of mother with Oligohydramnios (9.2%), itis characterized by a lower-than-normal level of amniotic fluid, has been identified as a significant risk factor for NICU admission. This finding emphasizes the importance of vigilant monitoring and timely interventions for pregnancies with this particular complication. In our study mother with gestational diabetes is (2.8%) Furthermore, it is mentioned in one study that mothers with pregestational diabetes mellitus have a higher risk for complications such as FGR, asphyxia, and hypoglycemia.[13,14] The comprehensive identification of these maternal risk factors holds significant implications for antenatal care practices and public health interventions. Strategies aimed at mitigating the impact of these risk factors may include targeted surveillance, early detection, and specialized care pathways for at-risk pregnancies. By addressing these maternal risk factors, healthcare providers can contribute to a reduction in NICU admissions, ultimately improving both maternal and neonatal health outcomes.

CONCLUSION

This study is a first step in improving our understanding of the risk factors for NICU admission among mothers. The information gathered from this study could influence prenatal care procedures, direct healthcare policy, and eventually enhance the course of newborn health outcomes. Factors related to being in intensive care found in this study should be understood and interpreted in all of the steps of health services, and interventions should be executed when necessary

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Table: 1 Gender

Variable	Male	Female
Gender	57%	43%

Table: 2 Mother's and father's age

Variable	Minimum	Maximum	Mean	SD
Mother's age	17	46	28.20	± 4.50
Father's age	21	49	31.32	± 4.95

Table:3 Maternal risk factors

Risk factors	Frequency Total (284)	Percentage (%)
Mothers age >35	15	5.3
Any infection during pregnancy	10	3.5
Maternal Seizure	1	0.4
Diabetes	8	2.8
hypertension/Preeclamsia	32	11.3
Anemia	11	3.9
Multple Gestation	27	9.5
Intra Uterine Growth Retardation (IUGR)	3	1.1
Radiation exposure	1	0.4
TORCH Infection	2	0.7
History of miscarriages	20	7.0
Consanguineousmarriage	7	2.5
IVF Pregnancy	24	8.5
abnormal uterine blod flow	4	1.4
Maternal medication	3	1.1
Oligohydramnios	26	9.2
Any other history	4	1.4

Fig :1	Graph -1 Maternal Risk factors

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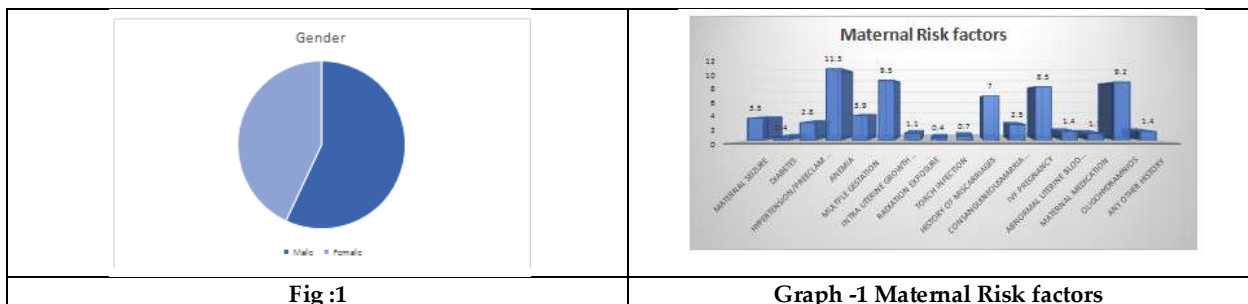
DUS Characterization of Blackgram [*Vigna mungo* (L.) Hepper] Genotypes using Morphological Characters and Clustering Them using Mahalanobis D² Analysis

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ABSTRACT

Twelve genotypes of Black gram (*Vigna mungo* L.) from the Tamilnadu region were examined for morphological characterization utilizing 21 Distinctiveness, Uniqueness and Stability descriptors (DUS) provided by Protection of Plant Varieties and Farmer's Rights, 2007 (PPV and FR). Based on the data and analysis, 16 characters showed genetic variance among genotypes, helpful in choosing genotypes for the Crop Improvement Program. Mahalanobis D² statistics was employed to analyze the observed data and associated scores in order to cluster genotypes with similarity. Each of the twelve genotypes was divided into four clusters. Cluster I had the highest number of genotypes with seven, followed by Clusters II and III with two each, and Cluster IV with one genotype. There was significant genetic diversity evident since the inter-cluster distance between two clusters was greater than the intra-cluster distance. Clusters II and III, with the greatest inter-cluster distance, could be employed in the hybridization program to create superior and agronomically competent varieties.

Keywords: Black gram, Morphological markers, DUS, D² analysis, Cluster analysis.

INTRODUCTION

Pulse crops are valued for their rich protein, vitamins, mineral, and fiber content making them essential for millions worldwide [*Apurva Verma et. al., 2022*][1]. Black gram [*Vigna mungo* L. Hepper] is suitable for both irrigated and rainfed condition [*Singh et. al., 2020*][2] and occupies the bulk of 10.16% of India's total pulse production (27.30 M.T.)[3]. It is the fourth most important pulse crop in India after Chickpea, Pigeon pea and Green gram in terms of area and production[3]. Despite a 3% increase in net area sown of black gram in Tamilnadu, it is yet to achieve its full potential of productivity. Enhancing crop yield relies significantly on genetic variability within the base population, necessitating a thorough evaluation of variation and diversity. Distinctiveness, Uniqueness and Stability (DUS) assessment is a mandate to differentiate genotypes on the basis of their morphology. Morphological markers are cost-effective and easy to score that facilitates grouping of genotypes with specific traits efficiently [*Kumawat et. al.*, 2020][4]. In this context, the current study was undertaken to evaluate 12 popular genotypes from Tamilnadu by scoring 21 characters in line with Protection of Plant Varieties and Farmer's Rights (PPV and FR) guidelines.

MATERIALS AND METHODS

The field trial was conducted during *Kharif – 2024*, at the experimental farm of the Department of Genetics and Plant Breeding in the Faculty of Agriculture, Annamalai University, Cuddalore, India., following Randomized Block Design. The trial involved planting of twelve genotypes (Table 1) in rows with 16 plants per row in three replication, each sized 740 x 440 cm^2. The plant spacing was maintained as 45 x 15 cm^2, at the rate of 16 hills per row and three seeds per hill, that later thinned out. Recommended agricultural practices and crop protection measures were implemented. In each replication, 10 plants were randomly tagged, totaling 30 samples per genotype across three replications. Totally 21 DUS characters were observed. The anthocyanin colouration in hypocotyl was scored when the cotyledons unfolded i.e. 5-6 Days After Sowing (DAS). Time of flowering was recorded when 50% of the plants have had at least one fully opened flower. Plant growth habit, habit of the plant, stem colour, pubescence on the stem, terminal leaflet shape, foliage colour, colour of the leaf veins and pubescence on the leaves were recorded during 50% flowering stage. Colour of the petiole, colour of the premature pods and pubescence on the pod were scored when the green pods were fully developed. Peduncle length, pod length, colour of the matured pod and plant height were observed during harvest maturity. Seed characters such as seed colour, seed lusture, seed shape and the test weight were recorded after the harvest maturity. All the data recorded were analyzed for Clustering through d2m program available in TNAUSTAT platform [*Manivannan, 2014*][5].

RESULTS AND DISCUSSION

DUS characterization
All the 21 characters were either observed or measured as per PPV and FR guidelines. Scores from three replication were compared to arrive at the results shown in the Table 2 and 3. The results are discussed individually as follows.

Seedling character
Hypocotyl: Anthocyanin colouration
No variation was observed in any of the genotypes, as all the genotypes had purple colour hypocotyl. This uniformity was due to the accumulation of water-soluble pigments with anti-oxidant properties aiding plant defense mechanisms [*Satveer Kaur et. al., 2023*][6]. This uniformity may be indicated as common genetic background or conserved trait within the species or specific genotypes evaluated, that could serve as a baseline characteristic for the seedling stage and useful in identifying potential off-types or mutants in future breeding or genetic studies.

Flower character
Time of Flowering
Out of 12 genotypes observed, three genotypes (ADT 5, T 9 and VBN 10) exhibited early flowering (<40 DAS) and all other nine genotypes were of medium (40-50 DAS) duration. None of the genotypes was in late (>50 DAS) category, suggesting limited genetic diversity for this trait. Early-flowering genotypes could be advantageous in regions with shorter growing season, while medium-duration genotypes could be preferred in regions with longer growing seasons or a balance between vegetative and reproductive development.

Plant characters
Plant Growth Habit
Out of 12 genotypes, only T 9 genotype had erect growth habit; nine genotypes (NUL 7, VBN 3, MDU 1, ADT 5, VBN 4, VBN 10, VBN 8, ADT 3 and VBN 5) exhibited semi-erect growth habit and two of them (VBN 11 and KBG 28) were of spreading type. Erect growth habits are preferred in certain cropping systems [Apurva Verma et. al., 2022][1], while semi-erect habit balances plant density and air circulation. Spreading growth habits are advantageous in low-input or organic farming systems, but may require more spacing between plants. Genetic differences in factors like internode length, branching patterns, and stem strength could be exploited in breeding programs to develop cultivars with desired growth habits.

Plant Habit
Out of twelve genotypes, only NUL 7 displayed indeterminate growth and all other eleven genotypes were observed with determinate growth. This has significant implications for crop management and yield potential. Indeterminate genotypes may have a longer growing period and higher yields, but may require more intensive management practices. Determinate genotypes have more predictable growth and better suited for mechanized harvesting. Therefore, selecting genotypes with determinate habit could be appreciated in plant breeding.

Plant Height
Plants were categorized into Short (<45 cm), Medium (45 - 60 cm) and Long (>60 cm). Out of twelve genotypes observed, four of them (VBN 3, MDU 1, VBN 11 and VBN 4) had medium-height and all other eight genotypes were short-height plants. No long-statured genotypes were recorded. Genetic differences in factors like internode length, stem strength, and plant architecture contribute to this variation. Short-statured genotypes are preferred in cropping systems or environments with lodging, while medium-height plants may balance yield potential and lodging resistance. The absence of long-statured genotypes suggested either limited genetic diversity or their exclusion from evaluation. This could guide breeding efforts and crop management strategies to develop cultivars better adapted to specific environmental conditions and production systems.

Stem characters
Stem colour
Out of the twelve genotypes, NUL 7 had green with purple splashes on the stem. Nine genotypes (MDU 1, VBN11, ADT 5, VBN 4, T 9, VBN 10, KBG 28, ADT 3 and VBN 5) exhibited purple with green splashes and two genotypes (VBN 3 and VBN 8) had purple stem and no genotypes displayed green stem. The difference is from pigment biosynthesis and accumulation influenced by genetic factors, environmental conditions, and interactions. Purple pigmentation may offer protection against stress and influence light absorption. Stem may take part in non-foliar photosynthesis contributing up to four percent of total photosynthetic activity [Andrew J Simkin et. al., 2020][2]. This trait can well be used as a marker for varietal identification and registration.

Stem Pubescence
The presence of minute hairs on the stem was observed across all twelve genotypes suggesting a conserved characteristic within the blackgram genotypes. While this lack of variation limits its usefulness for varietal identification or characterization, it could be associated with agronomic traits or stress tolerance mechanisms, which

could be of interest in breeding programs or understanding genotype adaptation. Stem pubescence in diverse germplasm resources can provide insights for future breeding aimed at enhancing stress resilience and productivity.

Leaf characters

Terminal Leaflet Shape

Out of twelve genotypes, five (VBN 3, MDU 1, VBN 11, KBG 28 and VBN 5) had ovate leaflet shape while six of them (NUL 7, ADT 5, VBN 4, T 9, VBN 8 and ADT 3) had cuneate type of leaflet. Only VBN 10 genotype exhibited lanceolate type. Leaf morphology is influenced by both phylogeny and developmental processes like heteroblastic progression and organ stage of a plant *[Daniel H Chitwood et. al., 2012]*[8]. As reported by *Vridi et. al.*[9], Leaflet shape affects crop canopy coverage and lanceolate type often showing drought tolerance *[Jayamani et. al., 2014]*[10]. Genotypes with narrow terminal leaflet should be selected for pest resistance breeding as it shows negative correlation with insect pest attack *[Taggar and Gill, 2012]*[11]. So, while breeding for crop architecture, one may choose VBN 10 to improve solar radiation harnessing efficiency and the production of more biomass potentially boosting yield.

Foliage colour

Out of twelve genotypes, four (NUL 7, T 9, KBG 28 and ADT 3) had green foliage and all other eight genotypes had dark green foliage. This variation results from both the genetic and environmental condition. Higher chlorophyll content produces dark green leaves, enabling sun-light capture even at low radiation level, as in stress-tolerant genotypes *[R. M. Nair et. al., 2024]*[12]. Chlorophyll content and seed yield is negatively correlated *[Mohanlal et. al., 2018]*[13]. Breeder may choose dark green foliage for tolerance and green foliage for yield optimizing.

Leaf Vein Colour

All the twelve genotypes were possessing green colour leaf vein. Although polymorphism was observed in T 9, it was not widespread among the samples considered. While leaf vein colour is not a primary target trait in blackgram breeding programs, it offers insights into plant health, photosynthetic efficiency, stress tolerance, and genetic marker identification; making it necessary to consider this trait alongside key agronomic characteristics for varietal improvement.

Leaf Pubescence

Minute hairs on the leaf surface were visually observed for all twelve genotypes and all exhibited this trait. Trichomes are the first line of plants' defense against biotic and abiotic stress *[Dan Gong et. al., 2024]*[14]. This uniformity shows the evolutionary path of genetics for tolerance against biotic and abiotic stress. While no variation was observed, breeders may still opt for genotypes with densely pubescence to enhance plants to tolerate stress compared with sparsely pubescence.

Petiole Colour

Out of twelve genotypes, eight (NUL 7, VBN 3, MDU 1, VBN 11, ADT 5, VBN 4, T 9 and ADT 3) had green with purple splashes petiole; three (VBN 10, VBN 8 and VBN 5) had entirely purple petiole and only KBG 28 had green petiole. This trait offers insight on genetic diversity, accumulation of pigments, potential stress tolerance mechanisms, and serve as a morphological marker for crop characterization. Further research could unravel the potential applications of petiole colour variation in black gram improvement and cultivation.

Pod characters

Intensity of green colour of pre-mature pods

Out of twelve genotypes, eight (NUL 7, MDU 1, VBN 11, T 9, VBN 10, KBG 28, ADT 3 and VBN 5) had green pre-mature pods; four (VBN 3, ADT 5, VBN 4 and VBN 8) had dark green pre-mature pods and none of them was with yellowish green pre-mature pods. Dark green colour of pre-mature pods contribute to the total crop yield through participation in non-foliar photosynthesis activity *[Andrew J Simkin et. al., 2020]*[7], and it can regulate seed growth and its timely maturation *[Young B Cho et. al., 2023]*[15], This makes dark green pods to be preferred over other in yield maximization program.

Pod Pubescence

Among the twelve genotypes, only NUL 7 and T 9 did not exhibit any pubescence on their pods while all other ten genotypes had pod pubescence. This trait is controlled by a single dominant gene *[Ramakrishna M. Nair et. al., 2024]*[12] and hairy pods are dominant over non-hairy pods. The presence of minute hairs on the pod provides resistance against attack of Pod borers. Pod pubescence is negatively correlated with pod shattering effect *[Gawhane et. al., 2022]*[16]. So, genotypes with dense pubescence on their pods may be preferred due to their increased level of biotic and abiotic stress tolerance as compared to sparsely or non-hairy genotypes.

Peduncle length

Plants were categorized into Short (<5 cm), Medium (5-10 cm) and long peduncle (>10 cm) based on their peduncle length. Out of twelve genotypes, four (VBN 11, ADT 5, VBN 4 and ADT3) had long peduncle and all other eight genotypes had medium peduncle. No genotypes exhibited short peduncle. Peduncle length shows a highly significant positive correlation with seed yield *[Gita Kumari et. al., 2022]*[17] indicating that longer peduncle is favourable for yield maximization program.

Pod length

Plants were categorized into Short (<5 cm), Medium (5 - 7 cm) and long peduncle (>7 cm) based on their pod length. Out of twelve genotypes, five (NUL 7, VBN 11, VBN 4, T 9 and KBG28) had small pods; five (MDU 1, ADT 5, VBN 10, VBN 8 and VBN 5) had medium sized pods and only VBN 3 and ADT 3 had long sized pods. Pod length shows high significant positive correlation with seed yield *[Gita Kumari et al., 2022]*[17] and negatively correlated with pod shattering *[Gawhane et al., 2022]*[16]. Hence, variation in this character may rightly be utilized to select genotypes for various breeding objectives.

Colour of the mature Pod

Among twelve genotypes, three (VBN 3, MDU 1 and VBN 10) had brown mature pods and all other nine genotypes had back mature pods. No genotypes displayed off-white/ buff pods. Consumer preferences or traditional beliefs may influence the choice of mature pod colour. Specific pod colors may be preferred for culinary purposes or cultural traditions. Understanding these preferences can guide variety selection and marketing strategies. Pod colour can provide insights into seed quality characteristics, such as size, vigor, and nutrient content; though the direct relationship requires further investigation. Some plant species link pod colour with enhanced resistance to pathogens, pests, or abiotic stress through specific pigments and compounds, such a direct relationship also warrants exploration.

Seed characters
Seed colour

Out of twelve genotypes, only T 9 had greenish brown seeds and MDU 1 had brown seeds while all other ten genotypes had black seeds. No genotypes displayed green colour seeds. Seed coat colour is a significant genetic marker in genotype identification. Seed coat colour results from the accumulation of anthocyanin on the outer seed coat. Research suggests that only black and dark brown-coloured seeds are having three variant of anthocyanin pigment while two of them are lacking in T 9 genotype and all are absent in genotypes with light brown, green or mottled seed coat, as cited from *Pandey et al., 1981*[18]. The absence of anthocyanin pigments may indicate an imbalance between biosynthesis and degradation. Thus, breeder may opt for black seeded genotypes capable of accumulating ample anthocyanin, showcasing the plant's ability to combat biotic and abiotic stress through antioxidant properties of anthocyanin.

Seed lusture

All the twelve genotypes were dull in nature and no shiny outer coat was reported. Seed lusture is linked to variation in seed coat morphology. Seeds with smooth and shiny surfaces are categorized as shiny and seeds with rough, pitted, adhered depression with surface deposits as dull *[C. Partheeban et. al., 2022]*[19]. Shiny seed surface is a resultant of monogenic dominant gene action over dull seed lusture *[(Nair et. al., 2023)*[12] *and (Gupta et. al., 2023)*[20]]. Sometime,

the deposit present on the seed surface may not be desirable, as creating 'seed dust' that affects allergic people. Correlation between seed lusture and seed quality is yet to be explored.

Seed shape

Among twelve genotypes, seven (VBN 3, MDU 1, ADT 5, VBN 4, KBG 28, VBN 8 and VBN 5) had globose seeds; only T 9 and VBN 10 had oval shaped seeds; three others (NUL 7, VBN 11 and ADT 3) had drum shaped seeds. It is a critical trait in identifying genotypes based on their width-to-length ratio, significantly influencing yield, quality and market preference. It is a criterion in selecting genotypes with desirable seed protein content and seed size. As like the works on the relationship of the seed shape and seed protein content in Chickpea and Soybean *[Karthick Babu et. al., 2023]*[21], further work is needed in blackgram to correlate the same. Notably, three genotypes including VBN 3, MDU 1 and VBN 5 which had large class of seed size are of globose seeds with other globose shaped seeds are also falling near the mean of large class (4.48 centimeter to 4.97 centimeter).

Seed Size (Weight of 100 seeds)

Based on the weight, the seeds were categorized as small (<3 grams), medium (3-5 grams) and large (>5 grams). Out of twelve genotypes, three (VBN 3, MDU 1 and VBN 5) were large in size; all other nine genotypes were medium. No genotype was recorded with small seeds. Seed size shows positive correlation with total seed yield i.e. as the size increases, the weight of the seed increases, boosting total seed yield *[Gita Kumari., 2022]*[17]. So, large-sized seeds may be preferred for yield maximization program. Out of 21 DUS characters observed, 16 characters had shown significance variation among the twelve genotypes studied, as shown in the Table 4.1 and 4.2.

D² analysis
Clustering Pattern

Based on the D² value (Table 5), the twelve genotypes of black gram were grouped into four clusters. Among these clusters, cluster I consisted maximum seven genotypes followed by two genotypes each in cluster II and cluster III and one genotype in cluster IV. The grouping pattern constellation proved the presence of significant amount of variability. The genotype clustering pattern revealed that the clustering did not follow any specific patterned clustering, in relation to the origin.

Intra and inter cluster distance

The average cluster distance (intra and inter) was measured for each cluster and each pair of clusters, in all possible combinations respectively (Table 6). The results revealed that the highest intra cluster distance was observed on cluster III (41215.9062) followed by cluster I (34668.6342), while the lowest intra cluster distance was recorded on cluster IV (each 0.00). The highest inter cluster distance of 1152780.6421, was observed between cluster II and cluster III followed by cluster I and II (511894.7425) while the lowest was observed between cluster I and cluster IV (107741.6485). Genotypes in the same cluster indicated that they were closely related as compared to genotypes in another cluster. Therefore, it may be expected that genotypes in one cluster is less divergent among themselves than those genotypes present in different cluster. The hybridization between the most diverse genotypes (higher inter cluster distance) may result desirable segregates with the accumulation of favourable genes in the segregating generation, which help in hybridization *[Elangaimannan et. al., 2008]*[22].

Cluster Mean

A considerable difference in cluster mean values were apparent for all the traits (Table 7). The preference ranking for the genotypes was allotted, not solely based on the cluster with the highest mean value, rather the ranking considered the scores allotted in the PPV FR manual, to the preferred class of character. As in flowering, early flowering is preferred to mitigate pest and pathogen attacks during the maturity stage. Therefore, the cluster with minimum value for time of flowering would be given the first rank, as the score allotted for earliness is the lowest compared to the other classes.

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Flower Character
Early flowering plants are beneficial in plant breeding. So, genotypes from Cluster III, which had taken less time to flower, may be preferred.

Plant Characters
Erect statured plants are preferred for their enhanced sunlight utilisation and their accommodation in a cropping system within less area. So, genotypes from cluster IV may be preferred here. While Plants with determinate growth are preferred over indeterminate to facilitate synchronization of maturity and mechanical harvest. So, genotypes from cluster I, II and IV may be preferred for plant habit. Plants with medium-height are preferred over short and long-height as it mediates the lodging resistance and yield maximizing. To remind, plant height is non-significant negatively correlated with seed yield *[Shanthi et. al., 2019][23]*. So, genotypes from cluster I may be preferred for plant height.

Stem Characters
Purple coloured stem is preferred as it provides stress tolerance with its high anthocyanin content. So, genotypes from cluster IV can be preferred. While, plants with stem pubescence are preferred due to their resistance for insect pest attack. So, for stem pubescence, genotypes from clusters II and IV can be preferred.

Leaf Characters
Plants with lanceolate leaf type are preferred. So, genotypes from cluster III can be preferred. While genotypes for foliage colour can be selected based on requirements as it is negatively correlated with seed yield *[Mohanlal et. al., 2018][13]*. Greenish petiole is preferred over purplish, for which, genotypes from cluster III can be preferred.

Pod Characters
Dark green pre-mature pods are preferred for efficient seed growth. So, genotypes from cluster IV can be preferred. As that, pod length and peduncle length have high significant positive correlation with seed yield *[Gita Kumari et. al., 2022][17]*, for which genotypes from cluster II are preferred for both the traits. Colour of the mature pod is preferred based on the consumer' preference and market status. Mostly, Blackish brown is preferred followed by deep brown. So, for colour of the mature pods, genotypes from cluster II and IV can be preferred.

Seed Characters
Seeds with other than black and brown seed coat are devoid of anthocyanin pigment as reported by *Pandey, 1989[18]*. Black seed coat is preferred for which genotypes from cluster I can be preferred. Seeds of large size and oval with slight curvature shape is preferred. So, for these two characters, genotypes from cluster II can be preferred. Out of 21 DUS characters, significant variation was exhibited for 16 characters (including time to flowering, plant habit, stem and leaf characteristics, pod traits, and seed properties like color, shape, and size). All those variabilities could well be tapped for Crop Improvement Program by comparing the results of D^2 analysis. Based on D^2 analysis, the genotypes were grouped into four separate clusters, with cluster II (ADT 3 and VBN 5) and cluster III showing the highest levels of divergence. Cluster II exhibited favorable characteristics for yield metrics, such as determinate habit, longer peduncles and pods, and large oval seeds, according to cluster means, while genotypes for early blooming were present in cluster III. The study suggests, to employ genotypes from the highly divergent clusters II and III in hybridization programs to combine advantageous features and create improved black gram varieties with increased productivity and adaptability based on the preference ranking of trait values.

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Table 1. Twelve Genotypes Used for Dus Characterization

S. NO.	NAME OF THE GENOTYPES
G1	NUL 7
G2	VBN 3
G3	MDU 1
G4	VBN 11
G5	ADT 5
G6	VBN 4
G7	T 9
G8	VBN 10
G9	KBG 28
G10	VBN 8
G11	ADT 3
G12	VBN 5

Table 2. Morphological Characterization of Six Blackgram Genotypes

CHARACTER	NUL 7	VBN 3	MDU 1	VBN 11	ADT 5	VBN 4
Hypocotyl: Anthocyanin colouration	Present	Present	Present	Present	Present	Present
Time of Flowering	Medium	Medium	Medium	Medium	Early	Medium
Plant: Growth Habit	Semi erect	Semi erect	Semi erect	Spreading	Semi erect	Semi erect
Plant: Habit	Indeterminate	Determinate	Determinate	Determinate	Determinate	Determinate
Stem: Colour	Green with purple splashes	Purple	Purple with green splashes	Purple with green splashes	Purple with green splashes	Purple with green splashes
Stem: Pubescence	Present	Present	Present	Present	Present	Present
Leaflet (Terminal): Shape	Cuneate	Ovate	Ovate	Ovate	Cuneate	Cuneate
Foliage: Colour	Green	Dark green	Dark green	Dark green	Dark green	Dark green
Leaf: Vein colour	Purple	Purple	Purple	Purple	Purple	Purple
Leaf: Pubescence	Present	Present	Present	Present	Present	Present
Petiole: Colour	Green with	Green with	Green with	Green with	Green with	Green with

	purple splashes	purple splashes	purple splashes	purple splashes	purple splashes	purple splashes
Pod: Intensity of green colour of mature pod	Green	Dark green	Green	Green	Dark green	Dark green
Pod: Pubescence	Absent	Present	Present	Present	Present	Present
Peduncle: Length	Medium	Medium	Medium	Long	Long	Long
Pod: Length	Short	Long	Medium	Short	Medium	Short
Pod: Colour of matured pod	Black	Brown	Brown	Black	Black	Black
Plant: Height	Short	Medium	Medium	Medium	Short	Medium
Seed: Colour	Black	Black	Brown	Black	Black	Black
Seed: Lusture	Dull	Dull	Dull	Dull	Dull	Dull
Seed: Shape	Drum	Globose	Globose	Drum	Globose	Globose
Seed: Size (Weight of 100 seeds)	Medium	Large	Large	Medium	Medium	Medium

Table 3. Morphological Characterization Oof Six Blackgram Genotypes

CHARACTER	T 9	VBN 10	KBG 28	VBN 8	ADT 3	VBN 5
Hypocotyl: Anthocyanin colouration	Present	Present	Present	Present	Present	Present
Time of Flowering	Early	Early	Medium	Medium	Medium	Medium
Plant: Growth Habit	Erect	Semi erect	Spreading	Semi erect	Semi erect	Semi erect
Plant: Habit	Determinate	Determinate	Determinate	Determinate	Determinate	determinate
Stem: Colour	Purple with green splashes	Purple with green splashes	Purple with green splashes	Purple	Purple with green splashes	Purple with green splashes
Stem: Pubescence	Present	Present	Present	Present	Present	Present
Leaflet (Terminal): Shape	Cuneate	Lanceolate	Ovate	Cuneate	Cuneate	Ovate
Foliage: Colour	Green	Dark green	Green	Dark green	Green	Dark green
Leaf: Vein colour	Green	Green	Green	Green	Green	Green
Leaf: Pubescence	Present	Present	Present	Present	Present	Present
Petiole: Colour	Green with purple splashes	Purple	Green	Purple	Green with purple splashes	Purple
Pod: Intensity of	Green	Green	Green	Dark Green	Green	Green

green colour of mature pod						
Pod: Pubescence	Absent	Present	Present	Present	Present	Present
Peduncle: Length	Medium	Medium	Medium	Medium	Long	Medium
Pod: Length	Short	Medium	Short	Medium	Long	Medium
Pod: Colour of matured pod	Black	Brown	Black	Black	Black	Black
Plant: Height	Short	Short	Short	Short	Short	Shorty
Seed: Colour	Greenish brown	Black	Black	Black	Black	Black
Seed: Lusture	Dull	Dull	Dull	Dull	Dull	Dull
Seed: Shape	Oval	Oval	Globose	Globose	Drum	Globose
Seed: Size (Weight of 100 seeds)	Medium	Medium	Medium	Medium	Medium	Large

Table 4. Frequency Distribution of Dus Characters in Twelve Blackgram Genotypes

S. NO.	CHARACTERS	CLASSES	NO OF GENOTYPES	PERCENTAGE OF GENOTYPES (%)
1	Hypocotyl: Anthocyanin colouration	Present	12	100
		Absent	0	0
2	Time of Flowering	Early (<40 DAS)	3	25
		Medium (40-50 DAS)	9	75
		Late (>50 DAS)	0	0
3	Plant: Growth Habit	Erect	1	8.33
		Semi Erect	9	75
		Spreading	2	16.67
4	Plant: Habit	Determinate	11	91.67
		Indeterminate	1	8.33
5	Stem: Colour	Green	0	0
		Green with purple splashes	1	8.33
		Purple with green splashes	9	75
		Purple	2	16.67
6	Stem: Pubescence	Absent	0	0
		Present	12	100
7	Leaf: Shape (Terminal)	Deltoid	0	0
		Ovate	5	41.67
		Lanceolate	1	8.33
		Cuneate	6	50
8	Foliage: Colour	Green	4	33.33

		Dark green	8	66.67
9	Leaf: Vein colour	Green	12	100
		Purple	0	0
10	Leaf: Pubescence	Absent	12	100
		Present	0	0
11	Petiole: Colour	Green	1	8.33
		Green with purple splashes	8	66.67
		Purple	3	25
12	Pod: Intensity of green colour of premature pods	Yellowish green	1	8.33
		Green	7	58.33
		Dark green	4	33.33
13	Pod: Pubescence	Absent	3	25
		Present	9	75
14	Peduncle: Length	Short (<5cm)	0	0
		Medium (5-10cm)	8	66.67
		Long (>10cm)	4	33.33
15	Pod: Length	Short (<5cm)	5	41.67
		Medium (7cm)	5	41.67
		Long (>7cm)	2	16.67

Table 5. Frequency Distribution Of Dus Characters In Twelve Blackgram Genotypes

S. NO.	CHARACTERS	CLASSES	NO OF GENOTYPES	PERCENTAGE OF GENOTYPES (%)
16	Pod: Colour of the mature pods	Buff	0	0
		Brown	3	25
		Black	9	75
17	Plant: Height	Short (<45cm)	8	66.67
		Medium (45-60cm)	4	33.33
		Long (>60 cm)	0	0
18	Seed: Colour	Green	0	0
		Greenish brown	1	8.33
		Brown	1	8.33
		Black	10	83.33
		Mottled	0	0
19	Seed: Lusture	Shiny	0	0
		Dull	12	100
20	Seed: Shape	Globose	7	58.33
		Oval	2	16.67
		Drum	3	25
21	Seed: Size (weight of 100 seeds)	Small (<3g)	0	0
		Medium (3-5g)	9	75
		Large (>5g)	3	25

Table 5. Grouping of Twelve Blackgram Genotypes into Clusters (by Tocher's Method)

CLUSTER	NUMBER OF GENOTYPES	NAME OF GENOTYPES
I	7	G2 G9 G4 G7 G3 G5 G6
II	2	G11 G12
III	2	G8 G1
IV	1	G10

Table 6. Average of Intra and Inter Cluster Distance Among Blackgram Genotypes

CLUSTER DISTANCE				
	Cluster I	Cluster II	Cluster III	Cluster IV
Cluster I	34668.6342	511894.7425	200393.0578	107741.6485
Cluster II		5759.9001	1152780.6421	312410.4433
Cluster III			41215.9062	301643.3965
Cluster IV				0

Table 7. Cluster Mean of Four Clusters Grouped Against Sixteen Dus Characters

CLUSTER/ CHARACTER	CLUSTER I	CLUSTER II	CLUSTER III	CLUSTER IV
Time of flowering	4.1428	5.6667	4.0000	5.6667
Plant: Growth Habit	5.4762	5.0000	5.6667	4.3333
Plant: Habit	1.6667	1.6667	2.0000	1.6667
Stem: Colour	3.0476	3.0000	2.6667	3.3333
Leaflet (terminal): shape	2.8095	3.0000	3.5000	3.3333
Foliage: colour	1.5714	1.5000	1.5000	1.6667
Petiole: colour	2.1428	2.1667	2.0000	2.3333
Pod: Intensity of green colour of premature pod	5.8572	5.0000	5.6667	6.3333
Pod: Pubescence	5.5714	6.3333	5.0000	6.3333
Peduncle: Length	5.9524	6.0000	5.6667	4.3333
Pod: Length	4.5238	5.6667	4.6667	4.3333
Pod: Colour of the mature pod	2.5714	2.6667	2.5000	2.6667
Plant: Height	4.0476	3.6667	3.6667	3.6667
Seed: Colour	3.2857	3.3333	3.3333	3.3333
Seed: Shape	1.7619	2.0000	2.5000	1.6667
Seed: Size (100 seed weight)	5.8572	6.0000	5.6667	5.6667

RESEARCH ARTICLE

A Case on Kala Sharir in Relation with Shleshmadhara Kala W.S.R to Osteoarthritis

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ABSTRACT

Kala Sharir is an essential concept in *Ayurved*, referring to the layers within the body that serve as interfaces between different *Dhatus* (tissues) and organs. *Shleshmdhara Kala*, one of these layers, is associated with the lubrication and proper function of joints. Osteoarthritis (OA), a degenerative joint disease, can be correlated with the dysfunction of *Shleshmdhara Kala* due to the vitiation of *Vata Dosha*. To explore the role of *Shleshmdhara Kala* in the pathogenesis of osteoarthritis and evaluate the effectiveness of *Ayurvedic* treatments aimed at restoring the balance of this *Kala*. A single case study was conducted on a 60-year-old male patient diagnosed with osteoarthritis of the knees. The patient underwent a comprehensive *Ayurvedic* treatment plan, including oral medications, *Panchakarma* therapies, and lifestyle modifications, over a period of 3 months. Clinical assessments and diagnostic evaluations were performed to monitor the patient's progress. The patient exhibited significant improvement in symptoms, including reduced pain, stiffness, and swelling in the knee joints. The range of motion in the affected joints improved, and the patient reported enhanced ability to perform daily activities. These outcomes suggest that the *Ayurvedic* treatment effectively addressed the vitiation of *Shleshmdhara Kala*, thereby alleviating the symptoms of osteoarthritis. This case study highlights the potential of *Ayurvedic* principles in managing osteoarthritis through the targeted treatment of *Shleshmdhara Kala*. The holistic approach, encompassing internal medications, *Panchakarma* therapies, and lifestyle modifications, proved beneficial in improving joint health and overall quality of life for the patient. Further research with larger sample sizes is recommended to validate these findings.

Keywords: *Kala Sharir*, *Shleshmdhara Kala*, Osteoarthritis, *Ayurved*,

INTRODUCTION

Kala Sharir is a fundamental concept in *Ayurved*, referring to the layers or membranes within the body that serve as interfaces between different *Dhatus* (tissues) and organs. [1,2] These layers are critical in maintaining the physiological functions and integrity of the body's structures. The term "*Kala*" signifies a protective sheath or a thin layer, and in the context of *Sharir* (body), it denotes specific layers that support and nourish the *Dhatus*. [3,4]

Classification and Description of *Kala*[5]
According to *Ayurvedic* texts, there are seven *Kalas* in the human body, each associated with a particular tissue or physiological function. These *Kalas* are:
1. *Mamsadhara Kala*
2. *Raktadhara Kala*
3. *Medodhara Kala*
4. *Shleshmdhara Kala*
5. *PurishdharaKala*
6. *Pittadhara Kala*
7. *ShukradharaKala*

Each *Kala* has a specific role and location within the body, which is essential for the proper functioning of the respective *Dhatus* and overall health.

Detailed Description of Each *Kala*
***MamsadharaKala* (Layer Associated with Muscle Tissue):[6]**
- **Location:** It is located between the skin (*Twak*) and muscles (*Mamsa*).
- **Function:** This *Kala* supports the muscle tissue by providing strength and nourishment. It plays a crucial role in the movement and structural integrity of the body.

***RaktadharaKala* (Layer Associated with Blood Tissue):[7]**
- **Location:** Found within the blood vessels (*Dhamanis*) and heart (*Hridaya*).
- **Function:** It is responsible for the formation, storage, and circulation of *Rakta* (blood). It ensures the nourishment and oxygenation of all body tissues.

***MedodharaKala* (Layer Associated with Fat Tissue):[8]**
- **Location:** Present around the muscles and organs, particularly in the abdominal region.
- **Function:** This *Kala* is involved in the metabolism and storage of fat. It provides lubrication and protection to the organs and acts as a reserve of energy.

***Shleshmdhara Kala* (Layer Associated with Lubrication and Joint Function):[9]**
- **Location:** Found in the joints (*Sandhis*) and synovial membranes.
- **Function:** It is responsible for producing and maintaining Sleshaka Kapha, which lubricates the joints, facilitating smooth movement and preventing friction. This *Kala* is crucial in maintaining joint health and preventing conditions like osteoarthritis.

***PurishdharaKala* (Layer Associated with the Formation of Faeces):[10]**
- **Location:** Located in the intestines (*Koshtha*), particularly the large intestine.
- **Function:** It helps in the formation and excretion of faeces. This *Kala* ensures the proper elimination of waste products from the body, maintaining digestive health.

***PittadharaKala* (Layer Associated with Bile and Digestive Enzymes):[11]**
- **Location:** Found in the stomach and small intestine.

▪ **Function:** It is responsible for the production and regulation of *Pitta* (bile and digestive enzymes), which are essential for digestion and metabolism. This *Kala* plays a key role in the digestive process and nutrient assimilation.

ShukradharaKala (Layer Associated with Reproductive Tissue):[12]
▪ **Location:** Present in the reproductive organs.
▪ **Function:** This *Kala* supports the formation, storage, and function of Shukra (reproductive tissue). It is crucial for reproductive health and the continuation of the species.

Significance of *Kala* Sharir in Health and Disease
The concept of *KalaSharir* underscores the importance of these protective layers in maintaining the integrity and function of body tissues.[13] Each *Kala* has a specific role in supporting the *Dhatus* and ensuring their proper function. Any imbalance or dysfunction in these *Kala*s can lead to various health issues, highlighting the need for maintaining their balance through appropriate *Ayurvedic* practices.[14]

Role of *Shleshmdhara Kala* in Osteoarthritis
Shleshmdhara Kala, associated with joint lubrication, is particularly significant in the context of osteoarthritis.[15] The vitiation of *Vata Dosha* leads to the depletion of *Shleshaka Kapha*, causing dryness and degeneration of joint cartilage.[16] This results in pain, stiffness, and restricted movement, characteristic of osteoarthritis.[17]*Ayurvedic* treatment aims to restore the balance of *Shleshmdhara Kala* through internal medications, external therapies, and lifestyle modifications to alleviate symptoms and improve joint health.[18]

CASE STUDY
Kala Sharir, as described in *Ayurvedic* literature, represents the distinct layers within the body responsible for various Anatomical Structure and functions. Among these, *ShleshmdharaKala* is specifically associated with the lubrication and nourishment of the joints, facilitating smooth movement and preventing friction. This case study delves into the correlation between *Shleshmdhara Kala* and osteoarthritis, elucidating how Ayurvedic principles can be effectively applied to manage this condition.

Patient Profile
• **Age:** 60 years
• **Gender:** Male
• **Occupation:** Retired School Teacher
• **Residence:** Urban Area
• **Medical History:** Diagnosed with osteoarthritis 7 years ago, history of hypertension and mild obesity.

Chief Complaints
• Chronic pain in the knee joints for the past 7 years
• Morning stiffness lasting for about 30 minutes
• Swelling and tenderness in the knee joints
• Difficulty in performing activities such as walking, climbing stairs, and standing for extended periods

History of Present Illness
Patient reported the gradual onset of knee pain, which initially started as a mild discomfort and progressively worsened over time. He noticed increased pain during cold weather and after prolonged periods of inactivity. Over-the-counter pain relievers provided temporary relief but did not address the underlying problem. Lastly, he came to PAH (Parul *Ayurved* Hospital), Limda, Vadodara for Ayurvedic Treatment.

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Personal History
- **Diet:** Mixed diet with a preference for spicy and oily foods
- **Appetite:** Normal
- **Bowel Movements:** Regular
- **Sleep:** Disturbed due to pain
- **Exercise:** Sedentary lifestyle with minimal physical activity

Examination:
- **General Condition:** Fair, moderately obese (BMI: 29)
- **Vital Signs:Blood pressure**: 140/80 mmHg, **Pulse**: 80 bpm, **Respiratory rate**: 18/min
- **Local Examination:**
  - Visible swelling and tenderness in both knees
  - Reduced range of motion in the knee joints
  - Audible crepitus on knee movement
  - Mild deformity of the knees

Investigations
- **X-Ray of Knees:** Revealed joint space narrowing, osteophyte formation, and subchondral sclerosis, indicative of osteoarthritis.
- **Blood Tests:** Elevated ESR and CRP levels, normal rheumatoid factor, and uric acid levels.

Diagnosis
Based on the clinical presentation and diagnostic findings, Patient was diagnosed with osteoarthritis, primarily affecting the knee joints. From an *Ayurvedic* perspective, this condition correlates with *SandhigataVata*, where the vitiated *Vata Dosha* affects the joints and impairs the function of *Shleshmdhara Kala*.

Ayurvedic Understanding
In *Ayurved*, the *Shleshmdhara Kala* is essential for maintaining the lubrication (*ShleshakaKapha*) in the joints, which prevents friction and wear and tear. The aggravation of *Vata Dosha* leads to the depletion of *Shleshaka Kapha*, causing dryness, pain, and restricted movement in the joints, characteristic of osteoarthritis.

Treatment Plan
Objectives:
- Pacification of aggravated *Vata Dosha*
- Nourishment and strengthening of *Shleshmdhara Kala*
- Reduction of pain and inflammation
- Improvement of joint function and mobility

Outcome
After 3 months of consistent *Ayurvedic* treatment and lifestyle modifications, Patient reported significant improvement in his symptoms. The pain and stiffness in his knees reduced considerably, allowing him to resume his daily activities with ease. The swelling around his joints diminished, and he experienced improved joint mobility.

Follow-up
Regular follow-up visits were scheduled to monitor his progress and adjust the treatment plan as necessary. Continued adherence to dietary and lifestyle recommendations was emphasized to maintain the benefits achieved.

DISCUSSIONS

Osteoarthritis (OA) is a degenerative joint disease characterized by the breakdown of cartilage, leading to pain, stiffness, and impaired joint function. In *Ayurved*, the condition can be correlated with *Sandhigata Vata*, where the vitiated *Vata Dosha* primarily affects the joints.[19] The concept of *KalaSharir*, particularly *Shleshmdhara Kala*, is crucial in understanding the pathogenesis and treatment of osteoarthritis from an *Ayurvedic* perspective.[20]

Understanding *KalaSharir* and *Shleshmdhara Kala*
KalaSharir refers to the protective layers within the body that support and separate the different *Dhatus* (tissues). *Shleshmdhara Kala* is one such layer associated with the production and maintenance of *ShleshakaKapha*, the synovial fluid that lubricates the joints.[21] The integrity of *Shleshmdhara Kala* ensures smooth joint movements and prevents friction and wear of the articular surfaces.[22] Vitiation of Vata Dosha disrupts this balance, leading to a reduction in Sleshaka Kapha, resulting in the clinical manifestations of osteoarthritis.[23]

Case Presentation and Ayurvedic Approach
The case study presented a 60-year-old male diagnosed with osteoarthritis of the knees. The patient exhibited typical symptoms such as chronic knee pain, morning stiffness, swelling, and limited range of motion. From an Ayurvedic perspective, these symptoms were indicative of aggravated Vata Dosha affecting the *Shleshmdhara Kala*.
The treatment plan was designed to pacify Vata Dosha, nourish the affected *Kala*, and restore joint function. This involved a combination of oral medications, local applications, Panchakarma therapies, and lifestyle modifications.

Treatment Efficacy and Outcomes
The treatment protocol included:
- **Oral medications** like *Rasnasaptaka Kashaya, Yograj Guggulu, and Ashwagandha Churna*, which have anti-inflammatory and *Vata*-pacifying properties.[24]
- **Local applications** of *PanchatiktaGhrita*and *MahaNarayanTaila* for reducing inflammation and nourishing the joints.[25]
- **Panchakarma therapies** such as Snehana, Swedana, Virechana, and Basti, aimed at expelling vitiated Vata and rejuvenating the *Shleshmdhara Kala*.[26] After three months of treatment, the patient reported significant improvements. Pain and stiffness were notably reduced, swelling diminished, and joint mobility improved. These outcomes suggest that the Ayurvedic treatment effectively addressed the imbalance in *Shleshmdhara Kala*, facilitating joint lubrication and function.

Comparative Analysis with Conventional Treatments
Conventional treatments for osteoarthritis often focus on pain management and symptom relief through NSAIDs, corticosteroid injections, and physical therapy. While these treatments provide temporary relief, they do not address the underlying pathology and may have side effects.
the Ayurvedic approach aims at Traditional healing by targeting the root cause, i.e., the vitiation of Vata Dosha and the impairment of *Shleshmdhara Kala*. This comprehensive strategy not only alleviates symptoms but also promotes long-term joint health and prevents disease progression.[27]

Implications for Future Research
This case study underscores the potential of Ayurvedic treatments in managing osteoarthritis. However, further research with larger sample sizes and controlled clinical trials is needed to validate these findings. Integrating Ayurvedic principles with modern medical practices could offer a more holistic and effective approach to managing osteoarthritis and other degenerative joint diseases.

CONCLUSION

The case study highlights the significance of *Shleshmdhara Kala* in the pathogenesis and treatment of osteoarthritis. The Ayurvedic approach, focusing on restoring the balance of this *Kala* through targeted therapies and lifestyle modifications, proved effective in alleviating symptoms and improving joint function. This reinforces the value of *Kala* Sharir in understanding and managing musculoskeletal disorders in *Ayurved*.(S3, 2022)

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Table 1:Treatment Plan

Treatment Protocol	Dose	Dosage	Duration	Purpose
Oral Medications				
Rasnasaptaka Kashaya	20 ml	Twice daily before meals	3 months	Pacify Vata Dosha, reduce inflammation
Yograj Guggulu	2 tablets	Twice daily after meals	3 months	Strengthen joints, reduce pain
Ashwagandha Churna	1 tsp	With warm milk at bedtime	3 months	Nourish Dhatus, reduce stress

Local Applications				
Panchatikta Ghrita	-	External application on affected joints	Daily	Reduce inflammation, nourish joints
Mahanarayan Taila	-	Local Abhyanga followed by hot fomentation	Daily	Lubricate joints, improve mobility
Panchakarma Therapies				
Snehana (Oleation)	-	*Abhyanga with Mahanarayan Taila*	Daily	Lubricate joints, prepare for *Swedana*
Swedana (Sudation)	-	Post-*Abhyanga*	Daily	Reduce stiffness, improve circulation
Virechana (Purgation)	-	-	Once during the treatment period	Expel aggravated Vata
Basti (Medicated Enema)	-	*Matra Basti* with *Sahacharadi Taila* and *Anuvasana Basti* with *Dashmooladi Taila*	Weekly	Pacify *Vata*, nourish *Shleshmdhara Kala*
Diet and Lifestyle Modifications	-	-	Ongoing	Maintain overall health, prevent Vata aggravation
Anti-inflammatory diet	-	Include fresh fruits, vegetables, whole grains, lean proteins	Ongoing	Reduce inflammation, support healing
Avoid *Vata*-aggravating foods	-	Exclude cold, dry, and processed foods	Ongoing	Prevent Vata imbalance
Gentle exercises	-	*Yoga*, walking	Daily	Improve joint mobility, maintain fitness
Adequate rest and sleep	-	-	Daily	Promote healing, reduce stress

Table 2: Investigation Readings

Investigation	Pre-Treatment Value	Post-Treatment Value
Blood Tests		
ESR	40 mm/hr	20 mm/hr
CRP	15 mg/L	7 mg/L
Rheumatoid Factor	Negative	Negative

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Uric Acid	6.2 mg/dL	5.8 mg/dL
Radiological Findings (X-Ray of Knees)		
Joint Space Narrowing	Present	Reduced
Osteophyte Formation	Present	Reduced
Subchondral Sclerosis	Present	Reduced
Clinical Assessments		
Pain (VAS Score)	8/10	3/10
Morning Stiffness	30 minutes	10 minutes
Swelling and Tenderness	Moderate	Mild
Range of Motion	Limited	Improved
Ability to Perform Daily Activities	Restricted	Improved

RESEARCH ARTICLE

Analysis of Physico-Chemical Parameters of Water in Periyakulam, Meenakshipuram, Katroad, Sengulathupatty and Kattakamanpatty Ponds in Theni and Dindigul District, Tamil Nadu

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ABSTRACT

This research article deals with the study of quality of pond water. They are the habitats of many aquatic animals and plants. The analysis of physico-chemical parameters of pond water from July 2021- June 2022, Periyakulam, Meenakshipuram, Kattakamanpatty, Sengulathupatty and Katroad ponds at Theni and Dindigul District, Tamil Nadu (India). The water samples were collected by 1 litre water bottle and analysed for 13 physico-chemical parameter. pH range is normal in all (Meenakshipuram, Periyakulam, Sengulathupatty, Katroad and Kattakamanpatty) pond water .Temperature, Total Dissolved Solids, Salinity Electrical Conductivity, Free CO_2 were maximum in summer season and minimum in winter season. Dissolved Oxygen were maximum in winter season and minimum in summer season. The result of these study revealed that the pond water is suitable for various purposes like domestic, outdoor bathing, agriculture, fish culture and aquatic life propagation by direct.

Keywords: Selected pond, Physico-chemical parameters, water quality

INTRODUCTION

Ponds are described as a small area filled with water, natural or man-made. They are smaller than a lake and are the habitat of various aquatic plants and animals (Swarnakar, A. K., & Choubey, S. 2016)[6]. Water is the most necessary component for the living being. Life on the earth is never possible without water. Water is one of the most vital elements of the human environments. It is being used for many purposes e.g., industrial, water supply, irrigation, drinking, propagation of fish and other aquatic systems and generation of hydro-power plants (Shrivastava and Kanungo, 2013)[5]. India with multifarious ecology has a huge number of freshwater rivers, lakes, wetlands, and ponds in different parts of the country. Water resources and quality of freshwater are the foremost basic need of flourishing ecological diversity and sustainable development. Nowadays, freshwater has become a scarce commodity due to over exploitation, population growth, and also pollution (Arivoli, Dhinamala, Persis, Meeran, & Pandeeswari, Citation 2018)[2]. Water quality assessment from any region is an important aspect for the development activities of the region, because the rivers, lakes etc. are used for water supply to domestic, industrial, agriculture and fish culture use (Jain and Senapati, 1996)[3]. In the ecosystem water is considered to be the most important component for the life but day by day the quality of water become degraded. There are several factors which are responsible for deterioration of water bodies such as increased human population, industrialization, use of excess fertilizers in the agriculture and other man-made activities etc. There are several diseases have been identified among the human beings, which are caused by using contaminated water. Water born disease infections occur during washing, bathing and consumption of contaminated water during food preparations. Therefore it is necessary that the quality of water should be checked at regular time of interval because the financial losses due to water born diseases have negative impact on the nation. Nowadays this is the major problem of developing countries throughout the world (A K Dixit *et.al*. 2015)[1]. The present work was undertaken to analyse the pahysico-chemical parameters of water in selected pond at Theni and Dindigul District.

MATERIALS AND METHODS

Study area

This investigation was carried out to evaluate the status of the pond w ater in Meenakshipuram, Periyakulam, Sengulathupatty, Katroad in Theni District and Kattakamanpatty in Dindigul District. Meenakshipuram pond is located in Bodinayakanur is a Town and a municipality in Theni District in the state of Tamil Nadu, 14 km from Bodi to Theni. Periyakulam pond is located in periyakulam, 22km from Theni to Periyakulam. Sengulathupatty is located in Periyakulam Taluk, 16 kms from Periyakulam to Sengulathupatty, 3kms from sengulathupatty to katroad. Katroad pond is located in Genguvarpatty. This village is located in Periyakulam Taluk of Theni district in Tamil Nadu, India. It is situated 21km away from sub-district headquarter periyakulam, 3 kms from katroad to sengulathupatty pond. Kattakamanpatty is a village in Vattalkundu Block in Dindigul District of Tamil Nadu State, India. It is located 39kms towards west from District headquarters of Dindigul. These pond water is used for agriculture, fisheries and   partially domestic activities. The present study was conducted to analyze the physico-chemical properties of water in the period of one year from July 2021 to June 2022.

Sample collection

Water samples were collected from July 2021 – June 2022 from the above mentioned ponds in plastic bottles each of one liter size the containers were properly washed with diluted hydrochloric acid and then rinsed with normal water fallowed by distilled water and then with sample water.

RESULT AND DISCUSSION

The results obtained in the physico chemical analysis of the water samples collected from July 2021 to June 2022. The concentration of 13 physical and chemical parameters of 5 ponds studied here. All the ponds can be easily compared.

Location variations in water revealed all the maximum and minimum values of all the physicochemical parameters which have been studied and calculated for thisresearch. Physicochemical parameters of the pond water displayed different characteristics with seasons of winter and summer. The results obtained from the physiochemical analysis are discussed below. The result of these 5 pond water is, pH range is normal in all (Meenakshipuram, Periyakulam, Sengulathupatty, Katroad and Kattakamanpatty) pond water .Temperature, Total Dissolved Solids, Salinity Electrical Conductivity, Free CO_2 were maximum in summer season and minimum in winter season. Dissolved Oxygen were maximum in winter season and minimum in summer season. Similar result of physico chemical parameters of water was reported by (Prasanjit Mukherjee et. Al. 2022)[4].

CONCLUSION

On the basis of above mentioned physico-chemical parameters of 5 pond water may be concluded that temperature, pH, Salinity, dissolved oxygen, free carbon dioxide, Total Dissolved Solids, alkalinity, Electrical Conductivity showed dissimilar values in Figure 1,2,3,4 and 5 at different places. Though based on this result these five pond should maintain in this way for various purposes like domestic, outdoor bathing, agriculture, fish culture and aquatic life propagation.

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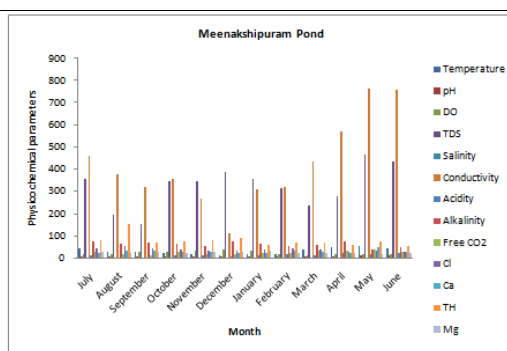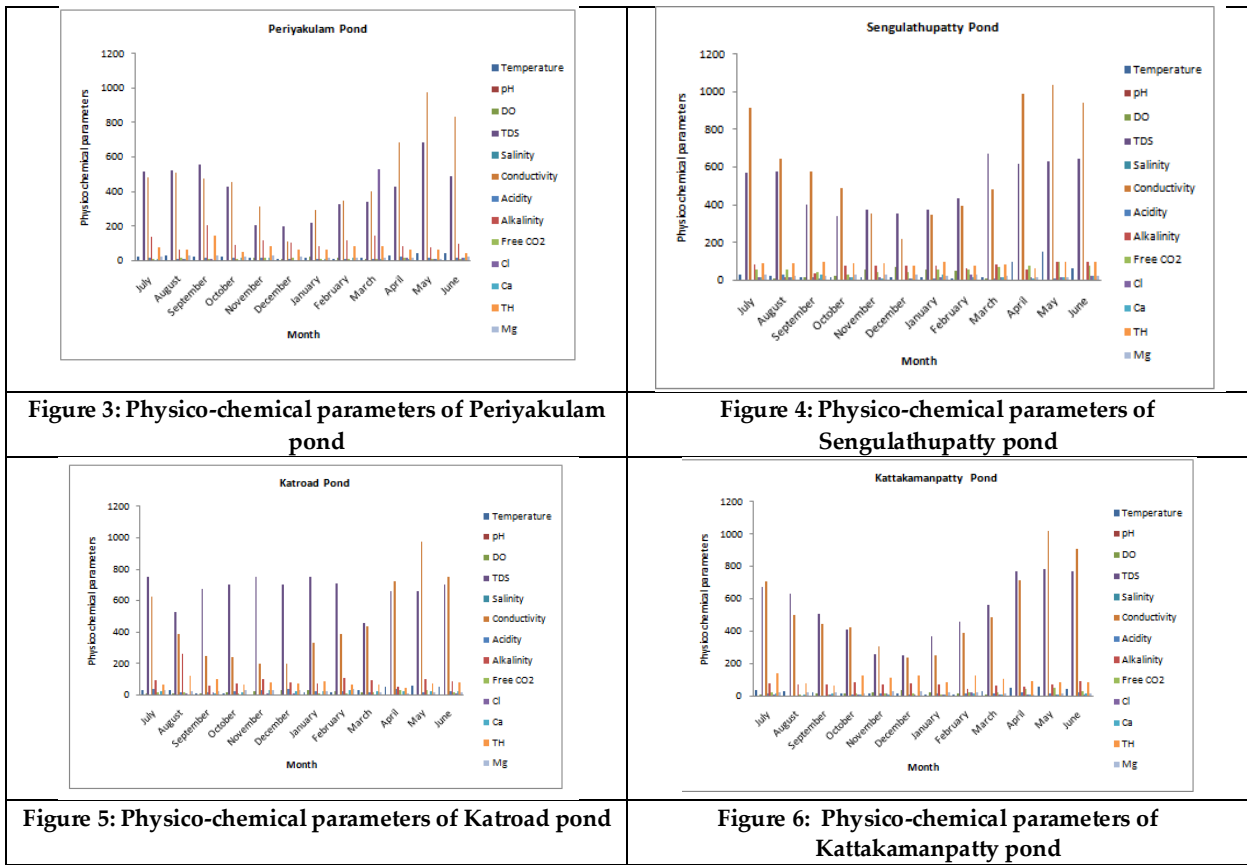
Figure 1	**Figure 2: Physico-chemical parameters of Meenakshipuram pond**

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Figure 3: Physico-chemical parameters of Periyakulam pond

Figure 4: Physico-chemical parameters of Sengulathupatty pond

Figure 5: Physico-chemical parameters of Katroad pond

Figure 6: Physico-chemical parameters of Kattakamanpatty pond

RESEARCH ARTICLE

Improving Amino Acid and Total Protein Composition of *Vigna radiata* L. Under Salt Stress by Foliar Spray of Brassinolide and Alpha - Tocopherol

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ABSTRACT

Soil salinity represents a significant global challenge that negatively impacts agricultural productivity. Salinity hinders plant growth and development through mechanisms such as water stress, cytotoxicity caused by the excessive accumulation of ions like sodium (Na^+) and chloride (Cl^-), and nutrient imbalances. Additionally, salinity is often associated with oxidative stress resulting from the production of reactive oxygen species (ROS). Salt stress disrupts the normal physiology of crop plants, leading to significant changes in ionic homeostasis, particularly in sodium, potassium, and calcium levels in roots, stems, and leaves.The application of plant growth regulators is a promising strategy to enhance crop productivity under stress conditions. Mungbean (*Vigna radiata* L.) is an important leguminous crop in South and Southeast Asia. Mungbeans contain approximately 20%–24% protein, along with essential amino acids, such as aromatic amino acids.In this experimental study, a pot culture experiment was conducted to evaluate the effects of NaCl and plant regulators Brassinolide and Alpha-tocopherol on *Vigna radiata* L. The growth regulators were applied foliar, with brassinolide at 4 mg/L and alpha-tocopherol at 200 mg/L concentration, while NaCl (80 mM) was applied via soil drenching. The plants were divided into six groups: control, NaCl, NaCl + Brassinolide, NaCl + Alpha-tocopherol, Brassinolide, and Alpha-tocopherol. Plant samples were collected for analysis randomly on the 25th, 35th, and 45th days after sowing to assess various biochemical parameters. The foliar application of alpha-tocopherol and brassinolide were found to mitigate salt stress in *Vigna radiata* L. enhancing growth and biochemical constituents**.**

Keywords: NaCl, Brassinolide, Alpha-tocopherol, Foliar, salinity.

INTRODUCTION

Soil salinity poses a significant challenge to agricultural productivity, impacting approximately 45 million hectares of irrigated land, with this figure anticipated to grow as a result of global climate change and various irrigation methods.[1]. The adverse impact of salt stress on crop yields is considerable, primarily because it leads to slower growth rates, decreased tillering, and, over time, negatively affects reproductive development. [2].The osmotic and ionic aspects of salt stress are recognized as the initial and secondary phases of the stress, respectively, with plants responding to each phase at distinct intervals. Osmotic stress, also known as the osmotic phase of salt stress, arises immediately when roots encounter solutions with excessively high salt concentrations in hydroponic systems or soil.[3]Following the application of NaCl, plants typically attain osmotic homeostasis promptly, typically within several hours or at least within the initial day after salt stress. [4]. The ionic stress from salinity stress, which comes in a second phase, starts to become more severe after 1-3 days of NaCl exposure. Although Na^+ ions quickly flow into the plants and travel to the shoots, it takes a few days for Na^+ levels to build up to a toxic point in the cells, leading to increased stress.[5].Salinization causes changes in the way electrons transfer from organelle central transport chains to oxygen-reduction pathways, which increases the generation of reactive oxygen species (ROS). Important biomolecules including lipids, proteins, nucleic acids, and amino acids are oxidized in part by these reactive compounds.[6].Reducing toxic reactive oxygen species (ROS) and addressing oxidative damage is crucial. Plants have evolved antioxidant defense systems comprising both enzymatic and nonenzymatic components. These systems help mitigate the harmful effects of ROS by converting them into less toxic forms. As a result, higher levels of antioxidants are generally linked to enhanced plant tolerance. [7].Plants respond to salinity stress in a variety of ways, which can result in changes to their morphology, physiology, biochemistry, and molecules. This is due to the fact that elevated salt levels are a major cause of nutritional imbalances.[8].

Plant growth regulators (PGRs) function as signaling molecules, providing plants with the flexibility required for growth and development, and are thus recognized as key components in the response of plants to both biotic and abiotic stressors [9]. PGRs are instrumental in mitigating the effects of salt stress by facilitating various physiological and developmental changes [10,11] In general, PGRs assist plants in decreasing the buildup of toxic salts while increasing the physiological availability of water and other nutrients. [12].The Application of Brassinolide and Alpha-tocopherol plant regulators on *Vigna radiata* L. effectively mitigated the adverse effects of salinity stress. Brassinolide, with the molecular formula $C_{28}H_{48}O_6$, enhances plant resilience to salinity stress by targeting redox regulation and osmotic adjustment mechanisms. This facilitates improved plant growth and development by elevating the activities of antioxidant enzymes and the levels of plant hormones, in addition to promoting the accumulation of osmolytes in response to salt stress.[13,14].similarly, Alpha-tocopherol has a prominent role in mitigating the salinity stress in plants by neutralizing singlet oxygen species and peroxides, which helps protect the photosystems and reduces lipid peroxidation under saline conditions. [15]. The ability to maintain membrane and organelle integrity under salt stress is strongly associated with the capacity to eliminate reactive oxygen species (ROS). This leads to enhanced activities of antioxidant enzymes, as well as increased levels of mineral ions (such as Ca^{2+} and K^+) and proline. [16,17].Mung beans (*Vigna radiata* L.) are a crucial edible legume crop cultivated on over 6 million hectares globally, accounting for approximately 8.5% of the world's total pulse cultivation area. They are widely consumed across many Asian households. [18].Mungbean is highly susceptible to salt stress, with significant effects on its growth and pigment composition. Even minimal quantities of saline water can provoke a strong response in Mungbeans. However, the application of Brassinolide and Alpha-tocopherol enhanced plant growth and reduced oxidative damage caused by NaCl-induced stress. [20,21]

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MATERIALS AND METHODS

Seed collection and Chemical reagents.

Vigna radiata L. (green gram) (CO-6 variety) seeds were purchased from Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. Chemical regulator Brassinolide and Alpha-tocopherol and analytical reagent NaCl were purchased from Sisco Research Laboratories [SRL]- Chennai-600117.

Experimental design

The experimental study was carried out at the Botanical Garden within the Department of Botany at Annamalai University in Tamil Nadu. The study was conducted at latitude 11°23'23.1" N and longitude 79°43'05.3"E. Healthy seeds were surface-sterilized using a 0.2% solution of mercuric chloride ($HgCl_2$) for two minutes, followed by thorough rinsing with double-distilled water (ddH_2O). The seeds were then distributed across 90 pots, divided into six groups. Each pot was filled with a soil mix consisting of red soil, sand, and farmyard manure in a 1:1:1 ratio. The treatments applied to the plants were as follows: (control), (80 mM NaCl), (80 mM NaCl + 4 mg/L BL) (80 mM NaCl+ 200 mg/L alpha-toc), (4 mg/L of BL,) and (200 mg/L of alpha-tocopherol.) To maintain the desired levels of salinity in each pot, soil samples were regularly monitored using an electrical conductivity meter.Plants were harvested for biochemical analysis at three distinct intervals: 25th, 35th, and 45th days after sowing (DAS). These collection times provided a basis for assessing the impact of the various treatments on the plants' growth and biochemical properties**.**

PROTEIN CONTENT

The soluble protein content was quantified following the Bradford (1976) protocol. The extraction process began by grinding one gram of fresh plant material in a mortar and pestle with 20 ml of 20% trichloroacetic acid (TCA). The homogenate was centrifuged for 15 minutes at 800 rpm, after which the supernatant was discarded. To solubilize the proteins in the pellet, 5 ml of 0.1 N sodium hydroxide (NaOH) was added, and the solution was centrifuged again at 800 rpm for 15 minutes. The supernatant was then collected, brought to a final volume of 10 ml with 0.1 N NaOH, and used for protein quantification. To estimate protein content, 0.1 ml containing 10 to 50 µg of protein was pipetted into 12×100 mm test tubes. To each test tube, 5 ml of Bradford protein reagent was added, and the contents were mixed with a vortex mixer. Absorbance was measured at 595 nm after 2 minutes against a reagent blank. The blank was prepared with 0.1 ml of distilled water, 0.1 ml of 0.1 N NaOH, and 5 ml of Bradford reagent. A standard curve was generated by plotting the absorbance against the corresponding weight of a known protein standard (bovine serum albumin, BSA), using a Nano Drop spectrophotometer (Implen- Inkarp 380). This standard curve was used to determine the protein content in the unknown samples, with results reported in milligrams per gram of dry weight.

FREE AMINO-ACID

The total free amino acids were extracted and quantified following the method described by Moore and Stein (1948). Initially, 500 milligrams of fresh plant material were ground in a mortar and pestle with 10 ml of 80% boiling ethanol. The homogenate was centrifuged at 800 × g for 15 minutes, and the supernatant was adjusted to a total volume of 10 ml with 80% ethanol, preparing it for further analysis.For the estimation of free amino acids, 1 ml of the ethanol extract was transferred to a 25 ml test tube and neutralized with 1 ml of 0.1 N sodium hydroxide (NaOH), using a drop of methyl red indicator to determine the point of neutralization. Subsequently, 1 ml of ninhydrin reagent was added to the test tube and thoroughly mixed. The entire mixture was then boiled in a water bath for 20 minutes. After boiling, 5 ml of a diluting solution was added, and the tube was cooled under running tap water. The volume was adjusted to 25 ml with distilled water, and the absorbance was measured at 570 nm using a UV-visible spectrophotometer (Model-118, Systronics India Limited, Gujarat, India) against an appropriate blank. A standard curve was generated using leucine as the standard, and the amino acid content in the sample was calculated based on this curve. The results were expressed in milligrams per gram of dry weight.

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Statistical Analysis

Experimental data were statistically analyzed using SPSS software (Version 22.0), with one-way analysis of variance (ANOVA) employed to determine significant differences among treatment groups. The data presented in the bar graphs represent the mean values from multiple replicates. Statistical significance was assessed using Dunnett's Multiple Range Test (DMRT), with a threshold of P ≤ 0.05.

RESULTS AND DISCUSSIONS

PROTEIN CONTENT

Leaf

As per our study Under NaCl stress, *Vigna radiata* L. plants experienced a reduction in leaf-soluble protein content compared to the control group across all observation periods. Specifically, the decreases were 50.43%, 53.42%, and 57.95% relative to the control on the 25th, 35th, and 45th days after sowing (DAS), respectively. However, the application of BL and alpha-tocopherol individually to NaCl-stressed *Vigna radiata* L. plants resulted in a notable rise in leaf protein content compared to NaCl-stressed plants without these treatments, with respective increases of 85.78% and 75.73% relative to the control on the 45th DAS. (Fig-1). Despite this improvement, the levels remained below those of the control group. However, the plants treated with Alpha toc and BL without salt stress protein content found to increase it was148.22 and 133.23 % respectively compared to the control. Previous studies have also found salt stress to decrease the total protein content in many plants like*Solanum lycopersicum* [22] *Vicia faba* [23]. *Phaseolus vulgaris* [24]. Exogenous application of BL and Alpha-toc enhances the protein content and mitigates the salinity stress in *maize* and *Helianthus annuus*, [25,26]. As these two regulators play a prominent role in mitigating the salinity stress in plants.

Stem

The protein content in the stems of green gram plants decreased when subjected to NaCl salt stress compared to the control group across all growth stages, with the most substantial reduction occurring at 50 days after sowing (DAS). (Fig-2)The recorded reductions in protein content were 46.87%, 52.27%, and 59.34% relative to the control at 25th, 35th, and 45thDAS, respectively. Conversely, the use of BLand alpha-tocopherol to NaCl-stressed green gram plants resulted in an increase in stem protein content compared to those plants experiencing NaCl stress alone, with observed increases of 91.35% and 79.67% relative to the control on the 45th DAS, respectively. However, these increases were lower than those in control plants and other non-stressed plants. Moreover, when brassinolide and alpha-tocopherol were applied to non-stressed plants, there was a further increase in the soluble protein content of the stem compared to the control group. The recorded increases were 154.67% and 139.01% relative to the control at 45 DAS, respectively.The decrease in soluble protein content caused by NaCl, as noted in our results, has also been observed in other plants like Cowpea [27] *Catharanthus roseus*[28] *Hordeum vulgare.* [29].Applying foliar alpha-tocopherol (α-Toc) at a concentration of 150 mg/L to *Pelargonium graveolens* L. improves plant health and increases crude protein levels. [30]. Inthe present study, the foliar applied growth regulators BL and Alpha-toc enhance the protein content in stems similar results were found by researchers in*Leymus chinesis* [31] *soybean* [32]

Root

The soluble protein content in the roots of *Vigna radiata* L. plants decreased under NaCl stress across all sampling days compared to the control group. The reductions were 37.07%, 52.67%, and 65.07% relative to the control on the 25th, 35th, and 45th days after sowing (DAS), respectively. However, foliar use of BL and alpha-tocopherol to NaCl-stressed plants led to an increase in root protein content compared to plants subjected to salt stress alone, with observed increases of 90.99% and 77.57% relative to the control on the 45th DAS, respectively. Despite these increases, the levels remained lower than those of the control group. Further, the individual foliar spray of BL and alpha-tocopherol to unstressed plants resulted in a greater increase in root protein content compared to the control group, with respective increases of 155.8% and 134.92% relative to the control on the 45th DAS.(Fig-3)As per this

study, the salt stress decreases the protein content in the plants treated with salt stress, however, the plants treated with BL and Alpha toc ameliorated the salinity stress similar results were found in *mustard* [33]. And *wheat* [34]

FREE AMINO ACID CONTENT.
Leaf
The concentration of free amino acids increased in the leaves of *Vigna radiata* L. plants under NaCl salt stress across all sampling days compared to the control group, with recorded increases of 177.09%, 187.22%, and 193.08% over the control on the 25th, 35th, and 45th days after sowing (DAS), respectively. However, individual foliar sprays of brassinolide and alpha-tocopherol to salt-stressed green gram plants resulted in a decrease in leaf,free amino acid content compared to NaCl-stressed plants. However, this reduction was still higher than that of the control group, with decreases noted as 183.60% and 188.12% over the control on the 45th DAS.Additionally, foliar spray of BL and alpha-tocopherol individually to non-stressed green gram plants further enhanced the leaffree-amino acid content compared to the control group, with increases of 108.27% and 101.20% over the control, respectively, on the 45th DAS. (Fig-4) The rise in amino acid levels in plants subjected to saline conditions is a result of protein degradation. [35]. Similar results of an increase in amino-acid content under salt stress have been found in *snap bean* [36]*Medicago sativa* [37] and *Solanum lycopersicum* L. [38]. However, the plants applied with Alpha-toc and brassinolide mitigated the salinity stress and an increase in amino acid content; similar outcomes were observed in *Vigna radiata* L. [39] and *Okra* plants [40].

Stem
According to our study, the free amino acid content increased in the stems of green gram plants subjected to NaCl stress across all growth stages and on all sampling, days compared to the control group. The recorded increases were 219.43%, 225.61%, and 229.39% over the control at 25, 35, and 45 days after sowing (DAS), respectively. However, foliar spraying of brassinolide and alpha-tocopherol on salt-stressed plants led to a decrease in stem free amino acid content compared to NaCl-stressed plants without these treatments, with values of 209.13% and 211.35% over the control on the 45th DAS, respectively. Despite the reduction, these levels remained higher than those in the control group. Additionally, the individual application of brassinolide and alpha-tocopherol via foliar spray to non-stressed plants led to a further increase in stem free amino acid content compared to the control group, with increases of 110.02% and 106.01% over the control on the 45th DAS, respectively (Fig-5). As per our Experimental study, the amino acid content was found high in NaCl-treated plants than the plants foliar applied with BL and Alpha-toc under salt stress many authors found similar resultsin *sorghum bicolor* [41]. *Pisum sativum.* [42] Additionally, free amino acids are osmoregulation compounds that protect plants from salt stress by lowering membrane permeability and thus improving membrane tolerance. [43]

Root
Our experimental study revealed that green gram plants exposed to NaCl stress experienced an increase in the free amino acid content of roots compared to the control group on all sampling days. The recorded values were 181.85%, 192.04%, and 195.37% over the control on the 25th, 35th, and 45th days after sowing (DAS), respectively (Fig. 6). However, the individual foliar spray of BL and alpha-tocopherol to NaCl-stressed plants caused a substantial decrease in the free amino acid content of roots compared to plants subjected to NaCl stress alone, with recorded values of 182.56% and 188.61% over the control on the 45th DAS. Nevertheless, these reductions were still higher than those in the control group. Additionally, the foliar spray of BL and alpha-tocopherol to non-stressed plants resulted in a further increase in root free amino acid content compared to the control group, with values of 108.54% and 105.16% over the control on the 45th DAS. Salt stress increased the root amino acid content it was found higher in the plants treated with salt alone than in the plants applied with Brassinolide and Alpha-tocopherol similar results were found by other authors in *Phragmites australis* [44]. In Rice [45] and in *Glycine max* [46].

CONCLUSION

Salinity poses a significant threat to agriculture, with far-reaching implications for crop productivity, and soil health. The accumulation of salts in soil and water leads to osmotic stress, and ion toxicity, ultimately impacting plant growth and yield. Salt stress adversely affects both protein and amino acid content in plants. The decrease in protein content hampers plant growth, while variations in amino acid levels indicate a stress response. The foliar Spray of BL and Alpha-tocopherol to salt-stressed plants shows a substantial increase in protein and amino acid contents overall the plants respond well to exogenous application of brassinolide and Alpha-tocopherol.

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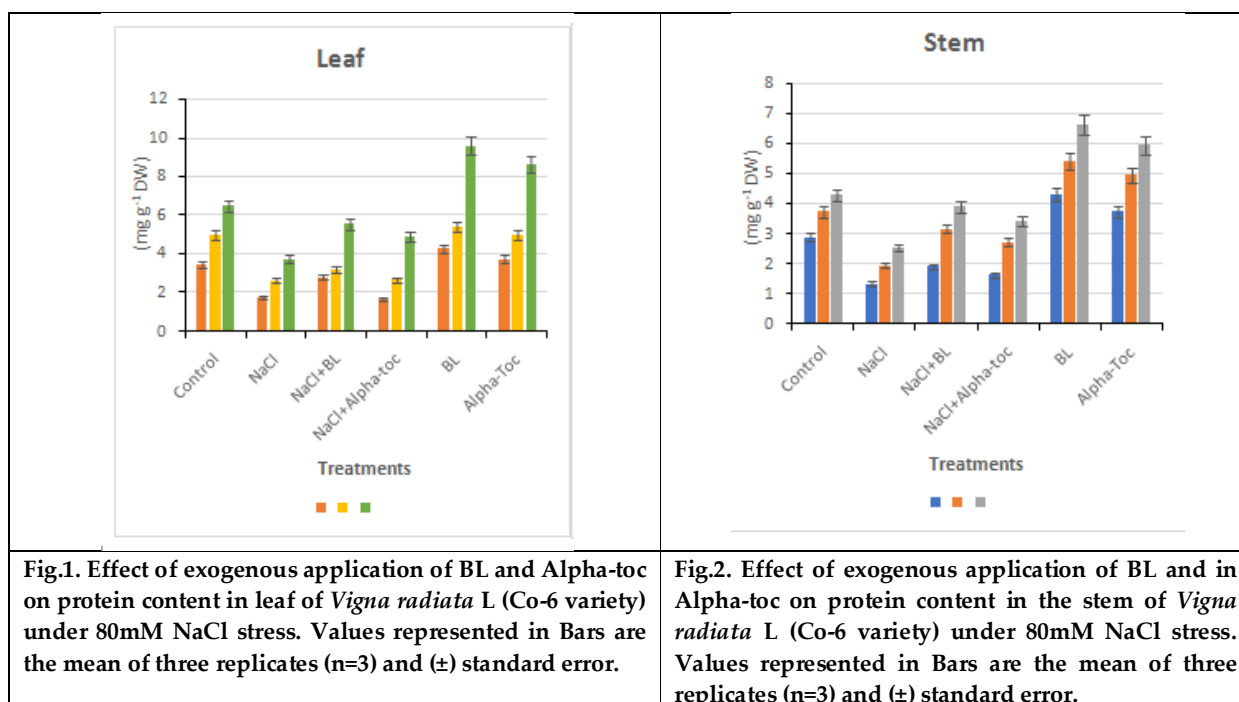
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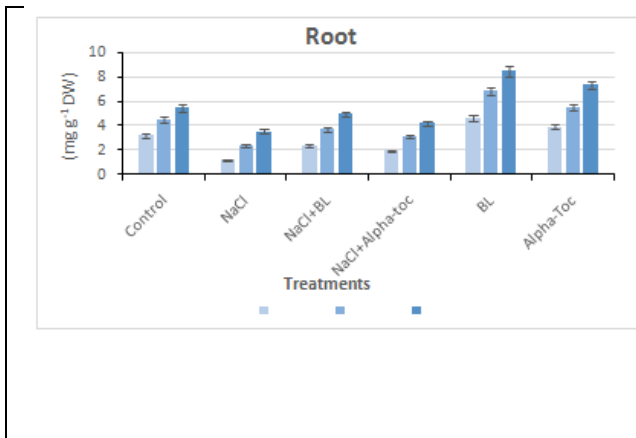
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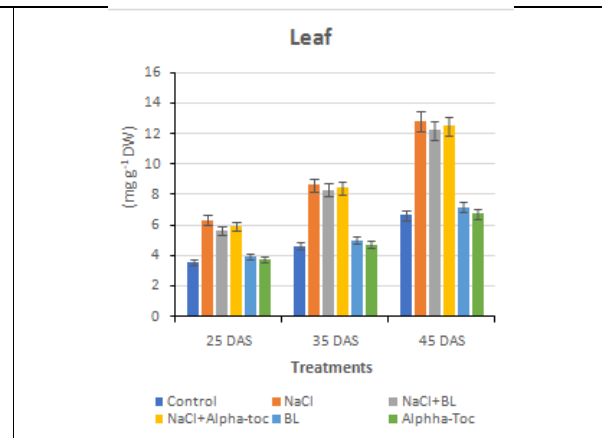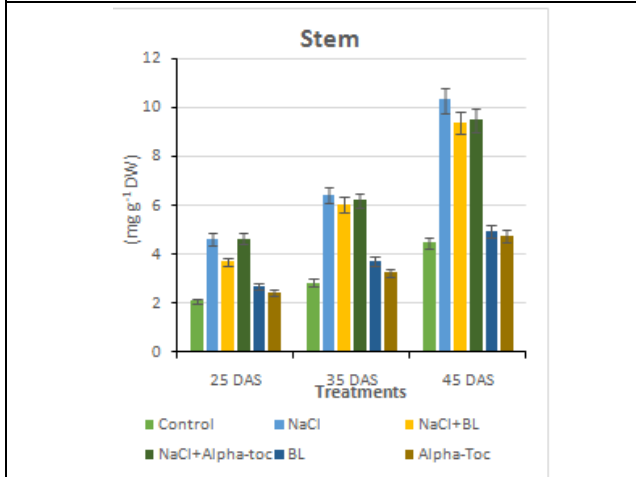
Fig.1. Effect of exogenous application of BL and Alpha-toc on protein content in leaf of *Vigna radiata* L (Co-6 variety) under 80mM NaCl stress. Values represented in Bars are the mean of three replicates (n=3) and (±) standard error.

Fig.2. Effect of exogenous application of BL and in Alpha-toc on protein content in the stem of *Vigna radiata* L (Co-6 variety) under 80mM NaCl stress. Values represented in Bars are the mean of three replicates (n=3) and (±) standard error.
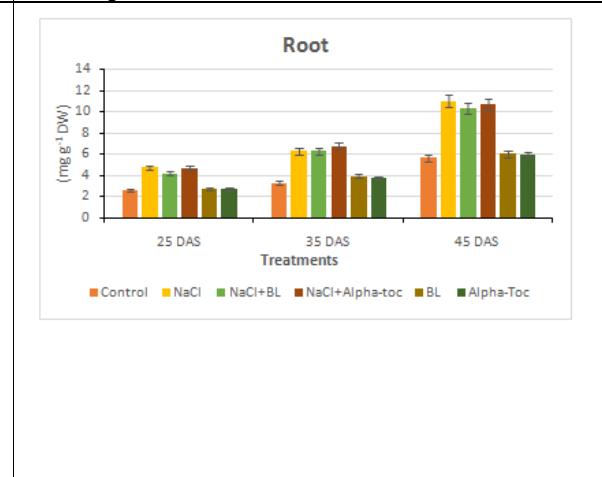
Fig.3. Effect of exogenous application of BL and in Alpha-toc on protein content in the Root of *Vigna radiata* L (Co-6 variety) under 80mM NaCl stress. Values represented in Bars are the mean of three replicates (n=3) and (±) standard error.

Fig.4. Effect of exogenous application of BL and Alpha-toc on Amino-acid content in the leaf of *Vigna radiata* L (Co-6 variety) under 80mM NaCl stress. Values represented in Bars are the mean of three replicates (n=3) and (±) standard error.

Fig.5. Effect of exogenous application of BL and Alpha-toc on Amino-acid content in the stem of *Vigna radiata* L (Co-6 variety) under 80mM NaCl stress. Values represented in Bars are the mean of three replicates (n=3) and (±) standard error.

Fig.6. Effect of exogenous application of BL and Alpha-toc on Amino-acid content in the root of *Vigna radiata* L (Co-6 variety) under 80mM NaCl stress. Values represented in Bars are the mean of three replicates (n=3) and (±) standard error.

RESEARCH ARTICLE

Optimization of Inventory Model with Carbon Emissions - Kuhn Tucker Technique Approach using MATLAB

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ABSTRACT

Companies are currently looking for solutions to reduce carbon emissions their functions. Functional adjustments such as volume sizes or order changes measures have proven to be an excellent way to reduce emissions. A model has been proposed that takes into account the relationship between an Freight Policy (EOQ) carbon emissions and price and tax. In one case the external price is determined by two optimal levels that maximize the retailer's profit and reduce carbon emissions. Conditions that allow a company to maximize profits when reducing the emissions and mechanisms that allow a company to increase its profitability is determined to reduce its carbon emissions. Companies are currently looking for solutions to reduce carbon emissions their functions. There are functional adjustments such as modifying block sizes or order sizes has been proven to be an excellent way to reduce emissions. In this paper, a model is proposed takes into account the relationship between a commodity policy (EOQ), total carbon emissions and both price and tax. In terms of external price, optimal measures to increase retailer profit and reduce carbon emission (EOQ) determined. In this paper, a model is proposed that the relationship between an inventory model (EOQ) and total carbon emissions, both crisp and fuzzy sense. This model has been considered and analyzed in trapezoidal fuzzy sense. The behavior of the main features of the inventory model is carried out through by using Robust ranking defuzzification method.

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Numerical assessment and affectability examination is cultivated for allowing the authenticity and strength of the model.

Keywords: Inventory model ,Order quantity, Robust ranking defuzzification, Kuhn-tucker method.

INTRODUCTION

Stock is in a real sense characterized as a stock or store of products. These products are kept up with by a business to satisfy need and satisfy its motivation. Business need to look closely at how they can optimize their inventory management to maximize their profits. The EOQ is a model used to determine the optimal order quantity for an item of stock that minimises ordering and carrying costs. Currently companies are increasingly responding to sensitivity and carbon emissions (Emissions of carbon dioxide and other greenhouse gases) related to their activities(Colette and Venkat, 2009; Stock et al., 2010). Under the influence of their customers, they enhance socially responsible consumption practices (Gonzalez et al. 2009), further governments and other pressure groups are working to reduce their carbon footprint track. in a recent paper Sen et al .(2013) note that companies are often the focus reducing emissions by discoveries of related physical processes, For example , Redesigning, sorting and utilizing low-pollution energy sources for products and packaging;or replacing energy-efficient equipment and facilities ... for example, determining how frequent supply distributions can be important in mitigating carbon emissions energy efficiency of vehicles used to make these deliveries (Benzafar et al., 2013). Functional adjustments such as changes in block sizes or order sizes have been demonstrated Should be a better way to reduce the impact of carbon emissions (Colette and Venkat, 2009; Hua and Al., 2011; Pouchery et al., 2012; Sen et al., 2013).Thus, in recent years, green and fixed supply chain management is fully explored seuring Literary Studies (2013). In the following art position, we will focus on papers inventory management, handling demand and vertical model stability integration. Hua et al. (2011) proposes an ecological approach to integrated inventory management implications of carbon cost for both order location (mainly transportation) and holding stock (savings).The proposed model extends the economic order size model (Harris, 1913; Wilson, 1934) to account for carbon emissions under cap and trade system. They conclude that there is an optimal sequence size between those calculated classically Economic quantity (excluding CO2 cost) and quantitative reduction Carbon emissions. They also prove that there are certain conditions for reducing both economies costs and carbon emissions.Wahab et al. (2011), meanwhile, provide an approach that is optimal define supply / production policy to reduce total distribution cost in global distribution chain.

 They show that taking into account the impact of the environment leads to reduction frequency of distributions. Bonney and Jaber (2011) show an increase in the volume of products frequency of delivery carried and reduced compared to those proposed by the traditional EOQ model gives the best results in terms of ordering costs and carbon emissions. The latter two models, however, are smaller than the Hua et al. (2011); They will not take into account the "cap and trade" system, and is limited to the study of reductionCO2 emissions from transport, (emissions associated with storage are not considered). Bouchery et al. (2012) proposes to integrate all parameters of sustainable development (SD), inventory management, including a social aspect not found in other works Samples. They restructure the classic economic order size model for a number of purposes problem (standard array size model - called SOQ). It follows two important points their work. First, it helps to minimize any SD impact by requiring a small increase cost, which is in line with the results of Hua et al. (2011) Second, it is sometimes not can have overall environmental, economic and social performance, which guided them proposes a trade between different parameters. Sen et al. (2013) First, provides conditions that can reduce emissions modifying order quantities and, secondly, the comparative reduction in emissions is greater than this comparative cost increase. This article is also interesting because the authors discuss it the applicability of their results to systems under different environmental regulations carbon tax, cap and offset and example systems with cap and price. Pattini et al. (2014) propose a standard EOQ model that integrates transport and environmental impacts storage. They evaluate the impact of sustainability considerations on purchasing decisions comparison with the traditional EOQ model. In particular, for

the same mode of transport, there is no significant difference between the traditional and standard model, but it is the difference increases with the rising prices of goods. El Sadani et al. (2011) studied a simple two-echelon supply chain model in which demand is required depending on the environmental quality of the systems (measured using thirty criteria) and related costs. Clock et al. (2012) Present a model illustrating the trade between sustainability, demand, costs and profit in the supply chain. They show that partners can attract more customers by controlling emissions and scrap. Also, gross profit is high but in terms of collaboration the product quality is low. Noira et al. (2013) proposal a non-linear non-profit activity that takes into account green-based demand. Choose allows production processes (technology) and input products to improve profitability in terms of environmental need. In particular, show that a company increases its profitability and reduces its carbon footprint green market. Chen and Wang [1] proposed fuzzy Economic production quantity model for items with imperfect quality. Wang and Ye [4] transformed a comparison between just in - time and economic order quantity models with carbon emissions. Chen and Chang [6] developed optimization of fuzzy production inventory model with unrepairable defective products. Fuzzy EOQ model with demand dependent unit cost under limited storage capacity provided by Roy and Maiti [10],Wee & Daryanto (2020)[3] introduced Imperfect quality item inventory models considering carbon emissions, Gupta (1988)[5] investigated An improved procedure for economic order quantity with all-units price discounts, Bjork[8]proposed An analytical solution to a fuzzy economic order quantity problem. This paper standardized as follows: The next section, In section2, Notation and mathematical crisp model are proposed , Mathematical fuzzy model , Kuhn- tucker technique and optimization method derived in section 3, In section 4, a numerical examples and sensitivity analysis are given, finally conclusion is provided in section 5.

Model Description
Notations
The notations used in this inventory models are :
θ = Order quantity
α =Storage cost per period
A = Average carbon emissions per unit
n = Number of goods per period
λ =Order cost per cycle
R = The price per unit
p = Power plant's standard emission
t = tax
F = Fixed costs
M = Mileage from the supplier
β =Fuel consumption if empty vehicles
γ =Additional fuel consumption per unit
w =Item weight
v =Variable costs for shipping goods
b =Cost of carbon emissions from vehicles
c =Additional costs of carbon emissions from transportation of one item
S= Fuel's standard emission
TI(θ) =The total inventory cost
TE(θ) = Total carbon emissions.

Sample development
In this inventory model, there are discount factors and carbon emissions that affect total inventory cost. Total inventory cost is the amount purchased expenses, ordering costs, storage costs and transportation costs. Purchase costs are the costs of purchasing goods. The provides discount table with supplier pricematerials per unit are defined as follows (Gupta, 1988;Taleizadeh & Pentico, 2014):

$$P_i = \begin{cases} P_0 \, for q_0 \le Q \le q_1 \\ P_1 \, for q_1 \le Q \le q_2 \\ \dots\dots\dots\dots\dots \\ P_n \, for q_n \le Q \end{cases}$$ ....(3.1)

Q is the array size, $P_i > P_{i+1}$, and i = 0, 1, 2, 3,…, N is the code for the discount table. If there is a n unit demand in a year, the total the cost of purchase in a year is the product of the price of the itema unit with the required quantity, viz

$$C_P = Rn$$ ....(3.2)

The cost of ordering is a one-time fee per order submitted. If the order costs are S, the sum the cost of ordering will increase once a year order cost with order frequency in one year.

$$C_0 = \frac{\lambda n}{\theta}$$ ....(3.3)

If the storage cost of a unit of goods is specified in hPi considering the average cost of carbon per year emission in warehouse, then

$$C_s = (\alpha R + APt)\frac{\theta}{2}$$ ....(3.4)

If t = 0, then the equations are (3.2), (3.3), and (3.4) like Gupta (1988), it is an EOQ model All unit discounts regardless of carbon emissions. The cost of transportation has a fixed cost, some variable costs, and the cost of carbon emissions vehicle use (We & Toronto, 2020). Therefore, the transportation cost per year

$$C_t = (F + (2M\beta v + M\gamma w\theta v) + 2Ma + Mb\theta)\frac{n}{\theta}$$ ....(3.5)

Total inventory cost for a year purchase cost, order cost, storage cost, and transportation cost

$$TI(\theta) = C_P + C_0 + C_s + C_t$$ ....(3.6)

$$TI(\theta) = Rn + \frac{\lambda n}{\theta} + \frac{\theta \alpha R}{2} + \frac{\theta Apt}{2} + \frac{n}{\theta}\left(F + (2M\beta v + M\gamma w\theta v) + (2Ma + Mb\theta)\right)$$ ....(3.7)

From equation (3.7), we can get an equation calculate total carbon emissions TE(θ) from storage and transport operations, namely:

$$TE(\theta) = \frac{\theta}{2}AP + \frac{n}{\theta}(2M\beta S + M\gamma wS\theta)$$ ....(3.8)

Inventory Model in crisp Sense
The total inventory cost is,

$$TI(\theta) = Rn + \frac{\lambda n}{\theta} + \frac{\theta \alpha R}{2} + \frac{\theta Apt}{2} + \frac{n}{\theta}\left(F + (2M\beta v + M\gamma w\theta v) + (2Ma + Mb\theta)\right)$$

The above total inventory cost partially with respective to
θ and equating it to zero, we get the crisp order quantity.
For the crisp order quantity

$$\theta = \sqrt{\frac{2n(\lambda + F + 2M\beta v + 2Ma)}{Apt + \alpha R}}$$

Inventory Model in Fuzzy Sense

We consider the price per unit and tax are taken as trapezoidal fuzzy numbers. Therefore the fuzzy total inventory cost becomes

$$TI(\theta) = Rn + \frac{\lambda n}{\theta} + \frac{\theta \alpha \tilde{R}}{2} + \frac{\theta Ap\tilde{t}}{2} + \frac{n}{\theta}\left(F + \left(2M\beta v + M\gamma w\theta v\right) + \left(2Ma + Mb\theta\right)\right)$$

Let $\tilde{R}$ denotes the fuzzy price per unit and $\tilde{t}$ denotes fuzzy tax which are characterized by the trapezoidal fuzzy numbers by $\tilde{R} = (R_1, R_2, R_3, R_4)$, $\tilde{F} = (F_1, F_2, F_3, F_4)$, $\tilde{t} = (t_1, t_2, t_3, t_4)$ respectively.

We get the fuzzy total inventory cost is,

$$\tilde{TI}_1(\theta) = \begin{bmatrix} \frac{\theta}{2}(\alpha R_1 + Apt_1) + \frac{n}{\theta}(\lambda + F_1 + 2M\beta v + 2Ma) + n(R_1 + M\gamma wv + Mb), \\ \frac{\theta}{2}(\alpha R_2 + Apt_2) + \frac{n}{\theta}(\lambda + F_2 + 2M\beta v + 2Ma) + n(R_2 + M\gamma wv + Mb), \\ \frac{\theta}{2}(\alpha R_3 + Apt_3) + \frac{n}{\theta}(\lambda + F_3 + 2M\beta v + 2Ma) + n(R_3 + M\gamma wv + Mb), \\ \frac{\theta}{2}(\alpha R_4 + Apt_4) + \frac{n}{\theta}(\lambda + F_4 + 2M\beta v + 2Ma) + n(R_4 + M\gamma wv + Mb) \end{bmatrix}$$

Defuzzification of Trapezoidal fuzzy numbers by Robust ranking method

Let $A = (a_1, a_2, a_3, a_4)$ be trapezoidal fuzzy number . Let $\tilde{A} = \int_0^1 (0.5)[A_L(\alpha), B_L(\alpha)]d\alpha$

Where $[A_L(\alpha), B_L(\alpha)] = \{(a_2 - a_1)\alpha + a_1, a_4 - (a_4 - a_3)\alpha\}$ .Then $\tilde{A} = \dfrac{a_1 + a_2 + a_3 + a_4}{4}$

Now, Using Robust ranking method for trapezoidal numbers defuzzification ,then the fuzzy total inventory cost becomes,

$$R\left(\tilde{TI}_1(\theta)\right) = \frac{1}{4}\begin{bmatrix} \frac{\theta}{2}(\alpha R_1 + Apt_1) + \frac{n}{\theta}(\lambda + F_1 + 2M\beta v + 2Ma) + n(R_1 + M\gamma wv + Mb) + \\ \frac{\theta}{2}(\alpha R_2 + Apt_2) + \frac{n}{\theta}(\lambda + F_2 + 2M\beta v + 2Ma) + n(R_2 + M\gamma wv + Mb) + \\ \frac{\theta}{2}(\alpha R_3 + Apt_3) + \frac{n}{\theta}(\lambda + F_3 + 2M\beta v + 2Ma) + n(R_3 + M\gamma wv + Mb) + \\ \frac{\theta}{2}(\alpha R_4 + Apt_4) + \frac{n}{\theta}(\lambda + F_4 + 2M\beta v + 2Ma) + n(R_4 + M\gamma wv + Mb) \end{bmatrix}$$

$$= \tilde{TI}$$

To find the fuzzy order quantity $\tilde{\theta}$ which can be obtained by the solution of the first order differential equation $\dfrac{d}{d\theta}TI_1(\theta) = 0$ .Then the result is,

$$\tilde{\theta} = \sqrt{\frac{2n\left(4\lambda + \left(F_1 + F_2 + F_3 + F_4\right) + 8M\beta v + 8Ma\right)}{\alpha(R_1 + R_2 + R_3 + R_4) + Ap(t_1 + t_2 + t_3 + t_4)}} \, .$$

Fuzzy optimal order quantity by using Kuhn-tucker method

Suppose the fuzzy order quantity $\tilde{\theta}$ be a trapezoidal fuzzy number $\tilde{\theta} = (\theta_1, \theta_2, \theta_3, \theta_4)$ with $0 < \theta_1 \le \theta_2 \le \theta_3 \le \theta_4$. Then the fuzzy total inventory cost after using Robust ranking methor for trapezoidal numbers defuzzification ,weget

$$R\left(\tilde{TI}_2(\theta)\right) = \frac{1}{4}\begin{bmatrix} \frac{\theta_1}{2}(\alpha R_1 + Apt_1) + \frac{n}{\theta_4}(\lambda + F_1 + 2M\beta v + 2Ma) + n(R_1 + M\gamma wv + Mb) + \\[2mm] \frac{\theta_2}{2}(\alpha R_2 + Apt_2) + \frac{n}{\theta_3}(\lambda + F_2 + 2M\beta v + 2Ma) + n(R_2 + M\gamma wv + Mb) + \\[2mm] \frac{\theta_3}{2}(\alpha R_3 + Apt_3) + \frac{n}{\theta_2}(\lambda + F_3 + 2M\beta v + 2Ma) + n(R_3 + M\gamma wv + Mb) + \\[2mm] \frac{\theta_4}{2}(\alpha R_4 + Apt_4) + \frac{n}{\theta_1}(\lambda + F_4 + 2M\beta v + 2Ma) + n(R_4 + M\gamma wv + Mb) \end{bmatrix}$$

By using Kuhn-tucker technique to find the optimal solution of $\theta_1, \theta_2, \theta_3 \,\&\, \theta_4$. To minimize the total inventory cost, subject to $\theta_2 \ge \theta_1 \ge 0, \theta_3 \ge \theta_2 \ge 0, \theta_4 \ge \theta_3 \ge 0, \,\&\,\theta_1 > 0$.

The Kuhn-tucker techniques are,

$\lambda \le 0$

$\nabla f\left(\tilde{TI}_2(\theta)\right) - \lambda i \nabla g(\theta) \;=\; 0$

$\lambda i \nabla gi\,(\theta) \;=\; 0$

$gi(\theta) \;\ge\; 0$

After simplifying we get,

$\lambda_1, \lambda_2, \lambda_3, \lambda_4 \le 0$

$$\left.\begin{aligned} &\frac{1}{4}\left[\frac{1}{2}(\alpha R_1 + Apt_1) - \frac{n}{\theta_1^2}(\lambda + F_4 + 2M\beta v + 2Ma)\right] + \lambda_1 - \lambda_4 = 0 \\[2mm] &\frac{1}{4}\left[\frac{1}{2}(\alpha R_2 + Apt_2) - \frac{n}{\theta_2^2}(\lambda + F_3 + 2M\beta v + 2Ma)\right] - \lambda_1 + \lambda_2 = 0 \\[2mm] &\frac{1}{4}\left[\frac{1}{2}(\alpha R_3 + Apt_3) - \frac{n}{\theta_2^2}(\lambda + F_2 + 2M\beta v + 2Ma)\right] - \lambda_1 + \lambda_3 = 0 \\[2mm] &\frac{1}{4}\left[\frac{1}{2}(\alpha R_4 + Apt_4) - \frac{n}{\theta_1^2}(\lambda + F_1 + 2M\beta v + 2Ma)\right] - \lambda_3 = 0 \\[2mm] &\lambda_1(\theta_2 - \theta_1) = 0 \\[1mm] &\lambda_2(\theta_3 - \theta_2) = 0 \\[1mm] &\lambda_3(\theta_4 - \theta_3) = 0 \\[1mm] &\lambda_4(\theta_1) = 0 \end{aligned}\right\} \to (1)$$

$But \left(\theta_2 - \theta_1\right) \geq 0$

$\left(\theta_3 - \theta_2\right) \geq 0$

$\left(\theta_4 - \theta_3\right) \geq 0$

$\theta_1 > 0$

Because $\theta_1 > 0$ and $\lambda_4\left(\theta_1\right) = 0$ then $\lambda_4 = 0$. If $\lambda_1 = \lambda_2 = \lambda_3$ then $\theta_4 < \theta_3 < \theta_2 < \theta_1$, it does not satisfy the constrains $0 < \theta_1 \leq \theta_2 \leq \theta_3 \leq \theta_4$. T

Therefore $\theta_2 = \theta_1, \theta_3 = \theta_2, \theta_4 = \theta_3$

i.e., $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \tilde{\theta}$.

Hence from equation from (1) ,we get the order quantity $\tilde{\theta}$ is given by,

$$\tilde{\theta} = \sqrt{\frac{2n\left(4\lambda + \left(F_1 + F_2 + F_3 + F_4\right) + 8M\beta v + 8Ma\right)}{\alpha(R_1 + R_2 + R_3 + R_4) + Ap(t_1 + t_2 + t_3 + t_4)}}$$

Numerical Example

Let us consider the following values ,

α=0.2 /period , n=1000 unit/period , A=1.44 k Wh/ unit / period , λ=10, p=0.0005 ton CO_2/k Wh , s = 2.6 kg CO_2/ L =0.0026 ton CO_2/ L , t =$ 75 /ton CO_2 ,M=100 km , β= 27 L/100 km , γ =0.57 L/100 km ,w =0.01 ton /unit , F=$50 , v=$0.75/L, a=$0.05265 /km , b=$ 1.1115 ×10^{-5}/unit/km ,R= $4.

Solution

Crisp model

The crisp optimal solution is, θ= **3106.43737**, $TI(\theta) = \$$ **7081.398**

In Table 4.1,If reduce the price per unit, then the crisp total cost and the total emissions decreases. Furthermore, the crisp optimum order quantity increase when reduce the price per unit.

The following figures 4. 1,4.2 ,4.3 are indicates graphical representation of θ ,TI,TE when decrease the price per unit

Fuzzy Model

Let F=(35,45,55,65) , R=(2.5,3.5,4.5,5.5) , t̃= (60,70,80,90) be trapezoidal fuzzy numbers. Then the fuzzy optimal solution

is, $\theta \cong$ **3106.43737**, $\tilde{TI}(\theta) = \$$ **7081.398**

CONCLUSION

In this paper, Optimization of inventory model with carbon emissions with fuzzy parameters and decision variable was developed. The model was solved for trapezoidal fuzzy numbers using kuhn-tucker technique. The results showed that the changes in the value of the price per unit to changes in the costs between the crisp and fuzzy sense. Thus, this work highlights, decrease of the carbon price leads to a decrease in the total emissions and decrease the total profit but increase order quantities. Finally a numerical examples and sensitivity analysis are illustrated for the proposed model.

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Table:1

R	θ	TI	TE
10	2003.048	14542.76	9.212416
9.8	2021.614	14302.5	9.150955
9.6	2043.233	14061.84	9.089026
9.4	2064.255	13820.77	9.026618
9.2	2085.939	13579.27	8.96372
9	2108.321	13337.33	8.900324
8.8	2131.439	13094.93	8.836417
8.6	2155.335	12852.06	8.77199
8.4	2180.053	12608.71	8.70703
8.2	2205.641	12364.86	8.641527
8	2232.152	12120.48	8.575469
7.8	2259.643	11875.56	8.508843
7.6	2288.175	11630.09	8.441638
7.4	2317.815	11384.03	8.373841
7.2	2348.639	11137.37	8.305441
7	2380.726	10890.07	8.236423
6.8	2414.164	10642.13	8.166776
6.6	2449.053	10393.5	8.096487
6.4	2485.499	10144.16	8.025544
6.2	2523.623	9894.068	7.953935
6	2563.556	9643.199	7.881648

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5.8	2605.447	9391.512	7.808672
5.6	2649.461	9138.967	7.734997
5.4	2695.783	8885.518	7.660615
5.2	2744.624	8631.119	7.585519
5	2796.219	8375.715	7.509704
4.8	2850.838	8119.25	7.433169
4.6	2908.788	7861.659	7.355916
4.4	2970.422	7602.874	7.277954
4.2	3036.147	7342.815	7.199295
4	**3106.437**	**7081.398**	**7.119964**

Fig:1

Fig:2

Fig:3

RESEARCH ARTICLE
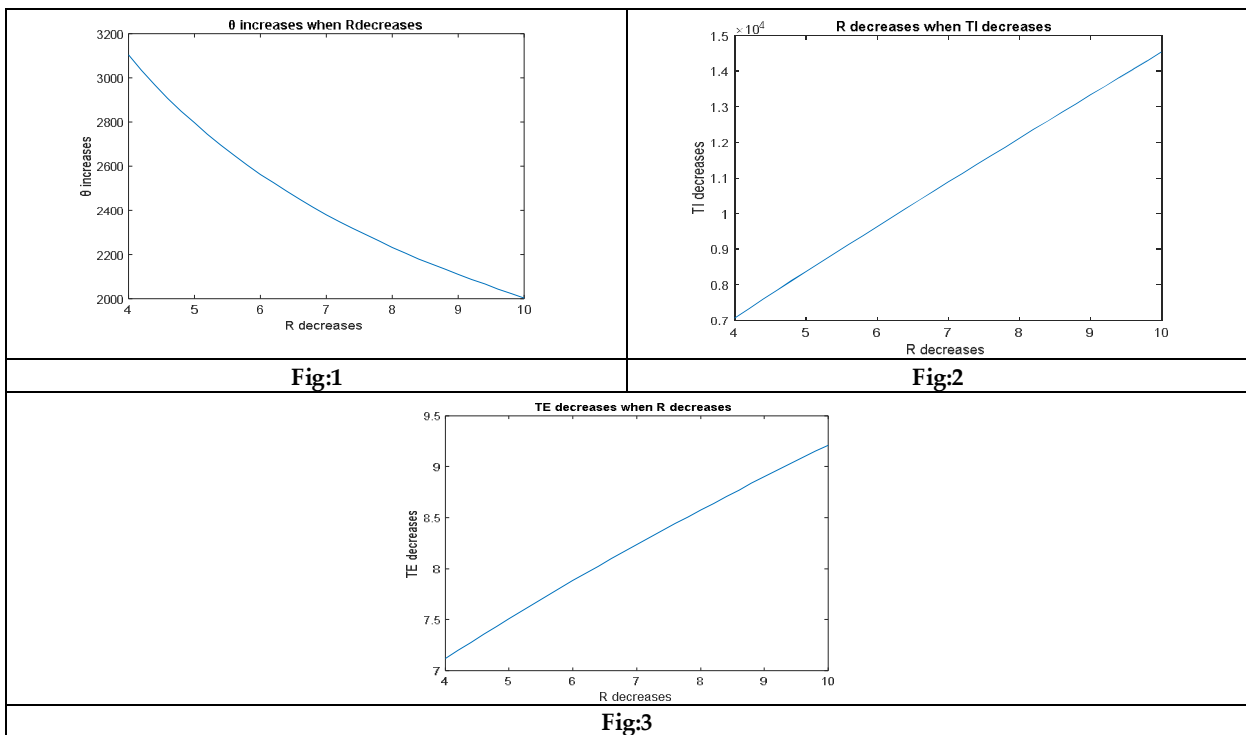
Haematological, Hepatic and Renal Biomarkers Responses in College Students Following a Short-Term Yoga Intervention Programme : A Pilot Study

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ABSTRACT

College students often deal with a variety of problems that could affect their physical, physiological and emotional health. Yoga is a non-pharmacological complementary therapy that has been proven to normalize the body's physiological functioning. In the present study we aimed to study the effects of short-term yoga intervention program on haematological, hepatic and renal biomarkers in college students. A total of 20 students with age ranges from 18–20 years, with no prior yoga experience were randomly selected for the study and divided randomly into experimental (n=10) and control (n=10) groups. For a period of 8 weeks, the experimental group practiced yoga five days a week for 45 minutes each day in the morning. All the dependent variables (haematological, hepatic and renal biomarkers) of the study were measured at day 0 (baseline), 4th week (intermediate) and 8th week (endline) of yoga program. The data was analysed using mean and standard deviation as descriptive statistics and repeated measures analysis of variance (RM ANOVA) as an inferential statistic. Following 4 and 8 weeks of yoga practises, repeated measures analysis of variance revealed a significant difference in the experimental group for haematological (TLC, Platelet, FBS), renal (blood urea, serum creatinine and potassium), and hepatic (total protein, globulin, alkaline phosphatise, SGOT, SGPT) biomarkers compared to the control group. Our findings suggested that yoga can be used as a non-pharmacological intervention for significant improving the well being and quality of life in college students.

Keywords: Biomarkers, Intervention, Meditation, Students, Yoga
Key Messages: Since the United Nations (UN) declared June 21 to be the International Day of Yoga in 2015, yoga has been growing in popularity. Yoga has been identified as an important complementary therapy, and understanding its benefits is critical because it may result in optimal organ functioning and, ultimately, a higher quality of life in the future. The results of the current study showed that even short-term yoga practise can improve quality of life by altering a number of physiological and biochemical markers.

INTRODUCTION

College students are occasionally confronted with a variety of issues that may have an impact on their physical and emotional well-being. Academic stress, poor eating habits, lack of physical activity and poor lifestyle choices can all cause physiological imbalances, including changes in haematological, hepatic and renal functioning [1]. Changes in these biomarkers can indicate serious health risks. It has been demonstrated that the ability of young adults to make healthy food choices becomes increasingly difficult as they progress from adolescence to young adulthood[2]. During this time, a new set of weight-related behavioural patterns such as binge drinking and physical inactivity start to emerge[3]. Yoga, an ancient Indian holistic mind-body practise, has grown in popularity as a complementary therapy for physical, mental and emotional well-being[4]. It has the possibility to contribute significantly to the growing field of integrative medicine. Yoga has its origins in Indian philosophy and has been used in traditional Indian spiritual and medical practises for approximately 5000 years[5]. Several researchers have recently investigated its impact and noticed reliable, positive psycho-physiological[6,7,8,9] and biochemical changes[10,11,12]. However, there has been a little study on the short term effects of yoga intervention program as suggested by Ministry of Ayush on haematological, hepatic, and renal biomarkers in college students over a period of time. As a result, the current study will investigate the impact of an eight week yoga intervention program on haematological, hepatic and renal biomarkers in college students. According to the study's hypothesis, frequent yoga practise will result in beneficial changes in haematological, hepatic and renal biomarkers, suggesting enhanced health, well-being and quality of life in college students.

MATERIALS AND METHODS

Study Sample
A yoga camp was held at Pandit Neki Ram Sharma government college Rohtak-Haryana, India in order to fulfill the goals of the current interventional study. A total of 30 male students ranging in age from 18 to 20 years old who were living in the college hostel, expressed their interest in participating in the yoga camp. All subjects came from similar socioeconomic backgrounds, were physically active, and had no yoga experience prior to start the yoga camp. On the basis of physical examination, six subjects were excluded from the study due to illness. Subjects in good health who were not taking any medications were considered for the study. All of the subjects had nearly identical lifestyle and dietary habits. The written informed consent was taken from the registered subjects.

Study Design
Pre-test, post-test randomized controlled design was used in this study. The Experimental Group (EG) and the Control Group (CG) were formed by randomly dividing the subjects into two equal groups. The experimental group was given a common yoga protocol designed by the Ministry of Ayush[13] for eight weeks, which includes a 45-minute morning yoga intervention five days a week consisting of prayer, loosening practices, yogasanas, pranayama, relaxation, and santihpatha. During the intervention phase, subjects were advised to practice yoga at the specified time and location while avoiding any other type of scheduled physical exercise. The control group, on the other hand, did not receive any yoga exercise components for eight weeks. The study's principal investigator, a senior yoga teacher, trained the subject in the study's yoga protocol.The College Research Committee (independent ethical approval board) approved the study (Letter No. Pt.NRS/GCR/22), and it was carried out in accordance with the Helsinki Declaration.

Study Variables
The independent variable (yoga intervention) chosen in the current study included selected asanas, pranayamas, and meditation, which was administered to experiment group, while haematological (haemoglobin (Hb), total leukocyte count (TLC), erythrocyte count (RBC), fasting blood sugar (FBS), platelets), hepatic (bilirubin, conjugated bilirubin, non-conjugated bilirubin, total protein, albumin, globulin, alkaline phosphate) and renal biomarkers (serum

creatinine (Cr), serum sodium (Na), serum potassium (K), serum calcium (Ca), blood urea) were considered as dependent variable. All of the subjects were tested three times in the same laboratory setting: on day one (baseline), four weeks later (intermediate), and eight weeks later (endline). At any point during the study, subjects could decide not to take part in the yoga camp. The total number of subjects in each group who finished the camp is depicted in the flow diagram [Figure-a].

Measurement
The expert phlebotomist took blood samples early in the morning before breakfast from the antecubital vein while sitting, during baseline, after 4 weeks and after completing the 8-week programme. The venous blood was centrifuged to separate the erythrocytes from the plasma (at 3,000 rpm for 20 minutes at room temperature), frozen, and kept at -80 °C until analysis. Haematological, renal, and hepatic biomarkers were tested by expert pathologists.

Statistical Analysis
For data analysis, data from various tests and measurements were processed. Prior to analysis, the data was examined for normality and homogeneity of variance. Mean, standard deviation (SD) and repeated measures analysis of variance (RM ANOVA) were used to analyse the data. The level of significance was set at 0.05 ($p<0.05$).

RESULTS

Table 1 revealed the descriptive statistics as mean and standard deviation (SD) of the experimental and control group for age is 18.9 (0.87) and 18.6 (0.51), for Height 5.74 (0.084) and 5.68 (0.27), weight 65.5 (3.47) and 65.5 (6.00) and for BMI (body mass index) 22.81 (0.978) and 23.09 (2.12) respectively. Table 2 revealed that the experimental and control groups had insignificant baseline differences. A RM ANOVA shown that the mean TLC score differed significantly between the experimental and control groups ($F_{(1, 9)} =17.50$, $p=0.002$) and across three time points ($F_{(2, 8)} =50.50$, $p=0.000$). A post hoc pair wise comparison showed that in comparison to baseline data, TLC score significantly improved in the experimental group after four ($p=0.000$), and eight weeks ($p=0.000$) of yoga camp, but not in the control group. Similarly, mean platelets score differed significantly between the experimental and control groups ($F_{(1, 9)} =6.300$, $p=0.033$) and across three time points ($F_{(2, 8)} =7.307$, $p=0.016$). A post hoc pair wise comparison showed that in comparison to baseline data, platelets score, significantly improved in the experimental group after four weeks ($p=0.006$) of yoga camp, but not in the control group. Likewise, mean FBS score differed significantly between the experimental and control groups ($F_{(1, 9)} =5.45$, $p=0.044$) and but insignificant across three time points ($F_{(2, 8)} =2.29$, $p=0.164$).On the other side, the variables (Hb and RBC) showed no significant improvement.

Table 3 revealed that the experimental and control groups had insignificant baseline differences. A RM ANOVA shown that there was a significant difference between the experimental and control groups in context to mean blood urea ($F_{(1, 9)} =8.44$, $p=0.017$), while insignificant across three time points ($F_{(2, 8)} =1.01$, $p=0.406$). Likewise, significant difference was found between the experimental and control groups for mean serum K ($F_{(1, 9)} =6.23$, $p=0.034$), while insignificant across three time points ($F_{(2,8)}=1.01$, $p=0.406$). However, following eight weeks ($p=0.008$) of yoga camp, the experimental group showed a significant improvement in Serum Cr ($F_{(2, 8)} =2.29$, $p=0.035$) compared to baseline data, whereas the control group showed no such changes. On the other side, the variables (Serum Na and, Serum Ca) showed no significant improvement. Table 4 revealed that the experimental and control groups had insignificant baseline differences. A RM ANOVA shown that the mean total protein score differed significantly between the experimental and control groups ($F_{(1, 9)} =26.44$, $p=0.001$) and across three time points ($F_{(2, 8)} =53.46$, $p=0.000$). A post hoc pairwise comparison showed that in comparison to baseline data, total protein score, significantly improved in the experimental group after four ($p=0.013$), and eight weeks ($p=0.000$) of yoga camp, but not in the control group. Likewise, a RM ANOVA shown that there was a significant difference between the experimental and control groups in context to mean globulin ($F_{(1, 9)} =44.88$, $p=0.000$), while insignificant across three time points ($F_{(2, 8)} =0.226$, $p=0.803$). Similarly, mean alkaline phosphatase score differed significantly between the experimental and control

groups (F(1, 9) =5.87, p=0.038) and across three time points (F(2, 8) =10.03, p=0.007). Following four (0.013) and eight weeks (0.002) of yoga camp, the experimental group showed a significant improvement in alkaline phosphatase score compared to baseline data, whereas the control group showed no such changes. However, in case of SGOT (F(1, 9) =14.26, p=0.004) and SGPT (F(1, 9) =12.27, p=0.007) there was a significant difference found between the experimental and control groups, and across three time points SGOT (F(2, 8) =6.43, p=0.022) and SGPT (F(2, 8) =4.47, p=0.05). A post hoc pair wise comparison displayed that in comparison to baseline data, SGOT (p=0.022)and SGPT (p=0.046) significantly improved in the experimental group after four of yoga camp, but not in the control group. On the other side, the variables (Bilurubin and, albumin) showed no significant improvement.

DISCUSSIONS

Yoga, an age-old discipline of the body, mind, and spirit, has been modernized and is now practised for its health advantages as complementary to more traditional medical therapy[14]. The present study aimed to determine the effect of 8 weeks yoga intervention programme on the haematological, hepatic and renal biomarkers of college students based on the hypothesis that yoga has beneficial effect on haematological, hepatic and renal biomarkers of college students. Our study's key finding is that, when compared to the control group, haematological biomarkers (TLC,Platelets and, FBS) and renal biomarkers (Blood urea, Serum Cr and Serum K) significantly changed after 8 weeks of intervention. Additionally, compared to the control group, we observed improved hepatic biomarkers (total protein, globulin, alkaline phosphatase, SGOT, and SGPT). The current study found a significant increase in total leukocyte count (TLC) and platelets following 4-week and 8-week yoga practice. This result clearly shows improved immune function to protect the body against invading microorganisms and repairing of damaged cells. The outcomes are in line with previous study done by Bhavanani et al. [8]who stated that yoga can produce a significant increase in the WBC and platelets. Another recent study by Purohit et al. [15]found that platelet count and clotting time both increased while bleeding time decreased significantly followed training gives support to our hypothesis. Similarly, result of the study revealed significant decrease in fasting blood sugar (FBS) following 8 weeks of yoga practice in comparison to control group. The Finding is in partial consonant with the study done by Chimkode et al. [16]who stated that reduction in mean values of FBS was highly significant when compared to the mean values before and during yoga practice, indicating a potential role of yoga in diabetes prevention and management strategies. Additionally, a study conducted by Gowri et al.[17] discovered significant improvements in FBG and came to the conclusion that integrated yoga therapy is the best adjuvant and non-invasive therapy for people with diabetes. Even though we could not find significant change in RBC and Hb, but we have observed a significant difference between experimental and control group.

Further, 8 weeks of yoga practice revealed significant changes in blood urea, serum Crand, serum K while no change was found in case of serum Na and, serum Ca following yoga practice in comparison to control group. The study's findings partially agreed with those of Yurtkuran, Alp, &Dilek, K. [18] who discovered thatmodified yoga intervention program result in significant decrease in serum urea and creatinine. According to a study by Pandey and his team [11], patients who underwent a yogic exercise regimen in addition to conventional treatment demonstrated a significant decline in blood urea and serum creatinine.Similarly, Agte, Jahagirdar, and Tarwadi[19] conducted a study to determine the effect of yoga on some biochemical parameters and discovered that serum urea level was significantly lower in comparison to the control group. Similar to this, we have noticed significant changes in total protein, globulin, alkaline phosphatase, SGOT and, SGPT after an 8-week yoga intervention programme, but not in bilirubin and, albumin. According to Kumar et al. [20], yogic intervention can stabilise SGOT and SGPT and that significant change has been noticed after just a short time of yoga practise. Similar to this, Sharma et al.'s [21] investigation into the impact of yogic practice on liver functions found that SGOT and SGPT levels significantly decreased after yogic interventions. Similarly, the current study's findings are partially consistent with the findings of another study [22], which found that globulin and alkaline phosphatase levels improved significantly when

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compared to the control group. Thus, even regular short-term yoga practise as suggested by ayush ministry has a positive effect on haematological, renal, and hepatic biomarkers.

CONCLUSION

The eight-week yoga intervention programme improved college students' haematological and, hepatic biomarkers, indicating improved blood parameters and, liver functions. Except for serum creatinine, no significant changes across three time points in renal biomarkers were observed. These findings suggest that yoga may have health benefits for college students, but more researches with larger sample sizes and longer follow-up times are required to confirm the findings. This study is significant because it expands on the body of knowledge already available about the benefits of yoga on biochemical biomarkers in college students. The study's findings may have implications for improving college students' health and well-being, as well as highlighting the potential benefits of incorporating yoga into their lifestyle. The findings may also aid educators and healthcare professionals in developing strategies to promote a healthy lifestyle among college students, thereby improving their overall well-being.

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Conflict of interest
Authors state no conflict of interest**.**

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Table 1: Descriptive Statistics

Characteristics	Experimental Group(n=10)	Control Group (n=10)
Age (year)	18.6(0.51)	18.9 (0.87)
Height (meter)	5.68(0.27)	5.74(0.084)
Body Weight (kilogram)	65.5(6.00)	65.5(3.47)
Body Mass Index (kilogram/meter²)	23.09(2.12)	22.81(0.978)

Table-2: Response of haematological biomarkers between experimental and control group

Variables	Control Group, mean (SD)			Experimental Group, mean (SD)		
	Baseline	Intermediate (Baseline Vs. Intermediate)	End line (Baseline versus Endline)	Baseline	Intermediate (Baseline Vs. Intermediate)	End line (Baseline versus Endline)
Hb	13.92 (0.77)	13.53 (0.64)	13.68 (0.65)	14.02 (0.77)	14.57 (0.73)	14.29 (0.80)
TLC#	4790 (585.85)	5070 (439.82)	5250 (313.58)	4380 (308.40)	6940 (870.76)***	7210 (789.44)***
RBC	5.10 (0.47)	4.47 (0.62)	4.52 (0.49)	5.11 (0.36)	4.78 (0.31)	4.74 (0.21)

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Platelet#	2.35 (0.50)	2.08 (0.40)	2.27 (0.50)	2.39 (0.73)	3.04 (0.88)***	3.21 (0.67)
FBS#	79.50 (2.55)	84.00 (5.35)	82.70 (4.32)	80.54 (5.71)	82.80 (5.19)	75.17 (4.58)

*P<0.05, **P<0.01 and ***P<0.001, RMANOVA, with a post hoc analysis to compare the values at baseline (pretest), 4 weeks (Intermediate) and 8 weeks (Endline) #significant difference between experimental and control group

Table-3: Response of renal biomarkers between experimental and control group

Variables	Control Group, mean (SD)			Experimental Group, mean (SD)		
	Baseline	Intermediate (Baseline Vs. Intermediate)	End line (Baseline versus Endline)	Baseline	Intermediate (Baseline Vs. Intermediate)	End line (Baseline versus Endline)
Blood Urea#	30.09 (7.05)	28.17 (4.26)	28.78 (2.20)	25.41 (3.89)	24.85 (3.89)	24.22 (2.42)
Serum Cr#	0.87 (0.08)	0.92 (0.16)	0.97 (0.12)	0.82 (0.06)	0.85 (0.05)	0.89 (0.13)*
Serum Na	142.28 (1.61)	142.63 (2.74)	142.58 (7.99)	143.09 (2.18)	142.54 (2.44)	142.62 (1.58)
Serum K#	4.19 (0.39)	4.10 (0.19)	3.98 (0.29)	4.04 (0.23)	3.96 (0.20)	3.97 (0.21)
Serum Ca	9.23 (0.11)	9.16 (0.33)	9.26 (0.75)	9.37 (0.40)	9.37 (0.29)	9.65 (0.26)

*P<0.05, **P<0.01 and ***P<0.001, RMANOVA, with a post hoc analysis to compare the values at baseline (pretest), 4 weeks (Intermediate) and 8 weeks (Endline) #significant difference between experimental and control group

Table-4: Response of hepatic biomarkers between experimental and control group

Variables	Control Group, mean (SD)			Experimental Group, mean (SD)		
	Baseline	Intermediate (pre Vs. mid)	End line (pre versus post)	Baseline	Intermediate (pre versus mid)	End line (pre versus post)
Bilirubin	0.70 (0.16)	0.91 (0.5)	0.77 (0.08)	0.83 (0.40)	0.76 (0.09)	0.71 (0.04)
Total Protein#	7.39 (0.27)	7.05 (0.27)	6.97 (0.19)	7.60 (0.23)	7.62 (0.23)**	7.53 (0.15)***
Albumin	4.13 (0.21)	3.88 (0.15)	3.77 (0.19)	4.20 (0.16)	3.99 (0.12)	3.90 (0.06)
Globulin#	3.26 (0.18)	3.17 (0.19)	3.22 (0.09)	3.52 (0.35)	3.64 (0.13)	3.62 (0.11)
Alkaline Phosphatase#	81.70 (10.72)	103.24 (2.18)	95.30 (11.73)	80.20 (7.55)	89.26 (8.25)*	87.32 (7.64)**

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SGOT[#]	30.80 (6.16)	42.68 (9.88)	32.35 (8.77)	27.90 (4.89)	25.21 (3.11)	23.91 (3.59)
SGPT[#]	32.40 (8.67)	43.69 (8.59)	38.23 (10.20)	27.70 (7.12)	27.64 (5.27)	28.71 (6.10)

*P<0.05, **P<0.01 and ***P<0.001, RMANOVA, with a *post hoc* analysis to compare the values at baseline (pretest), 4 weeks (Intermediate) and 8 weeks (Endline). #significant difference between experimental and control group

RESEARCH ARTICLE

Distribution and Occurrence of Phytoplankton in Santhekadur tank of Shivamogga Taluk, Karnataka

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ABSTRACT

The present study was carried out on the diversity of phytoplankton of Santhekadur tank of Shivamogga district, Karnataka for a period of six months (December 2021 to May 2022). A total of 55 species belonging to 35 genera were identified with 04 major classes viz., Bacillariophyceae, Chlorophyceae, Myxophyceae, Euglenophyceae and they are represented throughout the study period. Bacillariophyceae having 20 species followed by Chlorophyceae, Myxophyceae and Euglenophyceae with 16,11 and 08 species respectively. During the present study dominant genera found *are Navicula, Cymbella, Pinnularia, Synedra, Closterium, Spirogyra, Merismopedia* and *Trachelomonas.* Based on Boyd's diversity index the present water body is included under moderately polluted category. Although the tank is not protected from human activities and open for various activities, and they need regular monitoring.

Keywords: Phytoplankton, Occurrence, Santhekadur tank, Diversity indices.

INTRODUCTION

According to Panday et al (2004) phytoplankton are regarded as an essential component of aquatic flora and play a crucial role in maintaining equilibrium between the biotic and abiotic components of an aquatic ecosystem. Phytoplankton are the essential makers and structure the fundamental basic of food material for aquatic creatures

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and furthermore assume a significant part in the food chain of fishes and other aquatic living beings. The water quality corresponding to physico-chemical boundaries assumes a significant part in learning the distributional example and quantitative overflow of living beings occupying a specific environment (Singh et al., 2009). It is the need of today to monitor these environments. A few specialists have contemplated the physico-chemical elements of fluctuated lentic water bodies with the aim to survey the water quality (Islam, 2011; Venkateshwarlu et al., 2003, Sayaswara et al., 2010; Sachinkumar Patil et. al. ,2013). Subsequently intermittent checking of water nature of wetlands like lakes, ponds, reservoirs, ditches and pools is fundamental. The growth of phytoplankton is closely related to the physic-chemical properties of water. The higher the nutrient concentration in the water, the denser the population of phytoplankton, especially the Cyanophyceae (Prasad Umesh et al., 2001). Since the presence of an indicator species may reflect the state of cleanliness or contamination; The indicator organism cannot respond to all types of pollution (Hosmani, 2010; Rashmi and Somashekar Malammanavar, 2013). In the 20th century, extensive research was carried out on complexes of physical, chemical and biochemical components and their functional dynamics in the aquatic environment, both in temporary and tropical countries. Various researchers have made important contributions from different parts of the country since the last five to six decades. Freshwater bodies face pollution problems worldwide. Lentic waters such as ponds, lakes, dams etc. They are part of the freshwater habitat and are useful to humanity. The survival of life in the tank depends on the quantity and quality of water. Tanks play an important role in environmental sustainability. However, the continuous input of various chemical pollutants due to human activities has significantly deteriorated the quality of basin ecosystems in India. Water bodies are at risk from point and diffuse sources of pollution. The main factors of eutrophication include nutrient input (nitrate and phosphate), organic matter pollution, and construction and logging activities (Gangotri et al., 2017). Phytoplankton progression is a well-known phenomenon in aquatic ecology and several studies have described the underlying patterns and mechanisms of seasonal dynamics (Rothhaupt, 2000; Baba and Pandit, 2014). However, knowledge of the composition and abundance of phytoplankton organisms represents an essential feature for assessing the trophic status in water bodies in order to estimate the possible or optimal use of various water resources. Phytoplankton forms the base of the food chain in open water resources and serves as an indicator of water quality. Due to the interdependence between the different organisms that make up the systems, these differences in phytoplankton communities lead to changes in the food chain and lake productivity. The biological spectrum of lentic freshwater bodies is multidimensional, with phytoplankton useful in biomonitoring ecological disturbances caused by a range of physicochemical factors, wastewater pollutants and other anthropogenic factors (Baba and Pandit, 2014).. A detailed study on Santhekadur tank, one of the multipurpose water body of Malnad region is lacking. It is with this background, in the present study, an attempt has been made to study the occurrence and distribution of phytoplankton.

MATERIALS AND METHODS

Study area
Santhekadur tank is situated at Latitude of 13° 52' N and Longitude 75° 45' E in the Shivamogga city at the distance of 6 km respectively (Figure 1 and 2). This tank water is utilized for fish culture, irrigation and other human activities. The aquatic plants such *as Azolla,Pistia, Lemna, Spirodela, Chara, Nymphaea,Typha* and *Ipomea aquatica* are found in this water body.

Estimation of phytoplankton
Planktonic forms were collected using a 10-μm-mesh silk plankton net and attaching a 100-mL glass bottle to a narrow end. To collect the qualitative analysis samples, the net was dragged just below the water surface for 5 minutes (Green and Holden, 1960). Tows were limited to a small area around each sampling site. The samples were immediately transferred to other bottles and preserved by adding 4% formalin according to the practice of Welch (1948). The qualitative estimation of was carried out by taking one ml sample from each of the stock samples and repeating it five times. An even distribution was achieved by shaking the samples vigorously. The qualitative identification of planktonic organisms has been done with the help of monographs and plankton are identified down

to the species level (Adoni et al., 1985; Bharathi and Hegde, 1982; Hegde and Bharathi (1985). Few indices are calculated such as Boyd's and Shannon-Weaver index. The density, abundance and frequency of phytoplankton were discussed.

Water Analysis
The water sampling was carried out during morning hours between 8.00 and 9.00 AM hours. For physico-chemical analysis, water samples were collected in 2 litre plastic bottles . Dissolved oxygen was fixed on the site itself in BOD bottles. Various parameters like free CO_2, BOD, phosphate, nitrate, total hardness , Ca, Mg, TDS, sulphate and Chloride were estimated as per the standard methods APHA (1995)

RESULTS AND DISCUSSION

In the present study, a total of 55 species and 35 genera of phytoplankton were recorded in the water body (Table 1). Among the 04 classes of phytoplankton Bacillariophyceae having 20 species followed by Chlorophyceae , Myxophyceae and Euglenophyceae with 16,11 and 08 species respectively. Figure 4 depicts the average six months water quality data of Santhekadur tank. It appear that the presence of pH, dissolved oxygen, dissolved solids, phosphate, calcium and BOD are the factors which favored the growth of diatoms similar observation was noticed by Rashmi and Somashekar Malammanavar (2013) . Zafar (1967) has opined that high calcium and alkaline pH of the water bodies have favored the high number of diatoms. Mahadev and Hosmani (2004, 2005) have studied the community structure of cyanophyceae in two polluted lakes of Mysore city. Amit Kumar and Radha Sahu (2012) studied the ecology of the sewage stabilization pond of HEC area, Hatia, Ranchi to determine the occurrence and abundance of cyanobacteria in relation to physico-chemical characteristics of sewage pond. The Blue-Green algal diversity of this tank can be used as biomonitor of water quality. From the present findings, it is clear that Santhekadur tank water is most favourable for the formation of algae. Stevenson and White (1995), Gopinath (1995) and Niranjana (1996) opined that higher phosphate content supports luxuriant growth of cyanophyceae members. In the present study, the concentration of phosphate was more (average 0.45 mg/l) which harbored good number of blue greens . A large number of workers Zafar (1967), Seenayya (1971b), Rajkumar (1984), Venkateswarlu (1986) have pointed out that the desmids avoid polluted waters. In the present study, few desmids were found to grow at this tank revealing that desmids do not tolerate the high degree of organic pollution.

Hence, the observations made are in essential agreement with that of the above workers. Earlier reports on Euglenophyceae were by Munnawar(1970), Safiq-ur-Rehaman(1998), Hosmani (2008, 2012). These authors have reported that lake waters having high average concentrations of carbon dioxide are dominated by Euglenophyceae. Seenayya(1971) is of the opinion that levels of dissolved oxygen rise when Euglenophyceae are abundant. Water temperature above 320C and higher concentrations of Nitrates are effective for the growth of these forms. To explain the community structure in the tank, the Shannon-Weaver index is calculated. It is a diversity index that takes into account both the number of individuals and the number of taxa. The normal values were between 0 and 4. This index is a combination of the species present and the homogeneity of the species. Studying diversity across the spectrum of contaminated and unpolluted ecosystems (Wilham and Dorris, 1968) concluded that index values above 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate contamination. Values below 1 are characterized by severe pollution. According to this index (Table 3), the values are between 0.27 and 0.34. The maximum and minimum diversity was found in the summer months. According to Shannon and Weaver, the greater the diversity, the lower the contamination (Sudeep and Hosmani, 2007). The Boyd diversity index indicates that values greater than 4 indicate less contamination and clean water, values of 3-2 indicate moderate contamination, and values <1 indicate severe contamination of the water (Sudeep and Hosmani, 2007). The phytoplankton distributions in the tank are shown in Table 1. The calculated value of the diversity index is shown in Table 5. According to the diversity index of Boyd (1981), the Santhekadur tank, which is protected from major disturbances, is always moderately contaminated (Table 5).

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Table-1: Distribution of Phytoplankton

Class	Site 1	Site 2	Site 3	Site 4	Site 5
Chlorophyceae					
Cosmarium sp	+	−	+	−	+
Ankistrodesmus falcatus	+	+	−	+	+
Desmidium bailii	+	−	−	−	+
Mougeotia sp	+	+	−	+	+
Pediastrum simplex	+	+	+	−	+
Pediastrum duplex	+	−	+	+	+
Euastrum sp	+	−	−	−	+
Pleurotaenium sp	+	+	−	−	−
Scenedesmus acutus	+	+	−	+	+
Scenedesmus quadricauda	+	+	+	+	−

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Spirogyra sp	+	+	+	+	−
Staurastrum pyramidatum	+	+	−	−	+
Zygnema sp	+	+	+	−	−
Kirchneriella vulgaris	+	+	−	−	+
Coelastrum microporum	+	+	−	−	+
Selenastrum sp	+	+	−	+	+
Myxophyceae					
Oscillatoria formosa	+	+	+	−	−
Oscillatoria limosa	+	+	−	+	−
Oscillatoria curviceps	+	−	+	+	+
Spirulina platensis	+	−	+	+	−
Anabaena sp	+	+	+	+	−
Chrococcus sp	+	−	−	+	+
Lyngbya sp	+	+	+	−	−
Gleocapsa sp	+	+	+	+	−
Merismopedia gluca	+	+	+	−	−
Merismopedia punctata	+	+	−	+	+
Microcystis sp	+	−	−	−	+
Euglenophyceae					
Euglena sp	+	+	+	−	−
Euglena oxyuris	+	−	−	+	+
Phacus lismorensis	+	+	+	−	−
Phacus acuminatus	+	−	+	+	+
Phacus brevicaudatus	+	+	−	−	+
Trachelomonas hispida	+	−	−	−	+
Trachelomonas oblonga	+	−	+	+	−
Trachelomonas sp	+	+	+	+	−
Bacillariophyceae					

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Melosira granulata	+	+	−	+	+
Cymbella tumida	+	+	−	+	+
Cymbella lanceolata	+	−	+	−	+
Cymbella ventricosa	+	+	−	−	−
Cymbella sp	+	+	+	+	+
Gyrosigma accuminatum	+	−	−	−	+
Gyrosigma fasciola	+	+	−	−	+
Pinnularia major	+	+	+	+	−
Pinnularia gibba	+	+	−	−	−
Pinnularia streptoraphae	+	+	−	−	−
Synedra ulna	+	+	+	+	+
Synedra acus	+	−	−	+	+
Surirella sp	+	+	−	−	−
Navicula cuspida	+	+	+	−	−
Navicula sp	+	+	+	+	+
Nitzschia acicularis	+	+	−	−	+
Nitzschia recta	+	+	−	−	−
Nitzschia sp	+	+	+	+	+
Hantzschia sp	+	+	−	−	+
Cyclotella sp.	+	+	−	+	+

Note: += Present -=Absent

Table-2: Diversity of phytoplankton in Santhekadur pond of Shivamogga district

	Total no. of individual	Total sites	Density	Abundance	Frequency (%)
Myxophyceae	104	5	1.72	1.93	80.6
Chlorophyceae	132	5	1.83	2.12	70.4
Euglenophyceae	94	5	2.1	1.45	63.3
Bacillariophyceae	249	5	2.4	3.24	83.3

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Table-3: Shannan-Weiner index for phytoplankton in Santhekadur pond

Month	Dec	Jan	Feb	Mar	Apr	May
	0.32	0.28	0.31	0.34	0.27	0.29

Table-4: Boyd Diversity index for phytoplankton

Month	No. of genera (s)	Ln N	Total No. (N)	DI(H) s-1/ Ln N	Pollution status
Dec 2021	28	14.33	1685000	1.88	Mesotrophic
Jan	26	14.26	1574400	1.75	Mesotrophic
Feb	29	14.37	1752800	1.95	Mesotrophic
Mar	25	14.32	1651500	1.67	Mesotrophic
Apr	23	14.05	1264000	1.56	Mesotrophic
May 2022	21	13.98	1180300	1.43	Mesotrophic
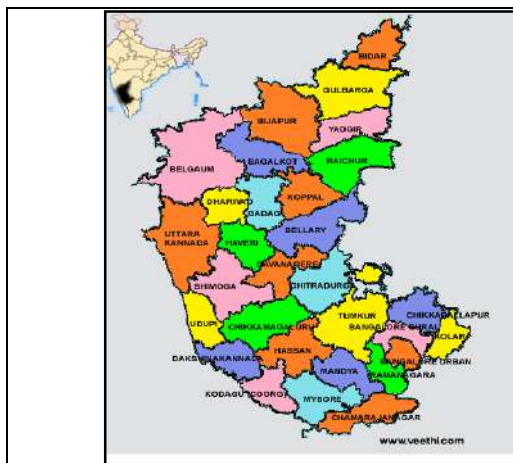
Figure 1: Study area map
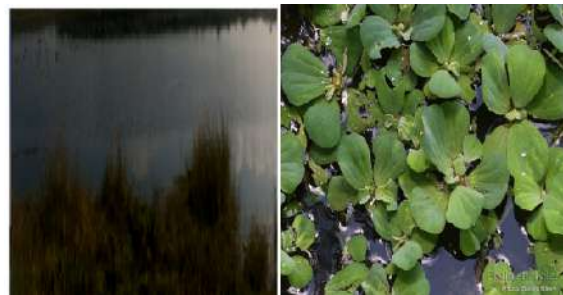
Figure 2: Aquatic plants in Santhekadur tank
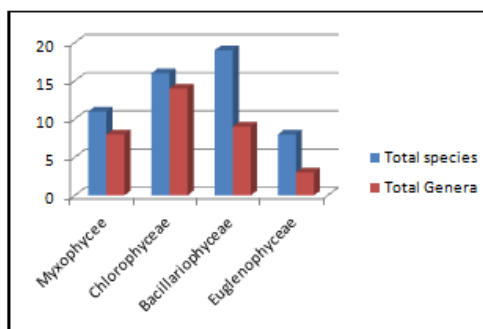
Figure 3: Total species and genera of phytoplankton in Santhekadur tank
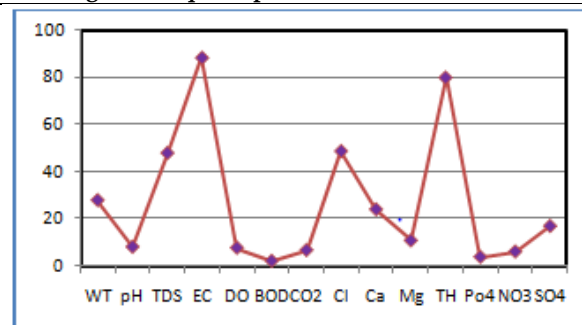
Figure 4: Average water quality of Santhekadur tank

RESEARCH ARTICLE

In Silico Analysis on Identification of Bioactive Compounds from Selected Medicinal Plants for the Treatment of Eczema

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ABSTRACT

Atopic Dermatitis (AD), also known as Eczema, is one of the persistent inflammatory skin conditions marked by chronic itching. It affects approximately one in ten individuals in the general population. AD is distinguished by an unbearable and untreatable itch.In Atopic Dermatitis, a primary issue lies in the compromised skin barrier, leading to dry and itchy skin. This condition is further worsened by the mechanical damage caused by scratching.It can lead to sleep disturbances and social stigma. The immune response in AD is mediated by T helper type 2 (Th2) cells, which drive allergic inflammation. The communication between epithelial cells and immune cells via the cytokine Thymic Stromal Lymphopoietin (TSLP) plays a crucial role in this process. Natural products claims that due to their Anit-Inflammatory and Immunosuppressant properties they can be used in the treatment of AD. The primary objective of thus current study is to uncover the potential phytocompounds from 21 selected medicinal plants with Anti-Inflammatory, Anti-Oxidant, Antitumour, Immunosuppressant properties were taken. The 3D structures of the phytocompounds were retrieved from IMMPAT and PubChem Databases. An intensive *In Silico* study starting with Molecular Docking against Human Thymic Stromal Lymphopoietin as a drug target for Eczema with 816 compounds were conducted using PyRx software. The docking results were compared with the standard drugs which are used for the treatment of AD. The Lipinski Rule of Five, ADMET and CYP properties were assessed for all the phytocompounds using SwissADME. Upon overall investigation, the phytocompound Sarasapogenin with binding affinity of -8.5 Kcal/mol

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showed excellent results and it is suggested that it has the capability to act as a Lead molecule in the treatment of AD. Further the *in vitro* and *in vivo* studies are suggested to validateits promising therapeutic capability.

Keywords: Immunosuppressant, Social stigma, Thymic Stromal Lymphopoietin, Allergic Inflammation, Cytokines, ADMET, CYP properties, drug-likeliness.

INTRODUCTION

The skin is the most substantial part of the integumentary system. It protects us from external troubles while also reflecting our internal harmony in the delicate shade of our bodies [1]. In the delicate balance between health and imbalance, there emerges a discordant note, known as eczema. Atopic Dermatitis (AD), commonly known as Eczema, is a chronic inflammatory skin condition characterized by persistent itching. [2] It impacts around one in ten individuals in the general population [3]. One of the distinguishing features of AD is the intense and often unrelenting itch, which can be challenging to alleviate effectively. [4] As we uncover the layers of this eczematic condition, examining its nuances, its impact, and the path to peaceful solace amidst its complications [3]. The condition known as eczema results in your skin getting dry, itchy, and bumpy, and it's responsible for weakening your skin's hedge function [5]. A significant challenge in Atopic Dermatitis is the weakened skin barrier, resulting in dry and itchy skin.[6] This condition is exacerbated by the scratching, which further damages the skin. This facilitates the penetration of pathogens through the skin and establishes an environment that influences the immune system's response to these pathogens.[6] The appearance of eczema varies depending on who's diagnosed with the condition. Dark skin tone can affect grandiloquent, brown, or Argentine eczema rash. In affluent countries, atopic eczema affects 20% of children and 10% of adults, ranking among the leading causes of disability-related time off.[7] Globally, approximately 4.4% of people experience depression, characterized by a diminished interest in daily activities, while roughly 3.6% contend with anxiety disorders, marked by excessive worry, fear, or avoidance behaviours. [8,9] Although eczema does not generally beget pain, scratching your skin can beget a painful sore. Contact dermatitis, among other forms of eczema, has the implicit to beget a burning sensation and discomfort. The impact of itching and disfiguring blisters extends beyond the individual to their family, diminishing their quality of life. This discomfort often leads to sleep disturbances and social stigma. [5]

Several proteins and molecular targets have been intertwined in the pathogenesis of eczema. Filaggrin (FLG) mutations are explosively linked to eczema, impacting skin hedge function. Interleukin (ILs) similar to IL- 4, IL- 13, and IL- 31, [10] along with excrescence necrosis factor- nascence (TNF- α), drive seditious responses in eczematous skin, aggravating towel damage. Interferons (IFNs), particularly IFN- γ, further disrupt the skin hedge and promote inflammation. Treatment might include a combination of life changes and specifics. In Atopic Dermatitis (AD), the immune response involves a type of T-helper cell called Th2 cells, which play a central role in allergic inflammation. [7] Studies using experimental models of allergen-induced allergic skin inflammation in mice have demonstrated the significant role of both Th1 and Th2 cytokines in the skin's inflammatory response [11]. This inflammation is characterized by the secretion of cytokines such as IL-4, IL-5, IL-13, and TNFα by a type of white blood cell called CD4+ T-cells. These cytokines stimulate the production of IgE antibodies by B-cells. IgE antibodies then bind to mast cells, triggering allergic reactions and leading to the infiltration of immune cells into the skin dermis [3]. Dendritic cells (DCs) play a crucial role in controlling the immune response by directing the differentiation of native CD4+ T-cells into TH2 lymphocytes [12]. The signalling between epithelial cells and immune cells via a cytokine called Thymic Stromal Lymphopoietin (TSLP) is believed to drive the development of Atopic Dermatitis [3]. This signalling mechanism also occurs in other allergic conditions like asthma and allergic rhinitis, a process known as the "Atopic March." [13] TSLP, a groundbreaking cytokine akin to 1L-7, was first isolated from murine thymic stromal cell lines, heralding a new era in immunology. Its role extends far beyond mere support, as it orchestrates the growth of B-cells, fosters T-cell proliferation, and guides cellular differentiation [14]. In the intricate landscape of

atopic dermatitis (AD) and asthma, TSLP emerges as a pivotal player, boasting high expression in human cutaneous epithelial cells and bronchial epithelial cells [15]. Within the microcosm of keratinocytes, TSLP's overexpression sets in motion a cascade of events, triggering relentless itch-induced scratching, culminating in an AD-like phenotype and mirroring the inflammation seen in asthma within murine models [16]. A murine counterpart to TSLP, christened TSLP-receptor (TSLPR), has been unveiled, exhibiting a modest affinity for TSLP. Yet, it's the formation of a potent heterodimer, coupling TSLPR with interleukin 7 receptor α (IL-7Rα), that heralds a cascade of cellular responses, underscoring the intricacies of immune regulation [17].When skin lesions or damage occur, cytokines such as IL-1β, TNF-α, IL-4, and IL-13 surge to heightened levels, creating a milieu ripe for inflammation. This potent cocktail can synergize to provoke the expression of TSLP by keratinocytes, setting off a chain reaction in the immune system [3]. TSLP, acting as a conductor orchestrating a symphony of cellular responses, exerts its influence predominantly on dendritic cells (DC). Upon activation by TSLP, DC undergo proliferation, maturation, and subsequent migration to lymph nodes, where they present antigens to immature T-lymphocytes.

This pivotal interaction serves as the catalyst for the differentiation of T-cells into Th2 cells, which play a crucial role in the immune responses characteristic of atopic dermatitis (AD)—a cascade known as "Th2 cell-mediated allergic inflammation." [18] In the arsenal against AD, TSLP inhibitors emerge as a promising strategy, often recommended as a preemptive measure before the onset of complications. [3] Various research report has indicated that a range of pure compounds derived from herbal materials, herbal extracts/ fractions & herbal formulations are effective on in vitro/ in vivo models [19]. Use of these natural products as a medicament has intensified in recent years, chiefly compounds derived from plants are used, since they are known to have fewer side effects than synthetic compounds [19,20]. With the use of *In Silico* methods using computational approaches make it easier to discover drugs because screening drugs with in vitro or in vivo assays is becoming more difficult, time-consuming, and costly because of the large number of compounds being studied [21,22]. In this present study, about 1007 phytocompounds from 21 locally available medicinal plants which is known for their Anti-Inflammatory, Anti-Oxidant, Antitumor, Immunosuppressant activity are taken. Molecular Docking studies were performed using the retrieved compounds and specified target protein, and their binding interactions were obtained. Pharmacokinetic properties which are also known as ADMET properties were assessed [23] and the results obtained were compared with the standard drugs which is involved in the treatment of Eczema. Thus, this study will provide insights in understanding the properties and the activeness of these phytocompounds as Lead molecule for new Drug Design and therapy.

MATERIALS AND METHODS

MATERIALS
The *in-silico* study has been performed by the following softwares and webservers.
- Protein Data Bank (PDB) (https://www.rcsb.org)
- IMMPAT (https://cb.imsc.res.in/imppat/home)
- PubChem (https://pubchem.ncbi.nlm.nih.gov)
- SAVESv6.0 (https://saves.mbi.ucla.edu)
- SwissADME (https://www.swissadme.ch)
- Discovery Studio suite 3.5
- PyRx version 0.8

METHODLOGY

Compounds from 21 selected medicinal plants have been identified, designed, optimised and screened using Molecular Docking to determine the most suitable natural compound that can inhibit Thymic Stromal Lymphopoietin (TSLP-1).

Selection and retrieval of the target protein
From the previous studies [3] and as per the literature, it was determined that one of the potential drug targets for the Eczema is Human Thymic Stromal Lymphopoietin (PDB ID: 5J11) [24] with Resolution 2.56 Aᵒ. The X-Ray crystallographic structure of Human Thymic Stromal Lymphopoietin (PDB ID: 5J11) and its 3D structure were obtained from the Protein Data Bank (PDB) (https://www.rcsb.org).

Stereochemical property of the retrieved protein
 The stereochemical properties of the retrieved protein was assessed using SAVESv6.0-Structure Validation Server (https://saves.mbi.ucla.edu). ERRATand PROCHECK features were used to analyse the quality of the Target protein to validate it as a suitable receptor for Molecular Docking and for recurrent studies [25]. To verify protein structures determined by crystallography, ERRAT Program is used. ERRAT is employed for scrutinizing the statistics concerning non-bonded interactions among various atom types. It then graphs the error function value against the position of a 9-residue sliding window, determined through a comparison with data from meticulously developed structures [26]. PROCHECK is used to check the stereochemical quality of a protein structure by analysing residue-by-residue geometry and overall structure geometry [27].

Preparation of the target protein
Preparation of the target protein (TSLP-1) involves with the addition of polar hydrogen atoms, addition of charges and removal of any unwanted substances which involves in the reaction. The miscellaneous substances like water molecules and the hetero atoms are removed and the polar hydrogens were added. Initially, all crystallographic water molecules and the inhibitors were removed from the original structure in order to dock herbal compounds into its substrate binding sites. Further, energy minimization of the target was performed followed by adding hydrogen atoms to construct a properly stabilized position of side chain atoms and hydrogen atoms using Discovery Studio 3.5 suite [28].

Selection and retrieval of the ligands
Using the literature and IMMPAT Database [29] around 1007 phytochemical compounds were selected from 21 medicinal herbs known for its Anti-Inflammatory, Anti-Oxidant, Antitumour, Immunosuppresant etc… The plants including *Abutilum Indium, Aegle marmelos, Aerva Lanata, Anisomelesmalabarica, Argemone mexicana, Bacopa monneri, Basella rubra, Boerhaviadiffusa, Bryophyllumpinnatum, Cheilocostusspeciosus, Cichorium intybus, Cissus quadrangularis, Cypernusrotundus, Datura metal, Ecliptaprostrasta, Elettaria cardamomum, Gingko biloba, Hemidesmus indicus, Hygrophila auriculata, Tribulus terrestris*and*Withaniasomnifera*aare used to inhibit Thymic Stromal Lymphopoietin.The 3D structures of these compounds with their physical and chemical properties were retrieved from the PubChem compound database [30]. The phytochemical compounds were downloaded in the SDF format and used for recurrent study.

Optimization of the ligands
The phytochemical compounds were downloaded in the SDF format and were converted to PDB format using OPEN BABEL software to carry out further in-silico studies. Structural geometry stabilization and protonation state of these ligands were reached using Discovery Studio 3.5 suite.

Drug-like property prediction
An online tool Lipinski's filter (https://www.scfbio-iitd.res.in/software/ drugdesign/lipinski.jsp) was used to retrieve the information about drug likeness of drugs with the help of Lipinski's rule of five. Lipinski's rule (or Lipinski's rule of five) helps to differentiate drug and non-druglike molecules [31].
It is used to identify the possibility of success or failure due to drug likeness for molecules fulfilling with two or more of the following rules [32]:
(a)   Molecular mass – Less than 500 Da
(b)   High lipophilicity - expressed as Log P Less than 5
(c)   Hydrogen bonds donors – More than 5

(d)   Hydrogen bond acceptors – Less than 10
(e)   Molar Refractivity (Range) – 40 to 130.
The Lipinski Rule of Five was observed in 816 phytocompounds and they were used in Molecular docking studies.

Molecular docking studies

PyRx software (Version 0.8, with virtual screening and Drug Discovery features) was used to perform Molecular Docking with the Target protein Human Thymic Stromal Lymphopoietin (PDB ID: 5J11). Selected natural compounds were virtually screened against the target protein in order to find efficient ligand using PyRx0.8 tool (https://pyrx.sourceforge. io/) [33]. Using this software, the target proteins were prepared for Molecular Docking studies. The target protein was converted into (. pdbqt) file format. The Open Babel feature in the PyRx was used to import the ligands. Then energy minimalization of ligands were carried out by the OPEN BABEL featureand it was used to convert ligands into (. pdbqt) file format.The library of ligand molecules was then subjected to virtual screening based on docking using the Vina Wizard feature, which remains in-built in the PyRx [28]. It was used to import the macromolecule and ligands. Then a molecular grid was built over the active site and the docking studies were performed [33].The ligands were classified according to their binding energy, which represents the highest potential interaction with the receptor. Finally, 2D and 3D view of atomic interaction between best-docked complexes were achieved using Discovery Studio 3.5 respectively.The best conformation with the lowest docked energy (Kcal/mol) indicated the best fit. Molecular docking was conducted to substantiate the efficiency of selected natural compounds obtained from drug-like property prediction. During docking, synthetic drugs like Methotrexate, Azathioprine in class of Immunomodulators, Upadacitinib in class of JAK inhibitor and Alitretinoin which are used in the treatment of Eczema were also included to compare their binding affinity with selected natural ligands. Subsequently, all binding poses of each docking were studied and most energetically as well as geometrically favourable conformation for each independent run was selected for further study.

Pharmacokinetic properties of the screened compounds (ADMET and CYP properties)

The ADMET and CYP characteristics of the top 15 phytochemical compounds for the target protein were assessed using SwissADME online web tool [34]. The parameters like BBB (Blood Brain Barrier permeability), HIA (Human Intestinal Absorption), PGP (P-Glycoprotein), XLogP3, TPSA (Topological Polar Surface Area), LogS, Fraction Csp3, Rotatable bonds, Cytochrome P450 enzyme inhibitor properties, Skin permeation, and Bioavailability score were examined for the compounds with the best interaction to the target [28].

Protein-ligand interaction

Discovery studio Visualizer, a visualization tool which is used for viewing, analysing a protein and modelling data. The best compounds which showed best results in above studied parameters were visualized using Discovery studio suite 3.5. The interaction between the ligand and the active site of the target protein were analysed and the 2D and 3D interaction plots were obtained in order to study the stability of the ligand in the active site.

RESULTS AND DISCUSSIONS

Selection and retrieval of target protein

The PubChem Compound Database was used to retrieve the 3D structure of the ligands and the 3D structure of the target proteins were retrieve from the Protein Data Bank Database (PDB) [35]. The PDB ID for X-Ray crystallographic structure of the Human Thymic Stromal Lymphopoietinis 5J11 **(Figure 1)**[36]. The target protein (TSLP-1) is prepared by the removal of unwanted hetero atoms like water and inhibitors. It is followed by addition of polar hydrogen atoms and addition of charges respectively. Hence, the Target protein has been prepared for *in-silico* studies.

Stereochemical property of the retrieved protein
The stereochemical properties of the retrieved protein was assessed using SAVESv6.0-Structure Validation Server (https://saves.mbi.ucla.edu) [37]. ERRATand PROCHECK features were used to analyse the quality of the Target protein. The quality of the target protein was evaluated via the Ramachandran plot using PROCHECK [27]. The Ramachandran plot for the target protein revealed that 87.1% of the residues were in the most favorable region, while 12.3% were in allowed region, confirming that the target protein is of good quality (Figure 2). ERRAT is termed as "Overall Quality Factor" for non-bonded interactions at atomic level, with elevated scores represent higher quality [26]. A top-quality model typically falls within the generally accepted range of >50 (Figure 3). For the current 3D model of the Target protein, the overall quality factor predicted by the ERRAT server was 89.688%.

PROCHECK
87.1% residues in favorable regions, 12.3% residues in additional allowed regions, 0.4% residues in generously allowed regions, 0.2% residues in disallowed regions. **Figure 2**, Ramachandran plot for 5J11 confirms that the protein is of good quality.

ERRAT
Figure 3 Illustrates that on the error axis, two lines are drawn to indicate the confidence with which it is possible to reject regions that exceed that error value. In high-resolution structures, values typically hover around 95% or higher, while lower resolutions tend to yield an average overall quality factor of approximately 91%. The Overall Quality Factor for 5J11 is 89.688, shows that the protein model is of High quality.

Selection and retrieval of the ligands and target protein
Using the literature and IMMPAT Database [29] around 1007 phytochemical compounds were selected from 21 medicinal herbs known for its Anti-Inflammatory, Anti-Oxidant, Antitumour, Immunosuppressant etc… The 3D structures were retrieved from the PubChem Database and they were converted from SDF to PDB format using OPENBABEL software.

Drug-like property prediction
Lipinski rule of five was assessed for the following compounds and the results were analysed whether the following compounds have drug-like property or not [31]. Lipinski rule of five was assessed for 1007 phytocompounds, about 816 compounds showed drug-like property. Hence, they are proceeded for Molecular Doking process using PyRx.

Molecular docking studies
PyRx 0.8 software was used to conduct docking experiment for the target protein Human Thymic Stromal Lymphopoietin (PDB ID: 5J11). About 816 compounds were docked against 5J11. From the results (Table 1), the following top 15 compounds showed a very good interaction with the target protein. The Binding affinity, interacting residues and their bond lengths were tabulated. The docking scores of 15 phytocompounds were compared with 4 standard drugs which are used for the treatment of Eczema. From the results (Table 1), among other compounds, 15 compounds showed very good results with the target protein. Of which, the phytocompound Boeravinone E showed excellent binding affinity of -8.9 Kcal/mol with the amino acid residues TYR C:152, LYS C:163, ASN B: 182, LEU B:183, LEU B: 183, LYS C: 163, VAL B: 181 of target. The phytocompound Isodemethylwedolactone also provided a strong affinity of (-8.9 Kcal/mol) with the amino acid residuesTYR C: 152, GLN C: 161, SER C: 162, THR B: 189, LEU B: 183, GLY C: 174, SER B: 184, LYS C: 163, LEU B: 188, LEU B: 183, LYS C: 163. The phytocompound Boeravinone F provided a good binding affinity of (-8.8 Kcal/mol) with the amino acid residues LYS C: 163, LYS C: 163, LYS C: 163, SER C: 162, SER B: 185, LEU B: 183, VAL B: 181, LEU B: 183, LYS C: 163, VAL B: 181. The phytocompound Jujubogenin provided a good binding affinity of (-8.8 Kcal/mol) with the amino acid residues MET A: 100, ILE A: 108, LYS B: 104. The phytocompound Boeravinone B provided a good binding affinity of (-8.7 Kcal/mol) with the amino acid residuesLYS C: 163, ASN B: 182, LEU B:183, LEU B: 183, LYS C: 163, VAL B:181. The phytocompound Withanolide L provided a good binding affinity of (-8.7 Kcal/mol) with the amino acid residues ALA B: 076, LYS B: 104, LYS A: 103, ALA A: 104. The phytocompound Diosgenone, 4-Dimethyl also provide a strong binding affinity of

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(-8.6 Kcal/mol) with the amino acid residues ARG C: 111, THR C: 198, ILE C: 032, PHE C: 107, PHE C: 107. The phytocompound Demetylwedeloactone also provide a strong binding affinity of(-8.6 Kcal/mol) with the amino acid residues SER B: 185, TYR C: 152, GLN C: 161, GLN C: 161, SER B: 184, SER B: 184, SER B: 184, LEU B: 183. The phytocompound Withanolide A also provide a strong affinity of (-8.6 Kcal/mol) with the amino acid residues LYS B: 104, GLY B: 103, GLY B: 103. The phytocompound, Boeravinone A also provide a strong binding affinity of (-8.6 Kcal/mol) with the amino acid residues ASN B: 182, LYS C: 163, LYS C: 163, LEU B: 183, VAL B: 181. The phytocompound Sarasapogeninalso provide a strong binding affinity of (-8.5 Kcal/mol) with the amino acid residues THR C: 041, THR C: 041, SER C: 201, SER C: 201, PHE C: 037. The phytocompound Tiliroside also provided a strong binding affinity of (-8.5 Kcal/mol) with the amino acid residues SER B: 184, HIS B: 211, SER B: 184, ASN C: 166, SER B: 185, GLN C: 164, MET C: 190, HIS B: 211, HIS B: 211, VAL B: 162, LEU C: 147, LEU C: 147, LEU B: 183. The phytocompound Asarinin provided a good binding affinity of (-8.5 Kcal/mol) with the amino acid residues VAL B: 181, GLU C: 173, GLU C: 173, GLU C: 173, LYS C: 163, LYS C: 163, LYS C: 163, SER B: 184. The phytocompound Isoginkgetin provided a good binding affinity of (-8.5 Kcal/mol) with the amino acid residue GLN C: 164, GLU C: 165, LYS C: 163, LEU B: 163, SER B: 184, SER B: 184, SER C: 162, LYS C: 163, VAL B: 162, LEU C: 147, LEU C: 147. The phytocompound Sequoiaflavone provided a good binding affinity of (-8.5 Kcal/mol) with the amino acid residues LYS B: 128, TRY B: 217, SER B: 041, SER B: 041, GLU B: 060, PHE B: 216, TYR B: 043, TRY B: 217, ALA B: 058, ALA B: 058. Morever, the phytocompound Methotrexate provided a good binding affinity of (-7.5 Kcal/mol) with the amino acid residues GLN C: 047, SER C: 082, THR C: 054, THR C: 081, TYR C: 051, GLN C: 077, HIS C: 080, SER C: 052, SER C: 052, SER C: 052, GLU C: 078, SER C: 049. The phytocompound Azathioprine provided a good binding affinity of (-6.5 Kcal/mol) with the amino acid residues GLY C: 064, ASN C: 063, GLY C: 064, PHE C: 062, SER A: 068, SER A: 068, LYS C: 069, VAL A: 067. The phytocompound Upadacitinib provided a good binding affinity of (-6.7 Kcal/mol) with the amino acid residues TYR A: 054, TYR A: 054, TYR A: 054, MET A: 097, MET A: 097, MET A: 097. The phytocompound Alitretinoin provided a good binding affinity of (-6.4 Kcal/mol) with the amino acid residues ALA B: 076, MET A:100, LYS A: 103, ALA A: 104, ALA A: 107, ALA A: 107, LYS A: 103.

According to the study conducted by Sathish Kumar and Rasiga *et al.*, 2019, the results of the *In-silico* docking study regarding the interactions between TSLP and the compounds from the medicinal plants like *Trigonellafoenum, Rosmarinusofficinalis, Ficuscarica, Althaeae radix, Prunuspersica, Achyranthesaspera, Allium cepa, Curcuma longa, Camellia sinensis, Lycopersiconesculentum, Cannabis sativus, Oenotherabiennisand Matricaria chamomile* were assessed. The compounds were analysed for their significant interaction with the target, ADMETproperties, drug-likeness using the Schrödinger software. The docking results were observed which indicates that 10 compounds were found to be active. The compound Rosmarinic acid had significant G.score value of -6.28 kcal/mol and interactions with the active site residues (GLU78, MET28, SER114 and GLN80) of TSLP. Given that TSLP acts as a pivotal regulator of allergic inflammation at the interface between epithelial cell-Dendritic Cell (DC) in Atopic Dermatitis, and the findings suggest recurrent investigation of plant compounds to potentially develop novel drug molecules [3]. Zhen-Zhen Wang *et al.*, 2021in his study, they have investigated the bioactive compounds and mechanisms of SZT in treating eczema using systems pharmacology and *in silico* docking analysis. SZT is composed of 4 medicinal herbs, *Atractylodismacrocephalae* rhizome, *Schizonepetaeherba, Sophoraeflavescentis radix*, and *Arctii fructus*. They first identified 51 active compounds from SZT and their 81 potential molecular targets by high-throughput computational analysis.They further identified top 5 compounds including cynarine, stigmasterin, kushenol, β-sitosterol, and (24S)-24-propylcholesta-5-ene-3β-ol as putative key active compounds on the basis of their molecular docking scores with identified hub target proteins. Finally, the study provides an insight into the therapeutic mechanism underlying multiscale benefits of SZT for eczema and paves the way for developing new and potentially more effective eczema therapies [38]. In this present study, all the top 15 phytocompounds tabulated in the table showed higher binding affinity (Range of -8.9 Kcal/mol to -8.5Kcal/mol) with the target protein TSLP, when compared with the previous studies.

Pharmacokinetic properties of the screened compounds
ADMET properties
In the present study, ADMET properties were tested for the best 15 interacted phytocompounds and Synthetic drugs Methotrexate, Azathioprine, Upadacitinib and Alitretinoin using SwissADME and the results were tabulated (**Table2**). From the results, all the best interacted phytocompounds and also the synthetic drugs Methotrexate, Azathioprine, Upadacitinib and Alitretinoin obey Lipinski Rule of Five. A lot of the phytocompounds did not cross Blood-Brain Barrier (BBB). Twelve compounds had High Intestinal Absorption and compounds Tiliroside, Isoginkgetin, Sequoiaflavone and synthetic compounds Methotrexate and Azathioprine had Low Intestinal Absorption. Among the 15 phytocompounds, two compounds and synthetic drug Upadacitinibare predicted to be effluated from CNS by P-glycoprotein. Among 15 phytocompounds, XLogP3 value of Five phytocompounds were predicted to be out of the range and remaining compounds were above the range. TPSA (Topological Polar Surface Area) and Log S value of the most of the compounds were within the limit. In all the Phytocompounds, Fraction Csp3 value of 9 phytocompounds was less than 0.25 and the value of other compounds were within the limit. All the compounds were within the limit in the criteria of Rotatable bonds. From the results of the Boiled egg image of the phytocompounds **(Figure 4)**, the compoundsSarasapogenin and Asarinin are located in the Egg-yolk region, which means the compounds can passively permeate through the Blood-Brain Barrier. Ten phytocompounds are located in the Egg-white region, which means they are passively absorbedby the gastrointestinal tract.Two best interacted compounds are predicted not to be effluated from the Central Nervous System by the P-glycoprotein.

CYP properties
The majority of the substances do not inhibit the CYP450 enzymes or cause any negative side effects, according to the results of CYP characteristics **(Table 3)**. The phytocompoundsBoeravinone E, Boeravinone B inhibits the CYP450 enzymes CYP1A2, CYP2D6 and CYP3A4.The phytocompoundsBoeravinone F, Isodemethylwedolactone, Demetylwedeloactone inhibits the CYP450 enzymes CYP1A2 and CYP2D6. The phytocompoundsBoeravinone A CYP1A2, CYP2D6, CYP2C9 and CYP3A4. The phytocompounds Jujubogenin, Diosgenone, 4-Dimethyl, Withanolide A, Sarasapogenin, and Tiliroside does not inhibits the CYP450 enzymes. The value of log Kp (Skin Permeant) is good for all compounds and A Bioavailability Score (ABS) is good for the most of the compounds. Compounds with a high log Kp negative value have limited ability to penetrate skin. According to this statement, all the compounds have limited ability to penetrate skin. The Bio-Availability score of all the compounds is 0.55, as it satisfies the rule of five.

Protein-ligand interaction
In Silico molecular docking speeds up the drug discovery process by anticipating the phytocompounds that can bind to the target protein in less time. This along with *In Silico* examination of pharmacokinetic, physiochemical, and pharmacodynamic features helps identification of lead compounds that can be developed into a medicinewhich is helpful in the prevention of disease[40]. Numerous studies used *in vitro* and *in vivo* activity evaluation investigations to corroborate the outcomes of their *In Silico* based virtual screening and molecular docking experiments[41]. This confirms the value of *In Silico*studies in the drug discovery processes. By learning greater detail about how compounds bind to, interact with, and up- or down-regulate associated proteins, researchers may be able to come up with alternatives to therapy that treat specific ailments [28]. While analysing the results, the phytocompounds Sarasapogenin and Asarinin were no +PGP Substrate, had a High Intestinal Absorption (HIA) and passed every pharmacokinetic and CYP properties and has higher affinity when compared with previous studies.In these two compounds, Sarasapogenin from **Cheilocostusspeciosus** had permeated through the Blood-Brain Barrier and does not inhibit CYP450 enzymes. Based on the above studied parameters, the phytocompound Sarasapogenin showed best results and it showed that it has the property for being a Lead like molecule. Sarasapogenin and the synthetic drugs were visualized using Discovery studio Suite 3.5 and their 2D and 3D interaction plots were obtained (Fig. 6 & 7). The 2D and 3D interaction plots of the Synthetic compounds were visualized using Discovery Studio Suite 3.5 (Fig. 8-13) [39].

CONCLUSION

In the present study, the phytocompounds from 21 locally available medicinal plants which is known for their Anti-Inflammatory, Anti-Oxidant, Antitumor, Immunosuppressant activity etc… which could be used to treat Eczema or Atopic Dermatitis were taken. Using IMPPAT Database 1007 phytocompounds were retrieved. Lipinski Rule of Five was assessed for the retrieved compounds and among those 816 compounds exhibited Drug like property. The compounds were further taken into Molecular docking studies using PyRx V0.8 software and the docking scores of the chosen phytocompounds against Thymic Stromal Lymphopoietin (TSLP-1) (PDB ID: 5J11) range from -2.5 Kcal/mol to -8.9 Kcal/mol. Among them, top 15 compounds were taken into recurrent study and compared with 4 standard drugs which are used to treat Eczema. The top 15 compounds and 4 Synthetic drugs were assessed with the ADMET and CYP properties using SwissADME. The Boiled Egg parameter was used to predict the Blood-Brain Barrier permeation and P-Glycoprotein substrate of the phytocompounds and Standard drugs. While analyzing the results, the phytocompounds Sarasapogenin and Asarinin were no +PGP Substrate, had a High Intestinal Absorption (HIA) and passed every pharmacokinetic and CYP properties. In these two compounds, Sarasapogenin from *Cheilocostusspeciosus* had permeated through the Blood-Brain Barrier and does not inhibit CYP450 enzymes and hence it will be a suitable drug candidate which can act as a Lead compound by inhibiting the active site of the Thymic Stromal Lymphopoietin to reduce the onset of AD complications.

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Table 1: Phytocompounds and synthetic drugs with their Binding affinity, interacting residues and its bond length (in Aᵒ).

S. No	NAME OF THE COMPOUND	PUBCHE M ID	PLANT NAME (For synthetic drugs – usage)	BINDING AFFININTY (kcal/mol)	NO. OF BONDS	INTERACTING RESIDUCES (in the receptor protein)	BOND LENGTH (Aᵒ)
PHYTOCOMPOUNDS							
1	Boeravinone E	11537197	*Boerhaviadiffusa*	-8.9	7	TYR C:152 LYS C:163 ASN B: 182 LEU B:183 LEU B: 183 LYS C: 163	2.61 2.24 2.36 5.29 5.48 4.17

						VAL B: 181	4.66
2	Isodemethylwedolactone	5318547	*Ecliptaprostrasta*	-8.9	11	TYR C: 152	2.75
						GLN C: 161	2.40
						SER C: 162	1.97
						THR B: 189	2.31
						LEU B: 183	2.59
						GLY C: 174	2.67
						SER B: 184	2.93
						LYS C: 163	5.06
						LEU B: 188	5.04
						LEU B: 183	5.43
						LYS C: 163	4.15
3	Boeravinone F	12004175	*Boerhaviadiffusa*	-8.8	10	LYS C: 163	2.70
						LYS C: 163	2.12
						LYS C: 163	2.67
						SER C: 162	1.94
						SER B: 185	2.88
						LEU B: 183	5.33
						VAL B: 181	5.35
						LEU B: 183	5.42
						LYS C: 163	5.03
						VAL B: 181	4.31
4	Jujubogenin	15515703	*Bacopa monneri*	-8.8	3	MET A: 100	2.93
						ILE A: 108	3.98
						LYS B: 104	4.36
5	Boeravinone B	14018348	*Boerhaviadiffusa*	-8.7	6	LYS C: 163	2.30
						ASN B: 182	2.61
						LEU B:183	5.29
						LEU B: 183	5.46
						LYS C: 163	4.17
						VAL B:181	4.63
6	Withanolide L	179575	*Withaniasomnifera*	-8.7	4	ALA B: 076	2.41
						LYS B: 104	1.83
						LYS A: 103	4.85
						ALA A: 104	4.04
7	Diosgenone, 4-Dimethyl	249449	*Cheilocostusspeciosus*	-8.6	5	ARG C: 111	2.07
						THR C: 198	2.64
						ILE C: 032	5.36
						PHE C: 107	5.36
						PHE C: 107	5.35
8	Demetylwedeloactone	5489605	*Ecliptaprostrasta*	-8.6	12	SER B: 185	2.59
						TYR C: 152	2.24
						GLN C: 161	2.70
						GLN C: 161	2.87
						SER B: 184	2.58
						SER B: 184	2.20

						SER B: 184	3.07
						LEU B: 183	5.15
						LYS C: 163	5.18
						LEU B: 183	5.33
						LYS C: 163	4.21
						LEU B: 188	5.05
9	Withanolide A	11294368	*Withaniasomnifera*	-8.6	3	LYS B: 104	1.80
						GLY B: 103	3.03
						GLY B: 103	2.91
10	Boeravinone A	14018346	*Boerhaviadiffusa*	-8.6	5	ASN B: 182	2.17
						LYS C: 163	2.75
						LYS C: 163	2.28
						LEU B: 183	5.48
						VAL B: 181	4.66
11	Sarasapogenin	92095	*Cheilocostusspeciosus*	-8.5	5	THR C: 041	2.36
						THR C: 041	3.09
						SER C: 201	3.03
						SER C: 201	2.64
						PHE C: 037	4.85
12	Tiliroside	5320686	*Tribulus terrestris*	-8.5	13	SER B: 184	2.61
						HIS B: 211	2.74
						SER B: 184	2.24
						ASN C: 166	2.83
						SER B: 185	2.54
						GLN C: 164	3.30
						MET C: 190	5.05
						HIS B: 211	5.53
						HIS B: 211	4.82
						VAL B: 162	5.14
						LEU C: 147	5.46
						LEU C: 147	4.64
						LEU B: 183	5.36
13	Asarinin	5204	*Gingko biloba*	-8.5	8	VAL B: 181	4.13
						GLU C: 173	4.25
						GLU C: 173	3.40
						GLU C: 173	2.33
						LYS C: 163	2.96
						LYS C: 163	2.36
						LYS C: 163	3.96
						SER B: 184	2.07
14	Isoginkgetin	5318569	*Gingko biloba*	-8.5	11	GLN C: 164	2.22
						GLU C: 165	2.24
						LYS C: 163	2.46
						LEU B: 163	3.40
						SER B: 184	3.39
						SER B: 184	2.78
						SER C: 162	4.19
						LYS C: 163	4.19
						VAL B: 162	4.45

						LEU C: 147	4.88
						LEU C: 147	5.04
15	Sequoiaflavone	5484010	*Gingko biloba*	-8.5	10	LYS B: 128	2.75
						TRY B: 217	2.93
						SER B: 041	2.11
						SER B: 041	3.09
						GLU B: 060	3.95
						PHE B: 216	2.66
						TYR B: 043	5.09
						TRY B: 217	4.93
						ALA B: 058	4.25
						ALA B: 058	3.43
SYNTHETIC DRUGS							
1	Methotrexate	126941	Immunomodulators	-7.5	12	GLN C: 047	2.18
						SER C: 082	2.42
						THR C: 054	2.79
						THR C: 081	2.56
						TYR C: 051	1.88
						GLN C: 077	2.31
						HIS C: 080	2.77
						SER C: 052	2.61
						SER C: 052	2.73
						SER C: 052	2.56
						GLU C: 078	3.76
						SER C: 049	3.65
2	Azathioprine	2265	Immunomodulators	-6.5	8	GLY C: 064	2.20
						ASN C: 063	2.89
						GLY C: 064	2.60
						PHE C: 062	3.63
						SER A: 068	2.74
						SER A: 068	4.48
						LYS C: 069	4.48
						VAL A: 067	5.45
3	Upadacitinib	58557659	JAK Inhibitor	-6.7	6	TYR A: 054	3.46
						TYR A: 054	3.09
						TYR A: 054	4.11
						MET A: 097	5.48
						MET A: 097	4.08
						MET A: 097	3.80
4	Alitretinoin	449171	Used in treatment of Eczema	-6.4	7	ALA B: 076	2.44
						MET A:100	5.25
						LYS A: 103	5.28
						ALA A: 104	3.97
						ALA A: 107	4.52
						ALA A: 107	3.57
						LYS A: 103	3.83

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Table 2: ADMET Properties of phytocompounds and Synthetic drugs.

S. N o	Compound Name	PubChem (CID)	Lipinski Rule (#violations)	BBB	HIA	PGP Substrate	XLOGP3	TPSA (A⁰)	Log S (ESOL)	Fraction Csp3	Rotatable Bonds
				Phytocompounds							
1	Boeravinone E	11537197	0	No	High	No	2.03	120.36	-3.65	0.12	0
2	Isodemethylwedolactone	5318547	0	No	High	No	2.05	124.27	-3.56	0	0
3	Boeravinone F	12004175	0	No	High	No	2.73	121.11	-4.14	0.06	0
4	Jujubogenin	15515703	1	No	High	No	6.27	58.92	-6.65	0.93	1
5	Boeravinone B	14018348	0	No	High	No	2.39	100.13	-3.8	0.12	0
6	Withanolide L	179575	0	No	High	Yes	2.91	83.83	-4.35	0.64	2
7	Diosgenone, 4-Dimethyl	249449	1	No	High	No	6.31	55.76	-6.63	0.83	0
8	Demetylwedeloactone	5489605	0	No	High	No	2.05	124.27	-3.56	0	0
9	Withanolide A	11294368	0	No	High	Yes	3.25	96.36	-4.67	0.79	2
10	Boeravinone A	14018346	0	No	High	No	2.92	89.13	-4.13	0.17	1
11	Sarasapogenin	92095	1	Yes	High	No	6.49	38.69	-6.51	1	0
12	Tiliroside	5320686	3	No	Low	No	2.47	216.58	-4.93	0.2	8
13	Asarinin	5204	0	Yes	High	No	2.68	55.38	-3.93	0.4	2
14	Isoginkgetin	5318569	1	No	Low	No	5.69	159.8	-7.17	0.06	5
15	Sequoiaflavone	5484010	1	No	Low	No	5.36	170.8	-6.96	0.03	4
				Synthetic drugs							
1	Methotrexate	126941	1	No	Low	No	-1.85	210.54	-1.19	0.25	10
2	Azathioprine	2265	0	No	Low	No	0.1	143.4	-1.97	0.11	3
3	Upadacitinib	58557659	0	No	High	Yes	2.69	78.32	-3.83	0.47	6
4	Alitretinoin	449171	1	Yes	High	No	6.3	37.3	-5.34	0.45	5

Note: Obey Lipinski: That's great if there were no violations. Blood-Brain Barrier: It does indicate preference. Human Intestinal Absorption (HIA): High is acceptable, Molecules anticipated not to be eliminated from the central nervous system by P-glycoprotein are indicated by a PGP- ; an XLOGP3 score of 0.7 to +5.0 indicates excellent lipophilicity. Polarity: A good TPSA falls between 20 and 130 ، 2. Water Solubility: Log S value less than 6 indicates good, water solubility (Log S scale: Insoluble = -10, Poor = -6, Moderate = -4, Soluble = -2, Very = 0, Highly). Saturation (percentage Csp3): A percentage of carbons in the sp3 hybridization that is not less than 0.25 is deemed to be good saturation. Flexibility (Rotatable Bonds): Excellent provided that there aren't any more than nine of them. [42]

Table 3: CYP properties of the Phytocompounds and synthetic drugs.

S. No	Compound Name	PubChem ID	CYP1A2 Inhibitor	CYP2C19 Inhibitor	CYP2C9 Inhibitor	CYP2D6 Inhibitor	CYP3A4 Inhibitor	Log K_P (Skin Permeation) (cm/s)	A Bio-Availability Score (ABS)
	Phytocompounds								
1	**Boeravinone E**	11537197	Yes	No	No	Yes	Yes	-6.86	0.55
2	**Isodemethylwedolactone**	5318547	Yes	No	No	Yes	No	-6.68	0.55
3	**Boeravinone F**	12004175	Yes	No	No	Yes	No	-6.35	0.55
4	**Jujubogenin**	15515703	No	No	No	No	No	-4.73	0.55
5	**Boeravinone B**	14018348	Yes	No	No	Yes	Yes	-6.51	0.55
6	**Withanolide L**	179575	No	No	Yes	No	Yes	-6.99	0.55
7	**Diosgenone, 4-Dimethyl**	249449	No	No	No	No	No	-4.59	0.55
8	**Demetylwedeloactone**	5489605	Yes	No	No	Yes	No	-6.68	0.55
9	**Withanolide A**	11294368	No	No	No	No	No	-6.86	0.55
10	**Boeravinone A**	14018346	Yes	No	Yes	Yes	Yes	-6.22	0.55
11	**Sarasapogenin**	92095	No	No	No	No	No	-4.23	0.55
12	**Tiliroside**	5320686	No	No	No	No	No	-8.17	0.17
13	**Asarinin**	5204	No	Yes	No	Yes	Yes	-6.56	0.55
14	**Isoginkgetin**	5318569	No	No	Yes	No	No	-5.72	0.55
15	**Sequoiaflavone**	5484010	No	No	Yes	No	No	-5.86	0.55
	Standard Drugs								

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1	Methotrexate	126941	No	No	No	No	No	-10.39	0.11
2	Azathioprine	2265	No	No	No	No	No	-7.92	0.55
3	Upadacitinib	58557659	Yes	Yes	No	Yes	No	-6.71	0.55
4	Alitretinoin	449171	Yes	Yes	Yes	No	No	-3.66	0.85

Note: Yes, indicating that the drug inhibits CYP450 enzymes and has unanticipated adverse effects; "No" means that the drug does not inhibit the CYP450 enzymes or have any adverse reactions that are harmful. The greater the negative the log Kp, the less skin-permeable the molecule is; ABS 0.55 shows that the rule of five is satisfied, while ABS 0.17 shows that it is not. [42]
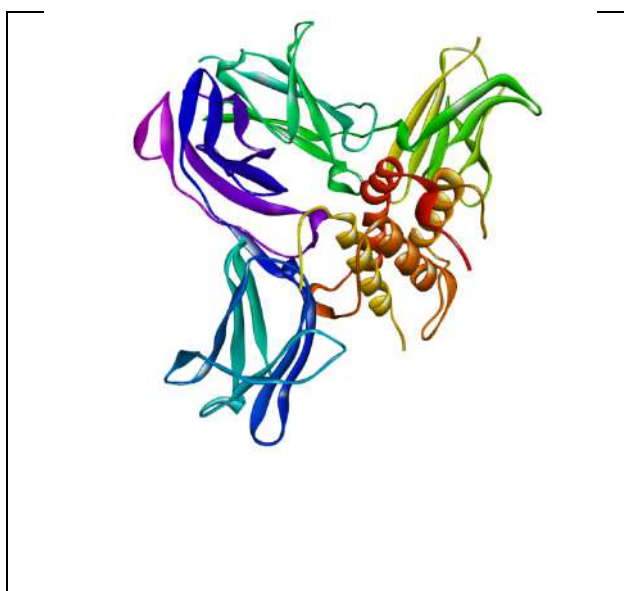
Figure 1: The 3D structure of the Target Protein Human Thymic Stromal Lymphopoietin (PDB ID: 5J11).
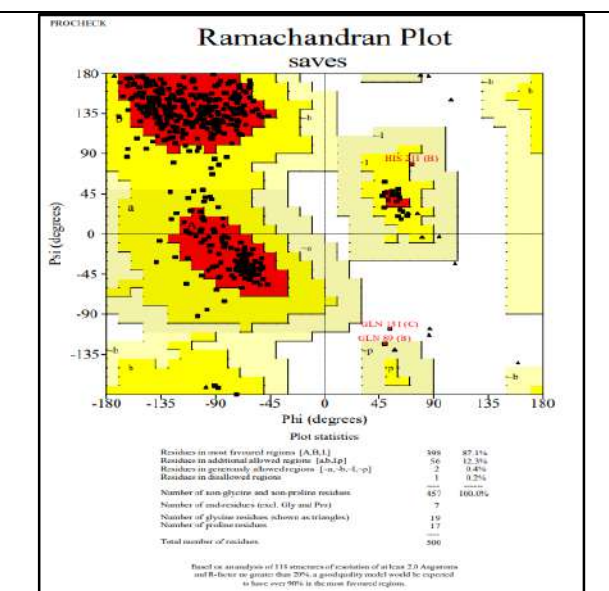
Figure 2: Ramachandran plot of 5J11.
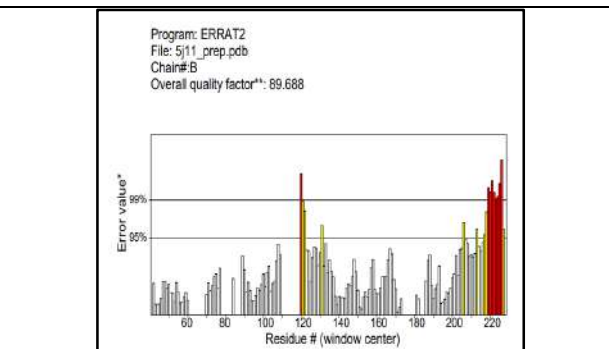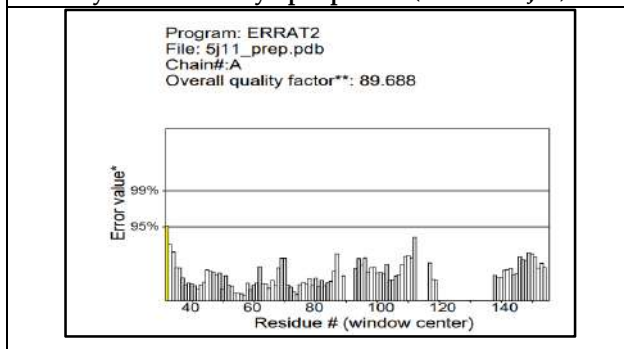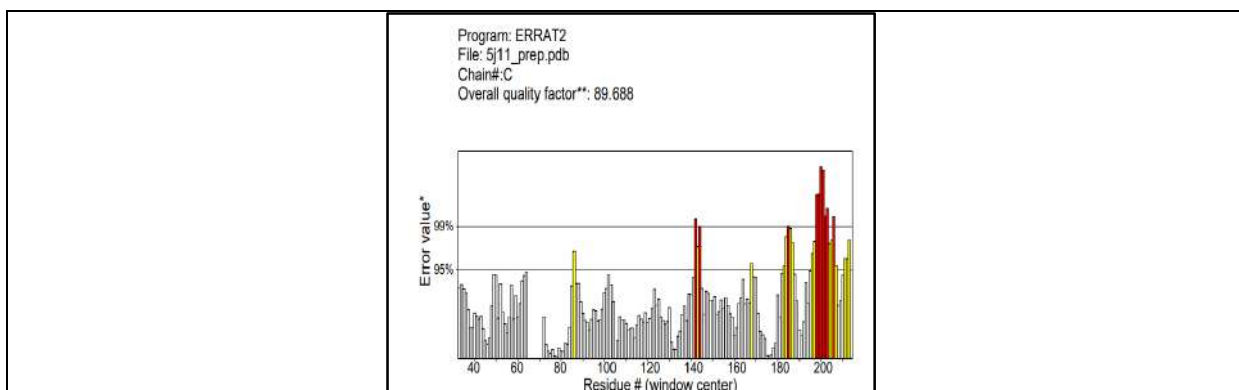
Figure 3:ERRAT: Overall Quality Factor: 89.688 For 5J11
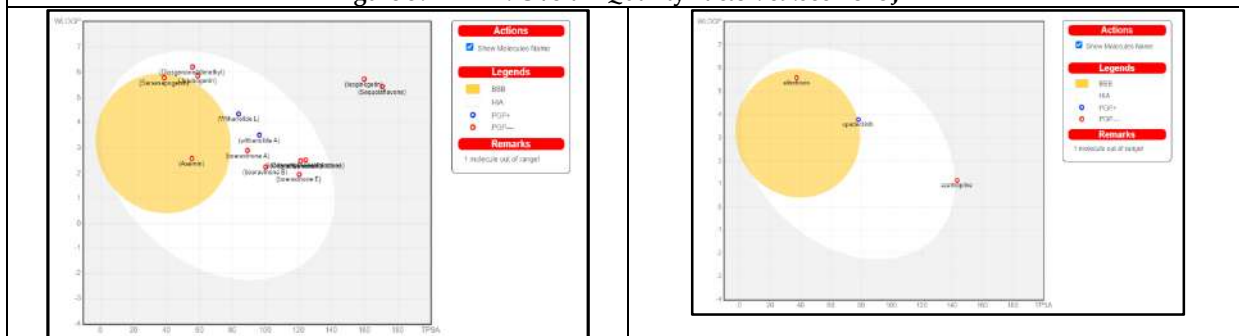
Figure 4: ADMET Properties – Boiled Egg for the Top 10 Phytocompounds	Figure 5: ADMET Properties – Boiled Egg for the Synthetic compounds

Note:

BBB: Points located in BOILED-Egg's yolk are molecules predicted to passively permeate through the blood-brain barrier.

HIA: Points located in BOILED-Egg's white are molecules predicted to be passively absorbed by the gastrointestinal tract.

PGP+: Blue dots are for molecules predicted to be effluated from the central nervous system by the P-glycoprotein.

PGP-: Red dots are for molecules predicted not to be effluated from the central nervous system by the P-glycoprotein.

Note:

BBB: Points located in BOILED-Egg's yolk are molecules predicted to passively permeate through the blood-brain barrier.

HIA: Points located in BOILED-Egg's white are molecules predicted to be passively absorbed by the gastrointestinal tract.

PGP+: Blue dots are for molecules predicted to be effluated from the central nervous system by the P-glycoprotein.

PGP-: Red dots are for molecules predicted not to be effluated from the central nervous system by the P-glycoprotein.

Figure 6: 3D interaction of the phytocompound Sarasapogenin with the target protein.

Figure 7:2D interaction of the phytocompound Sarasapogenin with the target protein.

Figure 8: 3D interaction of the Synthetic compound Methotrexate with the target protein.

Figure 9:2D interaction of the Synthetic compound Methotrexate with the target protein.

Figure 10:3D interaction of the Synthetic compound Azathioprine with the target protein.

Figure 11:2D interaction of the Synthetic compound Azathioprine with the target protein.

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Figure 12:3D interaction of the Synthetic compound Alitretinoin with the target protein.

Figure 13:2D interaction of the Synthetic compound Alitretinoin with the target protein.

RESEARCH ARTICLE
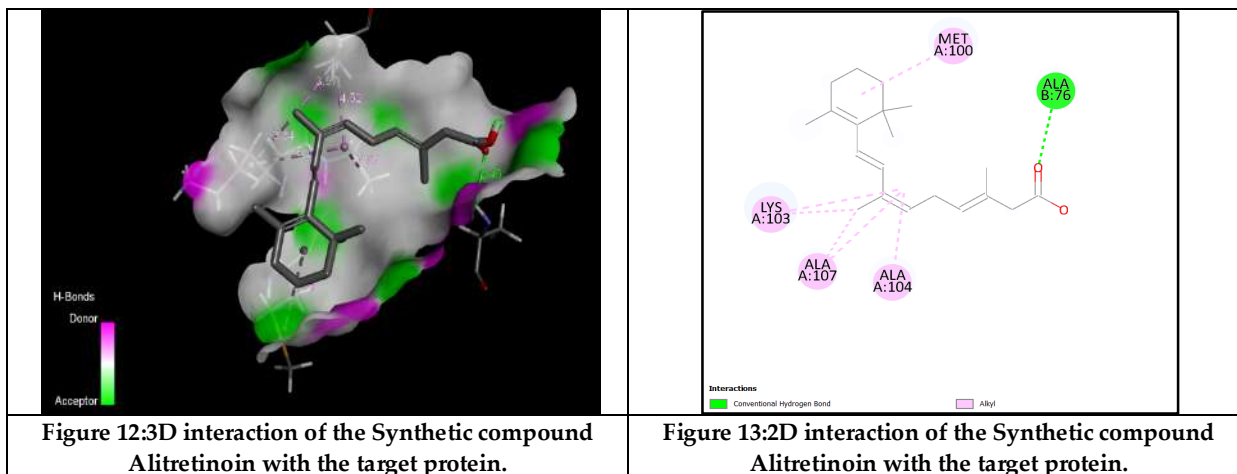
An Analysis of Patient Satisfaction with Medical Services from an Outpatient Facility at a Private Hospital in the Coimbatore District

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ABSTRACT

Patient satisfaction is an essential indicator for evaluating the calibre of services provided to outpatients. It is imperative to periodically assess the healthcare systems concerning patient satisfaction. To evaluate the level of customer satisfaction with the outpatient department's services to cost, waiting times, medical treatment, and accessibility of services. The study was designed by involvement of 200 participants**.** A pre-structured questionnaire was given to the outpatients or attendants and by face-to-face interviews data was collected at the end of their outpatient visit. A total of 200outpatients were selected at random in 15 days between 4 and 6 p.m. The items in the questionnaire referred to the particulars of the patient such as age, gender, occupation, concerned departments, service particulars in the registration area, the concerned junior medical officers and consultants in the respective department, the lab (such as pathology, microbiology) and the medical pharmacy. The availability of services and medical treatment care was found to be satisfactory.93% of the participants felt satisfactory about the cleanliness and overall availability of the facilities, 92 % were satisfied with nursing staff, 88% of the respondents found the communication by the doctor good, 92% of the respondents were satisfied with the explanation of the disease by the doctor. However, 32% of the participants were suffering in locating the place for consultation, investigation, and pharmacy. Suggestions for reducing wait times at pharmacy and registration counters, delectable cuisine in food courts, and investigation expenses must be made to boost consumer satisfaction. To satisfy customers, it is advised to offer drug discounts and reduce consultant registration fees.

Keywords: Outpatient satisfaction, medical treatment, availability of service, facilities.

INTRODUCTION

There are two meanings to health care. Medical care organizations and health care programs (a and b). The primary focus of medical care organizations is curative treatment. They should be reasonably priced, visually appealing, and focused on cutting-edge technology. Quality assurance has become a globally significant factor in the delivery of healthcare services in recent years [1]. Several factors, including accessibility, affordability, effectiveness, and viability, affect the healthcare system. It is acknowledged that a key factor in determining the Caliber of healthcare services is customer happiness. It is anticipated that treatment outcome and prognosis will be impacted by provider satisfaction about attitude towards these services. The healthcare system needs to be examined as frequently as feasible [2]. For medical facilities like tertiary care and Quaternary care hospitals to provide services to outpatients, their contentment is crucial[3]. Rural residents are not sufficiently aware of their rights, particularly when it comes to health care services [4]. This is why we decided to conduct a study to gauge patient satisfaction with clinical care, including the physician's and junior medical doctor's strategy to approach, investigation, medication education, Awareness about the diet, service accessibility, waiting time for consultation, and cost in private Mult specialty hospital's outpatient department.

MATERIALS AND METHODS

The study was carried out in the outpatient department of a private multi-specialty Hospital in Coimbatore district. A pre-structured questionnaire was given to the outpatients or attendants and by face-to-face interviews data was collected at the end of their outpatient visit. A total of 200outpatients were selected at random in 15days between 4 and 6 p.m. The items in the questionnaire referred to the particulars of the patient such as age, gender, occupation, concerned departments, service particulars in the registration area, the concerned junior medical officers and consultants in the respective department, the lab (such as pathology, microbiology) and the medical pharmacy. The questionnaire included choices like acceptable/disappointing, easy/difficult, adequate/inadequate, and 20-minute time slots of actual time spent in each stage of the visit. Informed consent was obtained from the patient. The participants were informed that the objective of the research was to gauge how satisfied outpatients were with the hospital's healthcare facilities to make future facility improvements. Additionally, the outpatients were informed that the investigator was not a member of the medical staff. It was also made clear that they were free to respond honestly. Both the patient and the doctor who was examining continued to be unnoticeable. The replies were given as percentages. There were 200 outpatients in the study group—102 males and 98 females.

Around 78% of the population fell into the 25–48 age range (graph:1). Nearly 90% of those who participated were outpatients, while the remaining 10% were family members of elderly outpatients, ages 60 to 65. In the organization, the outpatient department is 100% clean (93%). Concerning the seating arrangements in the outpatient department, the overall availability of facilities (Table 1) was excellent (82%). 71% of those who participated said they were satisfied with the outpatient department's hours and the remaining 29% were not satisfied because they are from a long distance, 92% said they were satisfied with the outpatient nursing staff's amenities, 46% said it was very difficult to find the relevant specialist section in the outpatient department, and 89% said the number of medical practitioners available in the outpatient department was sufficient. Merely 32% of the participants reported difficulty locating the pharmacy. About the clinical treatment area (Table 2), 98% of the participants considered the doctors' approach satisfactory, 88% thought the doctor communicated well, 92% were satisfied with the way the doctor explained the disease, 92% thought medical care was satisfactory, and 91% thought the doctor was efficient. 83% of respondents were satisfied with the quantity of necessary investigations, while 92% of participants felt that the investigations were necessary. In 97% of the cases, the patient felt that the doctor had satisfactorily interpreted the investigation findings. For 83% of those who responded, the drug prescription process was generally satisfactory or simple to understand. Regarding the delay (waiting time) (Table 3), 79% of outpatients reported that the registration procedure took them not comfortably. In all, 89% of the outpatients had no trouble finding the relevant accessory department. In 12% of the cases, the consultation with the doctor took less than 30 minutes, in 61% of the cases, it

took 30 to 60 minutes, in 26% of the cases, it took 60 to 90 minutes, and in 1% of the cases, it took 90 to 120 minutes. Merely 53% of the outpatients found their time in the pharmacy to be satisfactory, however, 68% of the cases had the satisfactory time required to locate the pharmacy within 10 minutes.For all participants, the cost of registration was a little high, and consultation was acceptable. 46 % of the participants felt that the cost of the investigation was high, 33% of the participants, it was moderate; and 21% of the respondents, it was low. 11% of the participants said the cost of the medications was acceptable and the remaining felt it was too high. The consumer's purchasing power and the various costs of medications may have an impact on this. According to 64% of interviewees, the food court was too expensive and unsatisfactory. The related flavor and taste are also not very appealing but can be purchased for an emergency.

DISCUSSION

The patient considered the study's conclusions about medical treatment and accessibility to be sound. Suggestions for reducing wait times at pharmacy and registration counters, delectable cuisine in food courts, and investigation expenses must be made to boost consumer satisfaction. To satisfy customers, it is advised to offer drug discounts and reduce consultant registration fees.

ACKNOWLEDGEMENTS

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Table: 1 Distribution of availability of facilities in Hospital

S.No	Availability	Percentage (%)
	Cleanliness of the OPD area	
1.	Satisfactory	100
	Unsatisfactory	00
	Arrangement of seating in OPD	
2.	Satisfactory	82
	Unsatisfactory	18
	OPD timing	
3.	Satisfactory	71
	Unsatisfactory	29
4.	**Verdict the concerned specialist department in the OPD**	

	Easy	54
	Difficult	46
5.	**Availability of the doctors & JMO in OPD**	
	Adequate	89
	Inadequate	11
6.	**Locating the pharmacy department**	
	Easy	68
	Difficult	32

Table: 2 Distribution of Clinical Treatment in Hospital

S. No	Availability	Percentage (%)
1.	**Approach by the doctors & JMO**	
	Satisfactory	98
	Unsatisfactory	2
2.	**Communication by consultants**	
	Satisfactory	88
	Unsatisfactory	12
3.	**Detailing about the disease to the outpatients**	
	Satisfactory	92
	Unsatisfactory	8
4.	**Medical treatment**	
	Satisfactory	92
	Unsatisfactory	8
5.	**Efficiency**	
	Satisfactory	91
	Unsatisfactory	9
6.	**Investigations assessed by the outpatients**	
	Good	92
	Average	8
7.	**Quantity of necessary investigations**	
	Necessary	83
	unnecessary	17
8.	**Interpretation of the investigation reports by the doctor to outpatients**	
	Good	97
	Average	3
9.	**Education on drug prescription**	
	Easy	83
	Difficult	17

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Table: 3 Distribution of waiting time and cost for other criteria

S. No	Availability	Percentage (%)
1.	**Waiting time for the registration area**	
	Convenient	79
	Inconvenient	21
2.	**Location of another Accessory department**	
	Satisfactory	89
	Unsatisfactory	11
3.	**Waiting Time in Pharmacy**	
	Satisfactory	53
	Unsatisfactory	47
4.	**Cost of registration**	
	High	46
	Moderate	33
	Low	21
5.	**Cost of drugs**	
	Acceptable	11
	Not acceptable	89
6.	**Cost of food in the food court**	
	High	64
	low	36
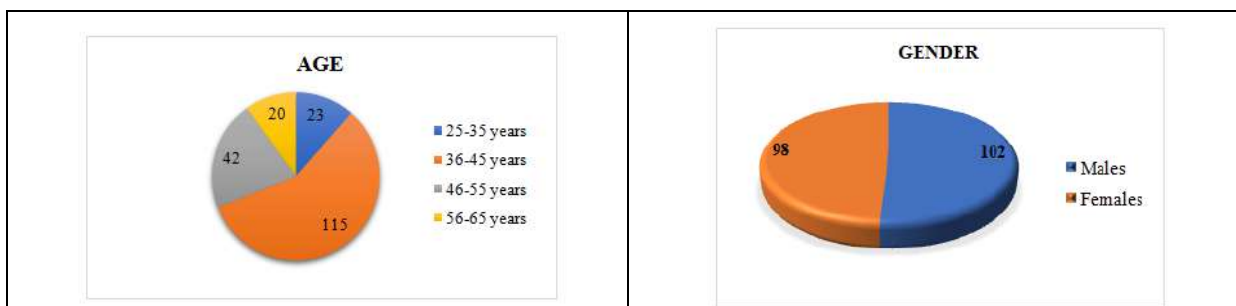
Graph 1:Age distribution among the participants

Graph 2: Gender distribution among the participants
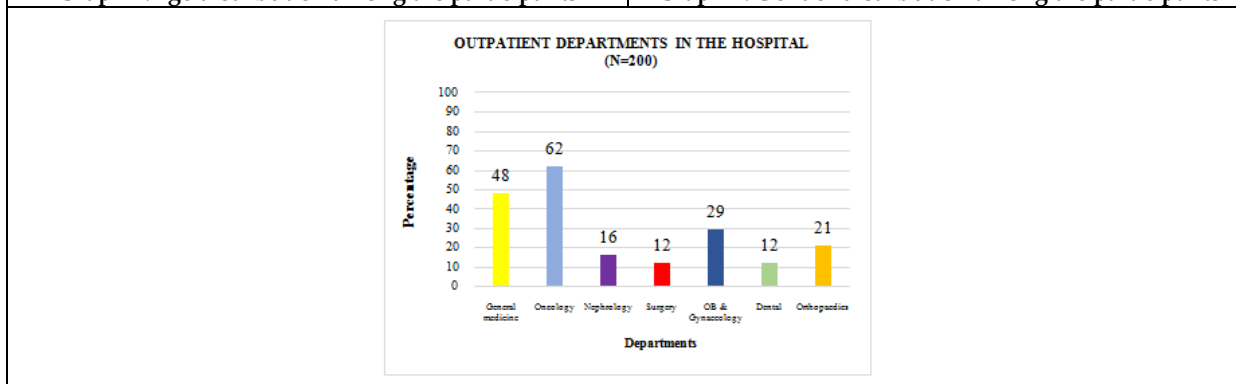
Graph 3: Outpatient departments in the hospital

RESEARCH ARTICLE

Associated Traditional Knowledge and Documentation of Weeds in Hiriyur, Karnataka

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ABSTRACT

Weeds pose a major threat to agricultural and horticultural cropping systems, reducing yields. Many scientific reports have shown that weeds have a better ability to compete for resources as compared to the major crops in various agro-ecosystems and in the absence of major crops, weeds acting as reservoir or alternative host for pathogens is a major obstacle reducing overall yields. An attempt was made to document the weeds in Hiriyur, Karnataka. The present study was conducted between March 2019 and February 2020 and nearly 57 weed species from 25 families were documented. I recorded 57 weed species taxonomically distributed in 25 families and 45 genera. Asteraceae and Amaranthaceae have the highest number of species (14.03% species), followed by Euphorbiaceae (10.52% species) and Poaceae (7.01% species) respectively.

Keywords: Weed survey, traditional knowledge, Hiriyur

INTRODUCTION

Weeds are the specialized plants that have evolved with abundant seed production, aggressive reproduction, high regeneration potential, and great phenotypic plasticity over temporal and spatial scales (Richards et al., 2006). Weedy plants are considered undesirable in certain locations (Dantonia and Meterson, 2002; Halzner and Numata, 2013). Among various biological pressures, weeds are considered to be one of the most detrimental to crop production (Einhelling, 1996; Weston and Duke, 2003). Moreover, these weeds provide harborage for numerous pests of crops and thus indirectly cause many plant diseases (Zimdahi, 2018). The presence of weeds in agricultural and horticultural fields competes with native plants for yields (Zimdahi, 2018). At the same time, information about weed

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seasonal phenomena is important for formulating effective control and management (Chmielewski, 2013; Kumar et al., 2019). The documentation of weeds is important for the management and control of weeds (Norsworthy et al., 2013; Haq et al., 2021). The identification and documentation of weed invasion are important for formulating various strategies for managing the weeds (Ward et al.,2014). Management decisions for agriculture and horticulture fields are dependent upon the phenological information of crops for improving yield (Chmielewski,2013). Most of the weeds are effectively well adapted to grow and proliferate in diverse areas (Kuester et al., 2014). The weed properties of these species are often advantageous over more desirable crop species. These species often grow and reproduce quickly or are short-lived, as their seeds typically remain in the soil for several years.

MATERIALS AND METHODS

Hiriyur is a taluk headquarter in Chitradurga district in the state of Karnataka, India. Hiriyur is located at 14.312°N 76.651°E. It has an average elevation of 585 meters (1919 ft). Hiriyur has a Subtropical steppe climate (Classification: BSh). The annual temperature in this district is 28.34 °C (83.01 °F), which is 2.37% higher than the average temperature in India. Typical rainfall in Hiriyur is approximately 84.55 mm (3.33 inches), with 124.03 rainy days per year (33.98% chance of rain). Plants were collected during March-2020 to Feb-2021 and identified with the help of flora up to species level (Arora et al., 1976; Caton et al.,2004; Cooke,1905; Elmore,1990; Gamble,2012 ; Parimala,2011;Quammen, 2012;Sastry et al.,1980; Stubbendieck et al.,1994; Whitson. and Burrill ,1991). Standard herbarium techniques are followed and specimens are preserved in the departmental herbarium for further reference.

RESULTS AND DISCUSSION

In this study, 57 weed species were recorded with 45 genera and 25 families (Table 1). Among 25 families, 5 families accounting for half of the species and 20 families for the other half. 15 families with single species. The Asteraceae and Amaranthaceae were the dominant family with 8 species (14.03%) followed by Euphorbiaceae with 6 species (10.52%) and Poaceae with 4 species (7.01%). The rest of the species were represented by Fabaceae, Capparidaceae, Solanaceae and other families (Table 2). The monotypic families are Lamiaceae, Plumbaginaceae, Cactaceae, Acanthaceae Apiaceae, and others represented in Table 1. Humans breed plants for yield, but nature breeds plants for survival. Weeds are strong competitors by nature and can withstand much adversity. The most competitive weeds always tend to dominate. Although agricultural weeds have some disadvantages, there are many more advantages that ensure soil stabilization. Wildlife habitat, diet, and aesthetic qualities ,add organic ingredients. and medicine. Different examples shown in Table 1 were used to explain the importance of weeds to local people in the selected areas. I also surveyed the local area and identified the most prevalent weeds in the selected area. I documented traditional knowledge of this type of traditional practitioners and village elders. Most people agree that weeds are just a nuisance in the field, and just thinking about them is like uprooting a seed. This research and awareness of the usefulness of weeds was well received by people, who were excited to share their knowledge about weeds and their traditional uses. Many weeds were used medicinally, and few were used as hedges or ornamentals. A literature review was conducted to support and confirm the medicinal properties claimed by local residents. Most of the weeds are studied for their medicinal properties.

CONCLUSION

This study identified the 57 most common weedy plants and documented associated traditional knowledge from traditional practitioners and local people. My study suggests that people are less aware of the ecological benefits of weeds in soil conservation, greening, and their medicinal properties. In addition to documentation, we raised awareness about the ecological importance of weeds and their medicinal properties through group discussions and meetings. I conducted a thorough literature search on the bioactive properties of the selected weed species and

verified their scientific properties against the latest publications from the scientific community. This study highlights the importance of weeds and their characteristics.

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Table 1: Associated Traditional Knowledge of Weeds

1	2	3	4	5	6
Sl No	Plant	Scientific Name	Family	Local Name	Associated Traditional Knowledge
1	Country mallow	*Abutilon indicum*	Malvaceae	Mallow	It used as a traditional medicine as a laxative, emollient, analgesic, anti-diabetic, anti-inflammatory and blood tonic agent and also in the treatment of leprosy, urinary disease, jaundice, piles, relieving thirst, cleaning wounds and ulcers, vaginal infections, diarrhea, rheumatism, mumps, pulmonary tuberculosis, bronchitis, allergy, blood dysentery, some nervous and some ear problems.
2	Indian copperleaf	*Acalypha indica*	Euphorbiaceae	Kuppe gida	Used as anthelmintic, anti-inflammation, anti-bacterial, anti-cancer, anti-diabetes, anti-hyperlipidemic, anti-obesity, anti-venom, hepatoprotective, hypoxia, and wound healing medicine.
3	Bristly starbur	*Acanthospermum hispidum*	Asteraceae	--	Used for treatment of jaundice, malaria, vomiting, cephalgias, head-ache, abdominal pain,convulsions, stomachache, constipation, eruptive fever, snake bite, epilepsy, blennorrhoea, hepato-biliary disorders,malaria, microbial infection and viral infections.
4	Uttaraani	*Achyranthes aspera*	Amaranthaceae	Uttaraani	Used as medicine , used in the treatment of boils, asthma, in facilitating delivery, bleeding, bronchitis, debility, dropsy, cold, colic, cough, dog bite, snake bite, scorpion bite, dysentery, earache, headache, leukoderma, renal complications, pneumonia, and skin diseases. Used in Poojas during festival
5	Acmella	*Acmella oleracea*	Asteraceae	Acmella	used as a Used as medicine, analgesic, antiseptic, antioxidant and diuretic Used as fodder
6	Grass	*Aegilops tauschii*	Poaceae	Hullu	Flowers are used in festival,, it has medicine property
7	Bilikasa	*Aerva lanata*	Amaranthaceae	Bilikasa	Fodder, used as medicine, used **as** diuretic with anti-inflammatory, antihelmintic, anti-bacterial and mild analgesic effects**.** It is used in the treatment of lithiasis, cough, asthma, and headache and as an antidote for rat poisoning
8	Goat weed	*Ageratum*		---	Used as common wound and the burned

		conyzoides	Asteraceae		one, antimicrobe, arthrosis, headache, and dyspnea. an antimicrobial, and mouthwash as manure, insecticide, pesticide, herbicide, nematicide, fodder.
9	Floss flower	*Ageratum houstonianum*	Asteracea	--	Used as curing fever, paste of leaves is useful in wound healing, essential oil shows cytotoxic effect, antimicrobial and mosquitocidal effects anti- fungal and antibacterial *properties*
10	Red calico plant	*Alternanthera bettzickiana*	Amaranthaceae	--	Used as laxative, galactagogue, antipyretic, wound healing. - Studies have suggested antibacterial, antioxidant, antiviral, antioxidant, phytoremediative, mutagenic, hypoglycemic, anti-arthritic, anticancer properties.
11	Brazilian joyweed	*Alternanthera brasiliana*	Amaranthaceae	--	used against inflammation, cough, and diarrhea, *used* as digestive, depurative and diuretic
12	Smooth joyweed	*Alternanthera paronychioides*	Amaranthaceae	--	Used to treat hepatitis, tight chest, bronchitis, asthma and other lung troubles. The leaves and shoots boiled and drunk as antihypertensive remedy
13	Sonna Mullu	*Alternanthera pungens*	Amaranthaceae	Khaki weed	Used as medicine, for constipation with griping, and as an enema for diarrhoea
14	Jal jamba	*Alternanthera sessilis*	Amaranthaceae	Jal jamna	Flowers are used in festivals, it has medicine property used to treat hepatitis, bronchitis, asthma and other longs problems. The leaves and shoots boiled and drunk as antihypertensive remedy. and milky latex is poisonous
15	Mullu dantu	*Amaranthus spinosus*	Amaranthaceae	Mullu dantu	Used as Ayurveda medicine, the boiled leaves and roots are used as laxative, diuretic, anti-diabetic, antipyretic, anti-snake venom, antileprotic, anti-gonorrheal, expectorant and to relieve breathing in acute bronchitis. It also has anti-inflammatory, immune modulator, anti-androgenic and anthelmintic properties.
16	Datura	*Argemone maxicana*	Papaveraceae	Daturi	Used as Ayurveda medicine, Seeds are poisonous, for the treatment of several diseases including tumors, warts, skin diseases, inflammations, rheumatism, jaundice, leprosy, microbial infections, and malaria.
17	Red spiderling	*Boerhavia diffusa*	Nyctaginaceae	--	Used to treating inflammation, jaundice, asthma, rheumatism, nephrological disorders, ascites, anemia, and

				gynecological disorders.
18	Shaggy button weed	*Borreria hispida*	Rubiaceae	--	Used to treating urinary infections, oliguria, venereal diseases, conjunctivitis, hemorrhoids, gallstones, stomach ailments, internal injuries of nerves, and kidney, coughs, malaria, internal heat, dyslipidemia, and for reducing weight.
19	Buffalo grass	*Bouteloua dactyloides*	Poaceae	Yemme hullu	Used as medicine for piles
20	Crown flower	*Calotropis gigantean*	Asclepiadaceae	Ekka	Used to treating skin, digestive, respiratory, circulatory and neurological disorders and was used to treat fevers, elephantiasis, nausea, vomiting, and diarrhea.
21	Calotropis	*Calotropis procera*	Asclepiadaceae	Ekka	Used as medicine, fevers, rheumatism, indigestion, cough, cold, eczema, asthma, elephantiasis, nausea, vomiting and diarrhea.
22	Sicklepod	*Cassia tora*	Fabaceae	Sicklepod	used in the treatment of leprosy, ring worm, flatulence, colic, dyspepsia, constipation, cough, bronchitis and cardiac disorders
23	Cassia	*Cassia fistula*	Caesalpiniaceae	Cassia	Used as medicine, antifungal, antiviral, antidiahorreal and antidysentry properties, used for treatment of diabetes, asthma, leprosy, thoracic obstructions
24	Ondelaga	*Centella asiatica*	Apiaceae.	Ondelaga	Used as medicine, used to treat various disorders, dermatological conditions, and minor wounds
25	Hurhur	*Cleome gynandra*	Capparidaceae	Hurhur	Fodder, used as medicine, used to treat conditions including food poisoning, rheumatism, inflammation, bacterial infections, and especially pain-related conditions such as headache toothache, headache, neuralgia, stomach pain, ear-ache, rheumatoid arthritis, skeletal fractures, colic pain and chest pain
26	Tick weed	*Cleome pentaphylla*	Capparidaceae	Kolikalina gida	Used to cure diseases such as scurvy. anti-inflammatory, anti-bacterial, antimicrobial, anticancer, antioxidant, antiallergenic.
27	Tick weed	*Cleome viscosa*	Capparidaceae	--	Used as medicine for rheumatic arthritis, hypertension, malaria, neurasthenia, stomachic, laxative, diuretic, and anthelmintic and wound healing
28	Kanne soppu	*Commelina benghalensis*	Commelinaceae	Kanne soppu	Flowers are used in festival, it has medicine property, used to treat leprosy, sore throat, opthalmia, burns, pain and infammation and also used as de pressant, demulcent,

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				emollient and laxative.
29	Crotolaria	*Crotalaria juncea*	Fabaceae	Crotolaria	Used as medicine for wounds and anti-inflammatory and antinociceptive activity Used to clean the black board
30	Three-leaved caper	*Croton bonplandianum*	Euphorbiaceaee	--	Used as fodder, used as *a laxative, expectorant, analgesic.*
31	Bermuda grass	*Cynodon dactylon*	Poaceae	Garike	Used as fodder, used as *a laxative, expectorant, analgesic.*
32	Datura	*Datura stramonium*	Solanaceae	Datura	Used for medicine, Used to treat back pain, antiepileptic, anti-asthmatic, analgesic, antioxidant, antimicrobial, insecticidal, repellent and organophosphate protective effects.
33	Duranta	*Duranta erecta*	*Verbenaceae*	Durantha	Used as medicine, diuretics, antidote to treat itches, infertility, pneumonia, malaria, intestinal worms, abscesses and neuralgic disorder. It exhibits antioxidant, antiparasitic, antibacterial, antifungal and antiviral activities against human pathogens
34	Indian globethistle	*Echinops echinatus*	Asteraceae	Brahmadhande	used as a stimulant to treat use the term Sexual debility, used to *treat different infectious diseases including trachoma, sepsis, typhoid, gonorrhea.*
35	Wild poinsettia	*Euphorbia geniculata*	Euphorbiaceae	Euphorbia	It is used as antibacterial, anti-inflammatory, antimalarial, galactogenic, antiasthmatic, antidiarrheal, anticancer, antioxidant, antiferlity, antiamoebic, and antifungal activities.
36	Euphorbia	*Euphorbia heterophylla*	Euphorbiacae	Euphorbia	Seeds are poisonous, used to treat ailments such as skin infections, fever, and gastrointestinal disorders.
37	Asthma herb	*Euphorbia hirta*	Euphorbiaceae	Euphorbia	It is used traditionally for female disorders, respiratory ailments ,cough, coryza, bronchitis, and asthma, worm infestations in children, dysentery, jaundice, pimples, gonorrhea, digestive problems, and tumors.
38	Morning glory	*Evolvulus alsinoides*	Convolvulaceae	----	used in Ayurveda as a brain tonic in the treatment of neurodegenerative diseases, asthma and amnesia, *treatment of neurodegenerative diseases as brain tonic, amnesia and asthma, epilepsy, nervous debility and loss of memory.*
39	Lantana	*Lantana camara*	Verbanaceae	Lantana, gadhigulabi	Used as fodder, medicine for wound healing, fever treatment, cough treatment, influenza treatment, stomach ache, malaria,
40	Leucas	*Leucas aspera*		Thumbe	Used as fodder, Used for cooking, it

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		Lamiaceae		shows antifungal, antioxidant, antimicrobial, antinociceptive and cytotoxic activity, *antipyretic and insecticide*
41	Touch me not plant	*Mimosa pudica*	Mimosaceae	Muttidare muni	Used as medicine, cure several disorders like cancer, diabetes, hepatitis, obesity, and urinary infections, piles
42	Opuntia	*Opuntia stricta*	Cactaceae	Papaskalli	Used as medicine, used *in the management of diseases that involves oxidative stress, especially diabetes*, obesity and cancer
43	Parthenium	*Parthenium hysterophorus*	Asteraceae	Parthenium	Used as medicine, for skin inflammation, rheumatic pain, diarrhoea, urinary tract infections, dysentery, malaria and neuralgia
44	Akki hullu	*Paspalum floridanum*	*Poaceae*	Akki hullu	Used as fodder, Used for cooking
45	Nele nelli	*Phyllanthus niruri*	Euphorbiaceae	Nele nelli	antibacterial, anti-hyperglycemia, anti-viral, diuretic, hepatoprotector, and immunomodulator, *role in treating ulcers and urinary tract stones*
46	Plumbago	*Plumbago zeylanica*	Plumbaginaceae	Plumbago	Used as medicine, used in the treatment of stubborn chronic rheumatoid arthritis, skin diseases and tumerous chronic menstrual disorders, viral warts and chronic diseases of nervous system Seeds are poisonous
47	Jigali	*Portulaca oleracea*	*Portulacaceae*	Jigali	Used as medicine acting as a febrifuge, antiseptic, vermifuge, anti-inflammatory, antidiabetic, skeletal muscle relaxant, hepatoprotective, anticancer/antitumor, antioxidant, gastroprotective, neuroprotective, wound healing
48	Sida	*Sida acuta*	Malvaceae	Sida	Used as medicine, used as astringent, tonic and useful in treating urinary diseases and blood disorders, bile, liver and as treatment for nervous diseases Seeds are poisonous
49	Heart-leaf sida	*Sida cordifolia*	Malvaceae	Heart-leaf sida	It is used to treat bronchial asthma, cold and flu, chills, lack of perspiration, head ache, nasal congestion, aching joints and bones, cough and wheezing, and edema.
50	Ganige gida	*Solanum nigrum*	Solanaceae	Ganige gida	Used as fodder, Used as Ayurveda medicine to treat pneumonia, aching teeth, stomach ache, tonsillitis, wing worms, pain, inflammation and fever, tumor, inflammation, and also as hepaprotective, diuretic, antipyretic
51	Mouth fresh	*Spilanthes calva*	Asteraceae	Mouth fresh	Used as medicine, antipyretic, antidiuretic, antiinflammatory, antioxidant,

				immunomodulatory, hepatoprotective, anticancer and antitoothache, leg pain
52	Kolkondika mullu	*Strobilanthes barbatus*	Acanthaceae	Kolkondika mullu	Used as fodder, Used during poojas, used as a valid anti-inflammatory and anti-microbial herbal drug
53	Wild indigo	*Tephrosia purpuria*	Fabaceae	----	Used as medicine, used to treat impotency, asthma, dyspepsia, hemorrhoids, syphilis gonorrhea, rheumatism, enlargement of kidney and spleen.
54	Puncture vine	*Tribulus terrestris*	Zygophyllaceae	Neggilu mullu	It has diuretic, aphrodisiac, antiurolithic, immunomodulatory, antidiabetic, absorption enhancing, hypolipidemic, cardiotonic, central nervous system, hepatoprotective, anti-inflammatory, analgesic, antispasmodic, anticancer, antibacterial, anthelmintic, larvicidal, and anticariogenic activities.
55	Tridax	*Tridax procumbens*	Asteraceae	Tridax	Used as medicine , used to treat bronchial catarrh, diarrhea, dysentery and liver diseases.
56	Burbush	*Triumfetta rhomboidea*	Tiliaceae	----	It is used to treat skin disorders or sometimes dysentery. The roots are used in the treatment of conjunctivitis. The leaves have analgesic, anti-inflammatory and antiviral effects. The seeds have powerful purgative virtues.
57	Ashwagandha	*Withania somnifera,*	Solanaceae	Ashwagandha	It is useful for different types of diseases like Parkinson, dementia, memory loss, stress induced diseases, malignoma and others.

Table-2: Familywise Distribution of weeds in Hiriyur

Sl. No	Family	Number of plants	Per centage	Sl. No	Family	Number of plants	Per centage
1	Acanthaceae	1	1.75%	14	Malvaceae	3	5.26%
2	Amaranthaceae	8	14.03%	15	Mimosaceae	1	1.75%
3	Apiaceae	1	1.75%	16	Nyctaginaceae	1	1.75%
4	Asclepidaceae	2	3.50%	17	Papaveraceae	1	1.75%
5	Asteraceae	8	14.03%	18	Plumbaginaceae	1	1.75%
6	Cactaceae	1	1.75%	19	Poaceae	4	7.01%
7	Caesalpinaceae	1	1.75%	20	*Portulacaceae*	1	1.75%
8	Capparaceae	3	5.26%	21	Rubiaceae	1	1.75%
9	Commelinaceae	1	1.75%	22	Solanaceae	3	5.26%
10	Convolvulaceae	1	1.75%	23	Teliaceae	1	1.75%
11	Euphorbiaceae	6	10.52%	24	*Verbenaceae*	2	3.50%
12	Fabaceaea	3	5.26%	25	Zygophyllaceae	1	1.75%
13	Lamiaceae	1	1.75%				

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| **Figure 1: Map showing Hiriyur, Chitradurga district** | **Figure 2: Family wise percentage distribution of weeds in Hiriyur** |
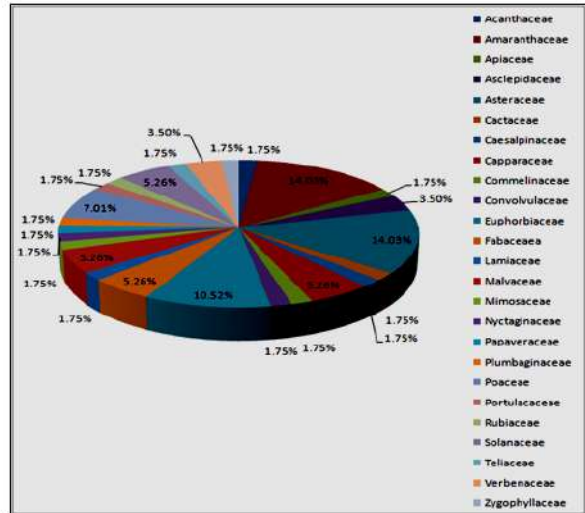
RESEARCH ARTICLE

Diversity in the Workforce: A Catalyst for Innovation, Success and Future Expansion

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ABSTRACT

Workforce diversity refers to the differences and similarities of the employees in terms of age, gender, race, sexual orientation, etc. With demographic shifts and the opening up of geographical boundaries, workforce diversity has presumed an important role in firm innovation. Diversity brings in a heterogeneous workforce. The heterogeneity in them helps in better and more creative idea generation. The study aims to understand the relationship between workforce diversity and firm innovation. The available literature on different dimensions of workforce diversity was reviewed to know its impact on firm innovation. This study will help the management to understand the importance of recruiting a diverse workforce and how to effectively manage them to achieve organizational goals.

Keywords: Workforce diversity, Cognitive diversity, Firm innovation, Value creation, Decision Making

INTRODUCTION

There is a rapid change in the world economy since the 21st century. Globalization and the advancement of technology have brought people around the globe closer to one another (Rizwan et al., 2016). The distance is shrinking day by day due to the advancements in transportation and telecommunication technology(Saxena, 2014). To be competent in the business world companies need to contemplate the statistics and work to attract, recruit, and retain a diverse group of the workforce(Aghazadeh, 2004). The concept of workforce diversity has transformed from a mandatory or government compulsion to a strategic move to improve the organization's performance(Kundu & Mor, 2017). Thus, the organization must recruit and maintain a diverse group of employees. Workforce diversity is

one of the core strategic values where companies are taking the responsibility to promote fairness and equality in the organization(Li et al., 2020). It creates a multicultural workspace that helps the employees to learn from multiple cultures. This also helps in coming up with innovative ideas as it creates a talent pool in the organization (Tamunomiebi & John-Eke, 2020). Organizational culture should be such that every employee can achieve his or her goal without being inhabited by diverse factors such as gender, age, religion, race, nationality, etc(Kundu, 2003). It is very important to give equal opportunities to all employees irrespective of their differences to ensure the achievement of workforce diversity(Kyriakidou, 2003). At the organizational level, the encouragement of a diverse workforce can lead to the pooling of talents that benefit the organization to provide better and more innovative products(Hossain et al., 2020). Innovation is a collaborative process that involves communication and interaction between people in the organization and draws diverse talents from all levels of the firm (Østergaard et al., 2011). There have been numerous research papers on innovation since the second half of the 20th century(República et al., n.d.). There is empirical and theoretical evidence from previous studies which suggest that there is a positive and direct relationship between workforce diversity and innovation (Maré et al., 2014).

Recent research studies on diversity factors like age, gender, status, and educational background explain its contribution to firm innovation(República et al., n.d.). Contemporary companies are facing a lot of pressure due to fierce market competition and rapid technological advancements which highlights the importance of firm innovation (Human, 1996). Every human being has cognitive and democratic characteristics in them. Intelligence level, vocational training, reasoning ability, and experience are some of the cognitive characteristics and age, gender, and ethnicity are democratic characteristics(Østergaard et al., 2011). Diversity creates a knowledge base for the company which builds the basis for learning and helps to develop new combinations. Innovation is an interactive process and diversity is a knowledge base. Diversity among the people who interact can develop innovative ideas. Consequently, workforce diversity creates a positive result on innovation, but too much diversity can also lead to conflicts(Østergaard et al., 2011). The ability of a firm to innovate is a critical aspect of success and growth. Creative Environment has an impact on both the organization and also on the individual employees. The evaluation of the inputs (innovative ideas) and outputs (productivity) of innovation have helped to improve the growth of organizations (Lhuillery et al., 2017). Knowledge creation is considered as the foundation of creating competitive advantage (Mitchell et al., 2009). As the organizations become complex, the employees are expected to engage in the innovation aspect along with the formal job requirements. As such innovation is a critical aspect that decides the future growth of the organization. The majority of the innovations happen while working in teams which may differ in size, structure, and location(Jones et al., 2021). Existing studies have shown that a culturally diverse workforce helps in firm innovation, especially in the ideation and implementation phase(Jones et al., 2021). Companies with higher diversity especially in the management rank are considered to be more innovative. A study conducted by Boston Consulting Group in 2018 highlighted the six diversity factors (age, gender, national origin, career path, industry background education) that have a positive impact on firm innovation (Jones et al., 2020).

It was found that companies in both developed and developing countries with above-average diversity had better payoffs from innovation (BCG, 2018). The ability to offer innovative products is recognized as a critical factor for organizational success and growth (Elias Carayannis, 2008)Innovation is the key to survival for the organization in the current competitive business world. Innovation means offering something new in the operations of the company, which is gained by using once analytical knowledge(Ozgen et al., 2013). Companies that offer a wide range of innovative products can be successful as they have a competitive advantage over others in the same industry. Studies of inventors and their close groups highlight the importance of exchanging knowledge among diverse groups(Ozgen et al., 2013). There is a chance that diversity can lead to an increase in conflicts within the organization, but in the meantime, it will have a greater positive impact on the decision-making of the firm(Bae & Han, 2020). In today's world, workforce diversity is an essential aspect of every organization but managing a diverse workforce is a great challenge for the organization (Saxena, 2014). The research scholars as well as the recruiters have argued that initiatives to foster a higher diversity of employees have a positive bearing on the bottom line(Manoharan & Singal, 2017). Despite stating the importance of workforce diversity most of the studies have focused on individual identity grouping without questioning the differences within these categories(Dennissen et al., 2020). The biggest

advancement in scientific literature shows it is not the firm but the employees in the organization that are seen as a source of innovation (Ozgen et al., 2013). Some studies have shown that workforce diversity areas are associated in improving innovation, decision-making, and also the overall organizational performance (Prasad, 2017). Diversity has become a fact of life and a major challenge to the business organization(Maturo et al., 2019). Workforce diversity also educates the employees to respect the difference and this understanding can increase innovative ideas (Alghazo & Shaiban, 2016). Promoting workforce diversity will result in an improved bottom line, competitive advantage, improved performance and loyalty of employees, ensuring better relationships, etc which affects the firm innovation (Callahan, 2016). This study helps to validate the effect of the workforce diversity factors on firm innovation which provides valuable insights for decision making and also increasing innovations in an organization. This paper highlights the impact of workforce diversity on firm innovation which will result in real economic benefits in terms of innovation and performance (Hossain et al., 2020). It can be said that firms with workforce diversity will be rewarded with high productivity and inventive efficiency (Manoharan & Singal, 2017). This is mainly because the diversity of the workforce leads to the pooling of ideas and sharing of knowledge which promotes employee involvement that will help the company to increase profits help the employee fulfill their psychological needs and also provide job security (Bizri, 2018).

Cognitive diversity theory

Cognitive diversity theory suggests that diversity provokes team members with creative ideas as there is exposure to people with diverse cultures and perceptions which can stimulate innovative ideas(Wang et al., 2016). This can lead to sharing a wide range of knowledge, skills, and abilities which are unique and non-redundant(Wang et al., 2016). The theory also suggests that the diverse group of employees analyses the problems from different angles which gives a wide range of alternatives for decision making(Wang et al., 2016). Thus, the decisions taken by such groups are considered to be the best compared to the groups with low cognitive diversity(Wang et al., 2016). This theory suggests that a work environment with heterogeneous employees provides the most creative and innovative ideas which also lead to the value creation of the firm. The cognitive diversity hypothesis explains how including heterogeneous groups can help in problem-solving and innovation. According to the theory, this change has a positive impact on the organization as the cognitive diversity of the group comprises diverse viewpoints which can generate more innovative ideas (Wang et al., 2016). Moreover, it helps in high-quality decision-making with the counter-arguments of the diverse group. It also broadens the network of relationships and contacts, which can help the company widen its horizon. The information and decision-making theories suggest that cognitive diversity provides a wide range of knowledge, abilities, and innovative ideas.

This knowledge base can create new strategies, products, and services. A diverse workforce with different value systems and cultures can use different viewpoints to explore the environment for opportunities, considering diverse angles and quite a lot of alternatives (Wang et al., 2016). Studies have shown that cognitive diversity helps in creating innovative ideas especially when the organization follows a transformational leadership style (Kim et al., 2021). Perception cognitive diversity helps to understand individuals' perceptions which can be directly related to motivation and creativity. Different perceptions give different outlooks within the team that may inspire the team members to come up with innovative ideas. Studies suggest that cognitive diversity results in a positive effect on the overall organizational outcome (Almeida et al., 2009). This study will assist managersin understanding the significance of recruiting a diverse workforce. Most managers believe that diversity among employees can benefit the firm, but it is difficult to verify or quantify, especially when it comes to measuring the impact of workforce diversity on firm innovation. The new researches provide evidence that diversity unlocks firm innovation and future growth, even then only a few common variables and dimensions have been focused on by the researchers. This study will highlight the importance of workforce diversity on firm innovation and also explore the unexplored diversity variables which have an impact on firms ability to innovate.

Objectives
- To explore the importance of workforce diversity on Firm Innovation
- To discover the diversity factors which have an impact on firm innovation.

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REVIEW OF LITERATURE

(Waterbury, 2018)In this article, the researcher has defined diversity as the collective combination of similarities and differences in the characteristics of employees in terms of value, beliefs, background, preferences, etc. He points out the significance of a diverse workforce in the growth of all sectors and emphasizes how diversity training leads to the value creation of executive managers.(James Bernard et al., 2019)In this article, the author points out that workforce diversity is an important asset for an organization. It helps in problem-solving, as the employees come up with different and innovative ideas that benefit the organization, giving a competitive advantage. Treating the employees well and understanding their expectations is an important factor in managing a diverse workforce. The results of the study show that there is no relationship between the challenges faced by managers due to diversity and the extent of workforce diversity.(Bantel and Jackson, 1989; Williams and O'Reilly, 1998; Faems and Subranamian, 2013) In this article, the author emphasizes that diversity enhances innovation as it leads to increasing the ability of employees to create new strategies and integrate diverse perceptions. Information processing is another benefit associated with team diversity which outweighs the challenges connected with diversity. (Maré et al., 2014)In this article, the author points out that a survey done to know the geography of innovation summarized the different ways to create knowledge spillover, and workforce composition had a very significant impact on innovation. Every individual is different in terms of skills and fundamentally how they interpret and solve a problem. This feature itself can be considered the origin of the connection between a heterogeneous workforce and firm innovation. He further emphasized that inclusion will help to maximize the creative advantage of the diverse team. (Biga-Diambeidou et al., 2021)The author points out that new undertakings are rarely the product of a single entrepreneur and they do usually depend upon co-founders and other employees for launching and managing the venture. The innovativeness of an organization can be increased by accepting the uniqueness of the employees and benefiting from it. Studies have shown that diversity increases the knowledge base thereby increasing the propensity for innovation(República et al., n.d.). (Griffin et al., 2021) The author of this article suggests that corporate innovation is the key to firm competitiveness, increasing productivity, and also a firm's value creation. The author has also depicted that broad gender diversity positively impacts corporate innovation. (Eklund & van Criekingen, 2022)In this article, the author points out that growth potential is more with the new ventures than the well-established firms and the main reason for this is the openness of new ventures to diversity. He emphasizes that diversity of knowledge helps firms to improve their product innovatively. He further suggests havinga diverse workforce in all levels of an organization as all the levels contribute to the outcome.(El Chaarani & Raimi, 2022) In this article, the author points out that to survive in the emerging knowledge-based economy, organizations need to rely on intangible assets like skills, knowledge base, ability, etc to gain a competitive advantage. This can be achieved by recruiting a diverse workforce.

(Yadav & Lenka, 2020)In this article, the author suggests that the dimensions of diversity such as disability, LGBT, language, and the community they belong to have a direct impact on firm innovation which has to be explored. The minority group faces a lot of challenges dealing with discernment, prejudice, and stereotyping(Aghazadeh, 2004). To overcome this situation, organizations have to set realistic goals for their management and employees to work together(Aghazadeh, 2004). (Vu, 2020) in his article has emphasized the importance of inclusion of LGBT in accelerating the innovation capability, through the enhancement of the quality of human capital.(Patel & Feng, 2021)Including LGBT in the workforce is beyond social and moral responsibilities. Studies have shown that including this minority community in the workforce has economic benefits in terms of firm performance, credit rating, and innovation. Moreover, it helps the companies in improving returns in intangibles.(Agovino & Corbisiero, 2021) The existence of LGBT employees inspires innovation and entrepreneurship as the diverse population contributes unique products and services, creating new opportunities and attracting new industrialists. (Vu, 2020)Creating an LGBT-friendly workplace environment helps in the inflow of human resources since it indicates the acceptance of diversity, creativity, and open-mindedness of the organization. Policies supporting minority groups in the workplace reduce job anxiety and improve firm performance. (Love, 2020)In this article, the author points out that the knowledge base of Indigenous people is unique and grounded in the incorporation of ideas. Even then, Indigenous cultural knowledge is given less importance in managing and organizing business.(Lazonick, 2004)the researcher has pointed

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out that the innovation capacity of the society is the main determinant for economic development. A strategy of indigenous innovation can lead to the development of the economy. (Waterbury, 2018)points out that companies hesitate to recruit people with disability as they are anxious about the lack of skills, efficiency, and accommodation costs. However, studies have shown that people with disability are more loyal and committed to the company resulting in low turnover and high productivity as well as profit**.** (Mayer & Zhao, 2016)In this article, the author points out that firms that treat their employees better have greater performance and creative ideas in general. This is because the employees get the economic benefit of profit sharing, promotions, etc for better performance which creates job security and commitment. Thus, inspiring the employees to come up with creative and innovative ideas without worrying about the negative consequences.(Yadav & Lenka, 2020)In this article, the author has discussed in detail the scope of workforce diversity in the future and emphasizes the importance of a diverse workforce in improving firm performance. He has mentioned the future opportunities due to a diverse workforce and ways to mitigate the negative impact of it on the business.

Statement of the Problem

There are many articles on workforce diversity factors like age, gender, race, etc. Diversity of ideas and strategies is beneficial in the innovation process, which thrives on creative tension and different viewpoints. This study proposes to highlight the importance of workforce diversity on firm innovation. Despite its potential to improve firm performance, very few studies have reported the influence of diversity on firm innovation. Besides, only a very few recent researchers have explored factors such as LGBT, Language, and Disability which have a significant role in problem-solving.

RESULTS AND DISCUSSIONS

After examining the existing literature on workforce diversity, it is clear that workforce diversity does have a greater impact on increasing firm innovation. Profit maximization is the objective of an organization and workforce diversity helps in achieving it by offering innovative products, better decision-making, and increasing productivity. Studies have shown that diversity is a very important essence in the current scenario for organizations to sustain in the competitive business world, but only if managed properly. It is a challenge for the management to coordinate the diverse workforce but if done properly can boost the organization's growth. Business organizations should be willing to adapt to policies that motivate and encourage the diverse workforce to reap the benefits. Some of the ways to tackle the negative effects are to adopt policies such as:

1. Equal opportunities for all employees irrespective of their culture, race, background, etc.
2. Use of common language in the workspace.
3. Every team with a diverse workforce encourages equal participation.
4. Take the problems faced by the workforce into consideration and have revisions in the policy for better employee management.
5. Conduct motivational and team-building sessions.
6. Consider the minority groups during the recruitment process.

CONCLUSION

Workforce diversity and managing the diverse workforce are considered to be complex tasks for the management, but in the current scenario, it is the need of the hour. Diversity in employees can have both positive and negative impacts and the positives surpass the negatives. Thus, the management must understand the diverse workforce and manage them effectively so that the positives are used effectively towards achieving organizational goals. The diverse workforce has diverse opinions, perceptions, attitudes, etc which leads to looking into problems from different angles which provides many alternative solutions and better decisions. The study focused on exploring the importance of workforce diversity on firm innovation and the diversity factors that impact firm innovation. A

descriptive method of research is used to analyze the data. The study is based on secondary data, including various Scopus articles, company reports, and the latest news articles. From the review of existing literature, it can be concluded that workforce diversity has a greater impact on a firm's creativity and innovation. The majority of the research papers have considered the common diversity factors such as age, gender, religion, and education background, ignoring the factors that can have an impact on innovation. By reviewing the existing literature, it is clear that workforce diversity increases the potential of the business in terms of Innovation and is the need of the hour. Proper implication of workforce diversity can impact the firm'sinnovation positively and can lead to better performance.

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| Fig.1 Workforce Diversity | Fig.2 Impact of Workforce Diversity on Firm Innovation |
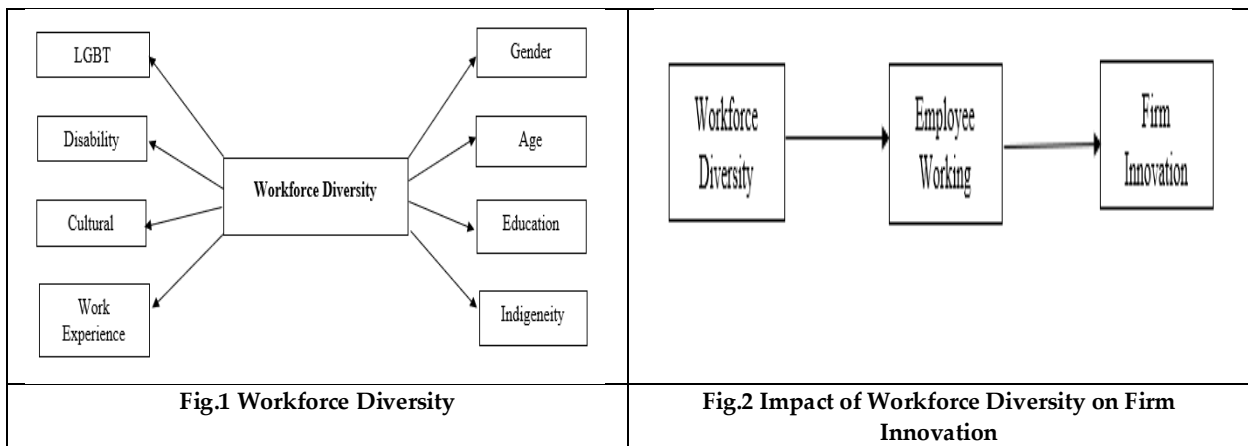
RESEARCH ARTICLE

Development of AgO Nanoparticles and Its Biological Elucidations

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ABSTRACT

A straightforward green synthesis method was employed to produce silver oxide nanoparticles. Following synthesis, the nanoparticles underwent thorough characterization using various analytical techniques including X-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FT-IR) and nuclear magnetic resonance (NMR). XRD analysis revealed a crystalline size of 32.4 nm for the silver oxide nanoparticles. SEM imaging displayed irregular structures and a spherical, agglomerated matrix on the surface of the nanoparticles. These nanoparticles were then evaluated for their potential as an anti-cancer agent. Remarkably, they demonstrated significant efficacy, exhibiting the ability to eliminate up to 86% of cancer-infected cells. The material also used as a anti-microbial agent to require the infected cells on human body tissue.

Keywords: Green synthesis, Silver nanoparticles, Cancer activity, MCF-7

INTRODUCTION

Nanobiotechnology represents a cutting-edge field with diverse applications in health and medicine, leveraging nanoscale particles for various biological activities. Nanoparticles, owing to their unique structural[1], biological[2], and optical properties[3], play pivotal roles across multiple domains, including drug delivery, biosensing, modulation of molecular processes, combating infectious agents, and regulating cell proliferation. Among the myriad of metal-based nanoparticles available, gold, silver, zinc, iron, titanium, magnesium, and alginate nanoparticles stand out. Cancer, a devastating illness claiming millions of lives annually worldwide, particularly affects women with cervical cancer being one of the most prevalent types[4]. Originating from the Human Papilloma Virus, cervical cancer ranks as the fourth leading cause of cancer-related deaths in women. Timely intervention can prevent and

treat it, as indicated by the development of warts around the vaginal area. This study focuses on evaluating the cytotoxic and apoptotic effects of environmentally friendly synthesized nanoparticles using HeLa cell lines. The unique morphological characteristics of silver nanoparticles may facilitate their penetration through barriers to reach target cells effectively[5].

MATERIALS AND METHODS

This work examined the pace at which the development of cancer cells is inhibited, as well as the generation of reactive oxygen species, malondialdehyde, and glutathione storage in MCF7 cells. The 48 hours, cancer cells were exposed to nanoparticles. Silver nanoparticles both slowed MCF-7's rate of development.

Synthesis of silver oxide nanoparticles
Silver oxide nanoparticles were synthesized using an environmentally friendly green synthesized sol-gel approach. Initially, 20 mg of plant extract underwent washing with water and ethanol. Subsequently, the washed extract was mixed with 70 mL of ethanol and 30 mL of water in a beaker. To this mixture, 3.2 g of silver nitrate was added[6]. The resulting reaction mixture was stirred at room temperature for 10 minutes before raising the temperature to 90°C, where it was maintained for one hour. Following this, a green-colored precipitate formed, which was then filtered to obtain silver hydroxide nanoparticles. The obtained silver hydroxide was subjected to calcination at 450°C for 5 hours, yielding the final product of silver oxide nanoparticles[7].

XRD analysis
XRD analysis was conducted to determine the crystalline size and structure of the prepared material, utilizing the Debye-Scherrer equation. Notably, the corresponding planes 202, 001, 111, 200, 132, 220 and 311 exhibited 2θ values of 32, 34, 36, 47, 56, 63 and 68, respectively. The presence of sharp peaks in the XRD pattern indicates that the prepared materials possess a well-crystallized nature with high purity[8]. The crystalline size of the prepared silver oxide (AgO) nanoparticles was measured to be 32.4 nm. Given their smaller crystalline size, AgO nanoparticles demonstrate promising potential as effective anti-cancer and anti-bacterial agents[9].

Functional group analysis
Functional group analysis was employed to identify the various functional groups present in our prepared material. The stretching vibration modes of M-O were observed at 623.4 and 1004 cm^{-1} respectively. Additionally, stretching modes of C=O and C-O were detected at 1486 cm^{-1}respectively[9]. The vibration peaks corresponding to H-O-H appeared at 3425 cm^{-1}. Furthermore, FT-IR analysis confirmed the presence of metal-oxygen stretching vibration modes below 1000 cm^{-1}, underscoring the purity of the prepared materials[10].

Morphology Analysis
Surface morphology analysis of prepared nanoparticle of AgO was conducted using SEM micrographs, as illustrated in Fig.3. The SEM images revealed distinct characteristics for each nanoparticle type. In Fig. 3, AgO nanoparticles displayed an agglomerated structure, indicating particle clustering[11]. Notably, AgOnanoparticles exhibited a agglomerated morphology from different viewpoints, as reported previously.

NMR analysis
^{1}H and ^{13}C NMR analysis A Bruker Avance DRX 500 was used to record NMR spectra. Every NMR spectrum was recorded at 303 K in DMSO-d6. The solvent resonance was used as a reference point for the ^{1}H and ^{13}C NMR chemical shifts (δ in ppm) for DMSO-d6 (2.50 (^{1}H) and 39.50 (^{13}C) respectively. The distinct 1H and 13C resonances were identified using gradient-selected COSY, gs-HSQC, gs-HMBC, and 2D NMR studies. The ^{1}H-^{13}C HMBC experiment was calibrated for long-range coupling of 500.13 and 125.758 MHz, and the gradient ratio was 30:18:24 G cm^{-1}[12].

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Anticancer Activity

Cancer is a multifaceted illness that often has a broad spectrum of increasingly severe consequences at the cellular and molecular levels. Therefore, it doesn't appear plausible that chemoprevention adheres to rigid guidelines and specifications.

Cell culture

The human gastric carcinoma cell line Kato-III, hepatocellular carcinoma cell line Hep G2, lung adenocarcinoma epithelial cell line SHP-77, and various mammalian breast cancer cell lines MCF-7 were all cultured in minimum essential medium (MEM) supplemented with EDTA, sodium bicarbonate, and fetal calf serum. Cultures were maintained in a humidified environment at 37℃ with 5% CO_2, and the medium was changed every two days. To closely mimic the potential effects of plant extracts on human cancer cells, only human cell lines were utilized. Cells were typically grown in 75 cm^2 tissue culture (T-75) flasks with 10 mL of the appropriate media at 37°C in a humidified atmosphere of 5% CO_2/95% air[13]. Weekly passages and bi-weekly medium changes were conducted.

Subculture

Aspiration was employed to remove the medium, followed by washing the adherent cells with 5 milliliters of Calcium and Magnesium Free solution (CMFS) to eliminate any residual media containing FCS and trypsin inhibitor. Subsequently, to detach the cells and dissolve the extracellular matrix, each flask was treated with approximately 1 milliliter of a 1X trypsin-EDTA solution in CMFS. Incubation at 37℃ for a maximum of 10 minutes allowed observation under a microscope for signs of cell detachment [14]. The addition of 9 milliliters of suitable medium containing FCS neutralized the trypsin. Depending on the cell line and the desired cell density, subculturing ratios ranging from 1/5 to 1/50 were utilized.

Cell viability assay

The MTT assay is utilized to quantify the number of viable cells by measuring the conversion of yellow tetrazolium salt (MTT) into purple formazan crystals, as described by Mosmann in 1983. Cells were plated at a density of $2×10^5$ cells/mL per well in 100 µL of Rosewell Park Memorial Institute 1640 (RPMI 1640) and then incubated in a CO_2 incubator at 37°C with 5% CO_2 for 24 hours. After this initial incubation period, each well received an ethanolic extract of Butea monosperma dissolved in DMSO, followed by further incubation for 48 hours [15]. Control groups received an equivalent volume of DMSO. Tamoxifen served as the positive control. Following 24 to 48 hours of incubation at 37℃ with 5% CO_2, 100 µL of MTT solution (0.5 mg/mL in Dulbecco's modified Eagle's medium) was added to each well and incubated for three hours. The ability of live cells to convert MTT into formazan was used to assess tumoral cell growth. The formazan product resulting from MTT reduction was dissolved in DMSO. After removing the medium, 100 µL of DMSO was added to each well to dissolve the MTT metabolic product. The plate was then shaken for five minutes at 150 rpm, and the optical density at 570 nm was measured. IC50 values were determined by calculating the percentage inhibition [100 - (absorbance of test wells/absorbance of control wells) × 100] and plotting against concentrations.

RESULTS

In the present day, Butea monosperma is employed as a medicinal remedy by the largest tribal community in the region. There is significant interest in refining natural treatments for various human ailments using plant-based components. Across rural areas worldwide, herbal remedies are widely used for medicinal purposes. Cancer is characterized by uncontrolled growth and proliferation of cells, infiltration and destruction of neighboring tissues, and potential metastasis to distant anatomical sites. Although cancer can affect individuals of any age, the risk tends to increase with age for the most common types, contributing to approximately 17% of all fatalities[16]. Traditional Indian medicine heavily incorporates plants, especially in the realm of cancer prevention. Numerous herbs and herbal products have been suggested for the prevention and treatment of cancer disorders. Recent research has demonstrated the antioxidant activity of the ethanolic extract of Butea monosperma, indicating its potential role in

preventing the development of cancer disorders.

Anticancer Activity of *Butea monosperma*

Cancer arises from an imbalance between cell growth and cell death, leading to abnormal cell proliferation and tumor formation. The study investigated the anticancer properties of the ethanolic whole plant extract of Butea monosperma through an MTT experiment conducted on four human cancer cell lines: HepG2, MCF7, SHP-77, and Kato-III. Succinate dehydrogenase, a mitochondrial enzyme, catalyzes the breakdown of the tetrazolium ring in viable cells, converting MTT into insoluble purple formazan[17]. The amount of formazan produced is directly proportional to the number of viable cells. As a positive control, 5-fluorouracil, a widely used anticancer drug, was employed in this study. The experiment evaluated four cell lines originating from different tissues: MCF-7 (breast cancer), HepG-2 (liver cancer), SHP-77 (lung cancer), and Kato-III (gastric cancer). All tested extract samples demonstrated cytotoxic effects ranging from 0% to 88.8% across the various cell lines. Notably, the highest cytotoxic activity was observed in SHP-77 cells, with growth inhibition rates exceeding 85.7%, followed by HepG2 and Kato-III cells with rates of 84.3% and 84.3%, respectively. The ethanolic whole plant extract of Butea monosperma exhibited significant growth suppression against all examined cell lines.

Anti-bacterial activity
Procedure

The antibacterial activity of the synthesized AgO nanoparticles was evaluated against bacterial pathogens using the agar well diffusion method. Initially, bacterial pathogens were cultured in nutrient broth and incubated for 12 hours prior to conducting the antibacterial assay. Each bacterial strain was then individually spread onto Muller Hinton agar plates. Wells were created in the agar plates using a cork borer with a diameter of 6mm. Samples were dissolved in DMSO, and different concentrations ranging from 25 μl to 100 μl of the samples were added to the wells. The plates were then incubated at 37°C for 24 hours. Chloramphenicol was utilized as a positive control in the assay[18]. The experiment was performed in triplicate. Following the incubation period, the zone of inhibition was measured in millimeters to assess the antibacterial activity of the nanocomposites.

Results of antibacterial activity

The antibacterial efficacy of the AgO was assessed against four clinical bacterial pathogens: Gram-positive bacteria including Staphylococcus aureus and Streptococcus pneumoniae, and Gram-negative bacteria including Escherichia coli and Klebsiella pneumoniae. Various concentrations (ranging from 25 μl to 100 μl) of the samples were employed to evaluate their antibacterial activity[19]. Notably, the AgO exhibited the highest zone of inhibition against Streptococcus pneumoniae (14 mm), followed by Escherichia coli (16 mm), Staphylococcus aureus (13 mm), with the minimum zone of inhibition observed against Klebsiella pneumoniae (12 mm) at a concentration of 100 μl. These findings underscore the potential antibacterial effectiveness of the AgOnanoparticles against the tested bacterial pathogens[20].

CONCLUSION

The continued prevalence of conventional medicine is attributed to various factors such as population growth, limited access to pharmaceuticals, adverse effects associated with allopathic treatments, and the emergence of resistance to current therapies. These challenges underscore the importance of utilizing plant-based materials as medicinal resources for human health. This review comprehensively discusses the phytochemical composition and biological activities of plant extracts, providing compelling evidence supporting their medicinal use. Butea monosperma shows promise as a potential source of beneficial phytochemicals that could significantly impact modern medicine. Further clinical investigations are warranted to validate the cytotoxic effects of β-sitosterol and the ethanolic extract of Butea monosperma in cancer patients. The study also highlights the antibacterial properties of Butea monosperma extract against both gram-positive and gram-negative infections, suggesting its potential therapeutic utility in combating bacterial and fungal infections. Additionally, the research underscores the significant

anti-cancer activity of the ethanolic extract of Butea monosperma, likely attributed to the presence of β-sitosterol phytochemical compounds. Also, the AgO nanoparticles used as a anti-bacterial agent to reduce the affected human cells.

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Table1.¹H,¹³CNMR spectral data of compound 2(β-sitosterol)

Carbon number	Chemical shifts(δ)	
	¹HNMRdata	¹³CNMRdata
1	-	37.250
2	-	31.652
3	3.52(1H,m)	71.818
4	-	42.294
5	-	140.752
6	5.35(1H,m)	121.713
7	-	31.904
8	-	31.905
9	-	50.135
10	-	36.501
11	-	21.075
12	-	39.773
13	-	42.294
14	-	56.766
15	-	23.068
16	-	29.254
17	-	56.060
18	0.66(3H,s)	11.847
19	1.1(3H,s)	19.451
20	-	36.135
21	0.91(3H,d.J-6.4Hz)	18.771
22	-	33.952
23	-	23.067
24	-	50.134
25	-	31.912

26	0.82(3H,d,J=6.8Hz)	19.810
27	0.69(3H,d,J=6.9Hz)	19.031
28	0.85(3H,t,J=7.8)	28.236
29	-	11.965

Table 2: Anticancer activity of MCF-7 cell line of ethanolic extracts of *Butea monosperma*

S.No	Concentration (mg/ml)	%ofCell viability	% of Cytotoxicity
1	Control	100	0
2	7.9	82.3	18.3
3	15.6	74.5	25.5
4	32.2	62.2	37.8
5	51.5(LC_{50})	48.9	50.8
6	62.5	45.6	54.4
7	125	38.2	61.8
7	250	32.9	67.3
8	500	26.5	73.5
10	1000	15.4	84.9
11	Positive control	10.8	89.5

Table 3.Anti cancer activity of MCF-7 cell line of β-sitosterol

S.No	Concentration (mg/ml)	% of Cell viability	% of Cytotoxicity
1	Control	100	0
2	0.78	78.2	21.8
3	1.56	67.4	32.6
4	3.12	57.8	42.2
5	4.71(LC_{50})	50.2	49.8
6	6.25	43.1	56.9
7	12.5	38.5	61.5
7	25	30.9	69.1
8	50	23.5	76.5
10	100	18.9	81.1
11	Positive control	10.5	89.5

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Table:4 Antibacterial activity of AgO nanoparticles

S. No	Bacterial Pathogens	Zone of Inhibition (mm)				
		25µl	50 µl	75 µl	100 µl	Standard (+Ve)
1	*Staphylococcus aureus*	9	10	12	15	14
2	*Streptococcus pneumonia*	11	14	16	17	26
3	*Esherchia coli*	8	10	12	14	19
4	*Klebsiella pneumonia*	6	8	11	12	22
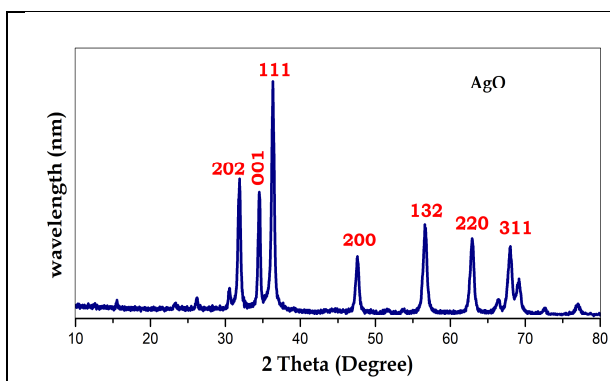
Fig.1.XRD analysis of AgO nanoparticles
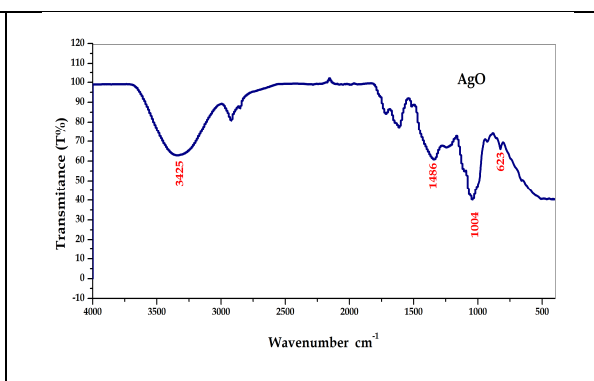
Fig.2.FT-IR analysis of AgO nanoparticles
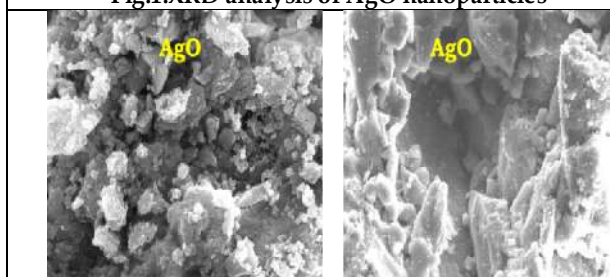
Fig.3.Morphology analysis of AgO nanoparticles
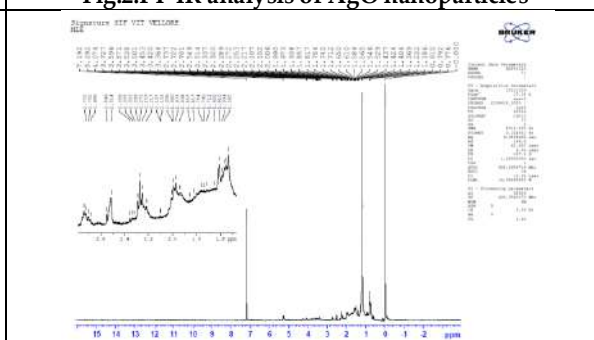
Fig.4.¹H NMR analysis of AgO nanoparticles
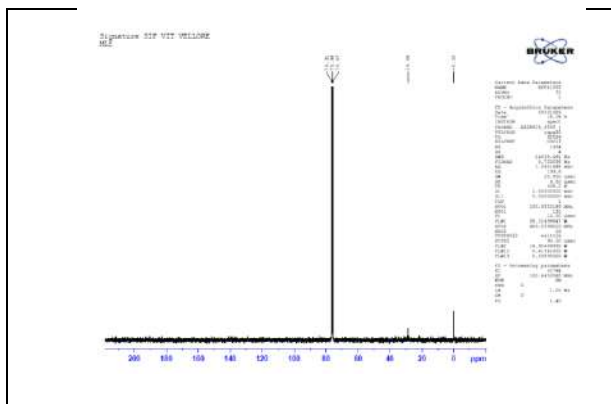
| Fig.4.¹³C NMR analysis of AgO nanoparticles | Fig.5.Antibacterial activity of AgO nanoparticles |
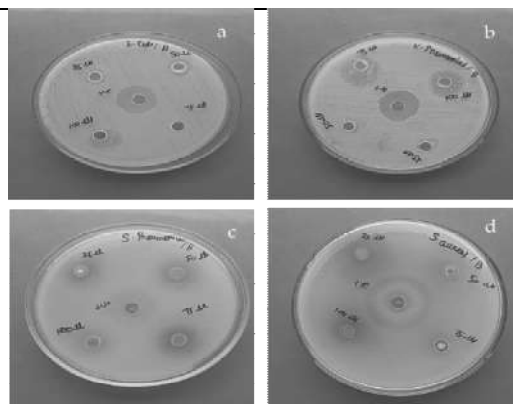
RESEARCH ARTICLE

Formulation and Assessment of a Bilayer Tablet Containing Divalproex Sodium

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ABSTRACT

Divalproex Sodium (valproic acid and sodium valproate) is a widely used antiepileptic therapy that is important for treating epilepsy, bipolar disorder, and preventing migraines. Our research focused on designing a bilayered valproic acid-containing anticonvulsant and antimanic drug. The tablet should release the drug as soon as it is administered and maintain a continuous released layer. The study used an FT-IR instrument to analyze the compatibility of divalproex sodium with the selected polymers and revealed no differences between the polymer and the drug. Therefore, tablets containing divalproex sodium can be safely developed using the formulated ingredients. The optimized immediate-release layer (IF6) which had a peak level of 98.11 in the laboratory study, was chosen for the bilayered tablet preparation. Polymers such as HPMC K4M and HPMCK100M were used to enhance the cohesive strength and its combinations. The optimized sustained-release (SF8) layer, which prolongs the antiepileptic therapeutic effect for up to eighteen hours or more, was selected. The USP Type II apparatus (paddle method) was used to perform the drug release evaluation in 900 mL of phosphate buffer at pH 6.8 and 50 rpm in the laboratory. Finally, Divalproex sodium bilayer tablets were created by compression technique. Bilayer tablets of divalproex sodium were studied for their physical proportions such as friability, hardness, thickness, weight variation, and drug release. All physical proportions result in acceptable limits according to pharmacopoeial specifications. The formulated divalproex sodium remained stable at75% relative humidity while the room temperature was set at 40C for a duration of three months.

Keywords: Bilayer tablet, wet granulation, epilepsy, sodium valproate, valproic acid, immediate-release, and sustained-release, FT-IR study, HPMC K4M, HPMC K100M

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INTRODUCTION

Despite various routes of administration being available for drug delivery, designing flexible drugs taken by mouth remains the best way to ensure patient compliance [1]. This preference is rooted in several factors, such as drug administration, high levels of patient acceptance, precise dosing, cost- effective manufacturing, and generally prolonged time frame of the product [2]. Bi-layer tablets are designed with one layer releasing the drug immediately, while the sustained layer release the drug later, either as a second dose or through extended release. These tablets are well-suited for sequentially releasing two drugs in combination, separating two incompatible substances, and serving as sustained-release tablets. The sodium valproate layer provides an immediate dose, while the valproic acid layer serves as the maintenance dose. The primary therapeutic objective is to create a consistent level of medication in the circulatory system for an extended period [3]. Epilepsy consists of abnormal high-frequency of nerve cell activity in the brain, leading to transient episodes known as seizures. These seizure attacks may occur when there is or isn't a loss of sense of the current moment and are often accompanied by distinctive body movements, such as convulsions. Globally, epilepsy ranks as the third major neurological disorder, following cerebrovascular and Alzheimer's disease[4]. Around 10 percent of individuals are expected to experience illness in the spaces between their childhood and older age. Medications that have a therapeutic effect in alleviating seizures operate through various mechanisms. These mechanisms include the blocking of voltage-gated channels (such as Na+ or Ca2+ channels), enhancing inhibitory GABAergic impulses, or disrupting excitatory glutamate transmission. Certain antiepileptic drugs have the ability to target multiple sites within degenerated neurons, while the functions of others remain unclear[5].

METHODOLOGY

Pre-formulation studies
The initial phase in the systematic development of dosage forms for a drug substance begins with pre-formulation testing. This preliminary evaluation is designed to improve drug delivery by analyzing the excipient's physicochemical properties. Pharmaceutical additives play a significant role in influencing the drug's performance and contribute to creating a dosage form that is effective and stable. This ensures safety by minimizing problems related to biopharmaceuticals and bioavailability. In summary, pre-formulation testing establishes a foundation for combining the drug with pharmaceutical additives in the dosage unit form[6].

Determination of λ 23
Initially, the main ingredient was added to methanol, which resulted in a solution that was further dissolved using the same solvent. The solution obtained was then placed inside a UV double beam to identify the maximum absorbance. FT-IR spectroscopy was conducted to assess the compatibility of the excipient and drug. Infrared spectroscopy was done using a Thermo Nicolet FT-IR instrument, and the spectrum was recorded within the range of 4000 to 400 cm-1. For this analysis, a sample consisting of the main ingredient and a drug- filling compound mixture in a 1:1 ratio was formed with KBr (200- 400mg) and compressed into discs by exerting a force of 5 tons for 5 minutes using a press. The compatibility between the adjuvants and the drug was examined through IR- spectral studies, with a focus on any shifts in the peaks of the remedy within the spectrum of the formulated coordination of the appropriate additives and the drug. Additionally, UV spectrophotometry was employed using a Shimadzu 1800 spectrophotometer to cover the wavelength range of 190 to 380 nm[7].

Solubility
Using the agitation flask method, we dissolved divalproex sodium in ethanol, methanol, chloroform, acetone, phosphate buffer at pH6.8 and distilled water to assess its solubility. An adequate quantity of the medication was dissolved into the selected solvent containing 10 mL in each vial until the solution reached saturation. In an isothermal shaker, the mixtures were agitated for 48 hours at 25°C ± 10°C, followed by filtration through Whatman's

filter paper. The absorbance was measured using a UV-Visible Spectrophotometer. Based on a standard graph, the solubility has been calculated[8].

Melting point
We determined Divalproex sodium by melting it using the capillary technique in triplicate[9].

Standardization Curve for Divalproex sodium
We precisely weighed 1000 mg of the drug and diluted it in 1000 mL of methanol to create the first stock solution. Then, 100 mL of the first stock solution was taken and dissolved in 1000 mL of methanol to create the II stock solution. The aliquot amount of the II stock solution was subsequently dissolved to obtain 5, 10, 15, 20, 25 and 30 grams of the drug per milliliter of the final solution. The absorbance was measured in a UV spectrophotometer at 210 nm against a methanol blank[10].

Compatibility studies
The drug's affinity for polymers using FT-IR spectroscopy[11].

FT-IR Spectroscopy
FT-IR spectroscopy was employed to assess the compatibility between the excipients and the drug. Infrared spectroscopy was performed using an FTIR instrument from Thermo Nicolet, with the spectrum recorded in the range of 4000 to 400 cm-1[12]. A sample consisting of the main ingredient and a drug-excipient mixture in a 1:1 ratio was mixed with potassium bromide (200-400mg) and compressed into discs. The study of the components and excipients was examined through IR-spectral studies, with a focus on any shifts in the peaks within the drug surface and excipient spectra. FT-IR spectroscopy was conducted to assess the compatibility of the excipient and drug. Infrared spectroscopy was done using a Thermo Nicolet FT-IR instrument, and the spectrum was recorded within the range of 4000 to 400 cm-1. For this analysis, a sample consisting of the main ingredient and a drug- filling compound mixture in a 1:1 ratio was formed with KBr (200- 400mg) and compressed into discs by exerting a force of 5 tons for 5 minutes using a press[13].

DSC Analysis for Formulation
The temperatures of the pure drug,excipient, physical mixture were examined using a Shimadzu Limited Differential Scanning Calorimeter -60. The illustrative powders were dried in tight closed aluminum surface. Heat runs for each drug were programmed to range from 25 to 350°C at a heating system rate of 10°C/min, with nitrogen serving as the blanket gas[14].

Design of the Sustained Release Layer, the design of the Immediate Release Layer
Preparation of the IRL
Immediate drug delivery was formulated through wet granulation, using various adjuvants such as SSG and croscarmellose sodium. A binding solution of PVP K30, along with a coloring agent, were utilized. Due to the oily characteristics of DS, the MCC adsorbent was preferred[15]. The manufacturing steps included:
- To sieve all ingredients through sieve #80.
- Geometrically mixed the ingredients with MCC and then combined it with lactose.
- Introduced super disintegrants and blended for a duration of 15 to 20 minutes with a mortar and pestle.
- Formed an aggregate using the colorant solution.
- Passed the mass through a sieve #16 to achieve uniform granules.
- To dry the granules at 50°C for 20 minutes in an autoclave.
- To Lubricate the granules with a lubricating agent and compressing them into 250 mg tablets each, adjusting the hardness accordingly[16].
- The formulations were detailed in Table No. 13.

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Preparation of SRL

We accurately weighed the active ingredient, polymer, and other ingredients in a mortar and pestle,mixed them well, and then mixed the resulting powder with the binding solution until a wet mass formed. The aggregates obtained through sieve # 16 should be dried as granules at 50℃ for 20 minutes. Then they should be reduced through sieve # 22. Next, the granules with magnesium stearate and talc are compressed into 300 mg tablets by adjusting the hardness[17]. The formulations are detailed in Table No. 14.

Formulation of Divalproex sodium

After studying the kinetic drug release profiles of SRL and IRL, the best formulations were selected, and the drugs were formed using double compression in a single rotary tableting machine[18].

Evaluation of pre-formulation parameters

Angle of repose

The direction of the flow of gunpowder was adjusted based on the funnel technique. The granules, which were accurately weighed, were placed into a funnel. The height of the funnel was set thus the sharp end would touch the top of the heap of granules. Next, we allowed the mass to enter the cone freely. Measure the length of the surface and the position of the viewpoint using the equation:

$\theta = \tan^{-1}(h/r)$

Where θ = the angle of repose,

h = height of the height of the powder, and r = radius of the heap of the powder[19]

Determination of Bulk Density and Tapped Density

We added 2 g of powder (W) from each formula to a 25 ml measuring cylinder. The cylinder was allowed to fall under its own weight onto a hard surface from a height of 2.5 cm at 2 sec intervals after appropriate consideration of the initial volume. The sound persisted until there was no further change in volume. The tapped density and bulk density were determined using the following formulas:

Db = mass of powder/bulk powder

Dt = mass powder/tapped volume[20].

Carr's Index

It helps measure the pressure needed to break the friction between the hopper and the particles.It is expressed in % and given by:

Carr's index % =   tapped density-bulk density/ tapped density[21].

RESULTS AND DISCUSSIONS

The study on the immediate-release layer:

The disintegration study was done using USP- II (paddle) dissolution apparatus at 50 rpm. The dissolving medium was set up at 37±0.500C. The volume of the medium should be replaced after withdrawing a 5 mL sample at specific time intervals. The drug sample that has been withdrawn should be diluted with pH 6.8, filtered, and analyzed on a UV photometer at a wavelength of 210 nm using pH 6.8 as a blank. The percentage of drug release should then be determined[22].

***In vitro* dissolution studies of the continuous release layer**

The sustained-release layer in the laboratory was carried out for 18 hours using the USP Type II apparatus (DT-1200) at 50 rpm for the first 45 minutes in 900 mL of 0.1N HCL set up at 37 ±0.50C and then in a buffer solution at pH6.8 in 900ml for another 18 hours. The 5ml sample that was withdrawn at specific time intervals should be replaced with a fresh medium of the same quantity. The drug was diluted with blank dissolution medium, filtered, and analyzed on a UV spectrophotometer at 210nm[23].

Assay for IRF, SRF and bi-layered tablet: 87
We measured ten tablets and calculated the average weight. After crushing all of them, an equivalent powder of 1000 mg of the drug was dissolved in distilled water adjusted to pH 6.8. The volume was adjusted to 100 mL using phosphate buffer with pH6.8. The solution was placed in a sonicator for one hour. From the stock solution, 10ml solution was introduced in 100 mL volumetric flask, and the solution was then adjusted with phosphate buffer to pH 6.8.The solution was filtered, and the absorbance was measured at a wavelength of 210 nm against pH6.8 phosphate buffer taken as a blank. The amount of drug content in one tablet was calculated[24].

Mathematical display of dissolution profile
Divalproex sodium released profiles from the formulated tablets at different time intervals was fitted to various kinetic models like Zero order kinetics, first-order kinetics, Higuchi model, and Korsmeyer-Peppas model to characterize the mechanism of drug release.
- Cumulative %drug release versus Time_ Zero order kinetic model.
- Log cumulative percentage of drug remaining versus Time_First order kinetic model.
- Cumulative percentage of drug released vs. square root of time _ Higuchi's model.
Log cumulative percentage of drug released versus log time_korsmeyer equation/ Peppa's model[25]

Determination of λmax
The λmax of divalproex sodium exhibited the highest peak at 210 nm in phosphate buffer with a pH of 6.8 and methanol. Calibration curve for Divalproex sodium: The absorbance values were recorded using a UV spectrophotometer at 210nm, with methanol as the reference.

Stability Studies8-9
The developed formulation underwent a two-month stability study following standard guidelines. The drugs were packed in aluminum sheets, which were placed in wide-mouth bottles and closed tightly. They were stored at 40C/75% RH for three months and evaluated periodically[26].

DISCUSSIONS

The bi-layered tablets underwent a short-term stability study, with the formulation kept at 40°C / 75 percent of the relative humidity for a duration of three months. The obtained data indicates that there were no significant differences observed in the stability of the physical parameters, drug content, and in simulated drug release rate of the drug during this period. In this study, we formulated and assessed a bilayered tablet containing Divalproex sodium. Various formulations for the immediate release and continuous release layers were prepared separately. Divalproex sodium tablets were then formulated. Divalproex sodium, chosen as the model drug, is a full- spectrum anti-epileptic drug suitable for both release layers of the formulations. The drug is soluble in 0.1 N NaOH, methanol, chloroform, and ethanol (95%), but it is only sparingly soluble in water. The results demonstrate that the formulated bilayer tablet has a higher solubility in chloroform compared to other solvents. The absorbance of the designed divalproex sodium exhibited the highest peak at 210 nm when studied in the range of 200-400 nm using a phosphate buffer prepared at pH 6.8 and methanol. The standardized curve for the divalproex bilayer tablet in methanol, measured at 210 nm, displayed a slope of 0.0094 and a regression coefficient of 0.9995. Both immediate-release and sustained-release formulations were manufactured using the wet granulation technique and a binding agent. Six batches (IF1-IF6) of the sodium valproate and nine batches (SF1-SF9) of the valproic acid release layer were developed by altering the excipients' ratios as given in Tables 13 and 14 respectively. Immediate-release tablets were designed using superdisintegrants such as SSG and croscarmellose sodium, while sustained-release tablets were designed using polymers. The tablets were assayed for friability, thickness, weight variation, drug content, and simulated dissolution parameters using standard procedures, as shown in tablet number 24. Based on the dissolution profile, the best formulation for bilayer tablets was selected. All formulations exhibited good friability, content uniformity,weight variation, hardness, and other parameters. Pre-formulation studies were conducted for all of them.

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Powder characteristic parameters, such as Carr's index, Hausner's ratio,angle of repose, bulk density, and tapped density were determined, which are shown on tablet number 23. Pre-formulation studies for the divalproex sodium tablets depicted a bulk density of 0.512 to 0.66 g/cm3 indicating packing characteristics in dies. The Carr's compressibility index showed values that are below 18% which indicates the blend's ability to be compressed.

CONCLUSION

Globally, the USA and the EU investigate and approve the bigger share of medical DADs. Even though the rules governing the processes in America and Europe share common goals and have many similarities, the different histories of DAD regulation in both regions contribute to significant regulatory dissimilarities30. Whereas the FDA was founded as a centralized agency for the protection of consumers, the current European systems were driven by a need to standardize commercial rules across the population of Europe. As a result, the FDA is sometimes seen as overplaying safety concerns at the cost of commercial enterprise, whereas the European systems are sometimes characterized as being primarily concerned with preserving commercial interests to the detriment of patient safety. Despite claims that drugs are accepted more slowly in America, analysis shows that they actually reach the public more quickly in the America than in Europe.

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Table 1: Spectrophotometric data for the designed bilayer tablet

Sr. No.	Conc. (µg/ml)	Absorbance Trial 1	Trial 2	Trial 3	Mean ±SD
1	0	0.000	0.000	0.000	0.000±0.000
2	5	0.050	0.043	0.06	0.046±0.004
3	10	0.099	0.095	0.103	0.097±0.002
4	15	0.145	0.143	0.149	0.144±0.002
5	20	0.187	0.185	0.189	0.187±0.002
6	25	0.250	0.237	0.237	0.238±0.002

Table 2: Affinity study of the active substance and excipients using FTIR

Functional group	Standard Peaks	Wave number (cm-1) Pure drug	SSG	Croscar mellose	HPMC K4M	HPMC K100M	Lactose	MCC
Aliphatic C-H Stretch	3300-2500	2919.4	2950.74	2950.80	2944.81	2947.67	2951.02	2954.13
C-H bend	1480-1450	1456	1386.87	1372.73	1453.64	1454.08	1380.44	1450.21
C-H stretch	1350-1000	1215	1213.14	1210.96	1210.29	1211.02	1210.4	1212.96
Carboxylic Acid	3100-3300	3119.41	3121.29	3277.37	3121.32	3122.44	3123.36	3123.77
O-H bend	-	1060.94	995.78	1041.53	1048.09	1046.80	1026.20	1025.50

Table 3: Pre-compression studies for IRL and SRL

Formulation	Bulk Density Mean ± SD	Tapped Density Mean ± SD	Carr's Index Mean ± SD	Hausner's Index Mean ± SD	Angle of Repose Mean ± SD
IF1	0.558±0.002	0.639±0.005	12.611±0.217	1.146±0.030	16.597±0.356
IF2	0.557±0.005	0.656±0.004	15.083±0.226	1.174±0.020	18.361±0.275
IF3	0.524±0.004	0.625±0.003	15.774±0.109	1.163±0.022	19.420±0.173
IF4	0.584±0.003	0.685±0.003	13.898±0.177	1.164±0.013	20.146±0.156
IF5	0.611±0.010	0.683±0.007	11.768±0.206	1.134±0.009	17.912±0.039
IF6	0.666±0.004	0.755±0.006	11.148±0.157	1.142±0.025	17.101±0.077
SF1	0.592±0.005	0.694±0.003	13.779±0.206	1.154±0.009	19.604±0.279
SF2	0.590±0.008	0.698±0.002	14.495±0.328	1.168±0.017	18.479±0.063
SF3	0.606±0.004	0.682±0.003	11.224±0.186	1.134±0.009	18.200±0.088
SF4	0.624±0.005	0.704±0.002	11.532±0.127	1.131±0.010	22.547±0.280
SF5	0.596±0.004	0.710±0.004	16.144±0.249	1.200±0.028	18.331±0.077
SF6	0.591±0.004	0.727±0.002	18.716±0.397	1.256±0.029	18.168±0.104
SF7	0.616±0.003	0.727±0.004	14.826±0.673	1.173±0.028	18.466±0.091
SF8	0.513±0.001	0.622±0.002	17.563±0.436	1.242±0.024	19.347±0.072
SF9	0.620±0.002	0.693±0.001	10.754±0.181	1.124±0.017	17.396±0.021

Table 4: POST-COMPRESSION EVALUATION PARAMETERS: Post-compression parameters for IRL and SRL

Batch code	Weight variation Mean ± SD	Hardness (kg/cm2) Mean ± SD	Friability (%) Mean ± SD	Thickness Mean ± SD	Drug content (%) Mean ± SD	*In vitro* disintegration time (sec) Mean ± SD
IF1	248.9±1.57	5.95±0.05	0.74±0.09	2.87±0.04	98.12±1.19	120.33±1.52
IF2	250.3±1.60	4.18±0.10	0.58±0.04	2.91±0.10	97.65±1.82	91.66±2.08

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IF3	250.9±1.60	6.35±0.03	0.56±0.06	2.90±0.07	98.65±1.28	73.33±2.51
IF4	251.55±1.99	6.17±0.07	0.65±0.05	2.87±0.03	99.61±0.94	48.33±3.05
IF5	251.45±2.52	4.14±0.04	0.63±0.03	2.92±0.06	99.43±1.32	59.33±2.08
IF6	250.05±1.81	4.53±0.11	0.69±0.04	2.89±0.09	99.51±1.81	37.33±1.52
SF1	302.6±1.41	5.38±0.10	0.32±0.06	3.34±0.09	99.38±1.19	-
SF2	302.9±2.29	4.33±0.02	0.35±0.02	3.30±0.14	98.61±1.03	-
SF3	302.5±1.59	6.14±0.04	0.43±0.03	3.31±0.03	97.43±1.28	-
SF4	301.75±1.14	6.23±0.06	0.36±0.02	3.28±0.05	98.57±0.85	-
SF5	300.65±1.37	5.14±0.03	0.41±0.06	3.30±0.06	98.43±1.27	-
SF6	302.30±1.31	4.52±0.02	0.48±0.03	3.33±0.03	97.63±0.61	-
SF7	303.20±1.46	6.74±0.04	0.42±0.06	3.28±0.08	99.47±1.04	-
SF8	301.25±1.55	6.16±0.02	0.37±0.04	3.30±0.04	99.51±1.20	-
SF9	302.42±1.04	6.56±0.03	0.31±0.03	3.32±0.07	98.49±0.93	-

Post-compression parameters for bi-layered tablet

Formulation	Weight variation Mean ± SD	Hardness Mean ± SD	Friability Mean ± SD	Thickness Mean ± SD	Drug content (%) Mean ± SD
BTF	550.75±0.46	7.05±0.15	0.38±0.01	6.28±0.14	99.23±0.53
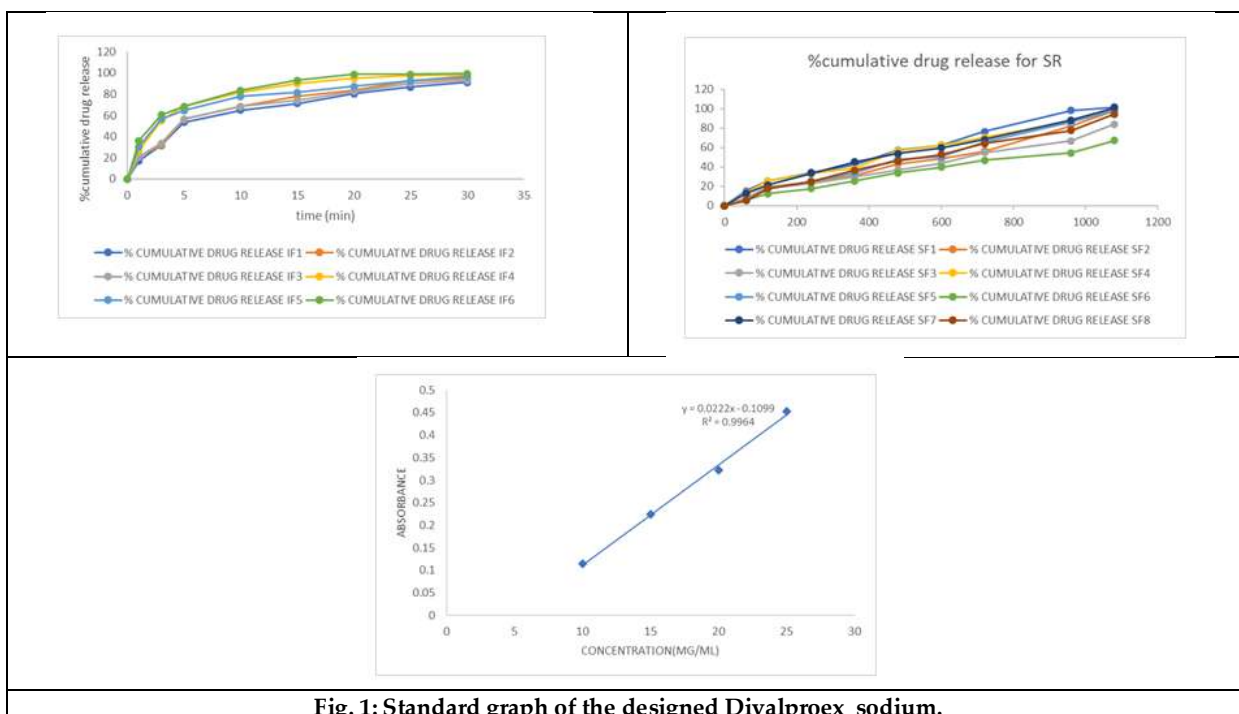
Fig. 1: Standard graph of the designed Divalproex sodium.

Generalized Orthopair Fuzzy Sub-Implicative D-Algebra in Terms of d Ideals

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ABSTRACT

In this paper, we introduce the notion of generalized ortho pair fuzzy sub-implicative d-algebra, level generalized ortho pair fuzzy sets and generalized ortho pair fuzzy sub-implicative d-ideals in d-algebra and investigated some of their results. Also we investigate homomorphism of generalized ortho pair fuzzy sub-implicative d-algebra and derived some standard results.

Keywords: Fuzzy set, d-algebra, generalized ortho pair fuzzy set, d-ideal, pre-image, homomorphism, level ortho pair fuzzy set .

INTRODUCTION

An intuitionistic fuzzy set (IFS) is a set developed to handle problems related to imprecise and incomplete information [7]. This set was introduced by Atanassov, which is a generalization of the fuzzy set (FS) theory [30]. In FS, an element is marked by the presence of its membership (M)degree or value (i.e., the non-membership (N) degree is directly complemented to it). Meanwhile, in IFS, it is indicated by the presence of its M and N degrees, where the sum of the two can be less than one (i.e., any hesitancy or incomplete information is allowed). This makes IFS more flexible and covers more uncertain events in the decision-making process. Several studies have been conducted to expand the IFS, including in aggregation operators [26], and correlation coefficient [17], to mention a few. In addition, many authors have applied the IFS to decision-making problems [1, 13].IFS has experienced numerous developments, especially in terms of the relationship between M and N degrees. Initially, the IFS met the condition

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M+ N ≤ 1. However, to cater for the issue beyond this inequality (i.e., M+ N >1), Yager [28] then defined the Pythagorean fuzzy sets (PFS), which changed the constraining relation to $M^2 + N^2 \le 1$. Prior to that, Atanassov[8] proposed IFS of second type to deal with the same issue. In 2011, Ciucci [15] introduced the term orthopair as an alternative pair of M and N degrees. This gives rise to the generalized orthopair fuzzy sets or called q-rung orthopair fuzzy sets (q-ROFS), which satisfy $M^q + N^q \le 1$ for any q positive integers [29]. Vassilev et al. [25] defined a similar concept called IFS of q-type to generalize the IFS. Note that this set can be reduced to IFS for q = 1, PFS for q = 2 and Fermatean fuzzy sets (FFS), which is another special form of q-ROFS with q = 3 [24]. Similarly, several studies have explored the q-ROFS in the cases of aggregation operations [21, 2], similarity measures [16,5], and some applications in decision-making problems [4, 3]. In general, the expression of q-ROFS is acknowledged to provide greater flexibility and expressive power for decision-makers in representing their preferences compared to IFS [29].In 1989, IFS was expanded from what was originally a singular point into an area in an intuitionistic fuzzy interpretation triangle (IFIT) with a rectangular shape called interval-valued IFS(IVIFS) [10]. The main motivation for this extension was to deal with imprecise of M and of N values. Recently, Atanassov introduced another extension of Mand N interpretation into a circle called circular IFS (CIFS) [9]. This set is characterized by a 3-tuple containing M, N and radius for each element. The difference with IFS lies in the existence of a circular imprecision area with radius r. Compared to IVIFS, CIFS has an equidistant centre point and boundary, which is not necessarily true for IVIFS, as their boundaries can take various shapes and distances from the centre point. The CIFS theory is still at an early stage of its development. Hence, not much research has been conducted on it. Initially, Atanassov [9] defined the basic relations and operations for CIFS with r ∈[0, 1], but then has been expanded to r ∈[0,√2] to cover the whole region in the IFIT [11].Some studies on CIFS have been conducted, including distance measures [11, 14] and divergence measures for CIFS [20]. Other than that, some extensions of decision-making models under the CIFS environment have also been proposed recently, such as in technique for order preference by similarity to ideal solution (TOPSIS) [18, 6], multiple criteria optimization and compromise solution (VIKOR) [19], the integration of analytic hierarchy process (AHP) and VIKOR [23] and a general multiple criteria decision making (MCDM) model [12]. In this paper, we introduce the notion of generalized orthopair fuzzy sub-implicative d-algebra, level generalized orthopair fuzzy sets and generalized ortho pair fuzzy sub-implicative d-ideals in d-algebra and investigated some of their results. Also we investigate homomorphism of generalized orthopair fuzzy sub-implicative d-algebra and derived some standard results.

PRELIMINARIES

Definition-2.1: An algebra $(X, *, 0)$ of type $(2,0)$ is called a BCK-algebra if it satisfies the following conditions:

(i) $\big((x * y) * (x * z)\big) * (z * y) = 0,$

(ii) $\big(x * (x * y)\big) * y = 0,$

(iii) $x * x = 0,$

(iv) $0 * x = 0,$

(v) $x * y = 0$ and $y * x = 0$ implies $x = y$, for all $x, y \in X$.

Remark-2.2: A partial ordering " ≤ " on Xcan be defined by $x \le y$ if and only if $x * y = 0$.

Definition-2.3: A non-empty set X with constant 0 and a binary operator $*$ is called a
Sub-implicative d-algebra, if it satisfies the following axioms:

Sd1: $x * x = 0$

Sd2: $0 * x = 0$

Sd3: $x * y = 0$ and $y * x = 0$ implies $x = y$, for all $x, y \in X$.

Example-2.4: Let $X = \{e, a, b\}$ be a set with the following table

∗	e	a	b
e	e	e	e
a	b	0	b
b	b	0	a

By usual calculation, it is clear that $(X, ∗, e)$ is a sub-implicative d-algebra.

Definition-2.5: Let X be a sub-implicative d-algebra and I be subset of X. Then I is called
sub-implicative d-algebra of X if it satisfies the following conditions:
SI1: $0 \in I$.
SI2: $x ∗ y \in I$ and $y \in I$ implies $x \in I$.
SI3: $x \in I, y \in I$ implies $x ∗ y \in I$.

Definition-2.6: Let ′A′ be a non-empty subset of a sub-implicative d-algebra X. Then A is called sub-implicative d-algebra of X if $x ∗ y \in A$ for all $x, y \in A$.

Definition-2.7: A fuzzy subset of X is a function $δ: X \to [0,1]$.

Definition-2.8: A Pythagorean fuzzy set (PFS) ′A′ non-empty set X is an object having the form $A = \left\{x, \alpha_A^2(x), \beta_A^2(x) / x \in X\right\}$ where the function $\alpha_A: X \to [0,1]$ and $\beta_A: X \to [0,1]$ denote the degree of membership and degree of non-membership respectively such that $0 \leq \alpha_A^2(x) + \beta_A^2(x) \leq 1$ for all $x \in A$.
A Pythagorean fuzzy set (PFS) $A = \left\{x, \alpha_A^2(x), \beta_A^2(x)/x \in X\right\}$ of the X can be identified to an ordered pair $\left(\alpha_A(x), \beta_A(x)\right)$ in $I^X \times I^X$. For the sack of simplicity, we shall use the symbol $A = \left(\alpha_A(x), \beta_A(x)\right)$ for Pythagorean fuzzy set (PFS) $A = \left\{x, \alpha_A^2(x), \beta_A^2(x)/x \in X\right\}$.

Definition-2.9: A fuzzy set $μ$ in sub-implicative d-algebra X is called a fuzzy sub-implicative d-algebra of X if it satisfies $μ(x ∗ y) \geq \min\{μ(x), μ(y)\}$ for all for all $x, y \in X$.

Generalized ortho pair fuzzy sub-implicative d-algebra

Definition-3.1: A generalized ortho pair fuzzy set A in X defined as
$A = \left\{x, \alpha_A^n(x), \beta_A^n(x)/x \in X\right\}$ where the function $\alpha_A: X \to [0,1]$ and $\beta_A: X \to [0,1]$ are respectively degree of membership and degree of non-membership for every $x \in X$ with $0 \leq \alpha_A^n(x) + \beta_A^n(x) \leq 1$ and degree of indeterminacy of $x \in X$ is
$\pi_A(x) = \sqrt[n]{1 - \left(\alpha_A^n(x) + \beta_A^n(x)\right)}$.

Definition-3.2: A generalized ortho pair fuzzy set $A = \left(\alpha_A(x), \beta_A(x)\right)$ in X called generalized ortho pair fuzzy sub-implicative d-algebra of X if it satisfies
GOPFDA1: $\alpha_A^n(x ∗ y) \geq \min\{\alpha_A^n(x), \alpha_A^n(y)\}$,
GOPFDA2: $\beta_A^n(x ∗ y) \leq \max\{\beta_A^n(x), \beta_A^n(y)\}$.

Example 3.3: Let $X = \{e, a, b\}$ be a d-algebra with the following table

∗	e	a	b
e	e	e	e

| a | b | 0 | b |
| b | b | 0 | a |

Define generalized ortho pair fuzzy set $A = \left(\alpha_A(x), \beta_A(x)\right)$ in X as follows

$\alpha_A^n(e) = \alpha_A^n(a) = 0.6 > 0.2 = \alpha_A^n(b)$

$\beta_A^n(e) = \beta_A^n(a) = 0.1 < 0.7 = \beta_A^n(a)$

By usual calculation we know that $A = \left(\alpha_A(x), \beta_A(x)\right)$ is a generalized ortho pair fuzzy d-algebra of X.

Definition-3.4 : A generalized ortho pair fuzzy set A is called as level generalized ortho pair fuzzy set if $A = \left\{x \in X / \alpha_A^n(x) \geq t \text{ and } \beta_A^n(x) \leq t\right\}$ for $0 \leq t \leq 1$.

Remarks-3.5

(i)   The upper and lower level subset of α_A is defined by $\alpha_A^t = \{x \in X / \alpha_A^n(x) \geq t\}$ and $\alpha_{A_t} = \{x \in X / \alpha_A^n(x) \leq t\}$ respectively.

(ii)   Two level generalized ortho pair fuzzy sets A_s and A_t are generalized ortho pair fuzzy set equal $(A_s = A_t)$ if $\alpha_A^s = \alpha_A^t$ and $\beta_A^s = \beta_A^t$.

(iii) Two level generalized ortho pair fuzzy sets A_s and A_t are generalized ortho pair fuzzy subsets $A_s \subseteq A_t$ if $\alpha_A^s \subseteq \alpha_A^t$ and $\beta_A^s \supseteq \beta_A^t$.

Proposition-3.6: For every generalized ortho pair fuzzy sub-implicative d-algebra of X

(i) $\alpha_A^n(e) \geq \alpha_A^n(x)$

(ii) $\beta_A^n(e) \leq \beta_A^n(x)$, for all $x \in X$.

Proof: It is easy and straight forward.

Proposition-3.7: A generalized ortho pair fuzzy set A of a sub-implicative d-algebra X is a generalized ortho pair fuzzy sub-implicative d-algebra if and only if for every $0 \leq t \leq 1$ the level generalized ortho pair fuzzy set A is either empty or a sub algebra of X.

Proof: Suppose that A is a generalized ortho pair fuzzy sub-implicative d-algebra and $A_t \neq 0$. For every $x, y \in A$ $\alpha_A^n(x * y) \geq \min\{\alpha_A^n(x), \alpha_A^n(y)\} = t$ and $\beta_A^n(x * y) \leq \max\{\beta_A^n(x), \beta_A^n(y)\} = t$. Hence $x * y \in A_t$. Conversely, take $t = \min\{\alpha_A^n(x), \alpha_A^n(y)\}$ and $t = \max\{\beta_A^n(x), \beta_A^n(y)\}$ for every $x, y \in A$, then $\alpha_A^n(x * y) \geq t = \min\{\alpha_A^n(x), \alpha_A^n(y)\}$ and $\beta_A^n(x * y) \leq t = \max\{\beta_A^n(x), \beta_A^n(y)\}$. Hence A is generalized ortho pair fuzzy sub-implicative d-algebra.

Proposition-3.8: Any generalized ortho pair fuzzy sub-implicative d-algebra X can be realisedas a level sub-implicative d-algebra of some generalized ortho pair fuzzy sub-implicative d-algebra of X.

Proof: Let A be a generalized ortho pair fuzzy sub-implicative d-algebra of X.

Define $\alpha_A^n(x) = \beta_A^n(x) = \begin{cases} t, & \text{if } x \in A \\ 0 \text{ or } 1, & \text{if } x \notin A \end{cases}$.

If $x, y \in A$, then

$\alpha_A^n(x * y) \geq \min\{\alpha_A^n(x), \alpha_A^n(y)\} = t$ and $\beta_A^n(x * y) \leq \max\{\beta_A^n(x), \beta_A^n(y)\} = t$.

Hence $x * y \in A_t$.

If $x, y \notin A$, then

$\alpha_A^n(x * y) \geq \min\{\alpha_A^n(x), \alpha_A^n(y)\} = 0$ and $\beta_A^n(x * y) \leq \max\{\beta_A^n(x), \beta_A^n(y)\} = 0$.

Hence $x * y \in A_{t^*}$.

If at most one of $x, y \in A$, then

$\alpha_A^n(x * y) \geq \min\{\alpha_A^n(x), \alpha_A^n(y)\} = t$ and $\beta_A^n(x * y) \leq \max\{\beta_A^n(x), \beta_A^n(y)\} = t.$

Hence $x * y \in A_t$.

Proposition-3.9: Let A_s and $A_t(s < t)$ be two generalized ortho pair fuzzy sub-implicative d-algebra of a d-algebra X. Then $A_s = A_t$ if and only if there is no $x \in X$ such that $s \leq \alpha_A^n(x) < t$ and $s > \beta_A^n(x) \geq t.$

Proof: Suppose that $A_s = A_t$ for some $s < t$. If there exists $x \in X$ such that $s < \alpha_A^n(x) < t$ and $s \geq \beta_A^n(x) \geq t$, than $A_s \subseteq A_t$ which is contradiction. Conversely, suppose that there is no $x \in X$ such that $s < \alpha_A^n(x) < t$ and $s > \beta_A^n(x) \geq t.$

If $x \in A_s$, then $\alpha_A^n(x) \geq s$ and $\beta_A^n(x) < s.$

Also $\alpha_A^n(x) < t$ and $\beta_A^n(x) \geq t$. Thus $\alpha_A^t \subseteq \alpha_A^{t^*}$ and $\beta_{A,s} \supseteq \beta_{A,t^*}.$

The converse inclusion is obvious since $s < t.$

Hence $A_s = A_{t^*}.$

Generalized ortho pair fuzzy sub-implicative d-ideals

Definition-4.1: A generalized ortho pair fuzzy set $A = (\alpha_A, \beta_A)$ in X is called generalized ortho pair fuzzy sub-implicative d-ideal of X if it satisfies

(i) $\alpha_A^n(0) \geq \alpha_A^n(x)$, $\beta_A^n(0) \leq \beta_A^n(x),$

(ii) $\alpha_A^n(x) \geq \min\{\alpha_A^n(x * y), \alpha_A^n(x)\}, \beta_A^n(x) \leq \max\{\beta_A^n(x * y), \beta_A^n(x)\}$

(iii) $\alpha_A^n(x * y) \geq \min\{\alpha_A^n(x), \alpha_A^n(y)\}, \beta_A^n(x * y) \leq \max\{\beta_A^n(x), \beta_A^n(y)\}$

Clearly, every generalized ortho pair fuzzy sub-implicative d-ideal of a d-algebra is a generalized ortho pair fuzzy sub-implicative d-algebra of X.

Example-4.2: Let $X = \{e, a, b\}$ be a d-algebra with the following table

*	e	a	b
e	e	e	e
a	b	e	b
b	b	0	a

Define a generalized ortho pair fuzzy set $A = \{\alpha_A, \beta_A\}$ in X as follows

$\alpha_A^n(e) = \alpha_A^n(b) = 1, \qquad \alpha_A^n(a) = t$

$\beta_A^n(e) = \beta_A^n(b) = 1, \qquad \beta_A^n(a) = s$, where $0 \leq t \leq 1$, $0 \leq s \leq 1$ and $t + s = 1.$

By usual calculation we know that $A = \{\alpha_A, \beta_A\}$ is a generalized ortho pair fuzzy d-ideal of X.

Theorem-4.3: Let $A = (\alpha_A, \beta_A)$ in X be generalized ortho pair fuzzy sub-implicative d-ideal of X. If $x * y \leq z$, then

(i) $\alpha_A^n(x) \geq \min\{\alpha_A^n(y), \alpha_A^n(z)\}, \beta_A^n(x) \leq \max\{\beta_A^n(y), \beta_A^n(z)\}$ and

(ii) $\alpha_A^n(0) \geq \alpha_A^n(z)$, $\beta_A^n(0) \leq \beta_A^n(z)$ for all $x, y, z \in X.$

Proof: Let $x, y, z \in X$ such that $x * y \leq z$ (If $x * y \leq z$ then $(x * y) * z = 0$).

Then, it is easy to prove that $\alpha_A^n(x) \geq \min\{\alpha_A^n(y), \alpha_A^n(z)\}$, $\beta_A^n(x) \leq \max\{\beta_A^n(y),\ \beta_A^n(z)\}$.

$\alpha_A^n((x * y) * z) \geq \min\{\alpha_A^n(x * y), \alpha_A^n(z)\}$

$\alpha_A^n(0) \geq \min\{\min\{\alpha_A^n((x * y) * z), \alpha_A^n(z)\}, \alpha_A^n(z)\}$

$\alpha_A^n(0) \geq \min\{\min\{\alpha_A^n(0), \alpha_A^n(z)\}, \alpha_A^n(z)\}$

$\alpha_A^n(0) \geq \min\{\alpha_A^n(z), \alpha_A^n(z)\}$

$\alpha_A^n(0) \geq \alpha_A^n(z)$

$\beta_A^n((x * y) * z) \leq \max\{\beta_A^n((x * y)), \beta_A^n(z)\}$

$\beta_A^n(0) \leq \max\{\max\{\beta_A^n((x * y) * z), \beta_A^n(z)\}, \beta_A^n(z)\}$

$\beta_A^n(0) \leq \max\{\max\{\beta_A^n(0), \beta_A^n(z)\}, \beta_A^n(z)\}$

$\beta_A^n(0) \leq \max\{\beta_A^n(z), \beta_A^n(z)\}$

$\beta_A^n(0) \leq \beta_A^n(z)$

Theorem-4.4: Let $A = (\alpha_A, \beta_A)$ in X be a generalized ortho pair fuzzy sub-implicative d-ideal of X. If $x \leq y$, then

(i) $\alpha_A^n(0) \geq \alpha_A^n(x) \geq \alpha_A^n(y)$ and

(ii) $\beta_A^n(0) \leq \beta_A^n(x) \leq \beta_A^n(y)$ for all $x, y \in X$.

Proof: For $x, y \in X$ and $x \leq y$ then $x * y = 0$.

$\alpha_A^n(x) \geq \min\{\alpha_A^n(x * y), \alpha_A^n(y)\}$

$\alpha_A^n(x) \geq \min\{\alpha_A^n(0), \alpha_A^n(y)\}$

$\alpha_A^n(x) \geq \alpha_A^n(y)$ and

$\alpha_A^n(x * y) \geq \min\{\alpha_A^n(x), \alpha_A^n(y)\}$

$\alpha_A^n(0) \geq \min\{\alpha_A^n(x), \alpha_A^n(y)\}$

$\alpha_A^n(0) \geq \alpha_A^n(x)$.

Hence, we have $\alpha_A^n(0) \geq \alpha_A^n(x) \geq \alpha_A^n(y)$.

Similarly, we can prove (ii).

Definition-4.5: Let $A = (\alpha_A, \beta_A)$ and $B = (\alpha_B, \beta_B)$ be two generalized ortho pair fuzzy sets of sub-implicative d-algebra of X. Then the Cartesian product of $A \times B: X \times X \to [0,1]$ is defined by $(\alpha_A^n \times \alpha_B^n)(x, y) = \min\{\alpha_A^n(x), \alpha_B^n(y)\}$ and $(\beta_A^n \times \beta_B^n)(x, y) = \max\{\beta_A^n(x), \beta_B^n(y)\}$ for all $x, y \in X$.

Theorem-4.6: If $A = (\alpha_A, \beta_A)$ and $B = (\alpha_B, \beta_B)$ be two generalized ortho pair fuzzy sub-implicative d-ideals of a d-algebra X. Then $A \times B$ is a generalized ortho pair fuzzy sub-implicative d-ideals of X.

Proof: For any $(x, y) \in X \times X$, we have

(i)$(\alpha_A^n \times \alpha_B^n)(0,0) = \min\{\alpha_A^n(0), \alpha_B^n(0)\} \geq \min\{\alpha_A^n(x), \alpha_A^n(y)\} = (\alpha_A^n \times \alpha_B^n)(x, y)$ and

$(\beta_A^n \times \beta_B^n)(0,0) = \max\{\beta_A^n(0), \beta_B^n(0)\} \leq \max\{\beta_A^n(x),\ \beta_A^n(y)\} = (\beta_A^n \times \beta_B^n)(x, y)$.

(ii) Let (x_1, x_2) and $(y_1, y_2) \in X \times X$. Then $(\alpha_A^n \times \alpha_B^n)(x_1, x_2) = \min\{\alpha_A^n(x_1), \alpha_B^n(x_2)\}$

$\geq \min\{\min\{\alpha_A^n(x_1 * y_1), \alpha_A^n(y_1)\}, \min\{\alpha_B^n(x_2 * y_2), \alpha_A^n(y_2)\}\}\ \min\{\min\{\alpha_A^n(x_1 * y_1), \alpha_B^n(x_2 * y_2)\}, \min\{\alpha_A^n(y_1), \alpha_A^n(y_2)\}\}$

$= \min\{(\alpha_A^n \times \alpha_B^n)(x_1 * y_1, x_2 * y_2), (\alpha_A^n \times \alpha_B^n)(y_1, y_2)\}$

$= \min\{(\alpha_A^n \times \alpha_B^n)(x_1, x_2) * (y_1, y_2), (\alpha_A^n \times \alpha_B^n)(y_1, y_2)\}$ and $(\beta_A^n \times \beta_B^n)(x_1, x_2) = \max\{\beta_A^n(x_1), \beta_B^n(x_2)\}$

$\leq \max\{\max\{\beta_A^n(x_1 * y_1), \beta_A^n(y_1)\}, \max\{\beta_B^n(x_2 * y_2), \beta_B^n(y_2)\}\}$

$\leq \max\{\max\{\beta_A^n(x_1 * y_1), \beta_B^n(x_2 * y_2)\}, \max\{\beta_B^n(y_1), \beta_B^n(y_2)\}\}$

$= \max\{(\beta_A^n \times \beta_B^n)(x_1 * y_1, x_2 * y_2), (\beta_A^n \times \beta_B^n)(y_1, y_2)\} = \max\{(\beta_A^n \times \beta_B^n)(x_1, x_2) * (y_1, y_2), (\beta_A^n \times \beta_B^n)(y_1, y_2)\}$

(iii) Let (x_1, x_2) and $(y_1, y_2) \in X \times X$. Then $(\alpha_A^n \times \alpha_B^n)((x_1, x_2) * (y_1, y_2)) = (\alpha_A^n \times \alpha_B^n)(x_1 * y_1, x_2 * y_2)$

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$$= \min\{\alpha_A^n(x_1 * y_1), \alpha_B^n(x_2 * y_2)\}$$

$$ax\{\beta_{Af}^n(a * b), \beta_{Af}^n(b)\}$$

$$= \max\{\beta_A^n(f(a * b)), \beta_A^n(f(b))\}$$
$$= \max\{\beta_A^n(f(a) * f(b)), \beta_A^n(f(b))\}$$
$$= \max\{\beta_A^n(x * y), \alpha_A^n(y)\}$$

(i)   Let $x, y \in Y$, there exists $a, b \in X$ such that $f(a) = x$ and $f(b) = y$. Then
$$\alpha_A^n(x * y) = \alpha_A^n(f(a) * f(b)) = \alpha_{Af}^n(a * b)$$
$$\geq \min\{\alpha_{Af}^n(a), \alpha_{Af}^n(b)\}$$
$$= \min\{\alpha_A^n(f(a)), \alpha_A^n(f(b))\}$$

$$= \min\{\alpha_A^n(x), \alpha_A^n(y)\} \text{ and}$$
$$\beta_A^n(x * y) = \beta_A^n(f(a) * f(b)) = \beta_{Af}^n(a * b)$$
$$\leq \max\{\beta_{Af}^n(a), \beta_{Af}^n(b)\}$$
$$= \max\{\beta_A^n(f(a)), \beta_A^n(f(b))\}$$
$$= \max\{\beta_A^n(x), \beta_A^n(y)\}$$

Hence the proof.

Definition- 4.6: Let f is mapping from a set X to Y. If $A = (\alpha_A, \beta_A)$ and $B = (\alpha_B, \beta_B)$ are generalized ortho pair fuzzy sets in X and Y respectively, then the pre image of B under f, defined by $f^{-1}(B)$ is generalized ortho pair fuzzy sets in X defined by $f^{-1}(B) = f^{-1}(\mu_B), f^{-1}(\gamma_B)$ where $f^{-1}(\mu_B) = (\mu_B)f$.

Theorem- 4.7 : Let S be sub d-algebra of X and $f: S \to S$ be a map defined by $f(x) = x$ for all
$x \in S$. If $A = (\alpha_A, \beta_A)$ is generalized ortho pair fuzzy sub-implicative d-ideal of X, then the pre image $f^{-1}(A)$ of A under f is a generalized ortho pair fuzzy sub-implicative d-ideal of S.

Proof:
(i) $f^{-1}(\alpha_A^n(0)) = \alpha_A^n(f(0)) = \alpha_A(0) \geq \alpha_A(x) = \alpha_A f((x)) = f^{-1}(\alpha_A)(x)$ and
$f^{-1}(\beta_A^n(0)) = \beta_A^n(f(0)) = \beta_A(0) \leq \beta_A(x) = \beta_A f((x)) = f^{-1}(\beta_A)(x)$.
(ii) For all $x, y \in S$, then
$f^{-1}(\alpha_A(x)) = \alpha_A(f(x)) = \alpha_A(x) \geq \min\{\alpha_A(x * y), \alpha_A(y)\}$
$= \min\{\alpha_A(f(x * y)), \alpha_A(f(y))\}$ (Since S is sub d-algebra of X)
$= \min\{f^{-1}(\alpha_A)(x * y), f^{-1}(\alpha_A)(y)\}$ and
$f^{-1}(\beta_A(x)) = \beta_A(f(x)) = \beta_A(x) \leq \max\{\beta_A(x * y), \beta_A(y)\}$
$= \max\{\beta_A(f(x * y)), \beta_A(f(y))\}$ (Since S is sub d-algebra of X)
$= \max\{f^{-1}(\beta_A)(x * y), f^{-1}(\beta_A)(y)\}$
(iii) For all $x, y \in S$, then
$$f^{-1}(\alpha_A)(x * y) = \alpha_A(f(x * y)) = \alpha_A(x * y) \geq \min\{\alpha_A(x), \alpha_A(y)\} = \min\{\alpha_A(f(x)), \alpha_A(f(y))\}$$
$= \min\{f^{-1}(\alpha_A)(x), f^{-1}(\alpha_A)(y)\}$
$f^{-1}(\beta_A)(x * y) = \beta_A(f(x * y)) = \beta_A(x * y) \leq \max\{\beta_A(x), \beta_A(y)\}$
$$= \max\{\beta_A(f(x)), \beta_A(f(y))\} = \max\{f^{-1}(\beta_A)(x), f^{-1}(\beta_A)(y)\}$$
Hence $f^{-1}(A)$ is generalized ortho pair fuzzy sub-implicative d-ideal of S.

CONCLUSION

Using generalized ortho pair fuzzy set, we define generalized ortho pair fuzzy sub-implicative d-algebra over the concept of d-ideal structures. Homomorphism structure is also defined in d-algebra in terms of d-ideals. Finally, we investigate the level ortho pair fuzzy set with suitable examples. In future we may obtain this generalized ortho pair fuzzy sets into the direct field various algebras like AB-algebra, MV-algebra and p-algebra.

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RESEARCH ARTICLE

Analysis of General Bulk Queueing Model with Binomial Service, Set Up Times and Multiple Adaptive Vacation on Empty Queues

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ABSTRACT

A binomial service and multiple adaptive vacation schedules for M^x/G/1 queue with setup time is considered. The server implements the notion of a binomial vacation schedule. The setup time policy in bulk queueing theory has been always a new and hot research field. An M^x/G/1 queueing system with Poisson arrival rate λ and the general service distribution is considered here. Under this policy, there is no customer at a service completion epoch the server takes multiple vacations. The number of vacations follows a binomial distribution with parameter p, otherwise the server provides the service with probability 1-p, if any new customers arrive in the queue. At the completion of an essential service, the batch of customers may request for a re-service with probability π.   Whenthe server returns from vacation if there is no customer in the queue then he avails another vacation and so on until the server finds single customers in the queue.   After completing an essential service and the number of customers in the queue becomes one then the server will continue the service with general service rule. The probability generating function of the steady state system size at an arbitrary time is obtained. Expression for expected system size, idle period, busy period and waiting time are also obtained.

Keywords: M^x/G/1 Queue, Setup Times, Binomial Service, Multiple Adaptive Vacation, Essential Service, Re-Service

INTRODUCTION

Queueing systems with bulk arrival and general service are common in many practical situations. Bulk queueing models have been analyzed extensively in the past by several authors. Vacation queueing models had been the subject of interest to queue theorists of deep study in recent years because of their applicability in real life situations. Server vacation model mainly characterized by utilizing the idle time of the server to carry out the secondary jobs, such as maintenance and repair work in the system. Vacation of queueing systems have found wide applications in the modeling and analysis of computer and communication networks, production line system, designing local and network area, data communication system, and core banking etc. The objective of this paper is to analyze a situation that exists in wireless networks. In a wireless network, different types of wireless devices have received more attention as a means of data communication among portable devices. As wireless devices usually rely on portable power sources such as batteries to provide the necessary operational power, power management in wireless networks has become a critical issue. For instance, to support battery-operated portable devices, mobile WiMAX has power-saving features that allow portable subscriber stations to operate for longer durations without having to recharge. Mobile WiMAX defines signaling methods that allow the MS to retreat into a vacation mode or idle mode when inactive. Vacation mode is a state in which the MS effectively turns itself off and becomes unavailable for predetermined periods, these periods are considered here as M vacation periods.The sleep window is exponentially increased from a minimum value to a maximum value. In this model the signals are arrives in batches from BS, the MS effectively receives the signals one by one. During the time of sleeping mode (M number of vacation) of MS, when the signals entering at 'p' discipline, the MS never receive the signals. At that time either the signals are able to withstand great force wait for transmitting or the weak signals leaves from the queue. The above process can be modeled as $M^x/G/1$ queueing system with multiple adaptive vacations, along with arrival to the system based on the choice of the customers during the vacation of the server with setup time.

Chunanyi Lou and Xisheng Yu [1] analyzed a single server markovian bulk arrival general service queue with multistage adaptive vacations in transient state.Queueing systems with vacations have been analyzed extensively by many authors like Levy and Yachiali [10], Heymann [3]. Doshi [2] and Takagi [14] have been made comprehensive survey of queueing systems with vacations. This includes the studies of Medhi [9] on bulk queueing models. Lee [8] has developed a procedure to find the system size probabilities for a server vacations bulk arrival queueing model. Lee et al.[9] analyzed a batch arrival queue with N policy, by considering single vacation and multiple vacations. Tang and Tang [15] developed, the queueing length distribution for $M^x/G/1$ queue with single server vacation. Ke [6] discussed the modified 'T' vacation policy for an M/G/1 queueing system with an unreliable server and startup. Ke and Chu [7], discussed a modified vacation model $M^x/G/1$ system. Yi-jun zhu, Bin Zhaung [16], discussed on a batch arrival queue with different arrival rate and N policy. Yinghui Tang and Yong Mao [17] discussed, the stochastic decomposition,Rameshkumar[12],[13]discussed for $M^x/G/1$ queue with p entering discipline during server vacations ,Jeyakumar and Rameshkumar[4],[5] discussed a multiple adaptive server vacations in which the customers who arrive during server vacations enter the system with probability p. Variations in the vacation policies of the queueing systems have gained much attention in the literature, recently. Many researcher's analysis queueing systems with working vacations, adaptive vacations, vacations with T policy, etc., In the literature of the vacation models, the server avails either single or multiple vacations, but in practice, there are situations in which server takes sequence of finite number of vacations in idle time to perform optional fixed number of jobs. Best of our knowledge, only two papers are available on 'p' entering discipline, that too analysed in transient state. But in practice, one can expect the solution in a steady state. Also, in those papers, the results are obtained only analytical. This motivates the authors to develop 'p' entering discipline for $M^x/G/1$ queue with 'p' entering discipline during server vacations in steady state for a practical problem and numerical results are presented. The model discussed in this paper is more reasonable. Suppose that the customer input rate depends on the server availability (being in vacation or not). The arriving customers directly enter the system when they find the server available in the system. However, they enter the system with probability `p` $(0 \le p \le 1)$, when the server is on vacation.

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The following points are addressed in this paper. Numerical solution is provided which is not available in the literature. Arrival to the system due to the choice of the customers during the server vacation. A practical situation is modeled and analyzed as a queueing system. Numerical illustration is presented to justify, the analytical results of the model and how it is useful to the management for taking decisions. The paper isorganized as follows: firstly, the steady state equations are developed by using supplementary variables. Secondly, the probability generating function of queue size at an arbitrary time epoch is obtained. Next through this some important performance measures such as expected queue length, expected busy period, expected waiting time and idle time are derived.

Model Description

The model consists of a single server, the customers are served one at a time in FCFS order. In this paper, we study the steady state behavior of a single server, general bulk service queue with restricted number of vacations. A batch of customers arrive according to Poisson with rate λ, after completing a service, if the queue length is empty then the server leaves for a vacation of random length. When he returns from a vacation, if the number of customer in the queue is still zero, then the server avails another vacation and so on until he completes M number of vacations, in successions or he finds at least one customer waiting for service. During the vacation time customers entering in to the system with probability `p`.We state some assumptions as follows,

1. The Customer bulk arrival is a time homogenous Poisson process, the intervals between bulk customers, are independent identically distributed random variables generated by distribution function x(t) =1- $e^{-\lambda t}$, t ≥ 0
2. The service order for customers in different bulk arrivals is under the rule of First Come First Serve and the order in one bulk arrival is arbitrary. The service times {μ ≥ 1} are independent identically distributed random variables each with distribution S(x).
3. The server takes adaptive multiple vacations when the system becomes empty. Let T be the times of vacation generating by distribution function with PGF Q(z).Assume that the length of each vacation Q_n are independent identically distributed random variables each with general distribution V(t) and finite mean E(v).
4. The arriving customers directly enter the system when the server does not take vacations. However, the customers who arrive during server vacations enter the system with probability `p`(0≤ p ≤ 1). The arrival, service, vacation and idle time are independent identically distributed of each other.

Notations and assumptions

The following notations are used in this paper

X(z)	:	probability generating function of X
λ	:	arrival rate
g_k	:	P(X=k)
S(·)	:	Cdf of service time
V(·)	:	Cdf of vacation time
$\tilde{S}(\theta)$	:	Laplace - Stieltje's transforms of S
$\tilde{V}(\theta)$	:	Laplace - Stieltje's transforms of V
Z (t)	:	j, if the server is on j^{th} vacation
s(x)	:	Pdf of S
v(x)	:	Pdf of V
S^0(t)	:	Remaining service time of S at time ' t '
$V^0(t)$	:	Remaining vacation time of V at time't '
N_s(t)	:	Number of customers in the service.
N_q(t)	:	Number of customers in the queue.

Define the random variables as

ξ (t) =   (0),[1],{2}, if the customers in the (service),[vacation],{dormant}.

Z (t) = j, if the server is on j^{th} vacation

The supplementary variables S^0(t), V^0(t) are introduced in order to obtain bivariate Markov process {N (t), ξ (t)}, where N(t) = {N_q(t)∪ N_s(t)}

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Let us define the following probabilities

P_{1j}(x, t) dt = p$\{N_s(t) =1, N_q(t) = j, x \le S^0(t) \le x + dt, \xi(t) = 0\}, j \ge 0$

which means that there are one customers under service, `j' customers in the queue, the server is busy with remaining service time x.   In similar manner, we define,

Q_{1n}(x, t) dt = p$\{N_q(t) = n, x \le V^0(t) \le x + dt, \xi(t) =1, Z(t) = j), n \ge 0\}, 1 \le j \le M$ denotes that n customers waiting in the queue and the server is on j^{th} vacation, and T_0(t)dt = p$\{(N_q(t) = 0, \xi(t) = 2\}$, denotes that there are `0` customers in the queue when server is on dormant period.

System equations

The following system equations are obtained for the queueing system using supplementary variable technique due to Cox(1955). These equations provide the basis for the analysis given in sequel. These equations are obtained at time t+Δt considering all possibilities. One can note that when time t is increased byΔt, the remaining service time or vacation time will be reduced by

x-Δt.

P_{10}(x-Δt, t+Δt) = P_{10}(x,t)(1-$\lambda\Delta$t)+P_{11}(0,t) s(x)Δt+$\sum_{l=1}^{M} Q_{l1}$(0,t)s(x)Δt + λT₀(t)g₁s(x)Δt   (1)

P_{1j}(x-Δt, t+Δt) = P_{1j}(x,t)(1-$\lambda\Delta$t) +P_{1j+1}(0,t) s(x)Δt+$\sum_{l=1}^{M} Q_{lj+1}$(0,t)s(x)Δt +λT₀(t)g_{j+1}s(x)Δt +$\sum_{k=1}^{j} P_{1,j-k} \lambda$g_k$\Delta$t, j≥1   (2)

Q_{10}(x-Δt, t+Δt) = Q_{10}(x,t)(1-$\lambda\Delta$t) +P_{10}(0,t) v(x)Δt   (3)

Q_{1n}(x-Δt, t+Δt) = Q_{1n}(x,t)(1-$\lambda\Delta$t) +$p \sum_{k=1}^{n} Q_{1n-k}$(x,t) λg_kΔt,   (4)

Q_{j0}(x-Δt, t+Δt) = Q_{j0}(x,t)(1-$\lambda\Delta$t) + $Q_{j-1,0}$(0,t) v(x)Δt,2≤j≤M   (5)

Q_{jn}(x-Δt, t+Δt) = Q_{jn}(x,t)(1-$\lambda\Delta$t) +$p \sum_{k=1}^{n} Q_{j,n-k}$(x,t) λg_kΔt, 2≤j≤M   (6)

T₀(t+Δt) =T₀(t)(1-$\lambda\Delta$t)+ $\sum_{l=1}^{m} Q_{l,o}$(0, t) Δt   (7)

Steady state analysis

In this section, the probability generating function of the queue size at an arbitrary time epoch is derived by supplementary variable techniques; it will be useful to derive the important performance measures such as expected number of customers in the queue, expected waiting time of customer in the queue, idle time and expected busy period etc .

Queue size distribution

In the steady state, let us define for x> 0,

$P_{1,j}(x)$=$\lim_{t\to\infty} P_{1j}$(x,t), $P_{1,j}(0)$=$\lim_{t\to\infty} P_{1,j}$(0,t), for j ≥ 0

$Q_{i,j}(x)$=$\lim_{t\to\infty} Q_{ij}$(x,t), $Q_{i,j}(0)$=$\lim_{t\to\infty} Q_{i,j}$(0,t), for 1 ≤ j ≤ M

The Steady state equations are obtained as difference – differential equations of the above are given as,

$-\frac{d}{dx}P_{10}(x) = -\lambda P_{10}(x) + P_{11}(0)$ s(x)+$\sum_{l=1}^{M} Q_{l1}(0)$S(x) + λT₀g₁s(x)   (8)

$-\frac{d}{dx}P_{1j}(x) = -\lambda P_{1j}(x) + P_{1j+1}(0)$ s(x)+$\sum_{l=1}^{M} Q_{lj+1}(0)$ s(x) + λT₀g_{j+1}s(x) +

$\sum_{k=1}^{j} p_{1,j-k} \lambda g_1$ j≥1   (9)

$-\frac{d}{dx}Q_{10}(x) = -\lambda Q_{10}(x) + P_{10}(0)$ v(x)   (10)

$-\frac{d}{dx}Q_{1n}(x) = -\lambda Q_{1n}(x) + P \sum_{k=1}^{n} Q_{1n-k}(x) \lambda g_1$ (11)

$-\frac{d}{dx}Q_{j0}(x) = -\lambda Q_{j0}(x) + Q_{j-1,0}(0)$ v(x),   2 ≤ j ≤M   (12)

$-\frac{d}{dx}Q_{jn}(x) = -\lambda Q_{jn}(x) +P \sum_{k=1}^{n} Q_{j,n-k}(x) \lambda g_1$ 2 ≤ j ≤ M   (13)

0= -λT₀+ $\sum_{l=1}^{m} Q_{l,o}(0)$ (14)

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To solve the above differential equations and to obtain PGF of the queue size we have used Laplace Stieltje's Transforms (LST).

The LST of $P_{ij}(x)$ and $Q_{jn}(x)$ are defined as follows:

$\tilde{P}_{1n}(\theta) = \int_0^\infty e^{-\theta x} P_{1n}(x)dx$ and $\tilde{Q}_{jn}(\theta) = \int_0^\infty e^{-\theta x} Q_{jn}(x)dx$ (15)

Multiplying Equations (8) – (13) by $e^{-\theta x}$ and integrating with respect to x over 0 to ∞, we get after using the LST,

$\theta\tilde{P}_{10}(\theta) - P_{10}(0) = \lambda\tilde{P}_{10}(\theta) - P_{11}(0)\tilde{S}(\theta) - \sum_{l=1}^M Q_{l1}(0)\tilde{S}(\theta) - \lambda T_0 g_1\tilde{S}(\theta)$

(16)

$\theta\tilde{p}_{1j}(\theta) - P_{1j}(0) = \lambda\tilde{P}_{1j}(\theta) - P_{1j+1}(0)\tilde{S}(\theta) - Q_{lj+1}(0)\tilde{S}(\theta) - \lambda T_0 g_{j+1}\tilde{S}(\theta) +$

$\qquad \sum_{k=1}^j \tilde{P}_{1,j-k}(\theta)\lambda g_k, \qquad j \geq 1$ (17)

$\theta\tilde{Q}_{10}(\theta) - Q_{10}(0) = \lambda\tilde{Q}_{10}(\theta) - P_{10}(0)\tilde{V}(\theta)$ (18)

$\theta\tilde{Q}_{1n}(\theta) - Q_{1n}(\theta) = \lambda\tilde{Q}_{1n}(\theta) - p\sum_{k=1}^n \tilde{Q}_{1n-k}(\theta)\lambda g_k$ (19)

$\theta\tilde{Q}_{j0}(\theta) - Q_{j0}(0) = \lambda\tilde{Q}_{j0}(\theta) - Q_{j-1,0}(0)\tilde{V}(\theta), \qquad 2 \leq j \leq M$ (20)

$\theta\tilde{Q}_{jn}(\theta) - Q_{jn}(0) = \lambda\tilde{Q}_{jn}(\theta) - p\sum_{k=1}^n \tilde{Q}_{j,n-k}(\theta)\lambda g_k 2 \leq j \leq M$ (21)

$0 = -\lambda T_0 + \sum_{l=1}^m Q_{l,o}(0)$ (22)

To obtain the PGF of the queue size at an arbitrary time, the following probability generating functions are defined

$\tilde{P}_1(z,\theta) = \sum_{j=0}^\infty \tilde{P}_{1j}(\theta)z^j$ and $P_1(z,0) = \sum_{j=0}^\infty P_{1j}(0)z^j$

$\tilde{Q}_j(z,\theta) = \sum_{n=0}^\infty \tilde{Q}_{jn}(\theta)z^n$ and $Q_j(z,0) = \sum_{n=0}^\infty Q_{jn}(0)z^n$ (23)

Multiplying equations (18) by z^0 and (19) by z^n and summing up from n= 1 to ∞, and using equation (23) we get

$(\theta - \lambda + \lambda px(z))\tilde{Q}_1(z,\theta) = Q_1(z,0) - P_{10}(0)\tilde{V}(\theta)$ (24)

Multiplying equations (20) by z^0 and (21) by z^n and summing up from n= 1 to ∞, and using equation (23) we get

$(\theta - \lambda + \lambda px(z))\tilde{Q}_j(z,\theta) = Q_j(z,0) - Q_{j-1,0}(0)\tilde{V}(\theta), j \geq 2$ (25)

Multiplying equations (16) by z^0 and (17) by z^j and summing up from j = 1 to ∞, and using equation (23) we get

$z(\theta - \lambda + \lambda x(z))\tilde{P}_1(z,\theta) = zP_1(z,0) - \tilde{S}(\theta)[P_1(z,0) - P_{10}(0) + Q_1(z,0) - Q_{10}(0) + \lambda T_0 x(z)]$ (26)

By Substituting $\theta = \lambda - \lambda px(z)$ in the Equations (24) and (25), we get,

$Q_1(z,0) = P_{10}(0)\tilde{V}(\lambda - \lambda px(z))$ (27)

$Q_{1,0}(z,0) = Q_{j-1,0}(0)\tilde{V}(\lambda - \lambda px(z))$

(28)

By Substituting $\theta = \lambda - \lambda x(z)$ in (26), we get,

$zP_1(z,0) = \tilde{S}(\theta)[P_1(z,0) - P_{10}(0) + Q_1(z,0) - Q_{l0}(0) + \lambda T_0 x(z)]$

Solving for $P_1(z,0)$ we get

$P_1(z,0) = \frac{\tilde{S}(\theta)[-P_{10}(0) + Q_1(z,0) - Q_{10}(0) + \lambda T_0 x(z)]}{z - \tilde{S}(\lambda - \lambda x(z))}$ (29)

By Substituting $Q_1(z,0)$ and $Q_j(z,0)$ in (27) and (28) we get

$\tilde{Q}_1(z,\theta) = \frac{P_{10}(0)[\tilde{V}(\lambda - \lambda Px(z)) - \tilde{V}(\theta)]}{(\theta - \lambda + \lambda px(z)}$ and (30)

$\tilde{Q}_j(z,\theta) = \frac{Q_{j-1,0}(0)[\tilde{V}(\lambda - \lambda px(z)) - \tilde{V}(\theta)]}{(\theta - \lambda + \lambda px(z)}$ (31)

By Substituting $P_1(z,0)$ in (29), we get,

$\tilde{P}_1(z,\theta) = \frac{[\tilde{S}(\lambda - \lambda x(z)) - \tilde{S}(\theta)[-P_{10}(0) + Q_1(z,0) - Q_{10}(0) + \lambda T_0 x(z)]}{(z - \tilde{S}(\lambda - \lambda x(z))(\theta - \lambda + \lambda x(z))}$ (32)

Let us define the following,

$p_0 = P_{10}(0)$, $q_0 = \sum_{l=1}^M Q_{1i}(0)$ and $c_0 = p_0 + q_0$ (33)

By Substituting $\theta = 0$ in (30),(31) and (32) we get,

$\tilde{Q}_1(z,0) = \frac{P_{10}(0)[\tilde{V}(\lambda - \lambda px(z)) - 1]}{(-\lambda + \lambda px(z)}$ (34)

$\tilde{Q}_j(z,0) = \frac{Q_{j-1,0}(0)[\tilde{V}(\lambda - \lambda px(z)) - 1]}{(-\lambda + \lambda px(z))}$ and (35)

$\tilde{P}_1(z,0) = \frac{[\tilde{S}(\lambda - \lambda x(z)) - 1][-P_{10}(0) + Q_1(z,0) - Q_{l0}(0) + \lambda T_0 x(z)]}{(z - \tilde{S}(\lambda - \lambda x(z))(-\lambda + \lambda x(z))}$ (36)

From (27) and (28), we have $\sum_{n=0}^\infty Q_1(z,0) = c_0\tilde{V}(\lambda - \lambda px(z))$ (37)

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LetP (z) be the PGF of the queue size at an arbitrary time epoch is the sum of PGF of queue size at service completion epoch, vacation completion epoch and idle time, thenP $(z) = \tilde{P}_1(z, 0) + \tilde{Q}_1(z, 0) + \tilde{Q}_j (z, 0) + T_0$

Using the equations (25),(26), (27) and (14) we get the PGF of queue size as

$$P(z) = \frac{\begin{array}{c}(\tilde{S}(\lambda-\lambda x(z))-1)(-C_0+C_0\tilde{V}+q_0 x(z))(-\lambda+\lambda p x(z)) + \\ C_0(\tilde{V}-1)(z-\tilde{S}(\lambda-\lambda x(z)))(-\lambda+\lambda x(z)) + \\ q_0(z-S(\lambda-\lambda x(z)))(-\lambda+\lambda x(z))(-\lambda+\lambda p x(z))\end{array}}{(z-\tilde{S}(\lambda-\lambda x(z)))(-\lambda+\lambda x(z))(-\lambda+\lambda p x(z))} \qquad (38)$$

Note 1:

From equations (27) and (28), the probability q_0 can be expressed in terms of p_0 as,

$$\sum_{l=1}^{m} p_l z^l = (p_0+q_0)\sum_{i=0}^{\infty} \alpha_i z^i, \quad p_0 = (p_0+q_0)\alpha_0, \text{ and } q_0 = (1-\alpha_0)p_0. \qquad (39)$$

Steady state condition

The steady state condition of the queue size is obtained as follows. The probability generating function has to satisfy p (1) =1. To satisfy the condition applying L' hospital's rule and evaluating

$$\frac{q_0[(p-1)\lambda E(S)E(X) + 2E(V)(I - \lambda E(S)E(X))(-\lambda+\lambda p)]}{4\lambda E(X)(I - \lambda E(S)E(X))(-\lambda+\lambda p)} = 1 \qquad (40)$$

Equating we get,$4\lambda E(X)(I - \lambda E(S)E(X))(-\lambda + \lambda p) > 0$ since p_0 and q_0 are probabilities of no customers being in the queue at service completion epoch and vacation completion epoch, respectively, it follows that left hand side of the above expression must be positive. Thus p(1) =1 is satisfied if and only if$1 - \lambda E(S)E(X) > 0$. Define ϱ as$\lambda E(S)E(X)$. Thus $\varrho < 1$ is the condition to be satisfied for the existence of steady state for the model under consideration.

Performance measures

We derive some important performance measures using the PGF of queue size in equation (38), as follows:

Expected busy period

Theorem: If E (B) is the expected busy period, then E(B) $= \frac{E(S)}{P_0}$

Proof

Let B be the random variable for busy period. Define a random variable J as:

J= 0; if the server finds less than one customer in the queue after first service.

J=1;if the server finds at least one customers in the queue after a first service.

Now the expected length of busy period

E (B) = E (B/J=0) P(J=0) +E (B/J=0) P (J=1)

= E (B/J=0) P(J=0) + (E (B) +E(S)) P (J=1)

= E (B/J=0) P (J=0) + (E (B) +E(S)) (1-P (J=1))

On solving for E (B), we get, E(B) $= \frac{E(S)}{P(J=0)}$. $\qquad (41)$

Expected queue length

The expected queue length E (Q) at an arbitrary time epoch is obtained by p`(1) and is given by

$$E (Q) = \frac{(C_0 V_p - P_0)f_1 + f_2 + (C_0 V_1 + q_0 X_1)f_3}{24(1-S_1)\lambda^3(p-1)} \qquad (42)$$

The functions f_1, f_2 and f_3 are given by,

$f_1 = 6\lambda^2 S_2 + 2pS_1\lambda + (3X_2 - 4S_2)\lambda^2 S_1 - 2S_2 - 3S_1\lambda^2$,

$f_2 = -12pS_1 - \lambda X_2 + S_2 + 6\lambda X_1^2 S_1 - 5pS_1\lambda^3 X_1 - 4pS_1\lambda^2 X_1$,

$f_3 = 6\lambda^2 (p-1)(1-S_1) + 6S_1(1+\lambda)$,$S_1 = \lambda X_1 E(S)$, $S_2 = \lambda X_2 E(S) + \lambda^2 X_1^2 E(S^2)$,

$V_1 = \lambda p X_1 E(V)$, and $X_1 = E(X) = X`(1)$, $X_2 = X``(1)$.

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Expected length of idle period

Let I be the random variable of ' idle period' .The expected length of idle period E(I) is given by E(I) = E(I$_1$) + E(I$_2$) +E(I$_3$), where I$_1$is the random variable idle period , I$_2$ is the random variable idle period generated by adaptive vacations and I$_3$ is the random variable is due to j (1$\leq j \leq M$)vacations.

The expected length of an idle period is defined by

E(I$_1$) = M E(V)   (43)

E(I$_2$) = (1/λ)T$_0$ (44)

E(I$_3$) =E(V)$\sum_{j=1}^{M} j$ [$(1 - p)$p$_0$ +q$_0$].   (45)

Expected waiting time

The expected waiting time is obtained by little formulaE (w) =$\frac{E(Q)}{\lambda E(X)}$,   (46)

Where $E(Q)$ is expected queue length as in equation (42).

Numerical illustration

This queueing model has a general service rule with single server. The customer has to wait if the server is on adaptive vacation. By considering the situation of customers waiting and the effective utilization of the operator and the machine, it is essential to have an optimal thresholds value for a quantity. We develop a cost model through which the total costs involved in the system can be minimized. We derive an expression for finding the total average cost with the following assumptions. Let C$_s$ be the setup cost, C$_h$ be the holding cost per customer, C$_o$ be the operating cost per unit time C$_r$ be the reward per unit due to the vacation. The length of cycle is the sum of the idle period and busy period. Now, the expected length of cycle;E (T$_c$) =E (I) +E (B) The total average cost per unit is given by, Total average cost = set-up cost per cycle + Holding cost of number of customer in the queue+operating cost$^*\rho$ - reward due to vacation per cycle.

= [C$_s$− C$_r \frac{E(V)}{P(U=0)}$+ C$_u$] +C$_h$E (Q) +C$_0 \rho'$ where ρ= λE(S)E(X)

The numerical results for various arrival values and performance measures with μ=5are presented in Table 1. From Table 1, one can observe that, the total average cost is minimum when λ =3.5at p=0.4,0.5 and λ = 4 at p=0.6. Also when p=0.4, the TAC is minimum than p=0.5 and p=0.6 The numerical results for various arrival values and performance measures with μ=6 are presented in Table 2. From Table 2, one can observe that, the total average cost is minimum when λ =3.5 at p=0.4. The numerical results for various arrival rates and performance measures with μ=6 are presented in Table 3. From Table 3, one can observe that, the total average cost is minimum when λ =4at p=0.5, The numerical results for various arrival values and performance measures with μ=6are presented in Table 4. From Table 4, one can observe that, the total average cost is minimum when λ =4.0 at p=0.6. From Fig. 1, one can observe that, the expected queue length is increasing when probability increasing

CONCLUSION

In this paper, a M^X /G/1 queueing system with control policy and setup times for the number of vacations in which the customers who arrive during server vacations enter the system with probability is analyzed. Probability generating function of queue size at an arbitrary time epoch is obtained. Some important performance measures such as expected queue length, expected busy period, expected waiting time are also obtained. PGF of queue size at an arbitrary time epoch and at different completion epochs are obtained. Theoretical development of the model is justified with numerical results as shown. A cost model is developed. An extensive numerical study is performed which indicate, due to M vacations the expected queue length, busy period of the server and waiting time of the customers are increases as well as the idle period of the server decreases.

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Table1. The arrival rate value vs. total average cost, and performance measures with Probability of 'p'enteringp=0.4, 0.5, 0.6and μ=5.

λ	ρ	E(Q)	E(W)	E(I)	TAC	TAC	TAC
2.0	0.3433	4.3438	0.7653	1.6932	5.0034	6.3347	7.8822
2.5	0.4402	4.7657	0.7794	1.6877	4.3561	5.9876	6.9133
3.0	0.4971	4.9657	0.7799	1.6098	3.0567	5.2314	6.2904
3.5	0.5028	4.9957	0.8801	1.6017	2.8341	4.6502	5.8290
4.0	0.6621	5.0077	0.8945	1.5801	3.0014	4.9870	5.2214
4.5	0.7878	5.1657	0.9890	1.5556	3.6728	5.0011	6.6721

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| 5.0 | 0.9901 | 5.2901 | 0.9919 | 1.5120 | 4.8782 | 6.2372 | 7.4389 |

Table 2.The arrival rate value vs. total average cost, at p=0.4and μ=6

E(B)	TAC	λ	ρ	E(Q)	E(W)
2.0	0.56	1.3433	0.3438	0.2653	4.9432
2.5	0.59	1.8402	0.7657	0.4794	4.3877
3.0	0.67	1.9971	0.9657	0.7799	3.0098
3.5	0.69	2.4528	0.9957	0.7981	2.4017
4.0	0.71	2.9521	1.0077	0.7845	2.9801
4.5	0.78	3.7878	1.1657	0.9890	3.6256
5.0	0.85	3.9001	1.2901	1.0899	3.8807
5.5	0.94	4.8178	1.3126	1.6104	4.0118
6.0	0.99	9.2228	1.3757	1.8178	

Table 3.The arrival rate value vs. total average cost, at p=0.5 and μ=6

TAC	λ	ρ	E(Q)	E(W)	E(B)
2.0	0.48	1.4703	1.3438	0.1643	6.9432
2.5	0.51	1.5090	1.4401	0.1994	6.5432
3.0	0.62	1.7901	1.8797	0.2299	5.9432
3.5	0.69	1.9528	1.9957	0.3621	4.9432
4.0	0.71	2.0521	2.2877	0.4427	3.9432
4.5	0.74	2.7908	2.1150	0.5811	4.1101
5.0	0.87	3.1001	2.2929	0.6899	5.9439
5.5	0.89	3.6170	2.8120	0.6904	6.7212
6.0	0.91	7.2548	2.9231	0.9108	6.9432

Table 4.The arrival rate value vs. total average cost, at p=0.6 and μ=6

λ	ρ	E(Q)	E(W)	E(B)	TAC
2.0	0.56	1.3433	0.3438	0.2653	9.8822
2.5	0.59	1.8402	0.7657	0.4794	8.2133
3.0	0.67	1.9971	0.9657	0.5199	6.9904
3.5	0.69	2.4528	0.9957	0.5901	6.8290
4.0	0.71	2.9521	1.0077	0.6845	5.2214
4.5	0.78	3.7878	1.1657	0.6990	5.6721
5.0	0.85	3.9001	1.2901	0.7899	6.4389
5.5	0.94	4.8178	1.3126	0.8104	7.1003
6.0	0.99	9.2228	1.3757	0.9778	8.9234

Figure – 1 Schematic representation of the queueing model

Figure 2. The arrival rate value vs. total average cost at p=0.4, 0.5, 0.6 and μ=7.

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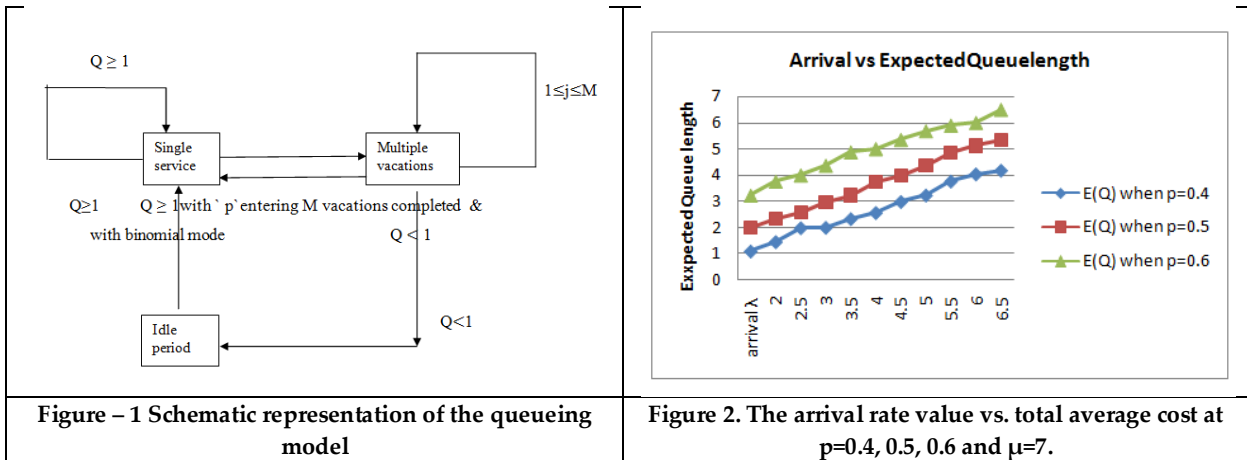
NSGB-Separatedness and NSGB-Connectedness in Nano Topological Spaces

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ABSTRACT

The goal of this paper is to investigate the separatedness, connectedness and disconnectedness that is, the Nsgb-separatedness, Nsgb-connectedness and Nsgb-disconnectedness in nano topological spaces for the Nano semigeneralized b-(Nsgb) (closed/open) set.

Keywords: Nano topology, Nsgb-open, Nsgb-closed, Nsgb-separated, Nsgb-connected, Nsgb-disconnected.
MSC 2020 Classification: 54A05, 54D05

INTRODUCTION

In general topological spaces, Levine [7] developed the generalized closed sets in 1970. The ideas of connectedness and disconnectedness in topological spaces were first presented by A. V. Archangelskii and R. Weiandy [2] in 1975. In 1996, Andrijevic [1] coined b-open sets. In 2013 El Atik, Abu Donia, and Salama [3] developed the concepts of b-connectedness and b-disconnectedness. Semi-generalized b-closed set was first coined in 2010 by Iyappan and Nagaveni [4], who further developed the notions of connectedness, compactness for semi generalized b-open sets in general topology. In 2013, Lellis Thivagar [9] proposed nano topological space concerning approximation spaces and boundary regions with regard to a subset of a universe set, and defined various kinds of nano open sets. In 2016, Parimala, Indirani, and Jafari [8] created the term nano b-open sets. In 2018, Suresh, Ramesh, and Krishnaprakash [6] established nano-compactness, nano-connectedness. Kavipriya and Indira [5] developed a nano semi generalized b-closed set in nano topological spaces. Pairs of subsets of a certain topological space that are connected to one another in a specific way are called *separated sets*; they are roughly neither touching nor overlapping in topology and related branches of mathematics. The fundamental topological characteristic of sets in mathematics that corresponds to the

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idea of having no breaks is called *connectedness*. ie)., The state of being linked or bound together. The separatedness and connectedness of Nsgb-(closed/ open) sets in nano topological spaces will be introduced and examined in this work.

PRELIMINARIES

In this paper we define $(U, \tau_R(S))$ as the nano topological space relative to S where S □ U.

Definition 2.1: [9]Assume U indicate a finite non-empty collection of elements referred as Universe, R signify an equivalence relation on U referred as Indiscernibility relation. U is partitioned into distinct equivalence classes. In one's equivalence class elements are indistinguishable. The Approximation space is represented by (U, R). Let S □ U. Then

The **Lower** Approximation of S ($L_R(S)$) relative to R is the collection of all elements that can be categorized as S in respect of R, R(S) is the equivalence class determined by s in S. $LR(S) = \bigcup_{s \in U} \{R(S): R(S) \subseteq S\}$

The **Upper Approximation** of S ($U_R(S)$) relative to R is the collection of all elements that can be categorized as S in respect of R. $U_R(S) = \bigcup_{s \in U} \{R(S): R(S) \cap S \neq \emptyset\}$

The **Boundary region** of S ($B_R(S)$) relative to R is the collection of all elements that can be labeled neither as S nor as not-S in respect of R. $B_R(S) = U_R(S) - L_R(S)$.

Definition 2.2: [9] Consider the universe as U and the equivalence relation be R on U, let the subset $S \subseteq U$ and $\tau_R(S) = \{U, \emptyset, L_R(S), U_R(S), B_R(S)\}$. Then the following axioms need to be met by $\tau_R(S)$.

i. U and $\emptyset \in \tau_R(S)$

ii. The arbitrary union of the elements of $\tau_R(S) \in \tau_R(S)$.

iii. The finite intersection of the elements of $\tau_R(S) \in \tau_R(S)$. Then with respect to S, $\tau_R(S)$ is referred as **Nano topology** on U. The Nano topological space is the pair $(U, \tau_R(S))$. The elements of $\tau_R(S)$ are nano open sets and its complements are the nano closed sets of U.

Definition 2.3: Let $E \subseteq U$ in $(U, \tau_R(S))$ then

1. **Nano semi open (Ns-open)** [9]: if $E \subseteq Ncl(Nint(E))$.
2. **Nano b-closed (Nb-closed)** [8]: if $Nint(Ncl(E)) \cap Ncl(Nint(E)) \subseteq E$

Definition 2.4 [8]: Nano b-closure of E (Nb-cl(E)): intersection of all Nb-closed subsets of U containing E. **Nano b-interior of E** (Nb-int(E)): union of all Nb-open sets contained in E.

Definition 2.5 [10]: Take the nano topological spaces as $(U, \tau_R(S))$ and $(V, \tau_R(T))$ where $S \subseteq U$ and $T \subseteq V$. A function d: $U \rightarrow V$ is **Nano continuous** if inverse image is nano closed in $(U, \tau_R(S))$ for each nano closed set in $(V, \tau_R(T))$.

Definition 2.6: In $(U, \tau_R(S))$, two non-empty subsets E and F are **nano separated** if $E \cap Ncl(F) = \emptyset$ and $Ncl(E) \cap F = \emptyset$. Equivalently, $[E \cap Ncl(F)] \cup [Ncl(E) \cap F] = \emptyset$.

Definition 2.7 [6]: $(U, \tau_R(S))$ is **nano connected** if U can't be written as a union of two disjoint non-empty nano open sets. $E \subseteq U$ is nano connected if E is nano-connected as a subspace.

Definition 2.8 [6]: $(U, \tau_R(S))$ is **nano disconnected** if U is a union of non-empty two nano separated sets.

Definition 2.9 [5]: A subset E of $(U, \tau_R(S))$ is **Nsgb-closed** if $Nb-cl(E) \subseteq K$, whenever $E \subseteq K$, where K is nano semi-open in U. E^C is **Nsgb-open.**

Definition 2.10 [5]: Let $E \subseteq (U, \tau_R(S))$ then **Nsgb-interior of E** (Nsgb-int(E)) is stated as the union of all Nsgb-open sets contained in E. ⇒ Nsgb-int(E) $\subseteq$ E. **Nsgb-closure of E** (Nsgb-cl(E)) is stated as the intersection of all Nsgb-closed sets containing E.⇒ E $\subseteq$ Nsgb-cl(E)

Example 2.11: Let U = {dollar(d), yen(y), euro(e), rupees(r)} as universe all over the paper. Take U = {d, y, e, r}, S = {y, r} $\subseteq$ U, U/R = {{d}, {y}, {e, r}}, $\tau_R(S)$ = {U, ∅, {y}, {y, e, r}, {e, r}}, Nsgb-closed = {U, ∅, {d}, {y}, {e}, {r}, {d, y}, {d, e}, {d, r}, {e, r}, {d, y, e}, {d, y, r}, {d, e, r}}, Nsgb-open = {∅, U, {y, e, r}, {d, e, r}, {d, y, r}, {d, y, e}, {e, r}, {y, r}, {y, e}, {d, y}, {r}, {e}, {y}}. Let E = {y, e} then Nsgb-int(E) = {y, e}, Nsgb-cl(E) = {d, y, e}.

Consider $(U, \tau_R(S))$ and $(V, \tau_R(T))$ be the two nano topological spaces where S $\subseteq$ U, T $\subseteq$ V.

Definition 2.12 [11]: A function m: U → V is Nsgb-continuous if the pre image of each nano closed set in $(V, \tau_R(T))$ is Nsgb-closed in $(U, \tau_R(X))$.

Definition 2.13 [11]: A function m: U → V is Nsgb-irresolute if the pre image of each Nsgb-closed set in V is Nsgb-closed in U.

Example 2.14: Take U = {d, y, e, r}, S = {d, y}, U/R = {{d, y}, {e, r}}, $\tau_R(S)$ = {U, ∅, {d, y}}, Nano closed(U) = {U, ϕ, {e, r}}, Nsgb-closed(U) = {U, ∅, {d}, {y}, {e}, {r}, {d, e}, {d, r}, {y, e}, {y, r}, {e, r}, {d, e, r}, {y, e, r}}. Let V = {d, y, e, r}, T = {d, y}, V/R = {{d}, {y}, {e}, {r}}, $\tau_R(T)$ = {V, ∅, {d, y}}, Nano closed(V) = {V, ϕ, {e, r}}, Nsgb-closed(V) = {V, ∅, {d}, {y}, {e}, {r}, {d, e}, {d, r}, {y, e}, {y, r}, {e, r}, {d, e, r}, {y, e, r}}. Define m: U → V by m(d) = y, m(y) = d, m(e) = r, m(r) = e. Here m is Nsgb-continuous and Nsgb-irresolute.

Nsgb-Separatedness

Definition 3.1: The two non-empty subsets E, F of $(U, \tau_R(S))$ are Nsgb-separated iff E ∩ Nsgb-cl(F) = ∅ and Nsgb-cl(E) ∩ F = ∅. Equivalently, [E ∩ Nsgb-cl(F)] ∪ [Nsgb-cl(E) ∩ F] = ∅. In other words, E and F are Nsgb-separated iff E, F are disjoint sets and there isn't a Nsgb-limit point of other in either of them.

Example 3.2: Take U = {d, y, e, r}, S = {d, y}, U/R = {{d, y}, {e, r}}, $\tau_R(S)$ = {U, ∅, {d, y}}, τ_R-closed(S) = {U, ∅, {e, r}}, Nsgb-closed(U) = {U, ∅, {d}, {y}, {e}, {r}, {d, e}, {d, r}, {y, e}, {y, r}, {e, r}, {d, e, r}, {y, e, r}}, Nsgb-open(U) = {U, ∅, {d}, {y}, {d, y}, {d, e}, {d, r}, {y, e}, {y, r}, {d, y, e}, {d, y, r}, {d, e, r}, {y, e, r}}. Let E = {d}, F = {y}. Then E ∩ Nsgb-cl(F) = {d} ∩ {y} = ∅ and Nsgb-cl(E) ∩ F = {d} ∩ {y} = ∅. ∴ E and F are Nsgb-separated.

Definition 3.3: Two subsets E and F forms a Nsgb-separation of a subset G of U in $(U, \tau_R(S))$ iff
1. G = E ∪ F
2. E, F are non-empty
3. E ∩ F = ∅
4. Neither E contains a Nsgb-limit point of F nor F contains a Nsgb-limit point of E. ie., E ∩ Nsgb-cl(F) = ∅ and Nsgb-cl(E) ∩ F = ∅.

Example 3.4: From example 3.2,
i) Let G = {d, y, e} $\subseteq$ U. Let E = {d}, F = {y, e} $\subseteq$ U. Then
1. G = E ∪ F
2. {d} ≠ ∅, {y, e} ≠ ∅ ⇒ E, F are non-empty
3. {d} ∩ {y, e} = ∅ ⇒ E, F are disjoint
4. E ∩ Nsgb-cl(F) = {d} ∩ {y, e} = ∅; Nsgb-cl(E) ∩ F = {d} ∩ {y, e} = ∅ Here E and F forms a Nsgb-separation of G.

ii) Let G = {d, y, e} ⊆ U. Let E = {d, y}, F = {e} ⊆ U.. Then

1. G = E ∪ F
2. {d, y} ∩ {e} = ∅ ⇒ E, F are disjoint
3. {d, y} ≠ ∅, {e} ≠ ∅ ⇒ E, F are non-empty
4. E ∩ Nsgb-cl(F) = {d, y} ∩ {e} = ∅, Nsgb-cl(E) ∩ F = U ∩ {e} = {e}≠ ∅

Here E and F does not form a Nsgb-separation of G.

Definition 3.5: In (U, τ_R(S)) the **Nsgb-separation of U** is a pair of P, Q (whereas Q = U – P) of disjoint non-empty Nsgb-(closed/open) subsets of U whose union equals U. ie., U = P ∪ Q.

Example 3.6: Take U = {d, y, e, r}, S = {d, y, e}. U/R = {{d}, {e}, {y, r}}, τ_R(S) = {U, ∅, {d, e}, {y, r}}, Nsgb-open(U) = {U, ∅, {d}, {y}, {e}, {r}, {d, y}, {d, e}, {d, r}, {y, e}, {y, r}, {e, r}, {d, y, e}, {d, e, r}, {d, y, r}, {y, e, r}}. Let P = {d, e}, Q = {y, r}, where P, Q are Nsgb-open in U. Then P ∪ Q = {d, e} ∪ {y, r} = {d, y, e, r} = U shows P, Q forms a Nsgb-separation of U. Thus U is Nsgb-separated.

Remark: Suppose P and Q forms a Nsgb-separation of U then P, Q are both Nsgb-open and Nsgb-closed. Since Q is the complement of P.

Theorem 3.7: Every nano separated set is Nsgb-separated.

Proof: Consider two disjoint subsets E, F of (U, τ_R(S)) be nano-separated. Then E ∩ Ncl(F) = ∅ and Ncl(E) ∩ F = ∅. Since for any set R, R ⊆ Nsgb-cl(R) ⊆ Ncl(R) implies E ∩ Nsgb-cl(F) = ∅ and Nsgb-cl(E) ∩ F = ∅. Hence E and F are Nsgb-separated.
Conversely, from example 3.2, take E = {d}, F = {y} ⊆ U. Then E ∩ Nsgb-cl(F) = {d} ∩ {y} = ∅; Nsgb-cl(E) ∩ F = {d} ∩ {y} = ∅. ∴ E and F are Nsgb-separated. But E ∩ Ncl(F) = {d} ∩ U = {d} ≠ ∅; Nsgb-cl(E) ∩ F = U ∩ {y} = {y} ≠ ∅. ∴ E and F are not nano-separated.

Remark: Each two Nsgb-separated sets are always disjoint.
Let E, F are Nsgb-separated. Since E ∩ F ⊆ E ∩ Nsgb-cl(F) = ∅ implies E ∩ F = ∅. Similarly E ∩ F ⊆ Nsgb-cl(E) ∩ F = ∅ implies E ∩ F = ∅.Thus E and F are disjoint. *Conversely,* from example 3.2, take E = {d, y}, F = {e, r}. Here E ∩ F = {d, y} ∩ {e, r} = ∅ ⇒ E, F are disjoint and E ∩ Nsgb-cl(F) = {d, y} ∩ {e, r} = ∅; Nsgb-cl(E) ∩ F = U ∩ {e, r} = {e, r} ≠ ∅. So E and F are not Nsgb-separated. Thus disjoint sets need not be Nsgb-separated.

Theorem 3.8: The subsets of Nsgb-separated sets are also Nsgb-separated.
Proof: Let E_1 ⊆ E and F_1 ⊆ F where E, F are Nsgb-separated in (U, τ_R(S)). To prove: *E_1 and F_1 are also Nsgb-separated.*
Here E∩F = ∅, E ∩ Nsgb-cl(F) = ∅ and Nsgb-cl(E) ∩ F = ∅. Given E_1 ⊆ E and F_1 ⊆ F implies E_1∩F_1 = ∅ says E_1, F_1 are disjoint. Since E_1 ⊆ E ⇒ Nsgb-cl(E_1) ⊆ Nsgb-cl(E). We have F ∩ Nsgb-cl(E) = ∅ and F_1 ⊆ F then F_1∩ Nsgb-cl(E) = ∅, F_1∩ Nsgb-cl(E_1) = ∅ → (1). Since F_1 ⊆ F ⇒ Nsgb-cl(F_1) ⊆ Nsgb-cl(F). We have E ∩ Nsgb-cl(F) = ∅ and E_1 ⊆ E then E_1∩ Nsgb-cl(F) = ∅, E_1∩ Nsgb-cl(F_1) = ∅ → (2). From (1) and (2), E_1 and F_1 are Nsgb-separated.

Theorem 3.9: The two Nsgb-closed (or Nsgb-open) subsets E, F of (U, τ_R(S)) are Nsgb-separated iff they are disjoint.

Proof: Case i: Let E, F are non-empty **Nsgb-closed subsets** which are Nsgb-separated. Then E ∩ Nsgb-cl(F) = ∅ and Nsgb-cl(E) ∩ F = ∅ → (1). Since E, F are Nsgb-closed then Nsgb-cl(E) = E and Nsgb-cl(F) = F. Then (1) becomes E ∩ F = ∅ and E ∩ F = ∅. This says E, F are disjoint.
Conversely, let E, F are non-empty disjoint Nsgb-closed subsets. ie., E ∩ F = ∅. Since E, F are Nsgb-closed, then E = Nsgb-cl(E), F = Nsgb-cl(F). Now E ∩ F = E ∩ Nsgb-cl(F) = ∅ and E ∩ F = Nsgb-cl(E) ∩ F =∅. Hence E and F are Nsgb-separated.

Case ii: Let E, F are non-empty **Nsgb-open subsets** which are Nsgb-separated. Then E ∩ Nsgb-cl(F) = ∅ and Nsgb-cl(E) ∩ F = ∅   →   (2). Since E ⊂ Nsgb-cl(E) and F ⊂ Nsgb-cl(F). Then E∩F ⊂ E ∩ Nsgb-cl(F) = ∅ ⇒ E∩F ⊂ ∅ and E∩F ⊂ Nsgb-cl(E) ∩ F = ∅ ⇒ E∩F ⊂ ∅. But ∅ is a subset of every set so that ∅ ⊂ E∩F. Hence E∩F = ∅. Thus E, F are disjoint. *Conversely,* let E, F are non-empty Nsgb-open disjoint subsets. ⇒ E^C and F^C are Nsgb-closed and Nsgb-cl(E^C) = E^C, Nsgb-cl(F^C) = F^C →   (3). Also E∩F = ∅ ⇒ E ⊂ F^C and F ⊂ E^C. Nsgb-cl(E) ⊂ Nsgb-cl(F^C) and Nsgb-cl(F) ⊂ Nsgb-cl(E^C). By (3), Nsgb-cl(E) ⊂ F^C and Nsgb-cl(F) ⊂ E^C so that Nsgb-cl(E) ⊄ F and Nsgb-cl(F) ⊄ E which gives Nsgb-cl(E) ∩ F =∅ and E ∩ Nsgb-cl(F) = ∅. Therefore E and F are Nsgb-separated.

Example 3.10: If E, F are disjoint and one of the sets is Nsgb-open and other is Nsgb-closed then they are not Nsgb-separated. From example 3.2, let E = {d, y}, F = {e}, where E is Nsgb-open, F is Nsgb-closed. Then E ∩ Nsgb-cl(F) = {d, y} ∩ {e} = ∅ and Nsgb-cl(E) ∩ F = U ∩ {e} = {e} ≠ ∅. Here E and F are not Nsgb-separated. Hence both the sets must be either Nsgb-closed or Nsgb-open.

Theorem 3.11: Let (V, τ_R(T)) be a subspace of (U, τ_R(S)). Let E, F ⊆ V. Then E, F are Nsgb-separated in V iff they are Nsgb-separated in U.
Proof: Let E, F be Nsgb-separated in U. Then E ∩ Nsgb-cl(F) = ∅ and Nsgb-cl(E) ∩ F = ∅. Also [E ∩ Nsgb-cl(F)] ∪ [Nsgb-cl(E) ∩ F] = ∅. Since E, F ⊆ V, E = E∩V and F = F∩V. Also Nsgb-cl(E) in V = [Nsgb-cl(E) in U] ∩ V; and Nsgb-cl(F) in V = [Nsgb-cl(F) in U] ∩ V. To Prove: E, F are Nsgb-separated in V. Consider [E ∩ Nsgb-cl(F)$_V$] ∪ [Nsgb-cl(E)$_V$ ∩ F] = [E ∩ (Nsgb-cl(F)$_U$ ∩V)] ∪ [(Nsgb-cl(E)$_U$ ∩V) ∩ F] = [(E ∩ Nsgb-cl(F)$_U$)∩V] ∪ [(Nsgb-cl(E)$_U$ ∩F) ∩ V] = [∅ ∩ V] ∪ [∅ ∩ V] = ∅. E, F are Nsgb-separated in V. Hence [E ∩ Nsgb-cl(F)$_V$] ∪ [Nsgb-cl(E)$_V$ ∩ F] = ∅ iff [E ∩ Nsgb-cl(F)] ∪ [Nsgb-cl(E) ∩ F] = ∅. Therefore E, F are Nsgb-separated in U ⇔ E, F are Nsgb-separated in V for V ⊆ U.

Theorem 3.12: In (U, τ_R(S)) the union of two Nsgb-separated sets is Nsgb-closed then the individual sets are Nsgb-closed.
Proof: Let Q, T ⊆ U be the two Nsgb-separated sets such that Q∪T is Nsgb-closed. Since Q, T are Nsgb-separated then Q∩Nsgb-cl(T) = ∅; Nsgb-cl(Q)∩T = ∅. Since Q∪T is Nsgb-closed, Nsgb-cl(Q∪T) = Q∪T → (1) and Nsgb-cl(Q∪T) = Nsgb-cl(Q) ∪ Nsgb-cl(T).   Now Nsgb-cl(Q) = Nsgb-cl(Q) ∩ Nsgb-cl(Q∪T) = Nsgb-cl(Q) ∩ (Q∪T) = [Nsgb-cl(Q)∩Q] ∪ [Nsgb-cl(Q)∩T] = Q ∪ ∅ = Q. Thus Nsgb-cl(Q) = Q implies Q is Nsgb-closed. Similarly, Nsgb-cl(T) = Nsgb-cl(T) ∩ Nsgb-cl(Q∪T) = Nsgb-cl(T) ∩ (Q∪T) = [Nsgb-cl(T)∩Q] ∪ [Nsgb-cl(T)∩T] = ∅ ∪ T = T. Thus Nsgb-cl(T) = T implies T is Nsgb-closed.

Theorem 3.13: Two disjoint sets E, F are Nsgb-separated in (U, τ_R(S)) iff they are both Nsgb-open and Nsgb- closed in the subspace E∪F = G.
Proof: *Necessary Part:* Let E, F be disjoint and Nsgb-separated in U. Then E ∩ Nsgb-cl(F) = ∅ and Nsgb-cl(E) ∩ F = ∅. Given G = E∪F. Nsgb-cl(E) in G = [Nsgb-cl(E) in U] ∩ G = [Nsgb-cl(E) in U] ∩ (E∪F) = [Nsgb-cl(E) ∩E] ∪ [Nsgb-cl(E) ∩ F] = E ∪ ∅ = E ⇒ E is Nsgb-closed in G. Nsgb-cl(F) in G = [Nsgb-cl(F) in U] ∩ G = [Nsgb-cl(F) in U] ∩ (E∪F) = [Nsgb-cl(F) ∩ E] ∪ [Nsgb-cl(F) ∩ F] = ∅ ∪ F = F ⇒ F is Nsgb-closed in G. Also E, F are disjoint ie), E∩F = ∅ in G, they are complement of each other in G. Hence E, F are Nsgb-open in G.

Sufficient Part: Let the non-empty disjoint sets E, F be both Nsgb-open and Nsgb-closed in G = E∪F. *To Prove: E, F are Nsgb-separated in U.* As E is Nsgb-closed in G then E = Nsgb-cl(E)$_G$ = Nsgb-cl(E) ∩ G = Nsgb-cl(E) ∩ (E∪F) = [Nsgb-cl(E)∩E] ∪ [Nsgb-cl(E)∩F] = E ∪ [Nsgb-cl(E)∩F]. Since E, F are disjoint in U and E ⊆ Nsgb-cl(E), then E∩F = ∅ ⇒ [Nsgb-cl(E)∩E] ∩ F = ∅ ⇒ E ∩ [Nsgb-cl(E)∩F] = ∅. Since E ≠ ∅ gives Nsgb-cl(E)∩F = ∅   →   (i). Similarly, E ∩ [Nsgb-cl(F)∩F] = ∅ ⇒ [E ∩ Nsgb-cl(F)] ∩ F = ∅. Since F ≠ ∅ gives E ∩ Nsgb-cl(F) = ∅ →   (ii). From (i) and (ii), E and F are Nsgb-separated in U.

Example 3.14: Suppose one of the sets is Nsgb-open and other is Nsgb-closed then subspace G = E∪F is not Nsgb-separated. From example 3.2, let G = {d, y, r}, E = {d, y}, F = {r} where E is Nsgb-open, F is Nsgb-closed. Then G = E∪F. ⇒ E ∩ Nsgb-cl(F) = {d, y} ∩ {r} = □ and Nsgb-cl(E) ∩ F = U ∩ {r} = {r} ≠ □. ∴ E, F are not Nsgb-separated ⇒ G = E∪F is also not Nsgb-separated. Hence both the sets must be either Nsgb-closed or Nsgb-open.

Theorem 3.15: Let the subsets E and F of (U, τR(S)) are Nsgb-separated iff there exist Nsgb-open sets P and T with E ⊂ P, F ⊂ T and E∩T = □, F∩P = □.

Proof: *Necessary Part:* Let E, F be Nsgb-separated then E∩Nsgb-cl(F) = □; Nsgb-cl(E)∩F = □. Set T = U – Nsgb-cl(E) and P = U – Nsgb-cl(F). Then P, T are Nsgb-open sets of U such that E ⊂ P, F ⊂ T. Hence E∩T = □ and F∩P = □.
Sufficient Part: Let P, T be the Nsgb-open sets of U with E ⊂ P, F ⊂ T and E∩T = □, F∩P = □. Then E ⊂ U – T, F ⊂ U – P, where U – P and U – T are Nsgb-closed. Now Nsgb-cl(E) ⊂ Nsgb-cl(U – T) and since U – T is Nsgb-closed, gives Nsgb-cl(E) ⊂ U – T ⊂ U – F. ⇒ Nsgb-cl(E)∩F ⊂ (U – T)∩F ⊂ (U – F)∩F ⇒ Nsgb-cl(E)∩F ⊂ □ gives Nsgb-cl(E)∩F = □ → (1). Similarly, Nsgb-cl(F) ⊂ U – P ⊂ U – E ⇒ Nsgb-cl(F)∩E ⊂ (U – P)∩E ⊂ (U – E)∩E ⇒ Nsgb-cl(F)∩E ⊂ □ gives Nsgb-cl(F)∩E = □ → (2). From (1) and (2), E and F are Nsgb-separated.

Nsgb-Connectedness

Definition 4.1: A nano topological space (U, τR(S)) is **Nsgb-connected** if U can't be written as a disjoint union of two non-empty Nsgb-open sets. ie)., U has no Nsgb-separation.

Example 4.2: Take U = {d, y, e, r}, U/R = {{d}, {y}, {e}, {r}, S = {y} ⊂ U, then τR(S) = {U, □, {y}}, Nsgb-open = {U, □, {y}, {d, y}, {y, e}, {y, r}, {d, y, e}, {d, y, r}, {y, e, r}}. Here U is Nsgb-connected.

Definition 4.3: A subset E ⊂ U is **Nsgb-connected** iff it can't be written as a disjoint union of two non-empty Nsgb-open sets. Equivalently E has no Nsgb-separation.
In otherwords, a subset of U is Nsgb-connected if it is Nsgb-connected as a subspace. From example 4.2, E = {d, y, e} ⊂ U is Nsgb-connected.

Remarks 4.4:
➢ The empty set (□) is trivially Nsgb-connected.
➢ Each singleton set in the collection of Nsgb-open sets is Nsgb-connected. Since singletons can't be written as the union of two disjoint non-empty Nsgb-separated sets.

Theorem 4.5: Every Nsgb-connected space is nano connected.
Proof: Assume (U, τR(S)) be a Nsgb-connected space. So that U can't be written as a union of two disjoint non-empty Nsgb-open sets. Consider U is not nano connected. Then U can be written as union of two disjoint non-empty nano open sets. ie)., U = E∪F, where E, F are disjoint nano open sets. As each nano open set is Nsgb-open then E, F are disjoint Nsgb-open sets. Gives U = E∪F, where E, F are disjoint non-empty Nsgb-open sets shows U is not Nsgb-connected which contradicts U is Nsgb-connected. Hence U is nano connected.
Conversely, let U = {d, y, e, r}, U/R = {{d, y}, {e, r}}, S = {d, y}, τR(S) = {U, □, {d, y}}. Here U is nano connected. Nsgb-open = {U, □, {d}, {y}, {d, y}, {d, e}, {d, r}, {y, e}, {y, r}, {d, y, e}, {d, y, r}, {d, e, r}, {y, e, r}}. Here U is represent as union of disjoint non-empty Nsgb-open sets. ie)., U = {d, e} ∪ {y, r}. (U, τR(S)) is not Nsgb-connected.

Theorem 4.6: The claims are equivalent
  i)   (U, τR(S)) is Nsgb-connected
 ii) Only U and □ are both Nsgb-open and Nsgb-closed subsets of (U, τR(S)).
Proof: *To prove: (i) ⇒ (ii)* Let (U, τR(S)) be Nsgb-connected. Let a non-empty subset H be both Nsgb-open and Nsgb-closed in U. So that U – H is both Nsgb-closed and Nsgb-open in U ⇒ U = H ∪ (U – H), is a disjoint non-empty union of Nsgb-open sets of U, which contradicts U is Nsgb-connected. Hence H must be either □ or U.

To prove: (ii) ⇒ (i) Assume only U, □ are both Nsgb-open and Nsgb-closed. *To prove: U is Nsgb-connected.* Let U is not Nsgb-connected. Consider U = P∪Q, where P, Q are disjoint non-empty Nsgb-open sets. Here P = U – Q then P is

Nsgb-closed implies P is both Nsgb-open and Nsgb-closed. Then by assumption, P must be either □ or U, which is contradictory. Hence U is Nsgb-connected.

Theorem 4.7: Let (V, τ$_R$(T)) be a subspace of (U, τ$_R$(S)) and let R □ U. Then R is Nsgb-connected in V iff R is Nsgb-connected in U.

Proof: *Necessary Part:* Let R be Nsgb-connected in V. Suppose R is not Nsgb-connected in U. Then R = E∪F. ie)., E and F forms Nsgb-separation of R. So that [E ∩ Nsgb-cl(F)$_U$] ∪ [Nsgb-cl(E)$_U$ ∩ F] = □. Since E, F are also subsets of V, [E∩V ∩ Nsgb-cl(F)$_U$] ∪ [Nsgb-cl(E)$_U$ ∩ F∩V] = □, ⇒ [E ∩ Nsgb-cl(F)$_V$] ∪ [Nsgb-cl(E)$_V$ ∩ F] = □. E, F forms Nsgb-separation of R in V, which contradicts the assumption. Thus R is Nsgb-connected in V.

Sufficient Part: Let R be Nsgb-connected in U. Suppose R is not Nsgb-connected in V. Let E, F forms Nsgb-separation of R. Then [E ∩ Nsgb-cl(F)$_V$] ∪ [F ∩ Nsgb-cl(E)$_V$] = □ can be also written as [E ∩ V∩Nsgb-cl(F)$_U$] ∪ [F ∩ V∩Nsgb-cl(E)$_U$] = □. As E, F are subsets of V, E∩V = E, F∩V = F then [E ∩ Nsgb-cl(F)$_U$] ∪ [F ∩ Nsgb-cl(E)$_U$] = □. Hence E, F forms Nsgb-separation of R in U then R = E∪F shows R is not Nsgb-connected in U which contradicts the assumption. Therefore R is Nsgb-connected in V.

Theorem 4.8: If d: (U, τ$_R$(S)) → (V, τ$_R$(T)) is a onto Nsgb-continuous function. Then V is nano connected if U is Nsgb-connected.

Proof: Let V be not nano connected, then V is a union of two disjoint non-empty nano open sets of (V, τ$_R$(T)). ie)., V = C∪F, where C, F are disjoint nano open sets in V. Given d is onto, Nsgb-continuous. Then d^{-1}(V) = d^{-1}(C∪F) gives U = d^{-1}(C) ∪ d^{-1}(F), where d^{-1}(C), d^{-1}(F) are disjoint Nsgb-open in U that are non-empty. This says U is not Nsgb-connected which contradicts U is Nsgb-connected. Hence V is nano connected.

Theorem 4.9: If d: (U, τ$_R$(S)) → (V, τ$_R$(T)) is a surjective Nsgb-irresolute function. Then V is Nsgb-connected if U is Nsgb-connected.

Proof: Let V be not Nsgb-connected, then V is a union of two disjoint non-empty Nsgb-open sets of (V, τ$_R$(T)). ie)., V = C∪F, where C, F are disjoint Nsgb-open sets in V. Given d is onto and Nsgb-irresolute. Then d^{-1}(V) = d^{-1}(C∪F) gives U = d^{-1}(C) ∪ d^{-1}(F), where d^{-1}(C), d^{-1}(F) are disjoint Nsgb-open in U that are non-empty. This says U is not Nsgb-connected which contradicts U is Nsgb-connected. Thus V is Nsgb-connected.

Theorem 4.10: If the Nsgb-open sets E and F form a Nsgb-separation of U and if W is Nsgb-connected subset of U. Then W lies entirely within either E or F.

Proof: Given E, F forms a Nsgb-separation of U. Then U = E∪F, where E, F are disjoint in U and E∩Nsgb-cl(F) = ∅ = F∩Nsgb-cl(E). Then the sets E∩W and F∩W are disjoint and their union is W. ie)., W = (E∩W) ∪ (F∩W) → (*). If both the sets E∩W and F∩W are non-empty, ie)., E∩W ≠ ∅, F∩W ≠ ∅ then (E∩W) ∩ Nsgb-cl((F∩W) = E ∩W ∩ Nsgb-cl((F) ∩ Nsgb-cl(W) = W ∩ Nsgb-cl(W) ∩ ∅ = ∅. Similarly (F∩W) ∩ Nsgb-cl((E∩W) = F ∩W ∩ Nsgb-cl((E) ∩ Nsgb-cl(W) = W ∩ Nsgb-cl(W) ∩ ∅ = ∅. implies they constitute a Nsgb-separation on W gives W is not Nsgb-connected which is a contradiction. Hence one of them must be empty. ie)., either E∩W = ∅ or F∩W = ∅. Suppose F∩W = ∅, then (*) ⇒ W = (E∩W)∪ ∅ implies W ⊂ E∩W shows W ⊂ E and W ⊂ W. Therefore W lies entirely in E. Suppose E∩W = ∅, then (*) ⇒ W = ∅ ∪ (F∩W) implies W ⊂ F∩W shows W ⊂ F and W ⊂ W. Therefore, W lies entirely in F. Thus W lies entirely either within E or in F.

Theorem 4.11: Let E, F be subsets in (U, τ$_R$(S)). If E is Nsgb-connected subset of U where E ⊂ F ⊂ Nsgb-cl(E), then F is Nsgb-connected.

Proof: Given E is Nsgb-connected and E ⊂ F ⊂ Nsgb-cl(E). *To prove: F is Nsgb-connected.* Suppose F is not Nsgb-connected. Then let P and T form a Nsgb-separation of F, where P, T are disjoint non-empty sets. Implies F = P∪T and Nsgb-cl(P) ∩ T = ∅ and P ∩ Nsgb-cl(T) = ∅ → (*). By theorem 4.10, and since E ⊂ F is Nsgb-connected, E must lie entirely within P or in T. ie)., E ⊂ P or E ⊂ T. Without loss of generality, If E ⊂ P then Nsgb-cl(E) ⊂ Nsgb-cl(P). Then Nsgb-cl(E)∩T ⊂ Nsgb-cl(P)∩T. By (*), Nsgb-cl(E)∩T = ∅. But always ∅ ⊂ Nsgb-cl(E)∩T ⇒ Nsgb-cl(E)∩T = ∅. Since E ≠ ∅ gives T = ∅ which contradicts T is non-empty. Thus F is Nsgb-connected. If E ⊂ T then Nsgb-cl(E) ⊂ Nsgb-cl(T). Then

Nsgb-cl(E)∩P ⊂ Nsgb-cl(T)∩P. By (*), Nsgb-cl(E)∩P ⊂ ∅ but always ∅ ⊂ Nsgb-cl(E)∩P ⇒ Nsgb-cl(E)∩P = ∅. Since E ≠ ∅, P = ∅ which contradicts P is non-empty. Thus F is Nsgb-connected.

Corollary 4.12: Nsgb-closure of a Nsgb-connected set is Nsgb-connected.ie)., If R is Nsgb-connected then Nsgb-cl(R) is Nsgb-connected.
Replace F by Nsgb-cl(E) in above theorem gives Nsgb-cl(E) is Nsgb-connected.

Theorem 4.13: The union of collection of Nsgb-connected subspaces of U that have a point in common (non-empty intersection) is Nsgb-connected.
Proof: Let {A_α} be the collection of Nsgb-connected subspaces of U. Let V = ∪ A_α. *To prove: V is Nsgb-connected.* Let V be not Nsgb-connected. Then V = R∪T, where R, T are non-empty disjoint Nsgb-separated sets of U. Since each A_α is Nsgb-connected and A_α ⊂ R∪T, by theorem 4.10, either A_α ⊂ R or A_α ⊂ T, ∀ α ⇒∪A_α ⊂ R or ∪A_α ⊂ T ⇒ V ⊂ R or V ⊂ T → (1). Let p be a point of ∩A_α. ie)., p ∈ ∩A_α whereas p ∈ A_α for all α so that p ∈ V then by (1), either p ∈ R or p ∈ T. But R and T are disjoint. Therefore p cannot belong to both R and T. Let p ∈ R, p ∉ T. By (1), V ⊄ T. Thus V ⊂ R. ie)., R∪T ⊂ R implies T = ∅ which is a contradiction. Hence V = ∪ A_α is Nsgb-connected having a point in common.

Definition 4.14: Two points e, f of (U, τ_R(S)) are known to be Nsgb-connected iff they are contained in a Nsgb-connected subset of U.

Example 4.15: Let U = {d, y, e, r}, U/R = {{d}, {y}, {e}, {r}, S = {y} ⊆ U, then τ_R(S) = {U, ∅, {y}}, Nsgb-open = {U, ∅, {y}, {d, y}, {y, e}, {y, r}, {d, y, e}, {d, y, r}, {y, e, r}}. Take d, y of U. Here the points d, y is Nsgb-connected. Since d, y ∈ {d, y} which is a Nsgb-connected set where {d, y} can't be represent as a union of two disjoint non-empty Nsgb-open subsets. Similarly, (y, e), (y, r) are Nsgb-connected points of U.

Theorem 4.16: Let each two points in a subset G of U are contained in some Nsgb-connected subset of G. Then G is Nsgb-connected subset of U.
Proof: Suppose G is not Nsgb-connected. Then ∃ non-empty disjoint subsets I and K of U such that I ∩ Nsgb-cl(K) = ∅ and Nsgb-cl(I) ∩ K = ∅ and G = I∪K. Since I, K are non-empty, there exists a point i ∈ I and k ∈ K. By hypothesis, i and k must be contained in some Nsgb-connected subset E of G. ie)., i, k ∈ E ⊂ G (= I∪K). Since E ⊂ I∪K, then E contained in I or in K. By theorem 4.10, it follows that either i, k both in I or i, k both in K. Suppose let i, k ∈ K and since k ∈ K. Then I∩K = k ≠ ∅ is a contradiction to I and K are disjoint. Thus G is Nsgb-connected in U.

Nsgb-Disconnectedness

Definition 4.17: A nano topological space (U, τ_R(S)) [or a subset P of U] is **Nsgb-disconnected** iff it is not Nsgb-connected. ie) if it is the union of non-empty two Nsgb-separated sets. **Nsgb-disconnected** if it has Nsgb-separation. ie)., there exists two non-empty sets such that E ∩ Nsgb-cl(F) = ∅ and Nsgb-cl(E) ∩ F = ∅ with U = E∪F [or P = E∪F].

Theorem 4.18: (U, τ_R(S)) is Nsgb-disconnected iff there exist a proper non-empty subset of U that is both Nsgb-open and Nsgb-closed.
Proof: *Necessary Part:* Let G be a proper non-empty subset of U which is both Nsgb-open and Nsgb-closed. Take H = G^C then H is both non-empty Nsgb-open and Nsgb-closed subset. So that U = G∪H and G∩H = ∅. Also Nsgb-cl(G) = G and Nsgb-cl(H) = H. Now G ∩ Nsgb-cl(H) = G ∩ H = ∅ and Nsgb-cl(G) ∩ H = G ∩ H = ∅. This shows G and H are Nsgb-separated. Thus U is written as union of disjoint non-empty Nsgb-separated sets. Hence U is Nsgb-disconnected.

Sufficient Part: Let U be Nsgb-disconnected. Then ∃ non-empty disjoint subsets F and G of U where F ∩ Nsgb-cl(G) = ∅ and Nsgb-cl(F) ∩ G = ∅ and U = F∪G. WKT: F ⊂ Nsgb-cl(F) and Nsgb-cl(F) ∩ G = ∅ ⇒ F∩G = ∅ then F = G^C. Since G is non-empty, G ∪ G^C = U. It shows G = F^C is a proper subset of U. Since F∪G = U and G ⊂ Nsgb-cl(G) ⇒ F ∪ Nsgb-cl(G)

⊇ U but always F ∪ Nsgb-cl(G) ⊂ U. So that F ∪ Nsgb-cl(G) = U. Also we have F ∩ Nsgb-cl(G) = ∅ ⇒ F = [Nsgb-cl(G)]C. Similarly G = [Nsgb-cl(F)]C. Since Nsgb-cl(F) and Nsgb-cl(G) are Nsgb-closed sets implies F and G are Nsgb-open sets and FC and GC are Nsgb-closed sets. Since F = GC, where GC is Nsgb-closed gives F is Nsgb-closed. Since G = FC, where FC is Nsgb-closed gives G is Nsgb-closed. Therefore F and G are proper non-empty subsets of U that are Nsgb-open as well as Nsgb-closed.

Theorem 4.19: (U, τ_R(S)) is Nsgb-disconnected iff any one of the given claims is true:
i) U represent as the union of non-empty two disjoint Nsgb-open sets
ii) U represent as the union of non-empty two disjoint Nsgb-closed sets
Proof: Let U be Nsgb-disconnected. Then U can be expressed as the union of non-empty two disjoint Nsgb-sets. By theorem 4.18, then ∃ G of U which is a proper non-empty subset that is both Nsgb-open and Nsgb-closed. Then GC is also both Nsgb-open and Nsgb-closed. Also G ∪ GC = U. Hence the set G and GC satisfy both (i) and (ii).
Conversely, let U = G ∪ H and G ∩ H = ∅, whereas G, H are non-empty Nsgb-open sets. It follows that G = HC so that G is Nsgb-closed. Since H is non-empty, G is a proper subset of U. Thus G is proper non-empty subset of U that is both Nsgb-open and Nsgb-closed. By theorem 4.18, U is Nsgb-disconnected. Again let U = I ∪ K and I ∩ K = ∅, where I and K are non-empty Nsgb-closed sets. It follows that I = KC so that I is Nsgb-open. Since K is non-empty, K is a proper subset in U that is also both Nsgb-open and Nsgb-closed. By theorem 4.18, U is Nsgb-disconnected. Thus if any one of the conditions holds then U is Nsgb-disconnected. G ∪ H is known as **Nsgb-disconnection** of U.

Corollary 4.20: A subset K of (U, τ_R(S)) is Nsgb-disconnected iff K is the union of non-empty two disjoint sets both Nsgb-open (or Nsgb-closed) in K.

Theorem 4.21: In (U, τ_R(S)) with atleast two points if the collection of Nsgb-open sets of U is as same as the collection of Nsgb-closed sets of U. Then U is Nsgb-disconnected.

Proof: Assume that Nsgb-O(U, τ_R(S)) = Nsgb-C(U, τ_R(S)). Then there exist some proper non-empty subset of U that is Nsgb-open as well as Nsgb-closed. Then by theorem 4.18, U is Nsgb-disconnected.

Theorem 4.22: (U, τ_R(S)) is Nsgb-disonnected iff U is the union of non-empty two Nsgb-separated sets.

Proof: Let U be Nsgb-disconnected. Then by definition, there exist two non-empty Nsgb-sets G and H in which U = G∪H and Nsgb-cl(G) ∩ H = ∅, G ∩ Nsgb-cl(H) = ∅ shows G, H are Nsgb-separated. Thus U can be represent as a union of non-empty two Nsgb-separated sets.
Conversely, assume U is the union of non-empty two Nsgb-separated sets G and H. Then U = G∪H, G ∩ Nsgb-cl(H) = ∅ and Nsgb-cl(G) ∩ H = ∅. Hence U is Nsgb-disconnected.
The above theorem can be equivalently stated as, U is Nsgb-connected ⇔ The union of non-empty two Nsgb-separated sets not equals U.

CONCLUSION

This paper discussed separatedness, connectedness and disconnectedness of Nsgb-sets in nano topological space. Further this study can be continued to work on compactness, separation axioms based on the Nsgb-set.

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RESEARCH ARTICLE

On Accurate Strong Split Domination in Fuzzy Graphs

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ABSTRACT

This manuscript describes and illustrates the accurate strong split dominating set in fuzzy graphs. In fuzzy graphs, an accurate minimal strong split dominating set and an accurate strong split domination number are defined. For some popular fuzzy graphs, bounds on accurate strong split domination numbers are determined. Strong split domination number relationships with other well-known dominating parameters are discovered. We state and illustrate a few theorems relating to accurate strong split domination numbers.

Keywords: Accurate split dominating set, Accurate split domination number
2020 Mathematics subject classification: 05C72

INTRODUCTION

L.A. Zadeh developed fuzzy set theory in 1965 as a means of describing uncertainty[13]. The notion of domination in fuzzy graphs using effective edges was introduced for the first time by A. Somasundaram in 1998[12].NagoorGani and et al. brought the idea of Domination using strong arcs[10], accurate domination and connected accurate domination in fuzzy graphs[11].Accurate split and non-split dominant sets and their numbers were discussed by A. Mohamed Ismayil and H. Sabitha Begum in fuzzy graphs[9]. Accurate strong split dominating sets and their numbers are described and explored in this study with appropriate examples. Here, $G(\sigma, \mu)$ is a simple connected undirected fuzzy graph.

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PRELIMINARIES

Definition 2.1: A *fuzzy graph*($\mathcal{FG}$), $G = (\sigma, \mu)$is a pair of functions $\sigma: V \rightarrow [0,1]$and $\mu: V \times V \rightarrow [0,1]$such that$\mu(\ell, m) \leq \sigma(\ell) \wedge \sigma(m)$ for every $\ell, m \in V$. A $\mathcal{FG}H = (\kappa, \lambda)$is defined on $G'(V', E')$ is called a *fuzzy subgraph* of $G = (\sigma, \mu)$ if $\kappa(\ell) \leq \sigma(\ell)$ for all $\ell \in V'$and $\lambda(\ell, m) \leq \mu(\ell, m)$ for every $(\ell, m) \in E'$.

Definition 2.2: The underlying crisp graph of $G = (\sigma, \mu)$is labelled by$G^* = (\sigma^*, \mu^*)$, where $\sigma^* = \{\ell \in V: \sigma(\ell) > 0\}$ and $\mu^* = \{(\ell, m) \in VxV: \mu(\ell, m) > 0\}$

Definition 2.3: The *order p* and *size q,* of $\mathcal{FG}$are stated as $p = \sum_{\ell \in V} \sigma(\ell)$and $q = \sum_{(\ell,m) \in E} \mu(\ell, m)$ respectively. If$\mathcal{T} \subseteq V$, then the *fuzzy cardinality* of $\mathcal{T}$ is stated to be $\sum_{\ell \in \mathcal{T}} \sigma(\ell)$ and is labelled by $|\mathcal{T}|$.

Definition 2.4: A subset D of V is stated as a dominating set of $\mathcal{FG}(FD - set)$ if for each $m \in V - D$, there exists $\ell \in D$ such that ℓ *and* $m$are strong neighbors. A $FD - set$ is stated as a *minimal FD − set*if no proper subset of D is a $FD - set$ of $\mathcal{FG}$. The FD number of a $\mathcal{FG}G$ is termed as the least cardinality taken over all $FD - sets$ of a $\mathcal{FG}G$ and is symbolized by $\gamma_f(G)$.

Definition 2.5: Let D acts as a FD-set of V. Then D is stated as an *accurate dominating set* of $\mathcal{FG}(FAD - set)$, if $V - D$ contains no $FD - set$ of equivalent cardinality $|D|$. The FAD number of $\mathcal{FG}G$is defined to be the least cardinality taken over all $FAD - sets$and is denoted by $\gamma_{fa}(G)$.

Definition 2.6: A$FAD - set D \subset V$ is defined as an *accurate split dominating set* of $\mathcal{FG}$ $(FASD - set)$, if $< V - D >$ is disconnected. The $FASD$ number of $\mathcal{FG}G$ is defined as the least cardinality taken over all $FASD - set$and it is denoted by $\gamma_{fas}(G)$.

Definition 2.7: A $FD - set D \subset V$ is defined as a *strong split dominating se*t (FSSD-set) of$\mathcal{FG}$ G, if $< V - D >$ is disconnected. The $FSSD$ number of$G$ is defined as the least cardinality taken over all $FSSD - set$and it is denoted by $\gamma_{fss}(G)$.

ACCURATE STRONG SPLIT DOMINATION USING STRONG ARCS IN FUZZY GRAPH
Definition 3.1: Accurate strong split domination using strong arcs in $\mathcal{FG}$
A $FD - set D \subset V$ in $\mathcal{FG}$is stated to be an accurate strong split dominating set in $\mathcal{FG}(FASSD - set)$, if
(i) D is a $FAD - set$ and
(ii) D is a$FSSD - set$.
A$FASSD$-set is a minimal $FASSD$-set in a $\mathcal{FG}$ if it does not contain any proper$FASSD$subset.A minimum $FASSD$-set is a $FASSD$-set of least size in a given graph. The$FASSD$ number $\gamma_{fass}(G)$ is the least cardinality of a$FASSD - set$.

Example 3.1
Let the $\mathcal{FG}G = (\sigma, \mu)$ where $\sigma = \{u|0.2, v|0.3, w|0.6, \ell|0.4, m|0.7, z|0.9\}$and
$\mu = \{(u, v)|0.1, (v, w)|0.3, (w, \ell)|0.3, (\ell, m)|0.3, (m, z)|0.5, (z, u)|0.2, (u, m)|0.2, (v, \ell)|0.3\}$
Strong arcs are $(v, w), (w, \ell), (\ell, m), (m, z), (z, u), (u, m), (v, \ell)$. Here, some of the minimal dominating sets are $\{u, v\}, \{w, z\}, \{\ell, m\}, \{v, m\}, \{u, \ell\}$.
Clearly, $\gamma_{fa}(G) = 0.5$. FSSD-set is $\{u, v, \ell, m\}$and hence$\gamma_{fss}(G) = 1.6$.$FASSD - set$ is $\{u, v, \ell, m\}$and hence$\gamma_{fass}(G) = 1.6$.

Observations

(i)   Every Complete graph does not contain an $FASSD$-set. Since $< V - D >$ is not a totally disconnected graph.
(ii) $V - D$ has at least two vertices.

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(iii)   Subset of $FASSD$-set need not be a $FASSD$-set.

(iv)   An $FASSD$-set may not be a minimum dominating set.

(v)   Whole set must not a $FASSD$-set.

In this manuscript, only finite simple connected graphs, but except complete graphs are taken into consideration.

Theorem 3.1: For any connected graph G, $\gamma_f(G) \le \gamma_{fs}(G) \le \gamma_{fss}(G) \le \gamma_{fass}(G)$

Proof: Every $FASSD - set$ is a $FSSD - set$ of G,
$$\gamma_{fss}(G) \le \gamma_{fass}(G)$$
Every $FSSD - set$ is a $FSD - set$ of G,
$$\gamma_{fs}(G) \le \gamma_{fss}(G)$$
Since every $FSD - set$ is a $FD - set$ of G,
$$\gamma_f(G) \le \gamma_s(G)$$
Hence $\gamma_f(G) \le \gamma_{fs}(G) \le \gamma_{fss} \le \gamma_{fass}(G)$

Theorem 3.2: For any connected graph G,
$$\gamma_f(G) \le \gamma_{fa}(G) \le \gamma_{fas}(G) \le \gamma_{fass}(G)$$

Proof: Every $FAD - set$ is a $FD - set$ of G,
$$\gamma_f(G) \le \gamma_{fa}(G)$$
Every $FASD - set$ is a $FAD - set$ of G,
$$\gamma_{fa}(G) \le \gamma_{fas}(G)$$
Since every $FASSD - set$ is a $FASD - set$ of G,
$$\gamma_{fas}(G) \le \gamma_{fss}(G)$$

Theorem 3.3: A $FD - set$ of a connected graph G is an $FASSD - set$ iff the following conditions are satisfied:

(i) $V - D$ has atleast two vertices

(ii)   For any two vertices $u, v \in V - D$, every $u - v$ path contains at least one vertex of D.

(iii) $V - D$ has no $FD - set$ of cardinality $|D|$.

Proof Let D be an $FASSD$-set.

(i)   By observation (ii) $V - D$ has at least two vertices.

(ii)   Suppose there exists a path $u - v$ path containing no vertices of D. Then $< V - D >$ is connected. Hence every $u - v$ path contains at least one vertex of D.

(iii)   Suppose $V - D$ has a $FD - set$ of cardinality $|D|$. Then D is not $FAD - set$.

Hence Every $FASSD$-set satisfies the above three conditions.

Conversely, from (iii) D is $FAD - set$ and from (i) and (ii) D is a $FSSD$ −set. Hence D is an $FASSD$-set.

Theorem 3.4: For any Path FG, P_σ where $|\sigma| = p$ and $|\sigma^*| = n$ for $n \ge 3$,
$$\gamma_{fass}(P_p) \le \left\lceil \frac{p}{2} \right\rceil + 1$$

Proof: For finding accurate strong split dominating set D in any path, we have to choose vertices for $V - D$ with maximum membership value and no two of its vertices are adjacent such that $|V - D| \ne |D|$ and each vertex in D is next to some vertex in $V - D$. Then D does not exceed $\left\lceil \frac{p}{2} \right\rceil + 1$. Thus $\gamma_{fass}(P_n) = \left\lceil \frac{p}{2} \right\rceil + 1$

Theorem 3.5: For any cycle $FG C_\sigma$, where $|\sigma| = p$ and $|\sigma^*| = n$ for $n \ge 3$,
$$\gamma_{fass}(C_p) \le \left\lceil \frac{p}{2} \right\rceil + 1$$

Proof: Let us labelling the vertices of a cycle as $v_1, v_2, v_3, \ldots, v_{n-1}, v_n$.

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Case (i): All arcs are strong arcs. We have to choose vertices for $V - D$, with maximum membership value and no two of its vertices are adjacent such that $|V - D| \neq |D|$ and each vertex in D is next to some vertex in $V - D$.This implies$D$ does not exceed $\left\lceil \frac{p}{2} \right\rceil + 1$ vertices

Case (ii):Let (v_1, v_n) be an arc which is not strong. Then by theorem 3.4, D does not exceed $\left\lceil \frac{p}{2} \right\rceil + 1$ vertices

Theorem 3.6: For any star $\mathcal{F}\mathcal{G}K_{\sigma_1,\sigma_2}$, where $|\sigma_1{}^*| = 1, |\sigma_2{}^*| \geq 3, |\sigma| = p$ and $|\sigma^*| = n$, $n \geq 3$,u is the centre node of the fuzzy graph.

$$\gamma_{fass}\left(K_{\sigma_1,\sigma_2}\right) = \begin{cases} \sigma_1(u), & if\ |\sigma_1| \neq |\sigma_2| \\ \sigma_1(u) + \min_{v \in \sigma_2} \sigma_2(v), & if\ |\sigma_1| = |\sigma_2| \end{cases}$$

Proof: Let u be the centre of the star fuzzy graph. Since removing central node leaves the graph totally disconnected, $D = \{u\}$ is the one of the minimal $FSSD - set$ alsominimal $FSD - set$. Therefore, $\gamma_{fass}(S_\sigma) = \gamma_{fas}(S_\sigma)$. By the theorem in [9], $\gamma_{fass}\left(K_{\sigma_1,\sigma_2}\right) = \begin{cases} \sigma_1(u), & if\ |\sigma_1| \neq |\sigma_2| \\ \sigma_1(u) + \min_{v \in \sigma_2} \sigma_2(v), & if\ |\sigma_1| = |\sigma_2| \end{cases}$

Theorem 3.7: Let $G = (\sigma, \mu)$ be acomplete bipartite $\mathcal{F}\mathcal{G}$ with two partitions$|\sigma_1| \leq |\sigma_2|$ of vertices Then
$$\gamma_{fass}(G) = \begin{cases} |\sigma_1|, & if\ |\sigma_1| < |\sigma_2| \\ |\sigma_1| + \min_{v \in \sigma_2} \sigma_2(v), & if\ |\sigma_1| = |\sigma_2| \end{cases}$$

Proof: Since removing one partition of vertices leaves the graph totally disconnected, either one of the partition vertex set is a $FSSD - set$. But it may be a $FASSD - set$ or not a $FASSD - set$ according as $|\sigma_1| < |\sigma_2|$and $|\sigma_1| = |\sigma_2|$

Case (i): If$|\sigma_1| < |\sigma_2|$, then$\gamma_{fass}(G) = |\sigma_1|$.

Case (ii): If $|\sigma_1| = |\sigma_2|$, then for finding D, choose the vertex set either $\sigma_1$or$\sigma_2$which does not contains the vertex having least membership value say $v \in \sigma_2$. Thus$\gamma_{fass}(G) = |\sigma_1| + \min_{v \in \sigma_2} \sigma_2(v)$

Definition: Let P_{σ_1} be a path $\mathcal{F}\mathcal{G}$ with $|\sigma_1{}^*| = n$ vertices. The graph $P_{\sigma_1} \odot K_{\sigma_2}, |\sigma_2{}^*| = 1$ is called a ***comb fuzzy graph***.

Theorem 3.8: Let $T_{C_\sigma} = P_{\sigma_1} \odot K_{\sigma_2}, |\sigma_1{}^*| = n \geq 3, |\sigma_2{}^*| = 1$, be a comb $\mathcal{F}\mathcal{G}$. $\gamma_{fass}\left(T_{C_\sigma}\right) \leq |\sigma_1| + |\sigma_2|$

Proof: Let $U = \{u_1, u_2 \dots u_n\}$ be the vertices(cut vertices in T_{C_σ}) in P_{σ_1} and $Z = \{z_1, z_2, \dots z_n\}$ be the end vertices in T_{C_σ}, where $|V| = |U| + |Z|$. Since each vertex in $U$is adjacent to an end vertex, split dominating set (SD-set) has $U = \{u_1, u_2 \dots u_n\}$ vertices.

Case(i): $SD - set$maybe$FASSD - set$if$|\sigma_1| \neq n|\sigma_2|$. Thus$\gamma_{fass}\left(T_{C_\sigma}\right) \leq |\sigma_1|$.

Case (ii): $SD - set$ may not be $FSSD - set$ if $|\sigma_1| = n|\sigma_2|$. Since all vertices from Z having equal membership value, adding any vertex from the set,$FASSD$-set will be obtained and hence $\gamma_{fass}\left(T_{C_\sigma}\right) \leq |\sigma_1| + |\sigma_2|$

Corollary 3.1: Let T_{C_σ} be a comb graph, where $|\sigma| = p$ and $|\sigma^*| = n \geq 2$

(i) $\gamma_{fs}\left(T_{C_\sigma}\right) < \frac{|\sigma|}{2}$, if D is a FSD-set

(ii) $\gamma_{fas}\left(T_{C_\sigma}\right) < \frac{|\sigma|}{2} + 1$, if D is a $FASD$-set

(iii) $\gamma_{fss}\left(T_{C_\sigma}\right) < \frac{|\sigma|}{2}$, if D is a $FASD$-set

(iv) $\gamma_{fass}\left(T_{C_\sigma}\right) < \frac{|\sigma|}{2} + 1$, if D is a $FASSD$-set

Definition: Let P_{σ_1} be a path $\mathcal{F}\mathcal{G}$ with $|\sigma_1{}^*| = n$ vertices and P_{σ_2} be a path $\mathcal{F}\mathcal{G}$ with $|\sigma_2{}^*| = 2$. The graph $P_{\sigma_1} \times P_{\sigma_2}$ is called a ***Ladder $\mathcal{F}\mathcal{G}$***.

Theorem 3.9: Let $L_\sigma = P_{\sigma_1} \times P_{\sigma_2}$ be a ladder$\mathcal{FG}$, $|\sigma_1{}^*| \geq 3, |\sigma_2{}^*| = 2, |\sigma^*| = 2n$, Let us label the vertices $\{a_1, a_2, a_3, \dots a_n, \mathcal{b}_1, \mathcal{b}_2, \mathcal{b}_3, \dots \mathcal{b}_n\}$ where a_1 is adjacent to $\mathcal{b}_1$, a_2 is adjacent to $\mathcal{b}_2,\dots,a_n$ is adjacent to $\mathcal{b}_n$, $M_{\sigma_3} = \{a_1, \mathcal{b}_2 a_3, \mathcal{b}_4, \dots a_n \text{ or } \mathcal{b}_n\}, N_{\sigma_4} = \{\mathcal{b}_1 a_2, b_3, a_4, \dots a_n \text{ or } a_n\}$. Then

$$\gamma_{fass}(L_\sigma) = \begin{cases} |\sigma_3|, & |\sigma_3| \neq |\sigma_4| \\ |\sigma_3| + \min_{a_2 \in \sigma_4} \sigma_4(a_2), & |\sigma_3| = |\sigma_4| \end{cases}$$

Proof: In cartesian product of two graphs, all arcs are strong arcs[7].Removing either $M = \{a_1, \mathcal{b}_2 a_3, \mathcal{b}_4, \dots a_n \text{ or } \mathcal{b}_n\}$or $N = \{\mathcal{b}_1 a_2, b_3, a_4, \dots a_n \text{ or } a_n\}$leaves the graph totally disconnected.
Case (i): If $|\sigma_3| \neq |\sigma_4|$ and (say $|\sigma_3| < |\sigma_4|$) then M_{σ_3}be a$FASSD$-set.$\gamma_{fass}(L_\sigma) = |\sigma_3|$
Case (ii): If $|\sigma_3| = |\sigma_4|$, then adding a vertex from the set (say N) which has least membership value (say a_2) , we get $FASSD$-set and hence$\gamma_{fass}(L_\sigma) = |\sigma_3| + \min_{a_2 \in \sigma_4} \sigma_4(a_2)$

CONCLSION

In this manuscript, we stated the notions of $FASSD-set$ in fuzzy graphs. We found many bounds on $FASSD-set$ numbers. Exact values for some notable graphs are determined.

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Exploring the Role of Treatment in the Stability Analysis of Lassa Fever using Non-Linear Differential Equations

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ABSTRACT

This study presents a new mathematical model for Lassa fever, a highly lethal disease that spreads through contaminated food, direct contact with infected individuals, and aerosol inhalation. The model, consisting of nonlinear differential equations for both rodent and human populations, focuses on assessing the stability of disease-free conditions and identifying critical model parameters affecting this stability. The primary goal of this research is to explore the impact of treatment on Lassa fever control. These results emphasize that increasing treatment rates among humans can significantly alleviate the burden of Lassa fever, suggesting the potential for disease eradication when the basic reproduction number remains below one. Therefore, advocating for health policies that aim to maintain this threshold is critical for effectively managing and minimizing the occurrence of Lassa fever.

Keywords: Mathematical Model, Stability Analyses, Lassa Fever, Equilibrium Points, Numerical Simulation.

INTRODUCTION

Lassa fever, or hemorrhagic fever, is a severe viral hemorrhagic disease that poses significant public health issues in sub-Saharan Africa [12, 2, 4, 15, 8, 5, 11, 17]. The disease is caused by the Lassa virus (LASV), which belongs to the Arenaviridae family [15, 17]. LASV was first discovered in 1969 in Lassa, Nigeria's Borno State [14, 6]. It primarily spreads to humans through direct contact with rodent excrement or secretions contaminated with the urine or feces of infected rodents [19]. Human-to-human transmission can occur through contact with an infected person's blood,

tissue, secretions, or excretions. Still, casual contact without the exchange of bodily fluids does not transmit the virus [12].In healthcare settings, improper use of personal protective equipment (PPE) can lead to nosocomial infections, and reused medical equipment, such as needles, can also be a transmission source [2]. Researchers have also documented laboratory-acquired infections [2]. The multimammate rat (Mastomys natalensis), a common species in West Africa, is the primary host for the zoonotic transmission of LASV from animals to humans [4, 13]. Ecological factors such as agricultural practices and rainfall can enhance Lassa fever transmission by promoting rodent population growth [12, 2]. Since its identification, LASV has raised significant health concerns in sub-Saharan Africa, especially in West Africa [19]. High-risk regions encompass roughly 80% of Sierra Leone, 50% of Liberia, and 40% of Guinea and Nigeria [7]. The disease is estimated to cause between 100,000 and 300,000 cases annually, with around 5,000 fatalities, reflecting significant levels of both illness and death [12, 13]. Lassa fever outbreaks typically span about seven months, starting in November and reaching their peak within the first three months of the subsequent year. However, reports of occasional cases occur throughout the year [12, 19]. Symptoms of Lassa fever typically emerge 6 to 21 days after exposure. Around 80% of cases begin with mild symptoms, which can be challenging to identify. These mild symptoms include fever, weakness, and general discomfort. Without treatment, the illness can progress to more severe manifestations such as muscle pain, headaches, chest pain, and a sore throat. About 20% of cases develop severe symptoms, including bleeding, facial swelling, lung fluid accumulation, and low blood pressure [14, 19, 13, 1]. Although no vaccines are currently available for Lassa fever, the antiviral medication ribavirin can be effective early in the disease [12, 19, 13, 20, 16]. Researchers have developed several epidemiological models to study the transmission of Lassa fever. For instance, a comprehensive epidemic model in Nigeria investigated the interactions between humans and rodents, incorporating measures such as quarantine, isolation, and hospitalization [12]. This research shed light on the factors driving outbreaks from 2016 to 2019 and identified patterns in transmission dynamics. Onah et al. [13] developed a mathematical model highlighting crucial elements influencing disease spread and applied optimal control theory to reduce transmission cost-effectively. Another model examined how seasonal changes in rodent reproduction affect Lassa fever transmission [6]. A study on quarantine, reinfection, and environmental transmission noted that backward bifurcation complicates control efforts and underscores the need for effective rodent population management. Akhmetzhanov et al. [2] explored the impact of seasonal factors on Lassa fever transmission in Nigeria, revealing that rodent migration patterns significantly influence the risk of infection, particularly in the first nine weeks of the season. Additionally, their model analyzed the relationship between the disease's reproduction number and local rainfall, highlighting substantial spatial variability in outbreaks across different regions of Nigeria and the effect of rainfall on the severity of Lassa fever epidemics [21].

A Novel Model Framework for Lassa fever Transmission

The novel model explores the transmission dynamics of Lassa fever between humans and rodents, uniquely accounting for treated humans and rodents that recover through natural immunity. This inclusion of all potential interactions between the two species distinguishes this model. The total human population at time t is denoted by $\mathbb{N}_h(t)$, comprising susceptible humans $\mathbb{S}_h(t)$, infected humans $\mathbb{I}_h(t)$, treated humans $\mathbb{T}_h(t)$, and recovered humans $\mathbb{R}_h(t)$, such that $\mathbb{N}_h(t) = \mathbb{S}_h(t) + \mathbb{I}_h(t) + \mathbb{T}_h(t) + \mathbb{R}_h(t)$. The rodent population at time t is $\mathbb{N}_a(t)$, which includes susceptible rodents $\mathbb{S}_a(t)$, infected rodents $\mathbb{I}_a(t)$, and recovered rodents $\mathbb{R}_a(t)$, resulting in $\mathbb{N}_a(t) = \mathbb{S}_a(t) + \mathbb{I}_a(t) + \mathbb{R}_a(t)$.

$$\frac{d\mathbb{S}_h(t)}{dt} = \Psi_h - (\varpi_1 \mathbb{I}_a(t) + \varpi_2 \mathbb{I}_h(t))\mathbb{S}_h(t) - \mu_h \mathbb{S}_h(t),$$

$$\frac{d\mathbb{I}_h(t)}{dt} = (\varpi_1 \mathbb{I}_a(t) + \varpi_2 \mathbb{I}_h(t))\mathbb{S}_h(t) - (\eta_h + \varphi_h + \mu_h + \delta_1)\mathbb{I}_h(t),$$

$$\frac{d\mathbb{T}_h(t)}{dt} = \varphi_h \mathbb{I}_h(t) - (\kappa_h + \mu_h + \delta_2)\mathbb{T}_h(t),$$

$$\frac{d\mathbb{R}_h(t)}{dt} = \kappa_h \mathbb{T}_h(t) + \eta_h \mathbb{I}_h(t) - \mu_h \mathbb{R}_h(t), \qquad (1)$$

$$\frac{d\mathbb{S}_a(t)}{dt} = \Psi_a - \varpi_3 \mathbb{I}_a(t)\mathbb{S}_a(t) - \mu_a \mathbb{S}_a(t),$$

$$\frac{d\mathbb{I}_a(t)}{dt} = \varpi_3 \mathbb{I}_a(t)\mathbb{S}_a(t) - (\eta_a + \mu_a)\mathbb{I}_a(t),$$

$$\frac{d\mathbb{R}_a(t)}{dt} = \eta_a \mathbb{I}_a(t) - \mu_a \mathbb{R}_a(t)$$

where the initial conditions are
$\mathbb{S}_h(0) = \mathbb{S}_{h_0} \geq 0, \mathbb{I}_h(0) = \mathbb{I}_{h_0} \geq 0, \mathbb{T}_h(0) = \mathbb{T}_{h_0} \geq 0, \mathbb{R}_h(0) = \mathbb{R}_{h_0} \geq 0, \mathbb{S}_a(0) = \mathbb{S}_{a_0} \geq 0, \mathbb{I}_a(0) = \mathbb{I}_{a_0} \geq 0, \mathbb{R}_a(0) = \mathbb{R}_{a_0} \geq 0$, and the parameters in the model are defined accordingly. The transitions between the compartments of the model are illustrated.

Analysis Model

Lemma 1 *The solutions* $\mathbb{S}_h(t), \mathbb{I}_h(t), \mathbb{T}_h(t), \mathbb{R}_h(t), \mathbb{S}_a(t), \mathbb{I}_a(t), \mathbb{R}_a(t)$ *In system (2.1), all quantities remain non-negative, given that the initial conditions specified in (3.2) are also non-negative.*

Proof. [3] System (2.1) has

$$\frac{d\mathbb{S}_h(t)}{dt}\Big|_{\mathbb{S}_h=0} = \Psi_h > 0,$$

$$\frac{d\mathbb{I}_h(t)}{dt}\Big|_{\mathbb{I}_h=0} = \varpi_1 I_a(t)\mathbb{S}_h(t) > 0,$$

$$\frac{d\mathbb{T}_h(t)}{dt}\Big|_{\mathbb{T}_h=0} = \varphi_h \mathbb{I}_h(t) > 0,$$

$$\frac{d\mathbb{R}_h(t)}{dt}\Big|_{\mathbb{R}_h=0} = \kappa_h \mathbb{T}_h(t) + \eta_h \mathbb{I}_h(t) > 0,$$

$$\frac{d\mathbb{S}_a(t)}{dt}\Big|_{\mathbb{S}_a=0} = \Psi_a > 0,$$

$$\frac{d\mathbb{I}_a(t)}{dt}\Big|_{\mathbb{I}_a=0} = 0,$$

$$\frac{d\mathbb{R}_a(t)}{dt}\Big|_{\mathbb{R}_a=0} = \eta_a \mathbb{I}_a(t) > 0.$$

As a result, $(\mathbb{S}_h, \mathbb{I}_h, \mathbb{T}_h, \mathbb{R}_h, \mathbb{S}_a, \mathbb{I}_a, \mathbb{R}_a) \in \mathbb{R}_+^7$ Lemma ensures the non-negativity of all quantities (3.1). The following lemma demonstrates the boundedness of the system solution (2.1) within its feasible region.

Lemma 2

$$\Omega_h = \left\{ (\mathbb{S}_h, \mathbb{I}_h, \mathbb{T}_h, \mathbb{R}_h) \in \mathbb{R}_+^4 \Big| 0 \leq \mathbb{S}_h(t) + \mathbb{I}_h(t) + \mathbb{T}_h(t) + \mathbb{R}_h(t) \leq \frac{\Psi_h}{\mu_h} \right\}$$

and

$$\Omega_a = \left\{ (\mathbb{S}_a, \mathbb{I}_a, \mathbb{R}_a) \in \mathbb{R}_+^3 \Big| 0 \leq \mathbb{S}_a(t) + \mathbb{I}_a(t) + \mathbb{R}_a(t) \leq \frac{\Psi_a}{\mu_a} \right\}.$$

The biologically feasible region is defined by: $\Omega = \Omega_h \times \Omega_a.$

If $\mathbb{N}_h(0) \leq \frac{\Psi_h}{\mu_h}$ and $\mathbb{N}_a(0) \leq \frac{\Psi_a}{\mu_a}$, the region is positively invariant for system (2.1) when starting with non-negative initial conditions. $\mathbb{R}_+^7$.

Proof

Consider the total population split into two groups: the human population, which includes $\mathbb{S}_h(t)$, $\mathbb{I}_h(t)$, $\mathbb{T}_h(t)$, and $\mathbb{R}_h(t)$, and the rodent population, which consists of $\mathbb{S}_a(t)$, $\mathbb{I}_a(t)$, and $\mathbb{R}_a(t)$. By adding together the first four equations of system (2.1), we derive:

$$\frac{d\mathbb{N}_h(t)}{dt} = \frac{d\mathbb{S}_h(t)}{dt} + \frac{d\mathbb{I}_h(t)}{dt} + \frac{d\mathbb{T}_h(t)}{dt} + \frac{d\mathbb{R}_h(t)}{dt} = \Psi_h - \mu_h \mathbb{N}_h(t) - \delta_1 \mathbb{I}_h(t) - \delta_2 \mathbb{T}_h(t) \leq \Psi_h - \mu_h \mathbb{N}_h(t).$$

If we suppose that $\mathbb{N}_h(0) \leq \frac{\Psi_h}{\mu_h}$, we deduce that $\mathbb{N}_h(t) \leq \frac{\Psi_h}{\mu_h}$. Thus, Ω_h represents the biologically viable region for the human population. Next, we will demonstrate the same for the rodent population:

$$\frac{d\mathbb{N}_a(t)}{dt} = \frac{d\mathbb{S}_a(t)}{dt} + \frac{dI_a(t)}{dt} + \frac{d\mathbb{R}_a(t)}{dt} \leq \Psi_a - \mu_a \mathbb{N}_a(t).$$

If $\mathbb{N}_a(0) \leq \frac{\Psi_a}{\mu_a}$, then $\mathbb{N}_a(t) \leq \frac{\Psi_a}{\mu_a}$. Similarly, Ω_a it defines the biologically viable region for the rodent population. ensuring that $\mathbb{N}_h(t)$ and $\mathbb{N}_a(t)$ it remains bounded for all $t \geq 0$. Therefore, any system (2.1) solution with an initial condition within Ω stays within ⌐⌐. As a result, within the feasible region ⌐⌐, our system is both epidemiologically sound and mathematically well-defined.

Equilibrium Points

Next, we will identify the equilibrium points to assess the system's stability. The Lassa-free equilibrium, for example, represents a scenario where the disease is absent in both humans and rodents, meaning that the infected human populations are zero. Therefore, the Lassa fever-free equilibrium (LFE) of System (2.1) is defined by:

$$E^0 = \left(\mathbb{S}_h^0, I_h^0, \mathbb{T}_h^0, \mathbb{R}_h^0, \mathbb{S}_a^0, \mathbb{I}_a^0, \mathbb{R}_a^0\right) = \left(\frac{\Psi_h}{\mu_h}, 0, 0, 0, \frac{\Psi_a}{\mu_a}, 0, 0\right) \qquad (2)$$

The endemic equilibrium point of our model (2.1), represented by E^*, is found by setting $\chi_i(t) = 0$ for each state variable χ_i, $i = 1, 2, \ldots, 7$ and then solving the resulting equations. This yields the following results (see [10]):

$$E^* = \left(\mathbb{S}_h^*, \mathbb{I}_h^*, \mathbb{T}_h^*, \mathbb{R}_h^*, \mathbb{S}_a^*, \mathbb{I}_a^*, \mathbb{R}_a^*\right)$$

where

$$\mathbb{S}_h^* = \frac{\Psi_h}{\varpi_1 \mathbb{I}_a^* + \varpi_2 \mathbb{I}_h^* + \mu_h},$$

$$\mathbb{I}_h^* = \frac{(\varpi_1 \mathbb{I}_a^* + \varpi_2 \mathbb{I}_h^*)\mathbb{S}_h}{\mu_h + \varphi_h + \eta_h + \delta_1},$$

$$\mathbb{T}_h^* = \frac{\varphi_h \mathbb{I}_h^*}{\mu_h + \kappa_h + \delta_2},$$

$$\mathbb{R}_h^* = \frac{\kappa_h \mathbb{T}_h^* + \eta_h \mathbb{I}_h^*}{\mu_h},$$

$$\mathbb{S}_a^* = \frac{\Psi_a}{\varpi_3 \mathbb{I}_a^* + \mu_a},$$

$$\mathbb{I}_a^* = \frac{\varpi_3 \mathbb{I}_a^*}{\eta_a + \mu_a},$$

$$\mathbb{R}_a^* = \frac{\eta_a \mathbb{I}_a^*}{\mu_a}.$$

The endemic equilibrium point is given by using the next-generation matrix, the basic reproduction number (R_0):

$$R_0 = \frac{\varpi_2 \Psi_h}{\mu_h(\eta_h + \varphi_h + \mu_h + \delta_1)} \qquad (3)$$

If $R_0 < 1$, Lassa fever has lost its effect in the population, and the virus is eradicated from the population. If $R_0 > 1$, the number of infected individuals continues to rise as the infection remains active, and the disruptive effects of Lassa fever on the population endure.

Sensitivity Analysis

In epidemiological models, errors can occur during data collection or parameter estimation. To predict a pandemic accurately, it is crucial to estimate sensitive parameters with minimal error, as even minor deviations in these parameters can significantly alter the pandemic's trajectory. These models commonly employ sensitivity analysis to address the potential impact of minor inaccuracies in the estimated parameter values. We conduct sensitivity analysis by calculating the partial derivative of the fundamental threshold value, such as the R_0 number, for the parameters it relies on. In this study, the birth and death rates, such as Ψ_h, μ_h, and δ_1 are considered constant and therefore are not included in the analysis for the Lassa fever model. Instead, the sensitivity analysis focuses on the remaining parameters ϖ_2, η_h, and φ_h is conducted as follows:

$$\frac{\partial R_0}{\partial \varpi_2} = \frac{\Psi_h}{\mu_h(\eta_h + \varphi_h + \mu_h + \delta_1)} > 0,$$

$$\frac{\partial R_0}{\partial \eta_h} = -\frac{\varpi_2 \Psi_h}{\mu_h(\eta_h + \varphi_h + \mu_h + \delta_1)^2} < 0,$$

$$\frac{\partial R_0}{\partial \varphi_h} = -\frac{\varpi_2 \Psi_h}{\mu_h(\eta_h + \varphi_h + \mu_h + \delta_1)^2} < 0.$$

It is evident that the R_0 number is sensitive to the parameters ϖ_2, η_h, and φ_h. Specifically, an increase in the parameter leads to a more rapid escalation of the pandemic ϖ_2. To mitigate this, it is crucial to manage human-to-human transmission by wearing masks, practicing social distancing, and maintaining good hygiene. Conversely, as the parameters η_h and φ_h rise, the number decreases, indicating that higher treatment rates significantly slow the disease's spread.

R_0 . That is, if the rate of treatment of the disease increases, the spread of the disease is greatly slowed down. The results suggest that preventing transmission and enhancing treatment are more effective disease control strategies.

Stability Analysis

This section examines the stability of equilibrium points by analyzing system (2.1) with the Jacobian matrix.

Theorem 3.1 *The Lassa-free equilibrium point E^0 is locally asymptotically stable if the condition is satisfied.*

$$R_0 \leq 1 \text{and} \varpi_3 \frac{\Psi_a}{\mu_a} \leq \eta_a + \mu_a$$

is comfortable, in unsafe otherwise.

Proof: The Jacobian matrix of system (2.1) at E^0 is (see [9, 18])

$$J(E^0) = \begin{bmatrix} -\mu_h & -\varpi_2\frac{\Psi_h}{\mu_h} & 0 & 0 & 0 & -\varpi_1\frac{\Psi_h}{\mu_h} & 0 \\ 0 & M_1 & 0 & 0 & 0 & \varpi_1\frac{\Psi_h}{\mu_h} & 0 \\ 0 & \varphi_h & M_2 & 0 & 0 & 0 & 0 \\ 0 & \eta_h & \kappa_h & -\mu_h & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\mu_h & -\varpi_3\frac{\Psi_a}{\mu_a} & 0 \\ 0 & -\varpi_1\frac{\Psi_h}{\mu_h} & 0 & 0 & 0 & M_3 & 0 \\ 0 & \varpi_1\frac{\Psi_h}{\mu_h} & 0 & 0 & 0 & \eta_a & -\mu_a \end{bmatrix}$$

(4)

where

$$M_1 \quad = \varpi_2 \frac{\Psi_h}{\mu_h} - (\eta_h + \varphi_h + \mu_h + \delta_1),$$
$$M_2 \quad = -(\kappa_h + \mu_h + \delta_2),$$
$$M_3 \quad = \varpi_3 \frac{\Psi_a}{\mu_a} - (\eta_a + \mu_a).$$

The matrix includes the ensuing unfavorable eigenvalues:

$$\lambda_{1,2} \quad = -\mu_h,$$
$$\lambda_3 \quad = -(\kappa_h + \mu_h + \delta_2),$$
$$\lambda_{4,5} \quad = -\mu_a.$$

Further eigenvalues

$$\lambda_6 \quad = \varpi_2 \frac{\Psi_h}{\mu_h} - (\eta_h + \varphi_h + \mu_h + \delta_1) = (\eta_h + \varphi_h + \mu_h + \delta_1)(R_0 - 1),$$
$$\lambda_7 \quad = \varpi_3 \frac{\Psi_a}{\mu_a} - (\eta_a + \mu_a).$$

If $R_0 \leq 1$ and $\varpi_3 \frac{\Psi_a}{\mu_a} \leq \eta_a + \mu_a$, the system (2.1) is locally asymptotically stable at point E^0. However, if $R_0 > 1$ and $\varpi_3 \frac{\Psi_a}{\mu_a} > (\eta_a + \mu_a)$, the system (2.1) is unstable at point E^0, and there is a point E^* where the system is stable.

Theorem 3.2 *If $R_0 > 1$, If the system (2.1) reaches its endemic equilibrium point, it is considered to be locally asymptotically stable E^*.*

Jacobian matrix of system (2.1) at E^*

$$J(E^*) = \begin{bmatrix} -a_1 - \mu_h & -\varpi_2 \mathbb{S}_h^* & 0 & 0 & 0 & -\varpi_1 \mathbb{S}_h^* & 0 \\ a_1 & a_2 & 0 & 0 & 0 & \varpi_1 \mathbb{S}_h^* & 0 \\ 0 & \varphi_h & a_3 & 0 & 0 & 0 & 0 \\ 0 & \eta_h & \kappa_h & -\mu_h & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -\varpi_3 \mathbb{I}_a^* - \mu_a & -\varpi_3 \mathbb{S}_a^* & 0 \\ 0 & -\varpi_1 \mathbb{S}_h^* & 0 & 0 & \varpi_3 \mathbb{I}_a^* & a_4 & 0 \\ 0 & \varpi_1 \mathbb{S}_h^* & 0 & 0 & 0 & \eta_a & -\mu_a \end{bmatrix} \tag{5}$$

where

$$a_1 = \quad \varpi_1 \mathbb{I}_a^* + \varpi_2 \mathbb{I}_h^*,$$
$$a_2 = \quad \varpi_2 \mathbb{S}_h^{\cdot} - (\eta_h + \varphi_h + \mu_h + \delta_1),$$
$$a_3 = \quad -(\kappa_h + \mu_h + \delta_2),$$
$$a_4 = \quad \varpi_3 \mathbb{S}_a^{\cdot} - (\eta_a + \mu_a).$$

The negative eigenvalues are:

$$\chi_1 = \quad -\mu_h,$$
$$\chi_2 = \quad -(\kappa_h + \mu_h + \delta_2),$$
$$\chi_3 = \quad -\mu_a,$$
$$\chi_4 = \quad -(\varpi_1 \mathbb{I}_a^{\cdot} + \varpi_2 \mathbb{I}_h^{\cdot}) - \mu_h,$$
$$\chi_5 = \quad -\varpi_3 \mathbb{I}_a^* - \mu_a.$$

The following characteristic equation determines the remaining eigenvalues:

$$\chi^2 + q_1 \chi + q_2 = 0 \tag{6}$$

in which the coefficients are:

$$q_1 = \quad \delta_1 + \eta_a + \eta_h + \mu_a + \mu_h - \varpi_3 \mathbb{S}_a^* - \varpi_2 \mathbb{S}_h^* + \varphi_h,$$
$$q_2 = \quad \varpi_1 \mathbb{S}_h^{\cdot}(\varpi_1 \mathbb{S}_h^{\cdot} + \varpi_2 \mathbb{I}_a^{\cdot}) + \varpi_2 \mathbb{S}_h^{\cdot}(-\eta_a + \varpi_2 \mathbb{I}_h^{\cdot} - \mu_a + \varpi_3 \mathbb{S}_a^{\cdot}) - \mathbb{S}_a^{\cdot}(\delta_1 + \eta_h - \varpi_3 \mathbb{I}_a^{\cdot} - \mu_h)$$
$$+ \eta_a(\delta_1 + \eta_h + \mu_a + \mu_h) + \mu_a(\delta_1 + \mu_h) + \varphi_h(\eta_a + \mu_a - \mathbb{S}_a^{\cdot}).$$

If the coefficients q_1 and q_2 of the characteristic Equation (6) satisfy the conditions $q_1, q_2 > 0$, or $q_1 < 0, 4q_2 > (q_1)^2$, According to the Routh-Hurwitz criterion, the system is considered locally asymptotically stable when there are two negative eigenvalues. E^*.

Graphical Representations

Understanding disease spread and the impact of control measures is crucial in epidemiology. Epidemiological models divide populations into compartments representing different stages of infection and recovery for humans and animals. This allows for a thorough examination of disease dynamics and management strategies. Understanding disease spread and the impact of control measures is crucial in epidemiology. Epidemiological models divide populations into compartments representing different stages of infection and recovery for humans and animals. This allows for a thorough examination of disease dynamics and management strategies. One useful tool is the stacked area plot, which displays the cumulative sizes of various population groups (such as susceptible, infected, treated, and recovered) over time. This type of graph helps visualize the overall progression of an epidemic and the relative sizes of different disease states at any given point. By analyzing these trends, researchers can assess the effectiveness of public health measures such as vaccination and treatment strategies. Another important tool is the comparative analysis plot, which provides a detailed comparison between human and animal populations affected by the same disease. This plot typically shows separate lines or areas for each population, highlighting differences in infection rates, treatment outcomes, and recovery trends. Such comparisons are essential for understanding zoonotic diseases, where pathogens can transfer between animals and humans. The scatter plot offers a detailed view of individual trajectories within each disease compartment. Each point represents data from a specific simulation or observation, illustrating how individuals transition between different states over time. This level of detail helps researchers explore variations in infection dynamics, treatment responses, and recovery rates among individuals. These graphical tools not only aid in understanding fundamental epidemiological metrics like the reproduction number (R0) but also facilitate the exploration of more complex scenarios. They help analyze how changes in vaccination rates, treatment methods, or contact patterns affect disease transmission. In conclusion, graphical representations of epidemiological models are invaluable for researchers, public health officials, and policymakers. They provide clear insights into disease dynamics, support evidence-based decision-making, and help reduce the impact of infectious diseases on both human and animal populations. By presenting complex data in an accessible format, these graphs enhance our understanding of epidemic processes and contribute to improved global health outcomes.

CONCLUSION

This study presents a new mathematical model for Lassa fever, which looks at the interactions between rodent and human populations. It examines how the disease can be controlled and emphasizes the important role of treatment in reducing its impact. The findings suggest that effective treatment could significantly reduce the disease burden and possibly lead to its eradication, especially if the primary reproduction number remains below one. It highlights the need for health policies that focus on increasing treatment rates among humans to manage and ultimately decrease Lassa fever outbreaks.

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Table 1: Descriptions of the model parameters' values.

Parameter	Description
Ψ_h	Rate at which new humans are born into the population
ϖ_1	Rate at which the virus is transmitted from rodents to humans
ϖ_2	Rate at which the virus spreads from person to person
μ_h	Natural death rate of humans
η_h	Natural recovery rate for humans infected with the virus
φ_h	Treatment rate for human infections
κ_h	Recovery rate for treated humans
δ_1	Death rate of humans infected with the disease
δ_2	Death rate of treated humans infected with the disease
Ψ_a	Rodent birth rate in the overall rodent population
ϖ_3	Virus transmission rate to rodents from infected rodents
η_a	Rate at which infected rodents recover naturally
μ_a	Natural death rate of rodents
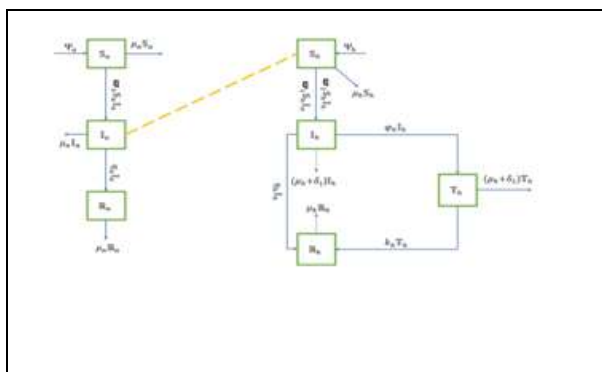
Figure 1: Model for Lassa Fevere model is constructed as follows:	**Figure 2: Graph of Human Population**
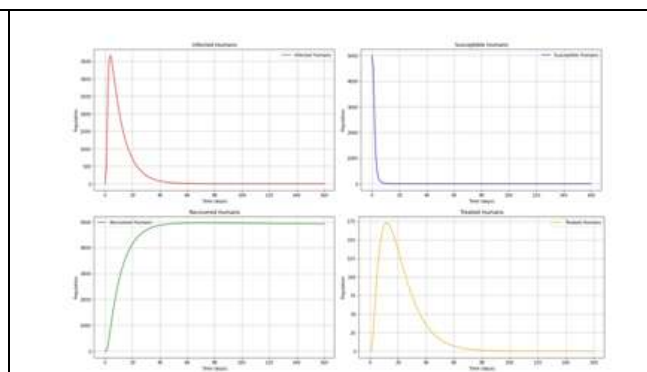
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Figure 3: Graph of Animal Population

Figure 4: Epidemiological Model: Stacked Area Plot

Figure 5: Phase Portrait

RESEARCH ARTICLE

Various Degrees of Vertices in Fuzzy Semigraphs and Some Relations among them

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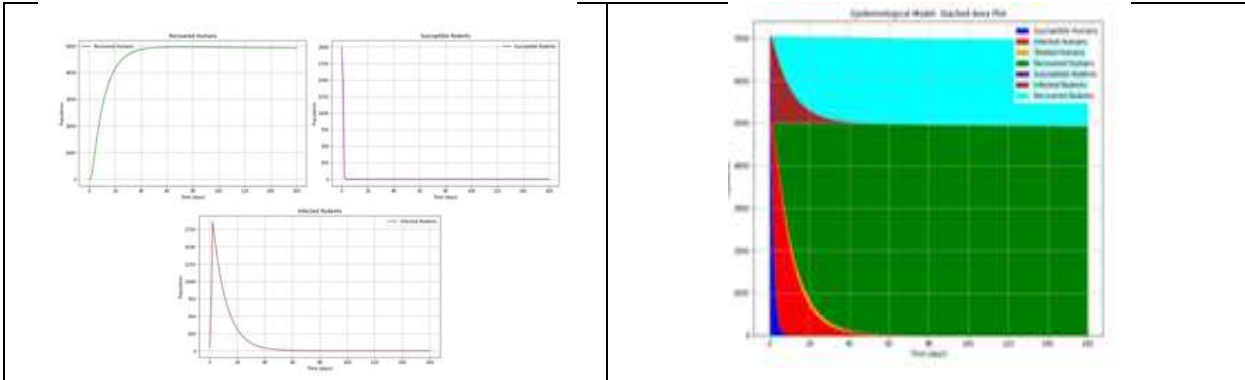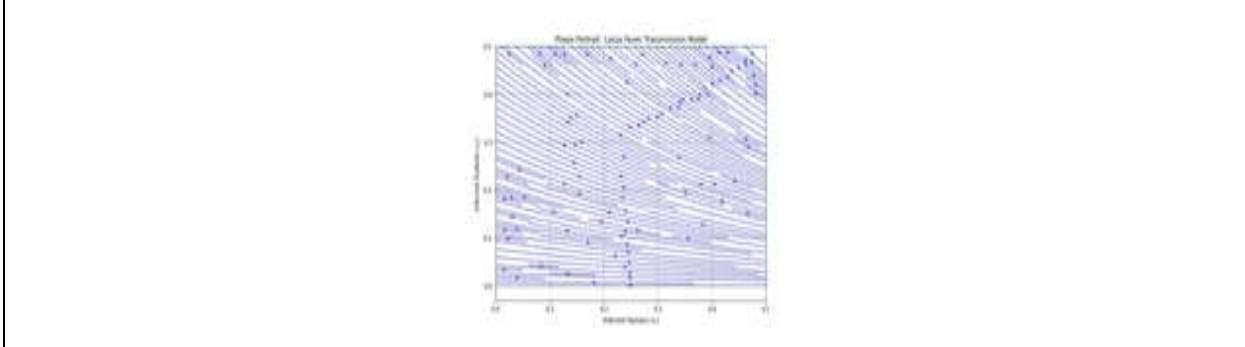[2]Department of Mathematics, Dr. Kalaignar Government Arts College, Kulithalai, (Affiliated to Bharathidasan University), Tiruchirappalli, Tamil Nadu, India.

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ABSTRACT

In this paper, various degrees of a vertex or a point in a fuzzy semigraph are defined. Degree, edge degree or line degree, adjacent degree and consecutive adjacent degree of a vertex in a fuzzy semigraph are introduced. Their properties under various isomorphisms are discussed.

Keywords: Degree, edge degree, adjacent degree and consecutive adjacent degree, isomorphism, semi edge, co-weak isomorphism, weak isomorphism, end vertex isomorphism, edge isomorphism.
AMS Mathematics Subject Classification: 05C72

INTRODUCTION

Fuzzy sets and Fuzzy relations gave birth to fuzzy graphs [11]. Fuzzy relations play a crucial role in the areas of clustering analysis, neural networks, computer networks, pattern recognition, etc… In each of the above areas the basic mathematical structure is that of fuzzy graphs.The notion of fuzzy graphs was introduced by Rosenfeld [11] in the year 1975. In recent years, fuzzy graph theory has emerged as one of the vast areas of research. Applications of fuzzy graphs include data mining, image segmentation, clustering, image capturing, networking, communication, planning, scheduling, etc.., Bhattacharya [2] contributed some useful remarks on Fuzzy graphs. Some Operations on Fuzzy graphs were characterized by Modeson J.N. and Peng. C.S [4].The concept of semigraph was introduced by E Sampath Kumar [12]. NagoorGani A. and Radha K [5] studied the degree of a vertex in some fuzzy graphs. Radha K [7] introduced the concept of fuzzy semigraphs. Radha K and P Renganathan [6] studied the effectiveness properties of fuzzy semigraphs..Radha.K and Kumaravel. N [9] introduced the concept of edge regular fuzzy graphs. They also

studied the degree of an edge in union and join of two fuzzy graphs. Radha K and Rosemine A [8] introduced the concept of degree sequence of a fuzzy graph. Radha K and Renganathan P [10] introduced the concept of various isomorphisms in fuzzy semigraphs and studied some of their properties.

Definition 1.1[12]:A semigraph is a pair: (V, X), where V is a non-empty set of elements called vertices or points and X is a set of n-tuples called edges or lines of distinct points for various n≥ 2 satisfying the conditions.1. Any two edges have at most one point in common 2.Two edges or lines $E_1 = (u_1, u_2, …, u_n), E_2 = (v_1, v_2, …, v_m)$ *are* considered to be equal if and only if (a) m=n (b) either $u_i=v_i$ for i = 1 to n or $u_i=v_{n-i+1}$ for i= 1to n. In the edge $E = (u_1, u_2, …, u_n)$, u_1 and u_n are called the end points and all the points in between them are called middle points.(m- points). If a middle point is an end point of some other line, then it is called a middle end point.

Definition1.2[7]: Consider a semigraph $G^*: (V, £, X)$.A fuzzy semigraph(fsg) $G: (\sigma, \mu, \eta)$ onG^*:(V, £, X)is characterized as $G: (\sigma, \mu, \eta)$ where $\sigma: V \to [0,1]$ μ:V×V→ [0,1],η:X→ [0,1]are such that (i) $\mu(uv)) \le \sigma(u) \wedge \sigma(v)$ $\forall (uv) \in V \times V$(ii) η (e) =μ(u₁u₂)∧μ(u₂u₃)∧…∧ μ(uₙ₋₁uₙ)≤ $\sigma(u_1) \wedge \sigma(u_n), \forall$ e ∈ X, if e=$(u_1, u_2, …, u_n)$,n ≥ 2 is an edge in G.Here (σ, μ) is a fuzzy graph.

Definition 1.3[6]:A line "e" of a fsgis called an effective line, if $\eta(e) = \eta(u_1, u_2, …, u_n) = \sigma(u_1) \wedge \sigma(u_n)$ $\forall e \in X$ and $\mu(uv)) = \sigma(u) \wedge \sigma(v)$ $\forall uv \in £$. Aline "e" of a fsg is called an e-effective line if$\eta(e) = \eta(u_1, u_2, …, u_n) = \sigma(u_1) \wedge \sigma(u_n)$ for n> 2

Definition 1.4[6]: Afsg$G: (\sigma, \mu, \eta)$is said to be an effective fsg if all the lines are effective lines. In other words $\eta(e) = \eta(u_1, u_2, …, u_n) = \sigma(u_1) \wedge \sigma(u_n), \forall e \in X$ and $\mu(uv) = \sigma(u) \wedge \sigma(v), \forall uv \in £$

Definition 1.5 [10]:Let $G: (\sigma, \mu, \eta)$ and $G': (\sigma', \mu', \eta')$ be two fsgs with underlying semigraphs G*and G'*. By **an isomorphism or a bijective similarity mapping of fsgs** f: G→ G'we mean a bijective map expressed by f : V→V' which satisfies 1. *If* E= (v₁,v₂,…, vₙ) is aline in G then (f(v₁), f(v₂),…, f(vₙ)) is aline in G' 2.$\sigma(u) = \sigma'(f(u))$ for all u∈V3. μ(uv)= μ'(f(u)f(v)) for all u$v \in £$ and 4.$\eta(e) = \eta'(f(e))$, for all e∈ X.

Definition 1.6 [10] : A **weak bijective similarity mapping of fsgs**f :G→ G'is a bijective map$f$:V→V'which satisfies 1. *if* E= (v₁,v₂,…, vₙ)is aline in G, then $\{f(v1), f(v2), …, f(vn)\}$forms aline in G'2.$\sigma(u) = \sigma'$(f(u)) for all u∈V 3. μ(uv) $\le \mu'$(f(u)f(v)) for all u, $v \in$V.

Definition 1.7 [10]: A **co-weak bijective similarity mapping of fsgs**f : G→ G',is a bijective map f : V→V' which satisfies 1.*if* E= (v₁v₂,…, vₙ) be aline in Gthen (f(v₁), f(v₂),…, f(vₙ)) is a line in G' 2.$\sigma(u) \le \sigma'(f(u))$ *for all* $u \in V$ 3.μ(uv)= μ'(f(u)f(v)) for all uv∈ £ and $\eta(e) = \eta'(f(e))$, for all e ∈ X.

Definition 1.8 [10] :An **end point bijective similarity mapping(ev-bijective similarity mapping)** of fsgs$f$: G→G' is a bijective map f :V→V'which satisfies1. If E= (v₁,v₂,…, vₙ) is alinein Gthen $\{f(v1), f(v2), …, f(vn)\}$forms aline in G' with end points f(v₁) and f(vₙ).2.$\sigma(u) = \sigma'$(f(u)) for all u∈V 3. μ(uv)= μ'(f(u)f(v)) for all uv ∈E and 4.$\eta(e) = \eta'(f(e))$, for all e∈ X.

Definition 1.9 [10] A linebijective similarity mapping (e-bijective similarity mapping) of fsgs$f$:G→ G'is a bijective map f:V→V'whichsatisfies1.ifE=(v₁,v₂,…,vₙ)is a line in Gthen $\{f(v1), f(v2), …, f(vn)\}$forms aline in G'2.$\sigma(u) = \sigma'$(f(u)) for all u∈V 3. μ(uv)= μ'(f(u)f(v)) for all u$v \in £$ and 4.$\eta(e) = \eta'(f(e))$, for all e ∈ X.

Definition 1.10 [10] :An **adjacency bijective similarity mapping (a-bijective similarity mapping)** of fsgs$f$: G→ G'is a bijective map f : V→V' which satisfies1. If the adjacent points in Gare mapped onto adjacent points in G',2.$\sigma(u) = \sigma'$(f(u)) for all u∈V,3. μ(uv)= μ'(f(u)f(v)) for all u$v \in £$ and 4.$\eta(e) = \eta'(f(e))$, for all e∈ X.

Degree of a Vertex or a Point in Fuzzy Semigraphs

Definition 2.1

If $G: (\sigma, \mu, \eta)$ is a fsg on $G^*: (V, £, X)$ and if u *is* any point in G, then the degree of u expressed by $d(u)$ is characterized by $d(u) = \sum \eta(E)$ where the $\sum$ covers all edges E having u as an end point.

The total degree of u expressed by $td(u)$ is characterized by $td(u) = \sum \eta(E)$ where $\sum$ covers all edges E having u as an end point.

Example 2.2

If we look at the fsg $G: (\sigma, \mu, \eta)$ in diagram 2.1, the degree of the points are $d(v_1) = 0.8$, $d(v_2) = 0$, $d(v_3) = 1.0$, $d(v_4) = 1.0$, $d(v_5) = 0.4$, $d(v_6) = 0.4$. The total degree of the points are $td(v_1) = 1.4$, $td(v_2) = 0.5$, $td(v_3) = 1.7$, $td(v_4) = 1.8$, $td(v_5) = 0.8$, $td(v_6) = 0.9$.

Theorem 2.3

If: (σ, μ, η) is a fsg on $G^*: (V, £, X)$, then the degree of a middle point of an edge is zero.

Proof: Since the middle point is not the end point of any edge, its degree is zero.

Theorem 2.4

If $G: (\sigma, \mu, \eta)$ is a fsg on $G^*: (V, £, X)$ then the degree of a point v in the end point fuzzy graph G_e is the degree of u in G, if v is the end point or middle end point of G. The degree of v in G_e is 0 if v is a middle point of G.

Proof: If u $\in$ V is an end point of G, then d $_{Ge}(u) = \sum_{uv \in £(G_e)} \eta_e(uv) = \sum \eta(E)$, the $\sum$ covers all lines with one end $u = d_G(u)$. If u $\in$ V is a middle point of G, then u is not adjacent to any other point of G_e. Therefore $d_{G_e}(u) = 0$.

If $G: (\sigma, \mu, \eta)$ is a fsg on $G^*: (V, £, X)$ where $V = \{v_1, v_2, \dots, v_n\}$ and $X = \{E_1, E_2, \dots, E_m\}$, then $\sum_{i=1}^n deg(v_i) = 2S(G) \leq 2m$.

Theorem 2.5

If $G: (\sigma, \mu, \eta)$ is a fsg on $G^*: (V, £, X)$ where $V = \{v_1, v_2, \dots, v_n\}$ and $X = \{E_1, E_2, \dots, E_m\}$, then $\sum_{i=1}^n deg(v_i) = 2S(G) \leq 2m$.

Proof : $\sum_{i=1}^n deg(v_i) = \sum_{i=1}^n \sum \eta(E)$ where $\sum$ runs over all the edges E having v as an end point. In $\sum_{i=1}^n \sum \eta(E)$, each $\eta(E)$ appears twice. Therefore $\sum_{i=1}^n deg(v_i) = 2 \sum_{i=1}^m \eta(E_i) = 2S(G)$.

Also $2S(G) = \sum_{i=1}^m \eta(E_i) \leq 2 \sum_{i=1}^m 1 = 2m$. Therefore $\sum_{i=1}^n deg(v_i) = 2S(G) \leq 2m$

Theorem 2.6

If $G: (\sigma, \mu, \eta)$ is a complete fsg on $G^*: (V, £, X)$ and If $n - 1$ points are strictly end points and one point be middle point of k semiedges $(v_i, u, v_{k+i}), i = 1, 2, \dots, k$. then

1. $d(u) \leq n - 1 - 2k$
2. $d(v_i) \leq n - 2, i = 1,2, \dots, 2k$
3. $d(v) \leq n - 1, v \in V - \{u, v_1, v_2, \dots, v_{2k}\}$
4. $S(G) \leq \frac{n^2 - n - 2k}{2}$

Proof: Since any two edges in x have at most one point in common; the end points of 1- semiedges $v_1, v_2, \dots, v_{2k}$ are all distinct. Therefore $2k \leq n - 1$, which implies $k \leq \frac{(n-1)}{2}$.

Hence the maximum possible value of K is $[\frac{n-1}{2}]$

$V - \{u, v_1, v_2, \dots, v_{2k}\}$ has $n - 1 - 2k$ elements.

If $V - \{u, v_1, v_2, \dots, v_{2k}\} = \{u_1, u_2, \dots, u_{n-1-2k}\}$

If $E_i = (v_i, u, v_{k+i}), i = 1,2, \dots, k$

u is the only middle point and all the other points are strictly end points.

Since G is complete, any two points must lie on the same edge.

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$X = \{E_1, E_2, \ldots, E_k\} \cup \{(u, u_i)/i = 1,2, \ldots, n-1-2k \cup \{(u_i, v_j)/ \ i = 1, 2, \ldots, n-1-2k, j = 1,2, \ldots, 2k\} \cup \{u_i, u_j)/i < j, \ i, j = 1,2, \ldots, n-1-2k\} \cup \{(v_i, v_j)/ \ j = 1,2, \ldots, 2k, j \neq k+i \ if \ i = 1,2, \ldots, k, j \neq i-k \ if \ i = k+1, k+2, \ldots, 2k\}$

(i) $d(u) = \sum \eta(E)$, $\sum$coversall E with u as an end point.

Therefore$d(u) = \sum_{i=1}^{n-1-2k} \eta(uu_i) \leq \sum_{i=1}^{n-1-2k} 1 = n-1-2k$

ii) For $i = 1,2, \ldots, k$

$d(v_i) = \sum \eta(E)$over all E with v_i as an end point.

$= \sum_{\substack{j=1 \\ i \neq j, j \neq k+i}}^{2k} \eta(v_i, v_j) + \eta(v_i, u, v_k + i) + + \sum_{j=1}^{n-1-2k} \eta(u_j, v_i)$

$\leq \sum_{\substack{j=1 \\ i \neq j, j \neq k+i}}^{2k} 1 + 1 + \sum_{j=1}^{n-1-2k} 1$

$= 2k - 2 + 1 + n - 1 - 2k$

$= n - 2$

For $i = k+1, k+2, \ldots, 2k$

$d(v_i) = \sum_{\substack{j=1 \\ i \neq j, j \neq i-k}}^{2k} \eta(v_i, v_j) + \eta(v_i - k, u, v_k + i, v_i) + \sum_{j=1}^{n-1-2k} \eta(u_j, v_i)$

$\leq 2k - 2 + 1 + n - 1 - 2k$

$= n - 2$

Hence $d(v_i) \leq n - 2, i = 1,2, \ldots, 2k$.

(iii) For $i = 1,2, \ldots, n-1-2k$,

$d(v) = \sum_{j=1}^{2k} 1 + 1 + \sum_{j=1}^{2k} \eta(u_i, v_j) + \sum_{\substack{j=1 \\ j \neq i}}^{n-1-2k} \eta(u_j, v_i)$

$\leq 1 + 2k + n - 1 - 2k - 1$

$= n - 1$

(iv) By theorem 2.4,

$$2S(G) = \sum_{v \in V} d(v)$$

$$= d(u) + \sum_{i=1}^{2k} d(v_i) + \sum_{i=1}^{n-1-2k} d(u_i)$$

$$\leq n - 1 - 2k + \sum_{i=1}^{2k} n - 2 + \sum_{i=1}^{n-1-2k} n - 1$$

$$= n - 1 - 2k + 2k(n-2) + (n-1-2k)(n-1)$$

$$= n^2 - n - 2k$$

Theorem 2.7

If$G: (\sigma, \mu, \eta)$is a complete fsg on $G^*: (V, £, X)$such that μ is conserved of constant value c and if$n - 1$ points be strictly end points and one point be middle point of k_1-semiedges (v_i, u, v_{k+i}),

$i = 1,2, \ldots, k$.then

1. $d(u) = (n-1-2k)c$
2. $d(v_i) = (n-2)c, i = 1,2, \ldots, 2k$
3. $d(v) = (n-1)c, v \in V - \{u, v_1, v_2, \ldots, v_{2k}\}$
4. $2S(G) = n^2 - n - 2k$

Proof: Consider V and X as in theorem 2.5,

Since $\mu(e) = c, \forall \ e \in E, \eta(E) = c, \forall \ E \in X$,

(i) $d(u) = \sum_{i=1}^{n-1-2k} \eta(u, u_i) = \sum_{i=1}^{n-1-2k} c = (n-1-2k)c$

(ii) $d(v_i) = \sum_{\substack{j=1 \\ i \neq j, j \neq k+i}}^{2k} \eta(v_i, v_j) + \eta(v_i, u, v_k + i) + \sum_{j=1}^{n-1-2k} \eta(u_j, v_i)$

$$= \sum_{\substack{j=1 \\ i \neq j, j \neq k+i}}^{2k} c + c + \sum_{j=1}^{n-1-2k} c$$

$$= (2k-2)c + c + (n-1-2k)c$$

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$= (n-2)c$

For $i = k+1, k+2, \ldots, 2k$,

$d(v_i) = \sum_{\substack{j=1 \\ i \neq j, j \neq i-k}}^{2k} \eta(v_i, v_j) + \eta(v_i - k, u, v_k + i, v_i) + \sum_{j=1}^{n-1-2k} \eta((u_j, v_i))$

$$= \sum_{\substack{j=1 \\ i \neq j, j \neq i-k}}^{2k} c + c + \sum_{j=1}^{n-1-2k} c$$

$$= (2k-2)c + c + (n-1-2k)c$$

$$= (n-2)c$$

(iii) $i = 1, 2, \ldots, n-1-2k$,

$d(v) = \eta(uu_i) + \sum_{j=1}^{2k} \eta(u_i v_j) + \sum_{\substack{j=1 \\ j \neq i}}^{n-1-2k} \eta(u_i v_j)$

$$= c + 2kc + (n-1-2k)c$$

$$= (n-1)c$$

(iv) $2S(G) = \sum_{v \in V} d(v)$, by theorem 2.5

$$= d(u) + \sum_{i=1}^{2k} d(v_i) + \sum_{i=1}^{n-1-2k} d(u_i)$$

$$= (n-1-2k)c + \sum_{i=1}^{2k} (n-2)c + \sum_{i=1}^{n-1-2k} (n-1)c$$

$$= (n-1-2k)c + 2k(n-2)c + (n-1-2k)(n-1)c$$

$$= (n^2 - n - 2k)c$$

Theorem 2.8

The degree of a point is preserved under a bijective similarity mapping.

Proof: Under a bijective similarity mapping $f: G \rightarrow G'$, $\eta(E) = \eta'(f(E))$, for all $E \in X$.

Therefore $d_G(u) = \sum \eta(E)$, where $\sum$ covers all E with u as an end point.

$= \sum \eta'(f(E))$, where $\sum$ covers all $f(E)$ with $f(u)$ as an end point.

$\qquad = d_{G'}(f(u))$

The following theorems can be proved easily in the same way.

Theorem 2.9

The degree of a point is preserved under end point bijective similarity mapping, edge bijective similarity mapping and adjacency bijective similarity mapping, a co-weak bijective similarity mapping, co-weak end point bijective similarity mapping, co-weak edge bijective similarity mapping and co-weak adjacency bijective similarity mapping.

Remark 2.10

The degree of a point need not be preserved under weak bijective similarity mapping, weak end point bijective similarity mapping, weak edge bijective similarity mapping and weak adjacency bijective similarity mapping since $\eta(E) \leq \eta'(f(E))$, for all $E \in X$ under any of these bijective similarity mappings.

Theorem 2.11

The total degree of a point is preserved under a bijective similarity mapping, end point bijective similarity mapping, edge bijective similarity mapping and adjacency bijective similarity mapping.

Remark 2.12

The total degree of a point need not be preserved under any weak bijective similarity mapping and under any co-weak bijective similarity mapping.

Edge Degree or Line Degree of a Vertex or a point in Fuzzy Semigraphs

Definition 3.1:
If $G: (\sigma, \mu, \eta)$ is a fsg on $G^*: (V, £, X)$ and if u is any point in G, then the line degree of u expressed by $d^e(u)$ is characterized by $d^e(u) = \sum \eta(E)$ here the $\sum$ covers all lines E containing u.
The line total degree of u expressed by $td^e(u)$ is characterized by $td^e(u) = \sum \eta(E) + \sigma(u)$. here the $\sum$ covers all lines E containing u.

Example 3.2
If we refer the fsg in fig. 2.1, then the line degree of the points are d$^e(v_1)$ = 0.8, d$^e(v_2)$ = 0.4, d$^e(v_3)$ = 1.0, d$^e(v_4)$ = 1.0, d$^e(v_5)$ = 0.8, d$^e(v_6)$ = 0.4. The total line degree of the points are
$td^e(v_1)$ = 1.4, $td^e(v_2)$ = 0.9, $td^e(v_3)$ = 1.7, $td^e(v_4)$ = 1.8, $td^e(v_5)$ = 1.2, $td^e(v_6)$ = 0.9.

Theorem 3.3
If $G: (\sigma, \mu, \eta)$ is a fsg on a semigraph $G^*: (V, £, X)$ If u is an end point in G, then $d_G(u) = d_G^e(u)$.

Proof: If u is the end point, the lines containing u are precisely the lines with end point u.
Therefore $d_G(u) = \sum \eta(E)$, here the $\sum$ covers all lines E with u as an end point.
　　　　　$= \sum \eta(E)$, here the $\sum$ covers all lines E containing u.
　　　　　$= d_G^e(u)$.

Theorem 3.4
If $G^*: (V, £, X)$ is a semigraph and if u is an end point of a line in G*, then $d_{G^*}(u) = d_{G^*}^e(u)$.

Proof:
If u is the end point, then the lines containing u are precisely the lines with end point u.
Therefore $d_{G^*}(u) = d_{G^*}^e(u)$.

Theorem 3.5
$G: (\sigma, \mu, \eta)$ is a fsg such that μ is conserved and if u is an end point, then d(u) = d^e(u).

Proof: If μ$(e) = c$ for every e in £ where c is conserved, then η$(E) = c$ for every line E.
　Therefore d$_G$(u) = $\sum$η(E), here the $\sum$ covers all lines E with u as an end point
　　　　　　　　= c × the number of lines E with u as an end point= cd$_{G^*}$(u)
　　　　d$_G^e$(u) = $\sum$η(E), the $\sum$ covers all lines E containing u.
= c × the number of lines E containing the point u = cd$_{G^*}^e$(u)
From theorem 3.4, if u is an end point, d$_{G^*}$(u) = d$_{G^*}^e$(u). Hence d$_G$(u) = d$_G^e$(u).

Theorem 3.6
The line degree of a point is preserved under a bijective similarity mapping, end point bijective similarity mapping, line bijective similarity mapping and adjacency bijective similarity mapping, a co-weak bijective similarity mapping, co-weak end point bijective similarity mapping, co-weak line bijective similarity mapping and co-weak adjacency bijective similarity mapping.

Remark 3.7
The line degree of a point need not be preserved under weak bijective similarity mapping, weak end point bijective similarity mapping, weak line bijective similarity mapping and weak adjacency bijective similarity mapping since $\eta(E) \leq \eta'(f(E))$, for all $E \in$ X under any of these bijective similarity mappings.

Theorem 3.8

The total line degree of a point is preserved under abijective similarity mapping, end pointbijective similarity mapping, linebijective similarity mapping and adjacency bijective similarity mapping.

Remark 3.9

The total line degree of a point need not be preserved under any weak bijective similarity mapping and under any co-weak bijective similarity mapping.

Adjacent Degree of a Vertex or a Point in Fuzzy Semigraphs

Definition 4.1

If $G: (\sigma, \mu, \eta)$ is a fsg on $G^*: (V, £, X)$ *and if* u is any point in G, then the adjacent degree of u expressed by $d^a(u)$ is characterized by $d^a(u) = \sum \sum_{e \in E} \mu(e)$, here the outer $\sum$ covers all the lines E containing u.

The adjacent total degree of u expressed by $td^a(u)$ is characterized by $td^a(u) = \sum \sum_{e \in E} \mu(e) + \sigma(u)$, here the outer $\sum$ covers all the lines E containing u.

Example 4.2: Referring the fsg in fig. 2.1.

The adjacent degrees of the points are $d^a(v_1)$ = 1.6, $d^a(v_2)$ = 0.9, $d^a(v_3)$ = 1.5, $d^a(v_4)$ = 1.3, $d^a(v_5)$ = 0.8, $d^a(v_6)$ = 0.4. The adjacent total degrees of the points are

$td^a(v_1)$ = 2.2, $td^a(v_2)$ = 1.4, $td^a(v_3)$ = 2.2, $td^a(v_4)$ = 2.1, $td^a(v_5)$ = 1.2, $td^a(v_6)$ = 0.9

Theorem 4.3

If $G^*: (V, £, X)$ is a k-uniform semigraph and if u is an end point in G^*, then $d_{G^*}^a(u)$ = $(k - 1)d_{G^*}(u)$ = $(k - 1) d_{G^*}^e(u)$.

Proof: Since G^* is k-uniform and u is an end point, the number of adjacent points to u from a single line is k-1. The number of lines adjacent to u is $d_{G^*}(u)$.

Therefore $d_{G^*}^a(u)$ = $(k-1)d_{a^*}(u)$.

If u is the end point, then the lines containing u are precisely the lines with end point u.

Therefore $d_{G^*}(u) = d_{G^*}^e(u)$. Hence $d_{G^*}^a(u)$ = $(k-1)d_{G^*}^e(u)$.

Theorem 4.4

If $G: (\sigma, \mu, \eta)$ is a k-uniform fsg on $G^*: (V, £, X)$ such that μ is conserved of constant value c. and if u is an end point in G, then $d_G^a(u)$ = $(k - 1).c.d_{G^*}^e(u)$

Proof: The adjacent degree of u is

$d_G^a(u)$ = $\sum_E \sum_{e \in £} \mu(e)$, where outer $\sum$ covers all lines with end point u

= $\sum_E \sum_{e \in £} c$, where outer $\sum$ covers all lines with end point u

= $\sum_E (k − 1)c$, $\sum$ covers all lines with end point u

    = $(k - 1)cd_{G^*}(u)$

Also since $d_{G^*}(u) = d_{G^*}^e(u)$, $d_G^a(u)$ = $(k - 1)cd_{G^*}^e(u)$.

Theorem 4.5

If $G^*: (V, £, X)$ is a k-uniform semigraph and if u is a middle point in G^*, then $d_{G^*}^a(u)$ = $(k- 1)$.

Proof: Since G^* is k-uniform, the number of adjacent points to a middle point u is k -1. Also u is a middle point of exactly one line. Hence $d_{G^*}^a(u)$ = $(k - 1)$.

Theorem 4.6

If $G: (\sigma, \mu, \eta)$ is a k-uniform fsg on $G^*: (V, £, X)$ such that μ is conserved of constant value c. If u is a middle point in G^*, then $d_{G^*}^a(u)$ = $(k- 1)c$.

Proof: Since G^* is k-uniform, the number of adjacent points to a middle point$u$ is k -1. Also u is a middle point of exactly one line. Therefore the adjacent degree of **u** is
$d_{G^*}^a(u)= \sum_{e \in £} \mu(e) = \sum_{e \in £} c = (k-1)c$.

Theorem 4.7
If G*(V,£,X)is a k-uniform semigraph and if u is a middle-end point in G*, then $d_{G^*}^a(u)= (k-1)[d_{G^*}(u)+1]$.

Proof: $d_{G^*}(u)$ lines have u as end point. The $(k-1)d_{G^*}(u)$ points in them are all adjacent to u. Also the $k-1$ points in the line containing **u** as middle point are also adjacent to the point$u$. Hence $d_{G^*}^a(u)= (k-1)d_{G^*}(u) + (k-1) = (k-1)[d_{G^*}(u) + 1]$.

Theorem 4.8 If$G: (\sigma, \mu, \eta)$is a k-uniform fsg on $G^*: (V, £, X)$ such that μ is conserved of constant value c. If u is a middle-end point in G*, then $d_{G^*}^a(u)= (k-1)c(d_{G^*}(u) + 1)$.

Proof:
$d_{G^*}(u)$ is the number of lines E with u as end point. Only one line has u as a middle point.
There for the adjacent degree of u is
$d_G^a(u)= \sum_E \sum_{e \in £} \mu(e)$, outer$\sum$ covers all lines E containing u
$= \sum_E \sum_{e \in £} c$, outer$\sum$ covers all lines E containing u
$= \sum_E (k-1)c$, $\sum$ covers all lines E containing u
$\quad = \sum_E (k-1)c$, ($\sum$ covers all lines E with u as end point).
$+ \sum_E (k-1)c$, ($\sum$ covers all lines E with u as a middle point).
$\quad = (k-1)cd_{G^*}(u) + (k-1)c$.
$\quad = (k-1)c[d_{G^*}(u) + 1]$.

Theorem 4.9
The adjacent degree of a point is preserved under abijective similarity mapping, end pointbijective similarity mapping, linebijective similarity mapping and adjacency bijective similarity mapping, a co-weak bijective similarity mapping, co-weak end pointbijective similarity mapping, co-weak linebijective similarity mapping and co-weak adjacency bijective similarity mapping.

Remark 4.10
The adjacent degree of a point need not be preserved under weak bijective similarity mapping, weak end pointbijective similarity mapping, weak linebijective similarity mapping and weak adjacency bijective similarity mapping since $\mu(uv) \leq \mu'(f(u)f(v))$ for all $uv \in £$ under any of these weak bijective similarity mappings.

Theorem 4.11
The total adjacent degree of a point is preserved under abijective similarity mapping, end pointbijective similarity mapping, linebijective similarity mapping and adjacency bijective similarity mapping.

Remark 4.12
The total adjacent degree of a point need not be preserved under any weak bijective similarity mapping and under any co-weak bijective similarity mapping.

Consecutive Adjacent Degree of a Vertex or a Point in Fuzzy Semigraphs

Definition 5.1

The consecutive adjacent degree of u expressed by $d^{ca}(u)$ is characterized by $d^{ca}(u) = \sum \mu(uv)$, here the $\sum$ covers all points v which are consecutively adjacent to u. The consecutive adjacent total degree of u expressed by $td^{ca}(u)$ is characterized by $td^{ca}(u) = \sum \mu(uv) + \sigma(u)$, here the $\sum$ covers all points v which are consecutively adjacent to u.

Example 5.2: If we refer the fsg in fig. 2.1, the Consecutive adjacent degrees of the points are $d^{ca}(v_1) = 0.8$, $d^{ca}(v_2) = 0.9$, $d^{ca}(v_3) = 1.1$, $d^{ca}(v_4) = 1.0$, $d^{ca}(v_5) = 1.2$, $d^{ca}(v_6) = 0.4$.
The Consecutive adjacent total degrees of the points are $td^{ca}(v_1) = 1.4$, $td^{ca}(v_2) = 1.4$, $td^{ca}(v_3) = 1.8$, $td^{ca}(v_4) = 1.8$, $td^{ca}(v_5) = 1.6$, $td^{ca}(v_6) = 0.9$

Theorem 5.3

If $G^*: (V, £, X)$ is a semigraph and if u is an end point of a line in G^*, then $d_{G^*}(u) = d^e_{G^*}(u) = d^{ca}_{G^*}(u)$.

Proof: If u is the end point, then the lines containing u are precisely the lines with end point u. So $d_{G^*}(u) = d^e_{G^*}(u)$. Also if u is the end point, then the number of lines with end point u is the same as the number of points consecutively adjacent to u. Hence $d_{G^*}(u) = d^{ca}_{G^*}(u)$.

Theorem 5.4

If $G: (\sigma, \mu, \eta)$ is a fsg such that μ is conserved and if u is an end point, then $d(u) = d^e(u) = d^{ca}(u)$.

Proof: If $\mu(e) = c$ for every $e \in £$ where c is a constant. Then $\eta(E) = c$ for every line E.
Therefore
$d_G(u) = \eta(E)$, the $\sum$ covers all lines E with u as an end point.
     = c × the number of lines E with u as an end point = $c.d_{G^*}(u)$
$d^e_G(u) = \sum \eta(E)$, the $\sum$ covers all lines E containing u.
     = c × the number of lines E containing the point u = $d^e_{G^*}(u)$
$d^{ca}_G(u) = \sum_{uv \in E} \mu(uv) = c \sum_{uv \in E} 1 = cd^{ca}_{G^*}(u)$
From theorem 3.4, if u is an end point, $d_{G^*}(u) = d^e_{G^*}(u)$ and therefore $d_{G^*}(u) = d^e_{G^*}(u) = d^{ca}_{G^*}(u)$. Hence $d_G(u) = d^e_G(u) = d^{ca}_G(u)$.

Theorem 5.5

If $G^*: (V, £, X)$ is a k-uniform semigraph and if u is an end point in G^*, then
$d^a_{G^*}(u) = (k - 1)d^{ca}_{G^*}(u)$. [or $d^a_{G^*}(u) = (k - 1) d^e_{G^*}(u)$ or $d^a_{G^*}(u) = (k - 1)(k - 1)d_{G^*}(u)$.]

Proof: Since G^* is k-uniform and u is an end point, the number of adjacent points to u from a single line is k-1. The number of lines adjacent to u is $d_{G^*}(u)$. So $d^a_{G^*}(u) = (k - 1)d_{G^*}(u)$.
From theorem 3.4, $d_{G^*}(u) = d^e_{G^*}(u)$, Hence $d^a_{G^*}(u) = (k - 1)d^{ca}_{G^*}(u)$.
The other expressions follow in a similar manner.

Theorem 5.6

If $G: (\sigma, \mu, \eta)$ is a k-uniform fsg on $G^*: (V, £, X)$ such that μ is conserved of constant value c and if u is an end point in G^*, then $d^a_{G^*}(u) = (k - 1) c\ d^{ca}_{G^*}(u)$.
[or $d^a_{G^*}(u) = (k - 1)c\ d^e_{G^*}(u)$ or $d^a_{G^*}(u) = (k - 1)cd_{G^*}(u)$.]

Proof: If u ∈V is any point, then $d_{G_a}(u) = \sum_{uv \in E(G_{ca})} \mu_{ca}(uv) = \sum_{uv \in E} \mu(uv) = \sum_{uv \in E} c =$
$(k - 1)cd_{G^*}(u)$.
If u is an end point, then $d_{G^*}(u) = d^e_{G^*}(u) = d^{ca}_{G^*}(u)$. Hence the theorem follows.

Theorem 5.7

If$G: (\sigma, \mu, \eta)$isafsg on $G^*: (V, £, X)$then the degree of a point u in the consecutive adjacency fuzzy graph G_{ca} is $d_G^{ca}(u)$.

Proof: If u ∈V is any point. Then $d_{G_a}(u) = \sum_{uv \in E(G_{ca})} \mu_{ca}(uv) = \sum_{uv \in E} \mu(uv) = d_G^{ca}(u)$.

Theorem 5.8

If$G: (\sigma, \mu, \eta)$isafsg on $G^*: (V, £, X)$such that $\mu$is conserved. Then for any point u, (i) $d_G(u) = cd_{G^*}(u)$, (ii) $d_G^e(u) = cd_{G^*}^e(u)$, (iii) $d_G^{ca}(u) = cd_{G^*}^{ca}(u)$ and (iv) $d_G^a(u) = cd_{G^*}^a(u)$

Proof:

If$\mu(e)$ = c for every e ∈ £. Then $\eta(E)$ = c for every E ∈ X.

   i. $d_G(u) = \sum \eta(E)$, the $\sum$ covers all the lines E with u as an end point,
           = $\sum c$, the $\sum$ covers all the lines with u as an end point,
        = $cd_{G^*}(u)$
  ii. $d_G^e(u) = \sum \eta(E)$, the $\sum$ covers all the lines containing u
              = $\sum c$, the $\sum$ covers all the lines containing u = $cd_{G^*}^e(u)$
 iii. $d_G^{ca}(u) = \sum_{uv \in E} \mu(uv) = \sum_{uv \in E} c = cd_{G^*}^{ca}(u)$
  iv. $d_G^a(u) = \sum_E \sum_{e \in E} \mu(e)$, the outer $\sum$ covers all the E containing u
              = $\sum_E \sum_{e \in E} c = cd_{G^*}^a(u)$

The following theorem gives the relation between the four degrees of afsg.

Theorem 5.9

For any point u in a fsg$G: (\sigma, \mu, \eta)$ on a semigraph$G^*: (V, £, X)$,then $d(u) \leq d^e(u) \leq d^{ca}(u) \leq d^a(u)$.

Proof :

In $d(u) = \sum \eta(E)$, $\sum$ runs over all the lines having u as an end point. But in $d^e(u) = \sum \eta(E)$,lines having u as middle point are also included. Therefore $d(u) \leq d^e(u)$.
For any line$E$, $\eta(E) \leq \mu(e)$ for every $e \in E$ which implies $\sum \eta(E) \leq \sum \mu(uv)$ where the $\sum$ on L. H. S runs over all the lines containing u and the $\sum$ on R. H. S runs over all the points$v$ consecutively adjacent to u. Hence $d^e(u) \leq d^{ca}(u)$.If uv ∈ E, then$\mu(uv) \leq \sum_{e \in E} \mu(e)$. Henced$^{ca}(u) \leq d^a(u)$.
Therefore $d(u) \leq d^e(u) \leq d^{ca}(u) \leq d^a(u)$

Remark 5.10

In the fsg in Fig 2.1, $d(v_1) = 0.8$, $d^e(v_1) = 0.8$, $d^a(v_1) = 1.6$, $d^{ca}(v_1) = 0.8$
Therefore $d(v_1) \leq d^e(v_1) \leq d^{ca}(v_1) \leq d^a(v_1)$.

Remark 5.11

If u is an end point in a semigraph $G: (\sigma, \mu, \eta)$, then $d_G(u)$ or $d_G^e(u)$ need not be equal to $d_G^{ca}(u)$. For example, look at the semigraph in Fig.5.1. Here u is the end point of the line E = (u, v, x, w). Here d(u) = η(E) = 0.3. d^e(u) = η(E) = 0.3. But d^{ca}(u) = μ(uv) = 0.5. Therefore d(u) ≠ d^{ca}(u) and d^e(u) ≠ d^{ca}(u).

Theorem 5.12

The consecutive adjacent degree of a point is preserved under abijective similarity mapping, end pointbijective similarity mapping, linebijective similarity mapping and adjacency bijective similarity mapping, a co-weak bijective similarity mapping, co-weak end pointbijective similarity mapping, co-weak linebijective similarity mapping and co-weak adjacency bijective similarity mapping.

Remark 5.13

The consecutive adjacent degree of a point need not be preserved under weak bijective similarity mapping, weak end point bijective similarity mapping, weak linebijective similarity mapping and weak adjacency bijective similarity mapping since $\mu(uv) \leq \mu'(f(u)f(v))$ for all $uv \in £$ under any of these weak bijective similarity mappings.

Theorem 5.14

The total consecutive adjacent degree of a point is preserved under abijective similarity mapping, end pointbijective similarity mapping, linebijective similarity mapping and adjacency bijective similarity mapping.

Remark 5.15

The total consecutive adjacent degree of a point need not be preserved under any weak bijective similarity mapping and under any co-weak bijective similarity mapping.

CONCLUSION

In this work, various degrees of a vertex of afsg are characterized and some results on degrees of points in a fsg are studied. Degree, edge degree, adjacent degree and consecutive adjacent degree of a vertex in afsg are introduced. Their properties under various bijective similarity mappings are discussed. Transport networks and telecommunication networks can be modelled as fsgs. Hence our findings may be useful for future Studies and Research.

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Fig.1 G: (σ, μ, η)	**Fig.2 $G : (\sigma, \mu, \eta)$**

RESEARCH ARTICLE
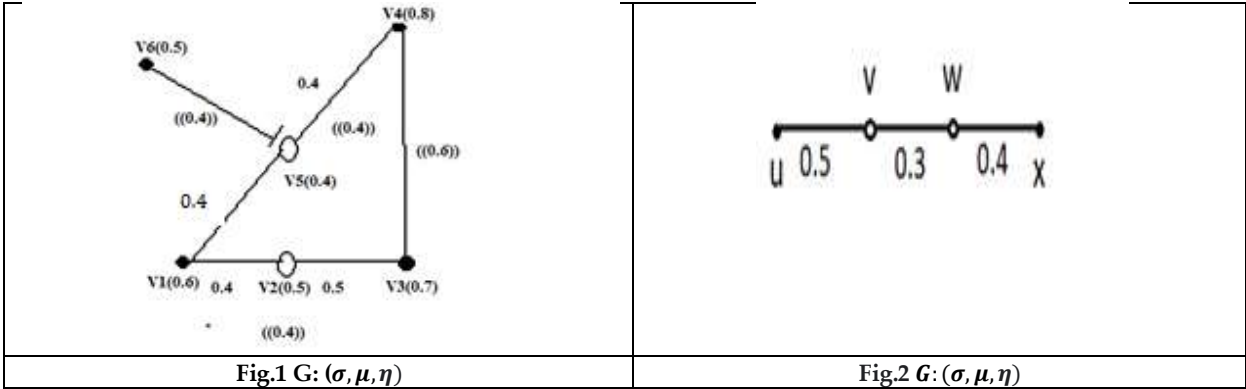
Non-Homogeneous Heptic with Five Unknowns $(x^2 - y^2)[\tau(x^2 + y^2) - (2\tau - 2)xy] = (2\tau + \sigma^2 + 2\sigma)(X^2 - Y^2)z^5$

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ABSTRACT

This communication aims at determining varies solution in integers to not – homogeneous quinary Heptic equation represented as $(x^2 - y^2)[\tau(x^2 + y^2) - (2\tau - 2)xy] = (2\tau + \sigma^2 + 2\sigma)(X^2 - Y^2)z^5$. The considered equation is reduced to a solvable quintic equation through employing linear transformations and four different patterns of integer solutions are presented.

Keywords: Heptic with five unknowns, Not-homogeneous Heptic, solutions in Integers

INTRODUCTION

Launch

In [1-4], numerous mathematicians have focused on finding solutions in integers to higher degree diophantine equations. Especially [5-8] concerns with quinary seventh degree diophantine equations. Here, the major force of this article is to determine varieties of solutions in integers to quinary seventh degree equation given by $(x^2 - y^2)[\tau(x^2 + y^2) - (2\tau - 2)xy] = (2\tau + \sigma^2 + 2\sigma)(X^2 - Y^2)z^5$. The considered equation is reduced to a solvable quintic equation through employing linear transformations and four different patterns of integer solutions are presented.

TECHICAL PROCEDURE

The not-comparable quinary heptic equalization below thought is
$$(x^2 - y^2)[\tau(x^2 + y^2) - (2\tau - 2)xy] = (2\tau + \sigma^2 + 2\sigma)(X^2 - Y^2)z^5. \tag{1}$$

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Different ways of getting solutions in integers for (1)is as follows:

Way 1
In (1), the choices of first-degree modifications
X =u+v, y = u-v , X=u+2v, Y=u-2v   (2)
in (1) leads to
$\mathbf{u}^2 + (2\tau - 1)v^2 = (2\tau + \sigma^2 + 2\sigma)z^5$ (3)
Let us hold of
Z = $a^2 + (2\tau - 1)b^2$ (4)
where a $\neq$ b
Take
$2p + q^2 + 2\sigma = \left[(\sigma + 1) + i\sqrt{2\tau - 1}\right]\left[(\sigma + 1) - i\sqrt{2\tau - 1}\right]$ (5)
From (4), (5) and (3),one has
$u + i\sqrt{2\tau - 1}v = \left[(\sigma + 1) + i\sqrt{2\tau - 1}\right]\left[a + i\sqrt{2\tau - 1}b\right]^5$
After specific algebraic computations and clarification, we obtain
$u = (\sigma + 1)f - (2\tau - 1)g$
$v = f + (\sigma + 1)g$
where
$f = a5\text{-}10a3b2(2p\text{-}1) +5a(2p\text{-}1)2b4$
$G = 5a4b\text{-}10a2(2p\text{-}1) b3+(2p\text{-}1)2b5$
In view of (2), it is seen that (1) is satisfied by
$x = (\sigma + 2)f + (\sigma - 2\tau + 2)g$
$y = \sigma f - (2\tau + \sigma)g$
$X = (\sigma + 3)f + (2\sigma - 2\tau + 3)g$
$Y = (\sigma - 1)f - (2\tau + 2\sigma + 1)g$ together (4)

Way 2
From (3), we have alternatively
$u^2 + (2\tau - 1)v^2 = (2\tau + \sigma^2 + 2\sigma)z^5 * 1$ (6)
Take 1 in R.H.s of (6) as
$1 = \frac{(\tau - 1 + i\sqrt{2\tau - 1})(p - 1 - i\sqrt{2\tau - 1})}{\tau^2}$ (7)
Consider
$z = \tau^2(a^2 + (2\tau - 1)b^2)$ (8)
Switch (7), (8) in (6).Applying the procedure as in way 1, we contain
$u + i\sqrt{2\tau - 1}\,v = \left[(\sigma + 1) + i\sqrt{2\tau - 1}\right]\left[f + i\sqrt{2\tau - 1}g\right]\left[\frac{(\tau - 1 + i\sqrt{2\tau - 1})}{\tau}\right]$

On compassion, we have
$u = \tau^4(\tau\sigma - \tau - \sigma)f - (2\tau - 1)(\tau + \sigma)g$
$v = \tau^4(\tau + \sigma)f + (\tau\sigma - \tau - \sigma)g$
Substituting$u$and v in (2), the integral solutions of (1) are as follows:
$$x = \tau^4[\tau\sigma f + (-2\tau^2 - \tau\sigma)g]\,y = \tau^4[(\tau\sigma - 2\tau - 2\sigma)f + (-2\tau^2 - 3\tau\sigma + 2\tau + 2\sigma)g]$$
$$X = \tau^4[(\tau\sigma + \tau + \sigma)f + (-2\tau^2 - \tau - \sigma)g]\,Y = \tau^4[(\tau\sigma - 3\tau - 3\sigma)f + (-2\tau^2 - 4\tau\sigma + 3\tau + 3\sigma)g]$$
along with (8).

Way 3
Take
$$v = \left(2\tau + \sigma^2 + 2\sigma\right)^3 w^2$$
                                    (9)
$$z = \left(2\tau + \sigma^2 + 2\sigma\right)w$$
Switch (9) in (3)and we have

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$u^2 = (2\tau + \sigma^2 + 2\sigma)^6 w^4 \big(w - (2\tau - 1) \big)$ (10)

Choose

w = $\quad 2\tau - 1 + \alpha^2$ (11)

Utilize (11) in (10) & (9) and applying the resolving activity, we have

$u = (2\tau + \sigma^2 + 2\sigma)^3 (2\tau - 1 + \alpha^2)^2 \alpha$

$v = (2\tau + \sigma^2 + 2\sigma)^3 (2\tau - 1 + \alpha^2)^2$

$z = (2\tau + \sigma^2 + 2\sigma)(2\tau - 1 + \alpha^2)$ (12)

In view of (2), (1) is satisfied by

$x = (2\tau + \sigma^2 + 2\sigma)^3 (2\tau - 1 + \alpha^2)^2 (\alpha + 1)$

$x = (2\tau + \sigma^2 + 2\sigma)^3 (2\tau - 1 + \alpha^2)^2 (\alpha - 1)$

$X = (2\tau + \sigma^2 + 2\sigma)^3 (2\tau - 1 + \alpha^2)^2 (\alpha + 2)$

$Y = (2\tau + \sigma^2 + 2\sigma)^3 (2\tau - 1 + \alpha^2)^2 (\alpha - 2)$

along with (12).

Way 4

Take

$$u = (2\tau + \sigma^2 + 2\sigma)^3 w^2$$
$$z = (2\tau + \sigma^2 + 2\sigma) w$$
                                                                                             (13)

substituting (13) in (3), we obtain

$(2\tau - 1)v^2 = (2\tau + \sigma^2 + 2\sigma)^6 w^4 (w - 1)$ (14)

Choose

$w = (2\tau - 1)\alpha^2 + 1$ (15)

Utilize (15) in (12) and applying the resolving activity, we have

u = $(2\tau + \sigma^2 + 2\sigma)^3 [(2\tau - 1)\alpha^2 + 1]^2$

v = $(2\tau + \sigma + 2\sigma)^3 [(2\tau - 1)\alpha^2 + 1]^2 \alpha$

z = $(2\tau + \sigma^2 + 2\sigma)\big((2\tau - 1)\alpha^2 + 1\big)$ (16)

In view of (2), (1) is satisfied by

x = $(2\tau + \sigma^2 + 2\sigma)^3 [(2\tau - 1)\alpha^2 + 1]^2 (1 + \alpha)$

y= $(2\tau + \sigma^2 + 2\sigma)^3 [(2\tau - 1)\alpha^2 + 1]^2 (1 - \alpha)$

X = $(2\tau + \sigma^2 + 2\sigma)^3 [(2\tau - 1)\alpha^2 + 1]^2 (1 + 2\alpha)$

Y = $(2\tau + \sigma^2 + 2\sigma)^3 [(2\tau - 1)\alpha^2 + 1]^2 (1 - 2\alpha)$

along with (16).

INFERENCE

This communication has been focused on determining many solutions in integers to the quinary heptic equation represented by $(x^2 - y^2)[\tau(x^2 + y^2) - (2\tau - 2)xy] = (2\tau + \sigma^2 + 2\sigma)(X^2 - Y^2)z^5$. The readers of this paper may attempt to determine infinitely many solutions in integers to other forms of quinary heptic equalizatio jointly by their explanation.

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RESEARCH ARTICLE

Existence Results for Second Order Neutral Functional Random Integro-Differential Equations with Infinite Delay

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ABSTRACT

This article explores the existence of solution for second-order neutral functional random integro-differential equationwith infinite delay. The study utilizes a Schauder fixed-point theorem within a stochastic framework to demonstrate the existence of mildsolution to this complex problem. By incorporating stochastic elements into the analysis, the research addresses the challenges posed by infinite delays and provides a solid theoretical foundation for understanding and solving these types of equations.

Keywords: Integro-differential equation; random fixed point; mild solution; infinite delay; semigroup theory.
MSC 2020: 45J05; 34K30; 47G20; 34K20/

INTRODUCTION

Researchers have conducted a myriad of investigations in the realm of neutral functional differential equations and integral equations to understand the existence, uniqueness, and properties of solutions in diverse settings. The references compiled here cover a wide range of research endeavors, each of which significantly contributes to understanding various aspects of this domain. The foundational work of Ahmed [1] on semigroup theory elucidates its applications in systems and control, laying the groundwork for subsequent developments. Baghli and Benchohra's contributions are notable, ranging from uniqueness results for partial neutral functional differential equations to existence results for different classes of neutral functional equations [2]. Dhage and Ntouyas have investigated the existence and attractivity of solutions for nonlinear random differential and integral equations [4]. Lupulescu and Lungan's exploration of random integral equations on time scales [5] contributes to understanding these equations in a broader context. Different studies have also been done on second-order neutral functional integrodifferential equations [6, 7], neutral functional equations [8], and some second-order nonlinear equations [9]. These works offer significant insights into diverse classes of neutral functional equations and their applications across various domains. Some recent developments in the field are Suresh et al.'s work on nonlocal impulsive neutral functional integro-differential equations [10], Gunasekar et al.'s study of non-linear impulsive neutral fuzzy delay differential equations with non-local conditions [11], and Raghavendran et al.'s way of solving fractional integro-differential equations using the Aboodh transform [12]. ere are also important papers in this collection by Travis and Webb [15], Engl [13], Hale and Kato [14], and Pachpatte [16], among others. These papers helped build the theory and methods used to study neutral functional differential equations. In summary, the range and depth of research to understand and solve various types of neutral functional differential and integral equations is evident in this list of references. It includes both classic and more recent contributions. In this study, we demonstrate that the second-order neutral functional integro-differential equation with delay and random effects is of the form.

$$\frac{d}{dt}[\delta'(\zeta,\varpi) + y(\zeta,\varepsilon,\delta_\zeta(.,\varpi),\varpi)] = A\delta(\zeta,\varpi) + \phi(\zeta,\varepsilon,\delta_\zeta(.,\varpi),\delta'(\varepsilon,\varpi),$$

$$\int_0^\zeta \chi(\varepsilon,\delta_\varepsilon(.,\varpi)d\varepsilon, \int_0^\omega \psi(\varepsilon,\delta_\varepsilon(.,\varpi))d\varepsilon,\varpi)\zeta \in [0,k] = \mathcal{M}_{(1)}$$

$$\delta(\zeta,\varpi) = \phi_1(\zeta,\varpi)$$

$$\delta'(0,\varpi) = \phi_2(\varpi)$$

where A is the infinitesimal generator of a strongly continuous cosine family $\{\mathcal{D}(\zeta):\zeta \in \mathbb{R}\}$ of a bounded linear operator in a Banach Space $\mathcal{S}$ with the norm $||.||$. Functions $\phi:\mathcal{M} \times \mathcal{M} \times \mathcal{D} \times \mathcal{S} \times \mathcal{S} \times \mathcal{S} \times \mathcal{S} \to \mathcal{S}$, $\chi:\mathcal{M} \times \mathcal{D} \to \mathcal{S}$, $\psi:\mathcal{M} \times \mathcal{D} \to \mathcal{S}$, and $y:\mathcal{M} \times \mathcal{M} \times \mathcal{D} \times \mathcal{S} \to \mathcal{S}$ are continuous functions.

PRELIMINARIES

This section presents several notations, definitions, and theorems used throughout the rest of this work. We will utilize the vocabulary from [14] and incorporate Hale and Kato's axiomatic description of the phase space $\mathcal{D}$. Satisfying the following axioms $(\mathcal{D},||.||_\mathcal{D})$ will result in a seminormed linear space of functions that project $(-\infty,\omega]$ into $\mathcal{S}$ the following:

(A) The following conditions are holds for all $\zeta \in \mathcal{M}$ if $\delta:(-\infty,\omega] \to \mathcal{S}, \omega > 0$, is continuous on $\mathcal{M}$ and $\delta_0 \in \mathcal{D}$:

1. $\delta_\zeta \in \mathcal{D}$;

2. There is a positive constant K such that $||\delta(\zeta,\varpi)| \le K||\delta_\zeta(.,\varpi)||_\mathcal{D}$

3. There are three functions $\mathcal{S},\vartheta,\vartheta':\mathbb{R}_+ \to \mathbb{R}_+$ independent of δ, with $\mathcal{S}$ continuous and bounded, ϑ,ϑ' locally bounded such that

$$||\delta_\zeta(.,\varpi)||_\mathcal{D} \le \mathcal{S}(\zeta)\sup\{|\delta(m,\varpi)|: 0 \le m \le \zeta\} + \vartheta(\zeta)||\delta_0(\varpi)||_\mathcal{D} + \vartheta'(\zeta)||\delta_{0'}(\varpi)||_\mathcal{D}$$

(B) δ_ζ is a $\mathcal{D}$-valued continuous function on $\mathcal{M}$ for the functions δ in (A).

(C) The space $\mathcal{D}$ is complete.

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Definition 2 [13] A mapping $y : \Omega \to X$ is known as a random (stochastic) fixed point of a random operator V if, for p-almost all $\omega \in \Omega$, it satisfies the properties $y(\omega) \in Q(\omega)$, where $Q(\omega)$ is a random operator with a stochastic domain, $V(\omega)y(\omega) = y(\omega)$, and $\{\omega \in \Omega : y(\omega) \in C\} \in F$ for every open set $C \subseteq X$ where F represents a σ-algebra which is a subset of Ω. (i.e., y is measurable).

Theorem 2.1 (Arzela-Ascoli theorem)
If a sequence of functions $\{f_n\}$ defined on $[a,b]$ is uniformly bounded and equicontinuous, then there exists a subsequence $\{f_{n_k}\}$ that converges uniformly to a continuous function f on $[a,b]$.

Theorem 2.2 (Scauder fixed point theorem)
Let $\mathcal{S}$ be a Banach space, and $\mathcal{B}$ a nonempty, closed, and convex subset of $\mathcal{S}$. Suppose $F : \mathcal{B} \to \mathcal{B}$ is a continuous mapping such that the image $F(\mathcal{B})$ is relatively compact in $\mathcal{S}$. Then there exists at least one point $\delta \in \mathcal{B}$ such that $F(\delta) = \delta$.

Definition 3 A collection $\{T_1(\zeta) : \zeta \in \mathbb{R}\}$ of operators in $B(\mathcal{S})$ is termed a strongly continuous cosine family if it meets the following criteria:
1. $T_1(0) = I$, where I represents the identity operator in $\mathcal{S}$.
2. For every $\zeta, \varepsilon \in \mathbb{R}$, the relation $T_1(\zeta + \varepsilon) + T_1(\zeta - \varepsilon) = 2T_1(\zeta)T_1(\varepsilon)$ holds.
3. For each $\delta \in \mathcal{S}$, the function $\zeta \mapsto T_1(\zeta)\delta$ is strongly continuous.
The infinitesimal generator of a strongly continuous cosine family $\{T_1(\zeta), \zeta \in \mathbb{R}\}$ is an operator $A : \mathcal{S} \to \mathcal{S}$ defined by

$$A\delta = \frac{d^2}{d\zeta^2} T_1(\zeta)\delta \bigg|_{\zeta=0}, \quad \delta \in D(A),$$

where $D(A)$ consists of those elements $\delta \in \mathcal{S}$ for which the function $T_1(\zeta)\delta$ is twice continuously differentiable with respect to ζ. We also define the set $B = \{\delta \in \mathcal{S} : T_1(\zeta)\delta$ is continuously differentiable in $\zeta\}$. We assume the following condition:
(G_1) The operator A serves as the infinitesimal generator of the strongly continuous cosine family $\{T_1(\zeta), \zeta \in \mathbb{R}\}$ consisting of bounded linear operators on the Banach space $\mathcal{S}$.

Existence Results for Neutral Functional Integro-differential Equation
We now present our primary existence result for problem (1.1). The definition of a mild random solution is presented first.

Definition 4 If $\delta_0 = \emptyset$ and the continuous function $\delta : (-\infty, \omega] \to \mathcal{S}, \omega > 0$ and $\mathcal{D} = [(-\infty, 0], \mathcal{S}]$, solves the integral equation, then it is referred to as a mild solution to equation (1.1).
$$\delta(\zeta, \varpi) = T_1(\zeta)\phi_1(0, \varpi) + T_2(\zeta)[\phi_2(\varpi) + y(0,0,\phi_1(0, \varpi), \varpi)] -$$
$$\int_0^\zeta T_1(\zeta - \varepsilon) y(\varepsilon, \eta, \delta_\varepsilon(., \varpi), \varpi) d\varepsilon + \int_0^\zeta T_2(\zeta - \varepsilon)\phi(\varepsilon, \eta, \delta_\varepsilon(., \varpi), \delta'(\eta, \varpi),$$
$$\int_0^\varepsilon \chi(\eta, \delta_\eta(., \varpi)) d\eta, \int_0^\omega \psi(\eta, \delta_\eta(., \varpi)) d\eta, \varpi) d\varepsilon$$

We assume the following hypothesis to prove our main result.
(G_2) There exist a continuous functions $k, l, m, n : \mathcal{M} \to \mathbb{R}_+$ such that
$$||\phi(\zeta, \varepsilon, \aleph, \delta, y, z, \varpi)|| \le k(\zeta, \varepsilon, \varpi)((||\aleph||_{\mathcal{D}} + ||\delta|| + ||y|| + ||z||), \varpi)$$

$$||\chi(\zeta, \aleph, \varpi)|| \le l(\zeta)(||\aleph||_{\mathcal{D}})$$

$$||\psi(\zeta, \aleph, \varpi)|| \le m(\zeta(||\aleph||_{\mathcal{D}})$$

$$||y(\zeta, \varepsilon, \aleph, \varpi)|| \le n(\zeta, \varepsilon, \varpi)(||\aleph||_{\mathcal{D}}, \varpi)$$

for all $\zeta, \varepsilon \in \mathcal{M}$ and $\aleph, \delta, y, z \in \mathcal{S}$
(G_3) For all $\zeta, \varepsilon \in \mathcal{M}$, the function $\phi(\zeta, \varepsilon, ., ., ., ., .) : \mathcal{D} \times \mathcal{S} \times \mathcal{S} \times \mathcal{S} \times \mathcal{S} \to \mathcal{S}$ is continuous and for all $(\aleph, \delta, y, z, \varpi) \in \mathcal{D} \times \mathcal{S} \times \mathcal{S} \times \mathcal{S} \times \mathcal{S}$ the function $\phi(., ., \aleph, \delta, y, z, \varpi) : \mathcal{M} \times \mathcal{M} \to \mathcal{S}$ is strongly measurable.

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(G_4)For all $\zeta, \varepsilon \in \mathcal{M}$, the function $y(\zeta, \varepsilon, . , .): \mathcal{D} \times \mathcal{S} \to \mathcal{S}$ is continuous and for all $\aleph \in \mathcal{D}$ the function $y(. , . , \aleph, \varpi): \mathcal{M} \times \mathcal{M} \to \mathcal{S}$ is strongly measurable.

(G_5)For all $\zeta, \varepsilon \in \mathcal{M}$ the function $\chi(\zeta, .), \psi(\zeta, .): \mathcal{D} \to \mathcal{S}$ is continuous and for all $\aleph \in \mathcal{D}, \delta \in \mathcal{S}$ the functions $\chi(. , \aleph), \psi(. , \aleph): \mathcal{M} \to \mathcal{S}$ are strongly measurable.

(G_6)For all positive integer m, there exist $\alpha_m, \beta_m \in L^1(\mathcal{M}, \mathbb{R}_+) \ni ||\phi(\zeta, \varepsilon, \aleph, \delta, y, z, \varpi)|| \leq \alpha_m(\zeta, \varpi), ||y(\zeta, \varepsilon, \aleph, \varpi)|| \leq \beta_m(\zeta, \varpi)$ for δ, y satisfying $||\aleph|| \leq m, ||\delta|| \leq m, ||y|| \leq m, ||z|| \leq m$ and for almost everywhere $\zeta, \varepsilon \in \mathcal{M}$.

(G_7) $\mathcal{D}(\zeta, \varpi), \zeta > 0$ is compact.

Theorem 3.1 If the hypotheses $(G_1) - (G_7)$ is satisfactory, the system (1.2) has a mild solution on $(-\infty, \omega]$, assuming that

$$r = \int_0^\zeta exp(\int_0^\eta ((L + \vartheta)q(\eta, \varpi) + (\vartheta + \vartheta')p(\alpha, \varpi)d\alpha)d\eta) < 1$$

where

$$\vartheta = sup||T_1(\zeta)||: \zeta \in \mathcal{M}$$

Proof: The map $F: \Omega \times \mathcal{D} \to \mathcal{D}$ is defined by

$$(F(\varpi)\delta)(\zeta) = \begin{cases} \phi(\zeta, \varpi), & \zeta \in (-\infty, 0] \\ T_1(\zeta)\phi_1(0, \varpi) + T_2(\zeta)[\phi_2(\varpi) + y(0,0, \phi_1(0, \varpi), \varpi)] - \\ \int_0^\zeta T_1(\zeta - \varepsilon)y(\varepsilon, \eta, \delta_\varepsilon(. , \varpi), \varpi)d\varepsilon + \int_0^\zeta T_2(\zeta - \varepsilon)\phi(\varepsilon, \eta, \delta_\varepsilon(. , \varpi), \delta'(\eta, \varpi), \\ \int_0^\varepsilon \chi(\eta, \delta_\eta(. , \varpi))d\eta, \int_0^\omega \psi(\eta, \delta_\eta(. , \varpi))d\eta, \varpi)d\varepsilon, & \zeta, \varepsilon \in \mathcal{M} \end{cases} \quad (2)$$

Using the hyposis G_2 and G_3 for each $\zeta \in \mathcal{M}$, we have

$$||\delta(\zeta, \varpi)|| \leq ||T_1(\zeta)\phi_1(0, \varpi)|| + ||T_2(\zeta)[\phi_2(\varpi) + y(0,0, \phi_1(0, \varpi), \varpi)]|| +$$
$$\int_0^\zeta ||T_1(\zeta - \varepsilon)||||y(\varepsilon, \eta, \delta_\varepsilon(. , \varpi), \varpi)d\varepsilon|| + \int_0^\zeta ||T_2(\zeta - \varepsilon)||||\phi(\varepsilon, \eta, \delta_\varepsilon(. , \varpi), \delta'(\eta, \varpi),$$
$$\int_0^\varepsilon \chi(\eta, \delta_\eta(. , \varpi))d\eta, \int_0^\omega \psi(\eta, \delta_\eta(. , \varpi))d\eta, \varpi)d\varepsilon||$$
$$\leq \vartheta||\phi_1|| + \vartheta'||\phi_2 + C_1\phi_1 + C_2||_\mathcal{D} + \int_0^\zeta \vartheta n(\varepsilon, \eta, \varpi)(||\delta_\varepsilon(. , \varpi)||_\mathcal{D}, \varpi)d\varepsilon +$$
$$\int_0^\zeta \vartheta'k(\varepsilon, \eta, \varpi)[(||\delta_\varepsilon(. , \varpi)||_\mathcal{D}) + ||\delta'(\eta, \varpi)|| + \int_0^\zeta l(\eta)(||\delta_\eta(. , \varpi)||_\mathcal{D})d\eta +$$
$$\int_0^\omega m(\eta)(||\delta_\eta(. , \varpi)||_\mathcal{D})d\eta, \varpi]d\varepsilon$$

Consider the function $\aleph_1$ given by

$$\alpha(\zeta, \varpi) = sup\{||\delta(\varepsilon, \varpi)||: -\infty \leq \varepsilon \leq \zeta, \zeta \in \mathcal{M}\}$$

Let $\zeta^*, \varepsilon^* \in (-\infty, \omega]$ be such that $\aleph(\zeta) = ||\delta(\zeta^*)||$. If $\zeta^*, \varepsilon^* \in [0, \omega] = \mathcal{M}$ by the previous inequality we have

$$\alpha(\zeta, \varpi) \leq \vartheta||\phi_1||_\mathcal{D} + \vartheta'||\phi_2 + C_1\phi_1 + C_2||_\mathcal{D} + \int_0^\zeta \vartheta n(\varepsilon, \eta, \varpi)(||\alpha_\varepsilon(. , \varpi)||_\mathcal{D}, \varpi)d\varepsilon +$$
$$\int_0^\zeta \vartheta'k(\varepsilon, \eta, \varpi)[(||\alpha_\varepsilon(. , \varpi)||_\mathcal{D}) + ||\alpha'(\eta, \varpi)|| + \int_0^\zeta l(\eta)(||\alpha_\eta(. , \varpi)||_\mathcal{D}d\eta) +$$
$$\int_0^\omega m(\eta)(||\alpha_\eta(. , \varpi)||_\mathcal{D})d\eta, \varpi]d\varepsilon$$

Let $\alpha'(\zeta, \varpi) = sup\{||\delta'(\varepsilon, \varpi)||: 0 \leq \varepsilon \leq \zeta\}, \zeta \in \mathcal{M}$ If $\zeta^*, \varepsilon^* \in (-\infty, 0]$ then $\alpha(\zeta, \varpi)\omega \leq ||\phi_1||_\mathcal{D}$ and the previous inequality obviously holds since $\vartheta \geq 1$. But for $\zeta \in \mathcal{M}$ using equation (3.9) we get

$$\delta'(\zeta, \varpi) = AT_2(\zeta)\phi_1(0, \varpi) + T_1(\zeta)[\phi_2(\varpi) + y(0,0, \phi_1(0, \varpi), \varpi)] - \int_0^\zeta AT_2(\zeta - \varepsilon)y(\varepsilon, \eta, \delta_\varepsilon(. , \varpi), \varpi)d\varepsilon$$

$$+ \int_0^\zeta T_1(\zeta - \varepsilon)\phi(\varepsilon, \eta, \delta_\varepsilon(. , \varpi), \delta'(\eta, \varpi), \int_0^\varepsilon \chi(\eta, \delta_\eta(. , \varpi))d\eta, \int_0^\omega \psi(\eta, \delta_\eta(. , \varpi))d\eta, \varpi)d\varepsilon$$

and using hypothesis (G_2) and (G_3) we obtain

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$$||\delta'(\zeta,\varpi)|| \leq ||AT_2(\zeta)[\phi_2(\varpi) + y(0,0,\phi_1(0,\varpi),\varpi)]|| + \int_0^\zeta ||AT_2(\zeta-\varepsilon)||||y(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\varpi)d\varepsilon|| +$$

$$||T_1(\zeta)\phi_2(\varpi)|| + \int_0^\zeta ||T_1(\zeta-\varepsilon)\phi(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\delta'(\eta,\varpi),$$

$$\int_0^\varepsilon \chi(\eta,\delta_\eta(.,\varpi))d\eta, \int_0^\omega \psi(\eta,\delta_\eta(.,\varpi))d\eta,\varpi)d\varepsilon||$$

$$||\delta'(\zeta,\varpi)|| \leq ||AT_2(\zeta)||||\phi_1||_\mathcal{D} + ||T_1(\zeta)||||\phi_2 + C_1\phi_1 + C_2||_\mathcal{D} +$$

$$\int_0^\zeta ||AT_2(\zeta-\varepsilon)||n(\varepsilon,\eta,\varpi)(||\delta_\varepsilon(.,\varpi))||_\mathcal{D},\varpi)d\varepsilon +$$

$$\int_0^\zeta Nk(\varepsilon,\eta,\varpi)[||\delta_\varepsilon(.,\varpi)||_\mathcal{D} + ||\delta'(\eta,\varpi)|| + \int_0^\zeta l(\eta)(||\delta_\eta(.,\varpi)||_\mathcal{D}d\eta) +$$

$$\int_0^\omega m(\eta)(||\delta_\eta(.,\varpi)||_\mathcal{D})d\eta,\varpi]d\varepsilon$$

Let $\zeta^{**}, \varepsilon^{**} \in \mathcal{M}$ be such that $\aleph'(\zeta,\varpi) = ||\delta(\zeta^{**},\varpi)||$ and let $L = \sup\{||AT_2(\zeta)||:\zeta,\varepsilon \in \mathcal{M}\}$ then, we have

$$\alpha'(\zeta,\varpi) \leq ||AT_2(\zeta)||||\phi_1|| + \vartheta||\phi_2 + C_1\phi_1 + C_2||_\mathcal{D} + \int_0^\zeta ||AT_2(\zeta-\varepsilon)||n(\varepsilon,\eta,\varpi)(||\alpha_\varepsilon(.,\varpi))||_\mathcal{D},\varpi)d\varepsilon +$$

$$\int_0^\zeta \vartheta k(\varepsilon,\eta,\varpi)[||\alpha_\varepsilon(.,\varpi)||_\mathcal{D} + ||\alpha'(\eta,\varpi)|| + \int_0^\zeta l(\eta)(||\alpha_\eta(.,\varpi)||_\mathcal{D}d\eta) +$$

$$\int_0^\omega m(\eta)(||\alpha_\eta(.,\varpi)||_\mathcal{D})d\eta,\varpi]d\varepsilon$$

Adding $\alpha(\zeta,\varpi)$ and $\alpha'(\zeta,\varpi)$, we get

$$\alpha(\zeta,\varpi) + \alpha'(\zeta,\varpi) \leq ||\phi_1||[L + \vartheta + C_1(\vartheta + \vartheta')] + \vartheta(1 + \omega)||\phi_2|| + C_2(L + \vartheta) +$$

$$\int_0^\zeta (L + \vartheta)n(\varepsilon,\eta,\varpi)||\alpha_\varepsilon(.,\varpi))||_\mathcal{D}d\varepsilon +$$

$$\vartheta(1 + \omega)\int_0^\zeta q(\varepsilon)k(\varepsilon,\eta,\varpi)[||\alpha_\varepsilon(.,\varpi)||_\mathcal{D} + ||\alpha'(\eta,\varpi)|| +$$

$$\int_0^\zeta l(\eta)(||\alpha_\eta(.,\varpi)||_\mathcal{D}d\eta) + \int_0^\omega m(\eta)(||\alpha_\eta(.,\varpi)||_\mathcal{D})d\eta,\varpi]d\varepsilon$$

$$\alpha(\zeta,\varpi) + \alpha'(\zeta,\varpi) \leq \frac{||\phi_1||[L + \vartheta + C_1(\vartheta + \vartheta')] + \vartheta(1 + \omega)||\phi_2}{1 - r^*}$$

$$\times \exp\left(\int_0^\omega [(L + \vartheta)n(\varepsilon,\eta,\varpi)\vartheta(1 + \omega)(k(\varepsilon,\eta,\varpi) + l(\varepsilon) + m(\varepsilon))]d\varepsilon\right)$$

Therefore $||\delta(\zeta)|| \leq \alpha(\zeta,\varpi) \leq k$ and $||\delta'(\zeta)|| \leq \alpha'(\zeta,\varpi) \leq k, \zeta \in \mathcal{M}$ and hence $||\delta||_\mathcal{D} \leq k$. Now we have to prove that the Operator defined in (3.3) is completely continuous. Let $\mathcal{D}_k = \{\delta \in \mathcal{D}: ||\delta||_\mathcal{D} \leq k, \zeta \in \mathcal{M}\}$ for $k \geq 1$. At first we have show F maps $\mathcal{D}_k$ into an equicontinuous family. Let us take that $\delta \in \mathcal{D}_k$ and $\zeta_1, \zeta_2 \in \mathcal{M}$ and $0 \leq \zeta_1 \leq \zeta_2 \leq \omega$ then

$$\leq ||AT_2(\zeta_1) - AT_2(\zeta_2)||||\phi_1(0,\varpi)|| + ||T_1(\zeta_1) - T_{(\zeta_2)}||$$

$$||\phi_2(\varpi) + y(0,0,\phi_1(0,\varpi),\varpi)||$$

$$+ \int_0^{\zeta_1} ||A(T_2(\zeta_1 - \varepsilon) - AT_2(\zeta_2 - \varepsilon))||\beta_{m_0}(\varepsilon,\varpi)d\varepsilon +$$

$$\int_{\zeta_1}^{\zeta_2} ||A(T_2(\zeta_1 - \varepsilon) - AT_2(\zeta_2 - \varepsilon))||\beta_{m_0}(\varepsilon,\varpi)d\varepsilon$$

$$+ \int_0^{\zeta_1} ||T_1(\zeta_1 - \varepsilon) - T_1(\zeta_2 - \varepsilon)\alpha_{m_0}(\varepsilon,\varpi)d\varepsilon$$

$$+ \int_{\zeta_1}^{\zeta_2} ||T_1(\zeta_1 - \varepsilon) - T_1(\zeta_2 - \varepsilon)||\alpha_{m_0}(\varepsilon,\varpi)d\varepsilon$$

where,

$$m_0 = 2kmax\{1 + m(\zeta) + l(\zeta), \zeta, \varepsilon \in \mathcal{M}\}.$$

As far as we are aware, $T_1(\zeta), T_2(\zeta)$ are uniformly continuous for $\zeta \in \mathcal{M}$ and their compactness for $\zeta > 0$ proves the uniform operator topology is continuous. Since $\delta \in \mathcal{D}_k$ the righthand side of the above inequalities are independent. Therefore $||(F(\varpi)\delta)(\zeta_1) - (F(\varpi)\delta)(\zeta_2)|| \to 0$ and $||(F(\varpi)\delta)'(\zeta_1) - (F(\varpi)\delta)'(\zeta_2)|| \to 0$ as $(\zeta_1 - \zeta_2) \to 0$. Hence F maps $\mathcal{D}_k$ into an equicontinuous family of functions. The equicontinuity for the cases $\zeta_1 \leq \zeta_2 \leq 0$ and $\zeta_1 \leq 0 \leq \zeta_2$ follows from the uniform continuity of F on $(-\infty, 0]$ and from the relation

$$||(F(\varpi)\delta)(\zeta_1) - (F(\varpi)\delta)(\zeta_2)|| \leq ||(F(\varpi)\delta)(\zeta_1) - (F(\varpi)\delta)(0)|| + ||(F(\varpi)\delta)(0) - (F(\varpi)\delta)(\zeta_2)||$$

Since proving that $F\mathcal{D}_k$ is uniformly bounded is straightforward, certain details will be omitted. Having established that $F\mathcal{D}_k$ forms an equicontinuous family, the task now is to demonstrate that $F\mathcal{D}_k$ is compact. To establish this, it suffices to show that the set

$$W(\zeta) = \{(F(\varpi)\delta)(\zeta): \delta \in \mathcal{D}_k\}$$

is precompact in $\mathcal{S}$ for each $\zeta \in (-\infty, \omega]$, employing the Arzela-Ascoli theorem. Let $0 < \zeta \leq \omega$ be fixed, and let ϵ be a real number satisfying $0 < \epsilon < \zeta$. We define:

$$(F_\epsilon(\varpi)\delta)(\zeta) = \ T_1(\zeta)\phi_1(0,\varpi) + T_2(\zeta)(\phi_2(\varpi) + y(0,0,\phi_1(0,\varpi),\varpi)) -$$
$$\int_0^{\zeta-\epsilon} T_1(\zeta-\varepsilon)y(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\varpi)d\varepsilon + \int_0^{\zeta-\epsilon} T_2(\zeta-\varepsilon)\phi(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\delta'(\eta,\varpi),$$
$$\int_0^\varepsilon \chi(\eta,\delta_\eta(.,\varpi))d\eta, \int_0^\omega \psi(\eta,\delta_\eta(.,\varpi))d\eta,\varpi)d\varepsilon, \ \zeta \in \mathcal{M}, \delta \in \mathcal{D}_k$$

Since $T_1(\zeta), T_2(\zeta)$ are compact operators the set $W\epsilon(\zeta) = \{(F_\epsilon(\varpi)\delta)(\zeta): \delta \in \mathcal{D}_k\}$ is relatively compact in $\mathcal{S}$ for every ϵ, $0 < \epsilon < \zeta$, Therefore by our hypothesis and for all $\delta \in \mathcal{D}_k$, we have

$$||(F(\varpi)\delta)(\zeta) - (F_\epsilon(\varpi)\delta)(\zeta)|| \leq \ \int_{\zeta-\epsilon}^\zeta ||T_1(\zeta-\varepsilon)y(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\varpi)||d\varepsilon +$$
$$\int_{\zeta-\epsilon}^\zeta ||T_2(\zeta-\varepsilon)\phi(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\delta'(\eta,\varpi),\int_0^\varepsilon \chi(\eta,\delta_\eta(.,\varpi))d\eta,$$
$$\int_0^\omega \psi(\eta,\delta_\eta(.,\varpi))d\eta,\varpi)d\varepsilon||$$
$$\int_{\zeta-\epsilon}^\zeta ||T_1(\zeta-\varepsilon)||\beta_{m_0}(\varepsilon,\varpi)d\varepsilon + \int_{\zeta-\epsilon}^\zeta ||T_2(\zeta-\varepsilon)||\alpha_{m_0}(\varepsilon,\varpi)d\varepsilon$$

$$||(F(\varpi)\delta)'(\zeta) - (F_\epsilon(\varpi)\delta)'(\zeta)|| \leq \ \int_{\zeta-\epsilon}^\zeta ||AT_2(\zeta-\varepsilon)y(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\varpi)d\varepsilon|| +$$

and

$$\int_{\zeta-\epsilon}^\zeta ||T_1(\zeta-\varepsilon)\phi(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\delta'(\eta,\varpi),$$
$$\int_0^\varepsilon \chi(\eta,\delta_\eta(.,\varpi))d\eta, \int_0^\omega \psi(\eta,\delta_\eta(.,\varpi))d\eta,\varpi)d\varepsilon||$$
$$\int_{\zeta-\epsilon}^\zeta ||AT_2(\zeta-\varepsilon)||\beta_{m_0}(\varepsilon,\varpi)d\varepsilon + \int_{\zeta-\epsilon}^\zeta ||T_1(\zeta-\varepsilon)||\alpha_{m_0}(\varepsilon,\varpi)d\varepsilon$$

Therefore, there exist precompact sets arbitrarily close to the set $W(\zeta)$. Consequently, the set $W(\zeta)$ is also precompact in $\mathcal{S}$. Finally, we aim to demonstrate the continuity of $F: \mathcal{D} \to \mathcal{D}$. Given $\delta_n \to \delta$ in $\mathcal{D}$, where $\{\delta_n\} \subseteq \mathcal{D}$, we have:

$$y(\varepsilon,\eta,\delta_{n\varepsilon}(.,\varpi),\varpi) \to y(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\varpi),$$
$$\phi(\varepsilon,\eta,\delta_{n\varepsilon}(.,\varpi),\delta_{n'}(\eta,\varpi),\int_0^\varepsilon \chi(\eta,\delta_{n\eta}(.,\varpi))d\eta, \int_0^\omega \psi(\eta,\delta_{n\eta}(.,\varpi))d\eta,\varpi)d\varepsilon \to$$
$$\phi(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\delta'(\eta,\varpi),\int_0^\varepsilon \chi(\eta,\delta_\eta(.,\varpi))d\eta, \int_0^\omega \psi(\eta,\delta_\eta(.,\varpi))d\eta,\varpi)d\varepsilon$$

as $n \to \infty$ and for all $\zeta, \varepsilon \in \mathcal{M}$, and

$$||y(\varepsilon,\eta,\delta_{n\varepsilon}(.,\varpi),\varpi)|| \to ||y(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\varpi)||$$
$$||\phi(\varepsilon,\eta,\delta_{n\varepsilon}(.,\varpi),\delta_{n'}(\eta,\varpi),\int_0^\varepsilon \chi(\eta,\delta_{n\eta}(.,\varpi))d\eta, \int_0^\omega \psi(\eta,\delta_{n\eta}(.,\varpi))d\eta,\varpi)d\varepsilon|| \to$$
$$||\phi(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\delta'(\eta,\varpi),\int_0^\varepsilon \chi(\eta,\delta_\eta(.,\varpi))d\eta, \int_0^\omega \psi(\eta,\delta_\eta(.,\varpi))d\eta,\varpi)d\varepsilon||$$

and

$$||y(\varepsilon,\eta,\delta_{n\varepsilon}(.,\varpi),\varpi) - y(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\varpi)|| \leq 2\beta_{m_0}(\varepsilon,\varpi),$$
$$||\phi(\varepsilon,\eta,\delta_{n\varepsilon}(.,\varpi),\delta_{n'}(\eta,\varpi),\int_0^\varepsilon \chi(\eta,\delta_{n\eta}(.,\varpi))d\eta, \int_0^\omega \psi(\eta,\delta_{n\eta}(.,\varpi))d\eta,\varpi)d\varepsilon$$
$$-\phi(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\delta'(\eta,\varpi),\int_0^\varepsilon \chi(\eta,\delta_\eta(.,\varpi))d\eta,$$
$$\int_0^\omega \psi(\eta,\delta_\eta(.,\varpi))d\eta,\varpi)d\varepsilon|| \leq 2\alpha_{m_0}(\varepsilon,\varpi)$$

Now we apply by dominance convergence theorem

$$||(F(\varpi)\delta_n)(\zeta) - (F(\varpi)\delta)(\zeta)|| \leq \ \int_0^\zeta ||T_1(\zeta-\varepsilon)||||y(\varepsilon,\eta,\delta_{n\varepsilon}(.,\varpi),\varpi) - y(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\varpi)||d\varepsilon +$$
$$\int_0^\zeta ||T_2(\zeta-\varepsilon)||||\phi(\varepsilon,\eta,\delta_{n\varepsilon}(.,\varpi),\delta_{n'}(\eta,\varpi),$$
$$\int_0^\varepsilon \chi(\eta,\delta_{n\eta}(.,\varpi))d\eta, \int_0^\omega \psi(\eta,\delta_{n\eta}(.,\varpi))d\eta,\varpi)d\varepsilon$$
$$-\phi(\varepsilon,\eta,\delta_\varepsilon(.,\varpi),\delta'(\eta,\varpi),\int_0^\varepsilon \chi(\eta,\delta_\eta(.,\varpi))d\eta,$$
$$\int_0^\omega \psi(\eta,\delta_\eta(.,\varpi))d\eta,\varpi)d\varepsilon||$$

$$\to 0 \ \text{ as } \ n \to \infty$$

$$||(F(\varpi)\delta_n)'(\zeta) - (F(\varpi)\delta)'(\zeta)|| \leq \int_0^\zeta ||AT_2(\zeta - \varepsilon)||||y(\varepsilon, \eta, \delta_{n\varepsilon}(., \varpi), \varpi) - y(\varepsilon, \eta, \delta_\varepsilon(., \varpi), \varpi)||d\varepsilon +$$

$$\int_0^\zeta ||T_1(\zeta - \varepsilon)||||\phi(\varepsilon, \eta, \delta_{n\varepsilon}(., \varpi), \delta_{n'}(\eta, \varpi),$$

and

$$\int_0^\varepsilon \chi(\eta, \delta_{n\eta}(., \varpi))d\eta, \int_0^\omega \psi(\eta, \delta_{n\eta}(., \varpi))d\eta, \varpi)d\varepsilon$$

$$-\phi(\varepsilon, \eta, \delta_\varepsilon(., \varpi), \delta'(\eta, \varpi), \int_0^\varepsilon \chi(\eta, \delta_\eta(., \varpi))d\eta,$$

$$\int_0^\omega \psi(\eta, \delta_\eta(., \varpi))d\eta, \varpi)d\varepsilon||$$

$$\to 0 \quad \text{as} \quad n \to \infty$$

Therefore $||F(\varpi)\delta_n - F(\varpi)\delta||_\mathcal{D} \to 0$ as $n \to \infty$ and hence F is continuous. Therefore the operator F has a fixed point in $\mathcal{D}$. Hence the theorem.

CONCLUSION

This article examines the challenge of solving second-order neutral functional integro-differential equations characterized by infinite delays and stochastic influences. It showcases the application of the Schauder fixed-point theorem within a stochastic framework to establish the existence of solutions to such intricate equations. This study offers a robust theoretical foundation for resolving these complex mathematical problems by addressing the complications introduced by infinite delays. Furthermore, this research contributes significantly to the comprehension of these equations and extends their utility in real-world scenarios that involve unpredictable delays and randomness, emphasizing the practical significance of these theoretical advancements of these equations and their practical applications in situations involving delays and randomness.

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RESEARCH ARTICLE

Green Rework Warehouse Inventory Model with Drone Delivery System

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ABSTRACT

Green inventory management enfolds both economic and environmental cost parameters. Industrial sectors embrace green initiatives in the process of product production to product delivery. Manufacturing units with rework warehouse amenities contribute to defect handling in optimal time so as to maintain continuous demand fulfillment. However, the business sectors are hurdled by the problems of defectiveness and prompt end customer delivery. This research work proposes an inventory model encompassing the features of green rework warehouse together with drone delivery system. The model proposed in this work intends to optimize the costs incurred in handling the challenges of tackling the defective items and product delivery. The model is validated with a numerical example. The sensitivity analysis is made to determine the influence of various cost parameters on the total profit. The limitations of the model are also identified based on the results. This model is more environmentally more responsible as it encompasses both the concerns of economic and environment.

Keywords: Rework warehouse, Inventory, Green Inventory Management, Inventory Cost, Drone Delivery

INTRODUCTION

Inventory management is highly significant in every business sector to ensure persistent and non-interrupted production scenario. The industrial units are performing the phenomenal tasks of transforming raw materials to finished products by networking with their suppliers and customers. The manufacturing sectors are encircling

various modern machinery to produce defect-free products, however the chances of generating defective items exist. The occurrences of such errors are caused due to the conditions of machinery mismanagement and human negligence. To resolve such a crisis, rework warehouses are established for corrective mechanisms before the phase of end delivery. Warehouses and inventory management are closely related and hence maintained in general to stock the products of various forms, but these avenues are not equipped with the provisions of defect maintenance. To make so, these warehouses are further augmented with the capacities of reworking the defective items. These rework warehouses are highly advantageous as they avoid transporting the defective items to the production unit for repair. Manufacturing sectors put rework warehouses in use to minimize the time in repairing the defective items. Another significance of these warehouses is to facilitate direct delivery of the products to the customers within the stipulated period of time. However, these rework warehouses also encounter a few challenges of environment and delivery lags. Rework warehouses with eco-consciousness led to the emergence of green rework warehouses (GRW). Inventory researchers have contributed a lot to green warehouses but the concept of GRW is not discussed in the literature to the best of knowledge. The green rework warehouse is embedded with the characteristics of sustainable construction, efficient operations, renewable energy utilization in addition to the features of defect maintenance. Moreover, the drone delivery system is also adopted to fulfill the customer orders. Every business sector is planning out several strategies to regulate the system of product delivery. In the product distribution phase, the delivery chart is maintained for staging optimal delivery system to effectively sustain the customer relationship. Quality products with Eco-consciousness and Quick delivery systems are expected from the customer end. As the manufacturing sectors are turning customer centric, the inventory models have to be formulated suiting the dynamic requirements of the customers. This research work presents a more feasible inventory model encompassing the cost parameters of establishing and maintaining GRW and drone delivery system. The model proposed is based on the model developed by Renee et al. In this extended version, the costs associated with GRW and drone delivery system are included. The other contents of this paper are structured into the following sections. The state of art of related inventory models is briefly discussed in section 2. The model development is outlined in section 3. The numerical example and sensitivity analysis is made in section 4. The industrial applications and future directions are sketched out in the conclusion.

LITERATURE REVIEW

This section presents the recent state of art of inventory models discussed in the context of rework warehouses, product distribution with eco-consciousness. Green warehouses are characterized as a sustainable measure in inventory management. Mashud et al discoursed on a sustainable green warehouse with economic and carbon costs [1]. Domagala deliberated on the impacts of green warehouses in sustainable logistics [2]. Paul et al elicited green inventory model with carbon taxations [3]. Jaouhari et al discussed the potential of green warehouses in semiconductors industries [4]. Ren et al conferred optimization of green warehouses [5] and Wen discussed the associational impacts between green warehouse and inventory [6]. Parida et al, Perotti et al deliberated on the efficiency of green warehouses integrated inventory models [7][8]. Wahab et al described green warehouses adopting drone technology [9]. Drone delivery systems are integrated with warehouses in recent times. Smart warehouses are equipped with such a modern delivery mechanism to overcome the traffic congestion causing delivery lags. Rhiat et al discussed inventory management with smart warehouses using drones and robotics [10]. Piramuthu detailed drone system of delivery for perishable items [11]. Najy et al proposed collaborative truck-drone system [12]. Nishar and Ali et al presented the positive implications of drone technology in warehouse management [13] [14]. The afore-mentioned literature clearly states the formulation of inventory models encompassing green warehouses and drone delivery. However, the following research gaps are identified.

- Rework warehouse inventory model discussed by Renee et al is the initiative of developing a new genre of inventory model dealing with defective items. However, the concept of green rework warehouse is not conceptualized and explored.

- Inventory models with drone delivery systems and the costs associated with such a modern delivery system are unveiled.
- Integrated inventory models with warehouse management embedded with rework features, green initiatives and drone technology have not developed so far. To bridge these gaps, a comprehensive kind of inventory model is framed with the inclusion of cost parameters pertinent to green initiatives, rework and drone management. The development of such an inventory model will certainly aid the decision makers in cost optimization.

Model Development

The inventory model developed in this session incorporates the concept of a rework warehouse together with the distribution expenses associated with the drone delivery system. The overall representation of the system is represented in Figure 3.1.

Notation

β: Lot size is received from the production place

c: Production Cost per unit

D : Demand rate of the product

P: Total Percentage of re-workable items and non-reworkable items

P_W : Total Percentage of non-reworkable items to be disposed of.

t_1: Inspection period

t_2 : Period till receiving the reworked defective items

t_3 : Remaining period to consume the entire inventory

α_1 : Inventory level after the inspection period

α_2: Inventory level after separating the reworkable items and non-reworkable items

α_3 : Inventory level just before receiving the reworked defective items

α_4 : Inventory level just after receiving the reworked defective items

S: Selling price per unit of good quality items

H_c : Holding cost per unit

d : Inspection cost per unit

m : Inspection rate

v: transportation cost

L: Rework rate of defective items

T : Cycle length

R : Rework cost per unit

h : Holding cost per unit

P_C : Packaging cost per unit

C_C: Customizing cost per unit

G_M: Green marketing cost

G_D: Green disposing cost per unit

G_T: Solar energy cost in rework warehouse

i : the rate percentage of incentive

Assumptions

1) The quantity of good items is sufficient to satisfy the demand phase during the inspection period t_1

2) The quantity of good items and repaired items are sufficient to satisfy the demand phase during the period t_2

Description of the Problem

Given the distance between the production and distribution centers, any damage incurred during transit as a result of uneven roads or unanticipated weather conditions is addressed at the rework warehouse. At time t = 0, the lot is received. The process of inspection happens at time t_1. During this time, the faulty materials are sorted. The minor

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faulty item has a rework rate of L. After time t_1, the faulty products' rework is started. At the conclusion of time t_2, the defective items are fully reworked and upgraded to the inventory. Then, during the time interval t_3, the entire inventory is depleted. T is interpreted as the whole cycle length. The inventory level is α_1 at the conclusion of the inspection period. Following the elimination of faulty products, the inventory level is α_2. Prior to the revised faulty goods being added, the inventory level was α_3. Following the inclusion of reworked goods, the inventory level is α_4. In the meantime, the products are packaged using biodegradable materials and tailored based on the preferences of the consumer. The use of drone delivery systems satisfies customer demand for quick delivery.

Determination of Total profit per cycle

The total net revenue and total profit per cycle is determined as follows.

$$\alpha_1 = \left(1 - \frac{D}{m}\right)\beta$$

$$\alpha_2 = \alpha_1 - P\beta = \left(1 - P - \frac{D}{m}\right)\beta$$

$$\alpha_3 = \left(1 - P - \frac{D}{m} - \frac{DP_R}{L}\right)\beta$$

$$\alpha_4 = \left(1 - P_W - \frac{D}{m} - \frac{DP_R}{L}\right)\beta$$

$$t_1 = \frac{\beta}{m}, \ t_2 = \frac{\beta P_R}{L}, \ t_3 = \frac{Z_4}{D}$$

Procurement cost = $v + c\beta$

Rework cost = $RP_R\beta$

Inspection cost = $d\beta$

Holding cost = $h\left[\frac{(1-P_W)\beta T}{2} + \frac{\beta^2 P_W}{m} - \frac{\beta^2 P_R^2}{L}\right]$

Packaging cost = $P_C(1 - P_W)\beta$

Customizing cost = $C_C(1 - P_W)\beta$

Green marketing cost = G_M

Solar energy cost in rework warehouse = G_T

Incentive provided by the government for using solar energy = iG_T where i is the rate percentage of incentive

Drone delivery cost = Total cost of drone use + Renting cost of depots + Cost of conveyor for sorting the package + Energy cost for recharging and operating the depot

Total Cost related to drones = Unit cost of delivering a package * $(1 - P_W)\beta$

Renting cost of depots = C_D

Cost of conveyor for sorting the package = C_s

Energy cost for recharging and operating the depot = C_E

The Total Cost = Procurement Cost + Rework Cost + Inspection Cost + Holding Cost + Packaging Cost + Customizing Cost + Green Marketing Cost + Total solar energy cost + Drone delivery Cost + Green disposing cost

The Total Average Cost =

$$= \frac{vD}{\beta} + cD + RP_R D + dD + h\beta\left[\frac{(1-P_W)}{2} + \frac{DP_W}{m(1-P_W)} - \frac{DP_R^2}{L(1-P_W)}\right] + P_C(1-P_W)D + C_C(1-P_W)D + \frac{G_M D}{\beta}$$

$$+ \frac{(G_T - iG_T)D}{\beta} + U_D * (1-P_W)D + \frac{(C_D + C_s + C_E) * D}{\beta} + \frac{G_D * P_W * D}{\beta}$$

The total revenue gained is $S\beta$

The total net revenue per cycle is $\frac{S\beta}{T}$

The total profit per cycle is

$$SD - \left(\frac{vD}{\beta} + cD + RP_R D + dD + h\beta\left[\frac{(1-P_S)}{2} + \frac{DP_S}{m(1-P_W)} - \frac{DP_R^2}{L(1-P_W)}\right] + P_C(1-P_W)D + C_C(1-P_W)D + \frac{G_M D}{\beta}\right.$$

$$\left. + \frac{(G_T - iG_T)D}{\beta} + U_D * (1-P_W)D + \frac{(C_D + C_s + C_E) * D}{\beta} + \frac{G_D * P_W * D}{\beta}\right)$$

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Numerical Analysis

Consider an inventory system with the following : S: 700 $, D: 40000, v = 50 $, c= 20$, β= 5000, R = 20$, P_R = 0.2, d = 0.05, h = 5$, P_W = 0.02, m = 10000, L = 800, P_C = 20$, C_C = 60$, G_M = 100$, G_T = 600$, i = 0.7, U_D = 500$, C_D = 300$, C_S = 100$, C_E = 50$, G_D = 50$. The total profit obtained ≈ 4328882 $

Sensitivity Analysis

Sensitivity Analysis is performed by changing the parameters and determining the change in the Total Profit. Table 4.1 denotes the numerical values of the changes in Total Profit in accordance with change in parameters.

1. The Selling Price is one of the important parameters determining the total profit. If the selling price decreases, then the total profit decreases dramatically. If the selling price increases, the total profit increases dramatically. It is represented in Figure 4.1.
2. The demand parameter is moderately important in determining Total Profit. If demand increases, the total profit increases and if demand decreases, Total Profit decreases. It is represented in Figure 4.2.
3. Change in the lot size does not much affect the Total Profit. A decrease in the lot size very slightly decreases Total Profit and an increase in the lot size increases Total Profit. It is represented in Figure 4.3.
4. The total profit increases if the percentage of scrap increases. It is represented in Figure 4.4.The total profit decreases if the percentage of reworkable items increases. It is represented in Figure 4.5.
5. If the rework rate increases, the Total Profit slightly decreases. It is represented in Figure 4.6.
6. The Total Profit decreases hugely if the Total cost of drone use increases and Total profit decreases if the parameter decreases. It is represented in Figure 4.7.

CONCLUSION

The model discussed in this paper has several industrial applications as this model is an instance of exercising quality, eco-centered product delivery with modern distribution system. The cost parameters incorporated in this model reflect the actual cost incurred in implementing the green rework warehouse with drone delivery system. This model shall be employed by the business sectors in facilitating quick delivery of the quality items. The green rework warehouses possess the provisions of rectifying the defective items with eco-energy and this is the pavement for the emergence of green industries. The implementation of this comprehensive model will certainly facilitate the industries switch to sustainable status. This model shall be further extended by discussing the decision parameters in fuzzy and its extended environments. Moreover, the model shall also be analyzed with different demand patterns and with the inclusion of other production and product distribution constraints. The sensitivity analysis shall be made to determine the impacts of decision parameters on the total inventory costs.

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Table 1: Table representing Total Profit with respect to Change in parameters

% Change	Total Profit (S)	Total Profit (D)	Total Profit (β)	Total Profit (P_S)	Total Profit (P_R)	Total Profit (L)	Total Profit (U_D)
-15%	128881.59	3677711.8	4321634.2	4259401	4338723.4	4337885	7268881.5
-10%	1528881.5	3894768.4	4324114.4	4282561.3	4335187.7	4334550	6288881.5
-5%	2928881.5	4111825	4326526.8	4305721.5	4331907.1	4331566.	5308881.5
0%	4328881.5	4328881.5	4328881.5	4328881.5	4328881.5	4328881.6	4328881.5
5%	5728881.5	4545938.1	4331187	4352041.5	4326111.1	4326452	3348881.5
10%	7128881.5	4762994.7	4333449.8	4375201.4	4323595.8	4324243.4	2368881.5
15%	8528881.5	4980051.3	4335675.5	4398361.2	4321335.6	4322226.8	1388881.5
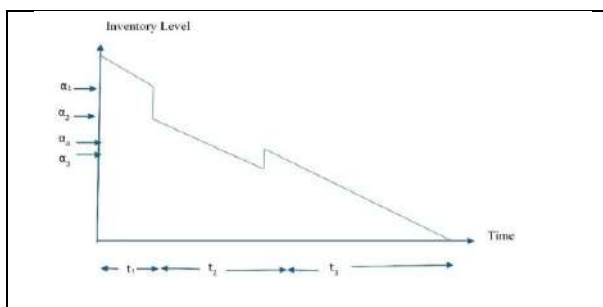
| **Figure 1: System Representation** | **Figure 2: Total Profit with respect to Change in S** |
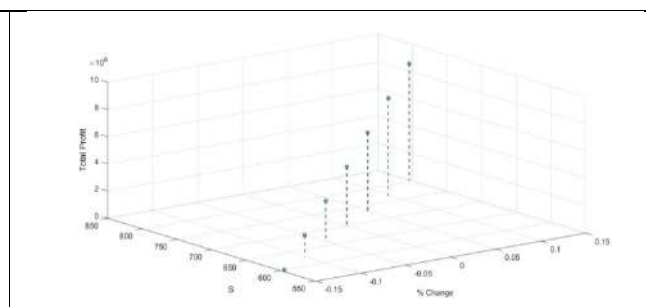
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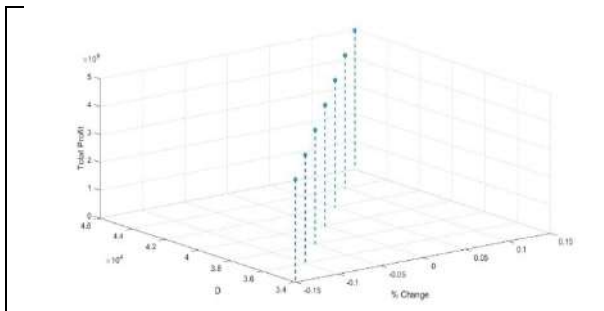
Figure 3: Total Profit with respect to Change in D
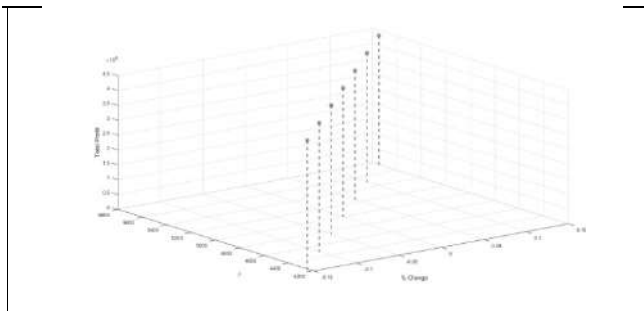
Figure 4 : Total Profit with respect to Change in β
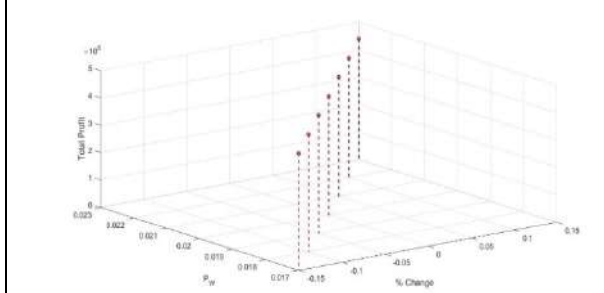
Figure 5: Total Profit with respect to Change in P$_W$
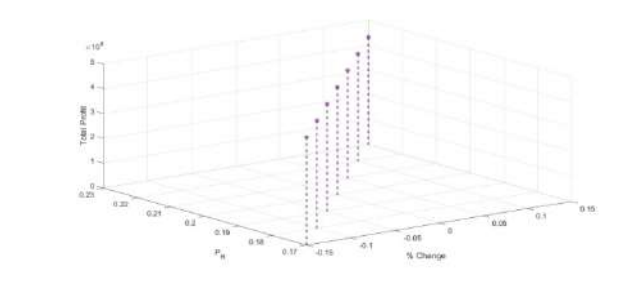
Figure 6: Total Profit with respect to Change in P$_R$
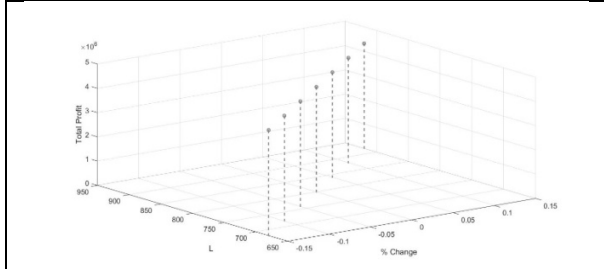
Figure 7: Total Profit with respect to Change in L
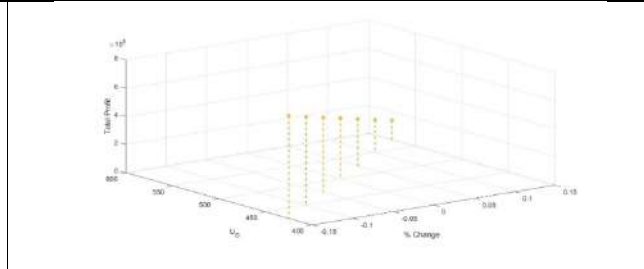
Figure 8: Total Profit with respect to Change in U$_D$

RESEARCH ARTICLE

Artificial Neural Network based MAGDM model with a New Class of Aggregation Operators for Trapezoidal Intuitionistic Fuzzy Sets

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ABSTRACT

Trapezoidal Intuitionistic Fuzzy Set (TzIFS) is an invaluable mathematical theory to express uncertain phenomenon in our real world. Firstly, the generalized aggregation operator is introduced for aggregating TzIFS information, such as the Generalized Trapezoidal Intuitionistic Fuzzy Weighted Averaging operator (GTzIFWA). Then, various properties of the proposed aggregation operator are established and then, the Modified Generalized Trapezoidal Intuitionistic Fuzzy Weighted Averaging operator (M-GTzIFWA) is developed and the evaluation of the MAGDM problem based on the proposed operator and Artificial Neural Network (ANN) under TzIFS environment is investigated. The TzIFS data is aggregated using M-GTzIFWA operator to produce individual column matrix which in turn is defuzzyfied using a new proposed Defuzzyfication function. The defuzzyfied entries are then used to compute the correlation coefficient for the final ranking of alternatives and also processed through an Artificial Neural Net (ANN)with hidden layers. The weights are initialized with random values and biases are set to be zero and the ReLU function is used for the hidden layer's activation. The forward pass, backward pass and the training loop helps adjust the weights and biases for the computations and finally the ranking of the best alternative is done based on the proposed ANN-MAGDM algorithm. A new type of A numerical illustration is provided with comparison of the proposed methods for effectiveness.

Keywords: Trapezoidal Intuitionistic Fuzzy Theory; Intuitionistic Fuzzy Set; Aggregation Operators; Weighted Averaging Operator; Artificial Neural Network.

INTRODUCTION

In the present global scenario, many real-life problems deal with either imprecise data or the various types of data involved with lot of ambiguity. Solving such problems with ambiguity is tedious, time consuming and cost involved task. Solving such problems using conventional decision-making algorithms is not an appropriate way to deal with the ambiguity involved in the problem. Hence, to deal with the ambiguity in those real-world problems, the Fuzzy Numbers (FN) can represent decision problems involving imprecise information in an appropriate manner; hence, they can be approached and dealt with and solved eventually using various algorithms with various aggregation operators and Artificial Intelligence (AI) techniques. As a further development, Intuitionistic Fuzzy sets (IFSs) was introduced and dealt with Deep Learning methodologies in [1]. Further, Trapezoidal Intuitionistic Fuzzy Numbers(TzIFNs) are most preferred by many researchers to solve problems with imprecise, adequate and qualitative information arising in day-to-day problems [5,7,8,9,11]. Researchers like all over the world have introduced and proposed various ranking techniques for comparing two arbitrary TzIFNs and one such is given in [7]. In this work, a new correlation coefficient for FNs is proposed in contrast with the existing correlation coefficients for FNs [3]. Most of the earlier correlation coefficients for FNs fall in the range [-1,1], where the correlation coefficient for FNs proposed in this work will fall in the range [0,1], which validates the positive attitude of the tool proposed. This correlation coefficient proposed is used to compare the final defuzzyfied values arising from the aggregation process of solving MAGDM problems and the perfect fuzzy number which will be used for the final comparison of the alternatives involved in solving the MAGDM problems. Along with the new correlation coefficient, a new defuzzyfication function is defined and proposed in this work for defuzzyfying the TzIFS values which will be ease to compute the Artificial Neural Net (ANN) for choosing the best alternative. Many authors have investigated ANN with some deep learning techniques [2,6,10] which will be useful to solve traditional MAGDM problems very easily. Hence this research work combines MAGDM along with some ANN techniques so that the overall decision making will be done with a good precision. Also, a new aggregation operator called the Modified Generalized Trapezoidal Intuitionistic Fuzzy Weighted Averaging (M-GTzIFWA) operator is proposed in the work since any aggregation process plays a vital role in decision making [4], for effective aggregation phase in solving the MAGDM problem.

The purpose of this paper is, therefore, to combine the ANN tools with the MAGDM solving techniques and propose a new algorithm to choose the best alternative from the available ones in a real life MAGDM problem. The remainder of this paper is organized as follows:1. Some basic concepts of the TzIFS is presented and a new defuzzification function is proposed.2. The new aggregation operator called the M-GTzIFWA operator is proposed with necessary properties and theorems. 3. A new correlation coefficient for fuzzy sets is proposed for ranking the alternatives which are defuzzyfied. 4. A new algorithm based on ANN is proposed to solve MAGDM problem. 5. Numerical illustration is provided for substantiating the theory and methods proposed. 6. Comparisons are made for the effectiveness of the proposed methods.

A NOVEL DEFUZZYFICATION FUNCTION FOR TZIFS AND THE G-TZIFWA OPERATOR
Now, a new defuzzification function for the TzIFNs will be proposed in the following:

Definition 1. If $\tilde{\alpha} = \big((a,b,c,d); \mu_{\tilde{\alpha}}, \gamma_{\tilde{\alpha}}\big)$ is a TzIFN, then $I(\tilde{\alpha})$ is called the Trapezoidal Intuitionistic Fuzzy Defuzzyfication (TzIFDF) function $\tilde{\alpha}$, where

$I(\tilde{\alpha}) = \frac{1}{8}\big[(a+b+c+d) \times \big(1 - \mu_{\tilde{\alpha}} - \gamma_{\tilde{\alpha}}\big)\big]$. Where $0 \leq I(\tilde{\alpha}) < 1$.

Generalized Intuitionistic Trapezoidal Fuzzy Aggregation Operators
In the following, the Modified Generalized Trapezoidal Intuitionistic Fuzzy Weighted Averaging (M-GTzIFWA) operator will be introduced with some properties and theorems proved.

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Definition-2 Let $\tilde{\alpha}_j = \left((a_j, b_j, c_j, d_j); \mu_{\tilde{\alpha}_j}, \gamma_{\tilde{\alpha}_j} \right) (j \in N)$ be a clump of TzIFNs, and let GTzIFWA:$F^n \to F$.Then

GTzIFWA$(\alpha_1, \alpha_2, \ldots, \alpha_n) = \left(w_1 \alpha_1^\lambda \oplus w_2 \alpha_2^\lambda \oplus \ldots \oplus w_n \alpha_n^\lambda \right)^{\frac{1}{\lambda}}$ is called the GTzIF aggregation operator, where$\lambda > 0$,$w = (w_1, w_2, \ldots, w_n)^T$ is a weight vector associated with the GTzIFWA operator, with$w_j \geq 0$, $j \in N$ and$\sum_{j=1}^n w_j = 1$.

Modified Generalized Intuitionistic Trapezoidal Fuzzy Weighted Average (M-GTzIFWA) Operator
In this section we modify the GTzIFWA operator by changing the orientation of λ as $1/\lambda$ so that the range of the aggregated trapezoidal part in the Trapezoidal Intuitionistic fuzzy information stays close to one.

Definition-3 Modified-GTzIFWA

Let $\tilde{\alpha}_j = \left((a_j, b_j, c_j, d_j); \mu_{\tilde{\alpha}_j}, \gamma_{\tilde{\alpha}_j} \right)$, $(j \in N)$ be a clump of TzIFNs, and let M-GTzIFWA:$F^n \to F$, then

M-GTzIFWA$(\alpha_1, \alpha_2, \ldots, \alpha_n) = \left(w_1 \alpha_1^{1/\lambda} \oplus w_2 \alpha_2^{1/\lambda} \oplus \ldots \oplus w_n \alpha_n^{1/\lambda} \right)^{\frac{1}{\lambda}}$

is called M-GTzIFWeighted Average operator, where $\lambda > 0$,$w = (w_1, w_2, \ldots, w_n)^T$ is a weight vector associated with the M-GTzIFWA operator, with$w_j \geq 0$, $j \in N$, and$\sum_{j=1}^n w_j = 1$.When$\lambda = 1$, then the M-GTzIFWA operator reduces to the TzIFWA operator. Hence,

$$M - GTzIFWA(\alpha_1, \alpha_2, \ldots, \alpha_n) = \left(\begin{array}{c} \left[\sum_{j=1}^n w_j a_j^{1/\lambda}, \sum_{j=1}^n w_j b_j^{1/\lambda}, \sum_{j=1}^n w_j c_j^{1/\lambda}, \sum_{j=1}^n w_j d_j^{1/\lambda} \right]; \\ (1 - \prod_{j=1}^n \left(1 - \mu_{\alpha_j} \right)^{w_j})^\lambda, 1 - (1 - \prod_{j=1}^n (1 - \left(1 - \gamma_{\alpha_j} \right))^{w_j})^\lambda \end{array} \right). \quad (1)$$

Theorem 1. Let $\tilde{\alpha}_j = \left((a_j, b_j, c_j, d_j); \mu_{\tilde{\alpha}_j}, \gamma_{\tilde{\alpha}_j} \right) (j \in N)$be a collection of TzIFNs, $w = (w_1, w_2, \ldots, w_n)^T$is the weight vector

of α_j $(j \in N)$ with $w_j \in [0,1]$and $\sum_{j=1}^n w_j = 1$. Then their aggregated value by using M-GTzIFWA operator is also a TzIFN and

$$M - GTzIFWA(\alpha_1, \alpha_2, \ldots, \alpha_n) = \left(\begin{array}{c} \left[\sum_{j=1}^n w_j a_j^{1/\lambda}, \sum_{j=1}^n w_j b_j^{1/\lambda}, \sum_{j=1}^n w_j c_j^{1/\lambda}, \sum_{j=1}^n w_j d_j^{1/\lambda} \right]; \\ (1 - \prod_{j=1}^n (1 - \mu_{\alpha_j})^{w_j})^\lambda, 1 - (1 - \prod_{j=1}^n (1 - (1 - \gamma_{\alpha_j}))^{w_j})^\lambda \end{array} \right)$$

Proof: We prove the Theorem 1 by using mathematical induction on n:
For n = 2.
$\tilde{\alpha}_1^{1/\lambda} = \left\langle [a_1^{1/\lambda}, a_1^{1/\lambda}, a_1^{1/\lambda}, a_1^{1/\lambda}]; \mu_{\tilde{\alpha}_1}^\lambda, 1 - \left(1 - \gamma_{\tilde{\alpha}_1} \right)^\lambda \right\rangle$ $(\lambda \geq 0)$,
$\tilde{\alpha}_2^{1/\lambda} = \left\langle [a_2^{1/\lambda}, a_2^{1/\lambda}, a_2^{1/\lambda}, a_2^{1/\lambda}]; \mu_{\tilde{\alpha}_2}^\lambda, 1 - \left(1 - \gamma_{\tilde{\alpha}_2} \right)^\lambda \right\rangle$ $(\lambda \geq 0)$.
Then

$$w_1 \tilde{\alpha}_1^{1/\lambda} \oplus w_2 \tilde{\alpha}_2^{1/\lambda} = \left(\begin{array}{c} \left[\prod_{j=1}^2 w_j a_j^{1/\lambda}, \prod_{j=1}^2 w_j a_j^{1/\lambda}, \prod_{j=1}^2 w_j a_j^{1/\lambda}, \prod_{j=1}^2 w_j a_j^{1/\lambda} \right]; \\ 1 - \prod_{j=1}^2 \left(1 - \mu_{\alpha_j}^\lambda \right)^{w_j}, \prod_{j=1}^2 \left(1 - \left(1 - \gamma_{\alpha_j} \right)^\lambda \right)^{w_j} \end{array} \right),$$

$(\lambda \geq 0)$

If this holds for $n = k$, that is

$$w_1 \tilde{\alpha}_1^{1/\lambda} \oplus w_2 \tilde{\alpha}_2^{1/\lambda} \oplus \ldots \oplus w_k \tilde{\alpha}_k^{1/\lambda} = \left(\begin{array}{c} \left[\prod_{j=1}^k w_j a_j^{1/\lambda}, \prod_{j=1}^k w_j a_j^{1/\lambda}, \prod_{j=1}^k w_j a_j^{1/\lambda}, \prod_{j=1}^k w_j a_j^{1/\lambda} \right]; \\ 1 - \prod_{j=1}^k \left(1 - \mu_{\alpha_j}^\lambda \right)^{w_j}, \prod_{j=1}^k \left(1 - \left(1 - \gamma_{\alpha_j} \right)^\lambda \right)^{w_j} \end{array} \right), (\lambda \geq 0).$$

Then, when n = k + 1, by the operational laws:
$w_1 \tilde{\alpha}_1^{1/\lambda} \oplus w_2 \tilde{\alpha}_2^{1/\lambda} \oplus \ldots \oplus w_k \tilde{\alpha}_{k+1}^{1/\lambda}$

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$$= \left\langle \left[\prod_{j=1}^k w_j a_j^{1/\lambda}, \ \prod_{j=1}^k w_j a_j^{1/\lambda}, \ \prod_{j=1}^k w_j a_j^{1/\lambda}, \ \prod_{j=1}^k w_j a_j^{1/\lambda} \right] ; 1 - \prod_{j=1}^k \left(1 - \mu_{\alpha_j}^\lambda\right)^{w_j}, \prod_{j=1}^k \left(1 - \left(1 - \gamma_{\alpha_j}\right)^\lambda\right)^{w_j} \right\rangle$$

$$\oplus \left\langle \left[w_{k+1} a_{k+1}^{1/\lambda}, w_{k+1} b_{k+1}^{1/\lambda}, w_{k+1} c_{k+1}^{1/\lambda}, w_{k+1} d_{k+1}^{1/\lambda} \right] ; \left(1 - \left(1 - \mu_{\alpha_{k+1}}^\lambda\right)^{w_{k+1}}, \left(1 - \left(1 - \gamma_{\alpha_{k+1}}\right)^\lambda\right)^{w_{k+1}}\right) \right\rangle$$

$$= \left\langle \left[\prod_{j=1}^{k+1} w_j a_j^{1/\lambda}, \ \prod_{j=1}^{k+1} w_j b_j^{1/\lambda}, \ \prod_{j=1}^{k+1} w_j c_j^{1/\lambda}, \ \prod_{j=1}^{k+1} w_j d_j^{1/\lambda} \right] ; 1 - \prod_{j=1}^{k+1} \left(1 - \mu_{\alpha_j}^\lambda\right)^{w_j}, \prod_{j=1}^{k+1} \left(1 - \left(1 - \gamma_{\alpha_j}\right)^\lambda\right)^{w_j} \right\rangle .$$

i.e. the result holds for $n = k + 1$. Thus, the equation in the statement of the theorem holds for all n. Then, the Theorem 1 is valid.

Example 1. Let
$\alpha_1 = ([0.301, 0.476, 0.594, 0.782]; 0.5, 0.4);$
$\alpha_2 = ([0.224, 0.456, 0.653, 0.903]; 0.8, 0.2),$
$\alpha_3 = ([0.381, 0.440, 0.523, 0.822]; 0.6, 0.3);$
$\alpha_4 = ([0.388, 0.501, 0.584, 0.792]; 0.7, 0.2)$ be four TzIFNs, and $w = (0.2, 0.3, 0.3, 0.2)^T$ be the weight vector of $\alpha_j (j = 1, 2, 3, 4)$. When the parameter λ takes different values, different aggregated values of the TzIFNs can be obtained as follows: When$\lambda = 1$,

$$M - GTzIFWA(\alpha_1, \alpha_2, \ldots, \alpha_n) = ([(0.301 * 0.2 + 0.224 * 0.3 + 0.381 * 0.3 + 0.388 * 0.2),$$
$$(0.476 * 0.2 + 0.456 * 0.3 + 0.440 * 0.3 + 0.501 * 0.2),$$
$$(0.594 * 0.2 + 0.653 * 0.3 + 0.523 * 0.3 + 0.584 * 0.2),$$
$$(0.782 * 0.2 + 0.903 * 0.3 + 0.822 * 0.3 + 0.792 * 0.2)];$$
$$(1 - [(1 - 0.5)^{0.2}(1 - 0.8)^{0.3}(1 - 0.6)^{0.3}(1 - 0.7)^{0.2}]),$$
$$1 - \left(1 - \left[\left(1 - (1 - 0.4)\right)^{0.2}\left(1 - (1 - 0.2)\right)^{0.3}\left(1 - (1 - 0.3)\right)^{0.2}\left(1 - (1 - 0.4)\right)^{0.2}\right]\right)).$$

$M - GTzIFWA(\alpha_1, \alpha_2, \ldots, \alpha_n) = ([0.3193, 0.4642, 0.5884, 0.8323]; 0.6793, 0.2595).$
The M-GTzIFWA operator has the following desirable properties.

Property 1. Let $\tilde{\alpha}_j = \left((a_j, b_j, c_j, d_j); \mu_{\tilde{\alpha}_j}, \gamma_{\tilde{\alpha}_j} \right) (j \in N)$and $\tilde{\alpha} = \left((a, b, c, d); \mu_{\tilde{\alpha}}, \gamma_{\tilde{\alpha}} \right)$ be a clump of TzIFNs. If for all j, $a_j = a, b_j = b, c_j = c, d_j = d, \mu_{\tilde{\alpha}_j} = \mu_{\tilde{\alpha}}, \gamma_{\tilde{\alpha}_j} = \gamma_{\tilde{\alpha}}$, then$M - GTzIFWA(\alpha_1, \alpha_2, \ldots, \alpha_n) = \alpha.$

Property 2. Let $\tilde{\alpha}_j = \left((a_j, b_j, c_j, d_j); \mu_{\tilde{\alpha}_j}, \gamma_{\tilde{\alpha}_j} \right) (j \in N)$ be a clump of TzIFNs, $\lambda > 0$, and $w = (w_1, w_2, \ldots, w_n)^T$ be the weight vector related to the M-GTzIFWA operator, with $w_j \geq 0$, $(j \in N)$, $\sum_{j=1}^n w_j = 1$, and let

$$\alpha_i^- = \left((\min\{a_j\}, \min\{b_j\}, \min\{c_j\}, \min\{d_j\}); \min\left\{\mu_{\tilde{\alpha}_j}\right\}, \min\left\{\gamma_{\tilde{\alpha}_j}\right\} \right) (j \in N),$$

$$\alpha_i^+ = \left((\max\{a_j\}, \max\{b_j\}, \max\{c_j\}, \max\{d_j\}); \max\left\{\mu_{\tilde{\alpha}_j}\right\}, \max\left\{\gamma_{\tilde{\alpha}_j}\right\} \right) (j \in N).$$

Then,$\alpha^- \leq M - GTzIFWA(\alpha_1, \alpha_2, \ldots, \alpha_n) \leq \alpha^+.$

Property 3. Let $\tilde{\alpha}_j = \left((a_j, b_j, c_j, d_j); \mu_{\tilde{\alpha}_j}, \gamma_{\tilde{\alpha}_j} \right) (j \in N)$ and $\beta_j = \left((e_j, f_j, g_j, h_j); \mu_{\beta_j}, \gamma_{\beta_j} \right) (j \in N)$be two clump of TzIFNs and $w = (w_1, w_2, \ldots, w_n)^T$ be the weight vector related to the M-GTzIFWA operator, where $w_j \geq 0$, $(j \in N)$, and $\sum_{j=1}^n w_j = 1$, $\lambda > 0$, if $a_j \leq e_j, b_j \leq f_j, c_j \leq g_j, d_j \leq h_j, \mu_{\tilde{\alpha}_j} \leq \mu_{\beta_j}$ and $\gamma_{\tilde{\alpha}_j} \geq \gamma_{\beta_j}$, for all j, then
$M - GTzIFWA(\alpha_1, \alpha_2, \ldots, \alpha_n) \leq M - GTzIFWA(\beta_1, \beta_2, \ldots, \beta_n).$

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CORRELATION COEFFICIENT FOR FUZZY SETS DERIVED FROM DEFUZZYFICATION PROCESS

Let $\tilde{A} = \{(u_{\tilde{A}})\}, \tilde{B} = \{(u_{\tilde{B}})\}$ be two Fuzzy Numbers. Then the Informational FuzzyEnergy of $\tilde{A}$ and $\tilde{B}$ are defined as follows:

$$E_{FN}(\tilde{A}) = \frac{1}{n}\sum_{n}[(u_{\tilde{A}}^2(x_i) + (1 - u_{\tilde{A}}(\tilde{x}_i))^2)] \tag{1}$$

$$E_{FN}(\tilde{B}) = \frac{1}{n}\sum_{n}[(u_{\tilde{B}}^2(x_i) + (1 - u_{\tilde{B}}(\tilde{x}_i))^2)] \tag{2}$$

Now the correlation between $\tilde{A}$ and $\tilde{B}$ is defined as:

$$C_{FN}(\tilde{A}, \tilde{B}) = \frac{1}{n}\sum_{i=1}^{n}\{[u_{\tilde{A}}(\tilde{x}_i)u_{\tilde{B}}(\tilde{x}_i)] + ([1 - u_{\tilde{A}}(\tilde{x}_i)][1 - u_{\tilde{B}}(\tilde{x}_i)])\} \tag{3}$$

Then the correlation coefficient between $\tilde{A}$ and $\tilde{B}$ is defined as:

$$K_{FN}(\tilde{A}, \tilde{B}) = \frac{C_{FN}(\tilde{A}, \tilde{B})}{\sqrt{E_{FN}(\tilde{A}) \cdot E_{FN}(\tilde{B})}}. \tag{4}$$

Proposition

For $\tilde{A}, \tilde{B} \in$ FN(X), the following are true: (i) $0 \le C_{FN}(\tilde{A}, \tilde{B}) \le 1$,(ii) $C_{FN}(\tilde{A}, \tilde{B}) = C_{FN}(\tilde{B}, \tilde{A})$, (iii) $K_{FN}(\tilde{A}, \tilde{B}) = K_{FN}(\tilde{B}, \tilde{A})$,(iv) $K_{FN}(\tilde{A}, \tilde{B}) = 1$ if $\tilde{A} = \tilde{B}$.

Theorem 1 For $\tilde{A}, \tilde{B} \in$ FN(X), then $0 \le K_{FN}(\tilde{A}, \tilde{B}) \le 1$.

Proof. Since $C_{FN}(\tilde{A}, \tilde{B}) \ge 0$, it can be proved that $K_{FN}(\tilde{A}, \tilde{B}) \le 1$. For any arbitrary real number ξ, the following inequality is true:

$0 \le \sum_{i=1}^{n}\{[(u_{\tilde{A}}(x_i) - \xi u_{\tilde{B}}(x_i))^2]\} = \sum_{i=1}^{n}[(u_{\tilde{A}}^2(x_i)) - 2\xi(u_{\tilde{A}}(x_i)u_{\tilde{B}}(x_i)) + \xi^2(u_{\tilde{B}}^2(x_i))].$

Hence,$\{\sum_{i=1}^{n}[(u_{\tilde{A}}(x_i)u_{\tilde{B}}(x_i))]\}^2 \le \sum_{i=1}^{n}\{(u_{\tilde{A}}^2(x_i))\} \times \sum_{i=1}^{n}\{(u_{\tilde{B}}^2(x_i))\}$

The above inequality can be written as:

$\frac{\{\sum_{i=1}^{n}[(u_{\tilde{A}}(x_i)u_{\tilde{B}}(x_i))]\}^2}{\sum_{i=1}^{n}\{(u_{\tilde{A}}^2(x_i))\} \times \sum_{i=1}^{n}\{(u_{\tilde{B}}^2(x_i))\}} \le 1.$

Therefore$\frac{\{C_{FN}(\tilde{A}, \tilde{B})\}^2}{E_{FN}(\tilde{A}) \cdot E_{FN}(\tilde{B})} \le 1$. Hence $K_{FN}(\tilde{A}, \tilde{B}) = \frac{C_{FN}(\tilde{A}, \tilde{B})}{\sqrt{E_{FN}(\tilde{A}) \cdot E_{FN}(\tilde{B})}} \le 1.$

Theorem 2. $K_{FN}(\tilde{A}, \tilde{B}) = 1 \Leftrightarrow \tilde{A} = \tilde{B}$.

Proof. Considering the inequality in the proof of theorem 1, then the equality holds if and only if the following are true: (i) $u_{\tilde{A}}(x_i) = \xi u_{\tilde{B}}(x_i)$, (ii) $[1 - u_{\tilde{A}}(x_i)] = \xi[1 - u_{\tilde{B}}(x_i)]$, for some positive real ξ.As $u_{\tilde{A}}(x_i) + [1 - u_{\tilde{A}}(x_i)] = u_{\tilde{B}}(x_i) + [1 - u_{\tilde{B}}(x_i)] = 1$, then it means $\xi = 1$, and therefore $\tilde{A} = \tilde{B}$.

Theorem 3. $C_{FN}(\tilde{A}, \tilde{B}) = 0 \Leftrightarrow \tilde{A}$ and $\tilde{B}$ are non-fuzzy sets and satisfy the condition $u_{\tilde{A}}(x_i) + u_{\tilde{B}}(x_i) = 1, \forall x_i \in$ X.

Proof. For all $x_i \in$ X, $(u_{\tilde{A}}(x_i)u_{\tilde{B}}(x_i) + [1 - u_{\tilde{A}}(x_i)][1 - u_{\tilde{B}}(x_i)]) \ge 0$.If $C_{FN}(\tilde{A}, \tilde{B}) = 0$for all $x_i \in$ X, then it should be that: $u_{\tilde{A}}(x_i) \cdot u_{\tilde{B}}(x_i) = 0$ and $[1 - u_{\tilde{A}}(x_i)][1 - u_{\tilde{B}}(x_i)] = 0$. If $u_{\tilde{A}}(x_i) = 1$ then $u_{\tilde{B}}(x_i) = 0$ and $[1 - u_{\tilde{A}}(x_i)] = 0$. If $u_{\tilde{B}}(x_i) = 1$ then $u_{\tilde{A}}(x_i) = 0$ and $[1 - u_{\tilde{B}}(x_i)] = 0$. Hence $u_{\tilde{A}}(x_i) + u_{\tilde{B}}(x_i) = 1$.Conversely, When A and B are non-fuzzy sets and $u_{\tilde{A}}(x_i) + u_{\tilde{B}}(x_i) = 1$. If $u_{\tilde{A}}(x_i) = 1$ then $u_{\tilde{B}}(x_i) = 0$ and $[1 - u_{\tilde{A}}(x_i)] = 0$. If $u_{\tilde{B}}(x_i) = 1$ then $u_{\tilde{A}}(x_i) = 0$ and $[1 - u_{\tilde{B}}(x_i)] = 0$.Therefore $C_{FN}(\tilde{A}, \tilde{B}) = 0$.

Theorem 4. $E_{FN}(\tilde{A}) = 1 \Leftrightarrow \tilde{A}$ is a non-fuzzy set.

Proof. If $\tilde{A}$ is a non-fuzzy set, then $E_{FN}(\tilde{A}) = 1$ is obvious. Conversely, it can be proved by the method of contradiction. Assume $\tilde{A}$ is not a non-fuzzy set. Then $0 \le u_{\tilde{A}}(x_i) < 1$ and $0 \le 1 - u_{\tilde{A}}(x_i) < 1$ for some x_i. Hence $u_{\tilde{A}}^2(x_i) + [1 - u_{\tilde{A}}(x_i)]^2 < 1$. Then $E_{FN}(\tilde{A}) = \frac{1}{n}\sum_{i=1}^{n}(u_{\tilde{A}}^2(x_i) + [1 - u_{\tilde{A}}(x_i)]^2) < 1$. This is a contradiction. Hence $\tilde{A}$ is a non-fuzzy set.

DECISION MAKING USINGM-GTZIFWA OPERATORFOR ANN-MAGDM

In this Section, we will apply the TzIFN aggregation operators to MAGDM problem with the application of Artificial Neural Network (ANN). Let $Y = \{X_1, X_2, \ldots, X_m\}$ be the set of alternatives, $C = \{C_1, C_2, \ldots, C_n\}$ the set of criteria. The decision makers evaluate the objects (the criterion C_j for the alternative X_i) and expressed by TzIFNs α_{ij}. Based on the combination of the new M-GTzIFW Aaggregation operator, the new Defuzzyfication function and the proposed ANN algorithm, the choice of the best alternative is performed as follows:

Step-1 Aggregate the TzIFNs α_{ij} for each alternative X_i by the M-GTzIFWA operator.

Step-2 Utilize the proposed Defuzzyfication function $I(\tilde{\alpha})$ and Defuzzify the collective TzIFNs obtained after aggregating with M-GTzIFWA operator.

Step-3 Utilize the proposed Correlation Coefficient of FNs and rank the alternatives.

Step-4 Utilize the defuzzyfied values of the obtained column matrix at different λ levels as the input vector for the Neural Network.
//*Process of ANN with the Y values as inputs at different λ Levels *//

Step-5 Parameters Initialization
- Define the network's architecture with n inputs as obtained from the defuzzification process, a hidden layer of 10 neurons, and 1 output with n different ranking of the decision alternatives.
- Initialize weights and biases for both layers using random values (for weights) and zeros (for biases).

Step-6 Activation Function
- Use the ReLU (Rectified Linear Unit) function for the hidden layer's activation, which helps introduce non-linearity into the model.

Step-7 Forward Pass
- This function computes the outputs of the hidden and output layers by performing matrix multiplications and adding biases.

Step-8 Backward Pass
- This function calculates the gradients of the loss with respect to weights and biases using the chain rule.
- It updates the weights and biases to minimize the loss.
- The forward and backward pass functions are designed to handle the entire batch of input samples (X_data) and their targets (y_data)

Step-9 Training Loop:
- The loop runs for a specified number of epochs. In each epoch, it performs a forward and backward pass to adjust the weights and biases.
- Every 100 epochs, it produces the current loss to track the training progress.

Step-10 Final Prediction

- After training, we perform a final forward pass to see the network's prediction on the input data.

NUMERICAL ILLUSTRATION

In the recent years, the enrollment of pupil in institutions for higher education have gone to a peak, and perhaps the stakeholders expect much ofimprovement in the quality of the education provided by the institutions. As a result, most of the institutions around the globe are working hard to strengthen the quality in teaching, monitoring and protecting the quality of the curriculum. Many institutions have developed their own mechanisms of obtaining the feedback from the stakeholders past and present in order to improve and maintain a conducive environment for Teaching-Learning. Hence it is of much importance for the administrators of any institution to develop new mechanisms to ensure quality education is provided for the students opting their institutions for higher studies.

Currently, the Department of Mathematics of a leading college in the city of Tiruchirappalli, Tamilnadu, India, of Bharathidasan University is planning to introduce a new course which will bridge the gap between the curriculum provided and the job market in IT industry in the country. This course comprehensively aims to focus on providing expertise in Data Analytics and Computer Applications coupled with higher Mathematical skills and aptitude, networking and communications, and other means of modern information technology, and more to mention.For the beginning of the new program, 5 qualified professors$(X_i(i = 1,2,3,4,5))$ can be employed who will be evaluated by experts panel of the department of Mathematical Sciences and Computational Sciences from some of the renowned institutes in the country, mainly from the following three attributes, i)Teaching Aptitude (C_1), ii) Subject Expertise$(C_2)$and iii) Ability to mobilize technology based classroom(C_3).The weight vector provided for the evaluation by the experts is $(0.34, 0.42, 0.24)^T$. The experts evaluation of the 5 professorswere provided as TzIFNS and is shown in Table 1.

Table 1.Experts' Evaluation data of 5 Professors under 3 Attributes

	C_1	C_2	C_3
X_1	$((0.3,0.4,0.6,0.8);0.8,0.2)$	$((0.3,0.4,0.7,0.8);0.4,0.5)$	$((0.2,0.3,0.5,0.6);0.3,0.6)$
X_2	$((0.2,0.4,0.7,0.8);0.3,0.5)$	$((0.3,0.5,0.8,0.9);0.7,0.2)$	$((0.2,0.3,0.4,0.7);0.4,0.2)$
X_3	$((0.2,0.3,0.5,0.6);0.4,0.6)$	$((0.2,0.3,0.4,0.5);0.8,0.1)$	$((0.3,0.5,0.6,0.9);0.5,0.1)$
X_4	$((0.4,0.6,0.7,0.8);0.5,0.4)$	$((0.4,0.5,0.6,0.7);0.9,0.1)$	$((0.2,0.3,0.5,0.6);0.5,0.3)$
X_5	$((0.1,0.2,0.7,0.8);0.9,0.1)$	$((0.2,0.3,0.6,0.7);0.5,0.3)$	$((0.3,0.4,0.5,0.6);0.8,0.2)$

When the parameter λtakes different values, the aggregated TzIFNs can be obtained as shown in Table 2. The corresponding defuzzyfied values are shown in Table 3.

$$M - GTzFWA(\alpha_1, \alpha_2, \ldots, \alpha_n)$$

$$= \left(\left[\sum_{j=1}^{n} w_j a_j^{1/\lambda}, \sum_{j=1}^{n} w_j b_j^{1/\lambda}, \sum_{j=1}^{n} w_j c_j^{1/\lambda}, \sum_{j=1}^{n} w_j d_j^{1/\lambda} \right]; \quad (1 - \prod_{j=1}^{n} \left(1 - \mu_{\alpha_j}^{\lambda} \right)^{w_j})^{1/\lambda}, 1 - (1 - \prod_{j=1}^{n} (1 - \left(1 - \gamma_{\alpha_j} \right)^{\lambda})^{w_j})^{1/\lambda} \right)$$

$\alpha_1 = ([0.3,0.4,0.6,0.8]; 0.8,0.2), \alpha_2 = ([0.3,0.4,0.7,0.8]; 0.4,0.5),$

$\alpha_3 = ([0.2,0.3,0.5,0.6]; 0.3,0.6).$ And $w = (0.34,0.42,0.24)^T.$

When $\lambda = 1, M - GITFWA(\alpha_1, \alpha_2, \ldots, \alpha_n) = ([(0.34 * 0.3 + 0.42 * 0.3 + 0.24 * 0.2),$

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$(0.34 * 0.4 + 0.42 * 0.4 + 0.24 * 0.3), (0.34 * 0.6 + 0.42 * 0.7 + 0.24 * 0.5), (0.34 * 0.8 + 0.42 * 0.8 + 0.24 * 0.6)]$; $(1 - [(1 - 0.8)^{0.34}(1 - 0.4)^{0.42}(1 - 0.3)^{0.24}]), 1 - (1 - [(1 - (1 - 0.2))^{0.34}(1 - (1 - 0.5))^{0.42}(1 - (1 - 0.6))^{0.24}])) M -$

$GITFWA(\alpha_1, \alpha_2, \dots, \alpha_n) = ([0.2760, 0.3760, 0.6180, 0.7520]; 0.5715, 0.3825)$

When $\lambda = 3$, $M - GITFWA(\alpha_1, \alpha_2, \dots, \alpha_n) = ([(0.3^{1/3} * 0.34 + 0.3^{1/3} * 0.42 + 0.2^{1/3} * 0.24), (0.4^{1/3} * 0.34 + 0.4^{1/3} * 0.42 + 0.3^{1/3} * 0.24), (0.6^{1/3} * 0.34 + 0.7^{1/3} * 0.42 + 0.5^{1/3} * 0.24), (0.8^{1/3} * 0.34 + 0.8^{1/3} * 0.42 + 0.6^{1/3} * 0.24)]; (1 - [(1 - 0.8^3)^{0.34}(1 - 0.4^3)^{0.42}(1 - 0.3^3)^{0.24}])^{\frac{1}{3}}, 1 - (1 - [(1 - (1 - 0.2))^3)^{0.34}(1 - (1 - 0.5))^3)^{0.42}(1 - (1 - 0.6))^3)^{0.24}])^{\frac{1}{3}})$.

$M - GITFWA(\alpha_1, \alpha_2, \dots, \alpha_n) = ([0.6519, 0.7229, 0.8515, 0.9088]; 0.6541, 0.3530)$.

When $\lambda = 5$, $M - GITFWA(\alpha_1, \alpha_2, \dots, \alpha_n) = ([0.7713, 0.8214, 0.9070, 0.9435]; 0.6655, 0.3251)$.

When $\lambda = 10$, $M - GITFWA(\alpha_1, \alpha_2, \dots, \alpha_n) = ([0.8781, 0.9062, 0.9523, 0.9713]; 0.7209, 0.2784)$.

Similarly all the other aggregated values can be computed and are registered in the following table.

Table 2. Intuitionistic trapezoidal fuzzy numbers obtained by the M-GTzIFWA operator

	M-GITFWA when $\lambda = 1$
X_1	$((0.2760, 0.3760, 0.6180, 0.7520); 0.5715, 0.3825)$
X_2	$((0.2420, 0.4180, 0.6700, 0.8180); 0.5274, 0.2731)$
X_3	$((0.2240, 0.3480, 0.4820, 0.6300); 0.6380, 0.1839)$
X_4	$((0.3520, 0.4860, 0.6100, 0.7100); 0.7457, 0.2085)$
X_5	$((0.1900, 0.2900, 0.6100, 0.7100); 0.7678, 0.1873)$
	M-GITFWA when $\lambda = 3$
X_1	$((0.6519, 0.7229, 0.8515, 0.9088); 0.6541, 0.3530)$
X_2	$((0.6233, 0.7467, 0.8698, 0.9349); 0.5673, 0.2602)$
X_3	$((0.6081, 0.7017, 0.7837, 0.8532); 0.6690, 0.1627)$
X_4	$((0.7028, 0.7828, 0.8480, 0.8920); 0.7748, 0.1964)$
X_5	$((0.5673, 0.6596, 0.8480, 0.8920); 0.7881, .1820)$
	M-GITFWA when $\lambda = 5$
X_1	$((0.7713, 0.8213, 0.9070, 0.9435); 0.6655, 0.3251)$
X_2	$((0.7505, 0.8373, 0.9181, 0.9599); 0.5995, 0.2491)$
X_3	$((0.7395, 0.8063, 0.8624, 0.9076); 0.6957, 0.1487)$
X_4	$((0.8067, 0.8613, 0.9047, 0.9329); 0.7988, 0.1847)$
X_5	$((0.7076, 0.7764, 0.9047, 0.9329); 0.8049, 0.1765)$
	M-GITFWA when $\lambda = 10$
X_1	$((0.8781, 0.9062, 0.9523, 0.9713); 0.7209, 0.2784)$
X_2	$((0.8661, 0.9149, 0.9578, 0.9797); 0.6425, 0.2308)$
X_3	$((0.8598, 0.8977, 0.9285, 0.9524); 0.7363, 0.1307)$
X_4	$((0.8978, 0.9277, 0.9211, 0.9658); 0.8353, 0.1613)$

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X_5	$\big((0.8404, 0.8808, 0.9511, 0.9658); 0.8322, 0.1629\big)$

When $\lambda = 1$, $X_1 = \big((0.2760, 0.3760, 0.6180, 0.7520); 0.5715, 0.3825\big)$.

Let us compute the defuzzyfied value for X_1, the correlation coefficients and the ANN process simultaneously.

$$Y_1 = I(\alpha) = \frac{1}{8}\big[(a + b + c + d) \times (1 - \mu_{\alpha^-} - \gamma_{\alpha^-})\big]$$

$= \frac{1}{8}\big[(0.2760 + 0.3760 + 0.6180 + 0.7520) * (1 - 0.5715 - 0.3825)\big]$ $Y_1 = I(\alpha)= 0.01162$.

Similarly, computing all the other values, we can observe the following:

Table 3.TzIFNs obtained by the Defuzzyfication operator $I(\tilde{\alpha})$

$I(\alpha)$	Y_1	Y_2	Y_3	Y_4	Y_5
$\lambda = 1$	0.01162	0.05356	0.03749	0.01235	0.01010
$\lambda = 3$	0.00113	0.06845	0.06199	0.01161	0.01108
$\lambda = 5$	0.00404	0.06559	0.06449	0.00723	0.00772
$\lambda = 10$	0.00032	0.05889	0.06048	0.00157	0.00222

Table 4.Computations of Correlation coefficient and ranking of Alternatives

Computations with $\lambda = 1$					
$I(\alpha)$	Y_1	Y_2	Y_3	Y_4	Y_5	Ranking of Alternatives
$\lambda = 1$	0.01162	0.05356	0.03749	0.01235	0.01010	
E(Y_i)	0.9884	0.8975	0.9278	0.9755	0.9800	
E(Y_j)	1	1	1	1	1	
C(Y_i, Y_j)	0.01162	0.05356	0.03749	0.01235	0.01010	$X_2 > X_3 > X_4 > X_1 > X_5$
K(Y_i, Y_j)	0.01168	0.05653	0.03892	0.01250	0.01020	
Computations with $\lambda = 3$					
$I(\alpha)$	Y_1	Y_2	Y_3	Y_4	Y_5	Ranking of Alternatives
$\lambda = 3$	0.00113	0.06845	0.06199	0.01161	0.01108	
E(Y_i)	0.9977	0.8730	0.8837	0.9770	0.9780	
E(Y_j)	1	1	1	1	1	
C(Y_i, Y_j)	0.00113	0.06845	0.06199	0.01161	0.01108	$X_2 > X_3 > X_4 > X_5 > X_1$
K(Y_i, Y_j)	0.00113	0.07325	0.06594	0.01174	0.01120	

Output received through the ANN process

OUTPUT: Final predictions for the 5 input samples given in Table-3:

Epoch 0, Loss: 0.011006005409875142

Epoch 100, Loss: 0.0036724357576259394

Epoch 200, Loss: 0.0016674862841974177

Epoch 300, Loss: 0.0007781076064813002

Epoch 400, Loss: 0.00038169771180886377

Epoch 500, Loss: 0.00020477407570497862

Epoch 600, Loss: 0.00012577045831853442

Epoch 700, Loss: 9.048000946600861e-05

Epoch 800, Loss: 7.470814944766635e-05
Epoch 900, Loss: 6.765232379683171e-05
[[0.09598131 0.09786093 0.10853524 0.09060561 0.07356854]
A3>A2>A1>A4>A5
 [0.10005516 0.09603084 0.09462111 0.1015855 0.10356258]
A5>A4>A1>A2>A3
 [0.09859891 0.10023022 0.09264853 0.10180767 0.1141067]
A5>A4>A2>A1>A3
 [0.09745681 0.10113613 0.09577964 0.09918899 0.10805433]]
A5>A2>A4>A1>A3

Comparing the rankings obtained from Correlation coefficient and the ANN process reveals that A_5, A_3 and A_2 play a prominent role in the choice of best alternatives.

CONCLUSION

In this work, we have investigated the trapezoidal intuitionistic fuzzy information aggregation problems and proposed the Modified Generalized Intuitionistic Trapezoidal Fuzzy Weighted Averaging (M-GTzIFWA) operator. Some desirable properties of the M-GTzIFWA have also been studied in this work with some properties and theorems being proved for the validity of the proposed concepts. In addition, a defuzzification function and a correlation coefficient are newly proposed for ranking the best alternatives. Furthermore, we have applied the M-GTzIFWA operator to MAGDM problem, a real problem about the evaluation of teaching quality in an Institute is provided. In the process of Artificial Neural Network combined with MAGDM problems the process of **Data Normalization** is performed in practical applications, consider normalizing or standardizing input data for better performance and faster convergence. Then the **Model Tuning** is done to adjust the number of neurons in the hidden layer, learning rate, and number of epochs to find the best configuration for the specific data and problem. Finally, the desired output is received after some finite number of iterations of weight updation with several hidden layers and learning rules. Hence the **extensibility of t**his basic structure can be extended with more complex architectures in the future research (e.g., multiple hidden layers) and other activation functions could also be employed for providing a better decision support system.

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RESEARCH ARTICLE

On Connected Detour Eccentric Domination in Graphs

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ABSTRACT

The connected detour eccentric dominating set and the connected detour eccentric domination numbers are defined in this paper. Connected detour eccentric domination numbers for various well-known graphs and family of graphs are obtained. The minimum and maximum cardinality of a connected detour eccentric dominating set are described in this study, and theorems relating to these concepts are stated and proved.

Keywords: Dominating set, Domination number, Detour eccentric dominating set, Detour eccentric domination number, Connected detour eccentric dominating set, Connected detour eccentric domination number.
Mathematics Subject Classification (2010) : 05C12, 05C69.

INTRODUCTION

The investigation of dominating sets in graphs was started by Ore [1]. H.B. Walikar and E. Sampathkumar [5] talked about the connected domination number. Eccentric domination in graphs is a concept that was developed by T.N. Janakiraman and M. Bhanumathi [3]. A. Mohamed Ismayil and R. Priyadharshini established the detour eccentric domination in graphs for the first time [4]. R. Jahir Hussain and A. Fathima Begam researched connected eccentric domination in graphs [2]. This paper covers the connected detour eccentric dominating set and its numbers.

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PRELIMINARY

Definition:2.1.[3]Any graph can be represented by $G = (V, E)$, where V stands for the set of vertices and E stands for the set of edges. The *order* of G is equal to the number of elements in a vertex set V, denoted by n and the *size* of G is equal to the number of elements in an edge set E, denoted by m. The shortest $u - v$ path, indicated by $d(u, v)$, measures the distance between u and v.The *eccentricity* of u is given by $e(u) = \max\{d(u, v) : v \in V, u \neq v\}$, where u and v can be any two vertices in a connected graph G. If $d(u, v) = e(u)$, a vertex v of G is said to be an *eccentric vertex* of u.

Definition:2.2.[4]The distance $D(u, v)$ is known as the *detour distance* and is determined by the length of the longest $u - v$ path in the connected graph G if u and v are any two vertices. Each vertex u of G is *detour eccentricity* is given by the formula $e_D(u) = \max\{D(u, v) : v \in V\}$. A vertex v of G is referred to as the *detour eccentric vertex (DEV)* of u when $D(u, v) = e_D(u)$.

Definition:2.3.[1]A set in a graph G is said to be a *dominating set(D-set)* if every vertex in $V - D$ is adjacent to at least one vertex in D. The domination number is defined and indicated by the equation $\gamma(G) = \min\{|D_i| | D_i \text{ is a D} - \text{set}\}$.

Definition:2.4.[5] A *connected dominating set (CD-set)D* to be a D-set D whose induced subgraph $\langle D \rangle$ is connected. The minimal cardinality of a CD-set is the connected domination number$\gamma_C(G)$ of a connected graph G.

Definition:2.5.[3]If D is a D-set of G andthere is at least one eccentric point in v in $D$for every $v \in V - D$, then the set $D \subseteq V(G)$ is an *eccentric domination set (ED-set)*.

Definition:2.6.[4]If for every v in the D-set $D \subseteq V$ of a graph G, there exists at least one detour eccentric vertex $u \in V - D$ the set is known as a *detour eccentric dominating set (DED-set)*. The detour eccentric domination number is indicated and defined by the expression $\gamma_{DE}(G) = \min\{|D_i| / D_i \text{ is a DED-set}\}$.

Definition:2.7.[2]If D is an ED-set of G and the induced subgraph $\langle D \rangle$ is connected, then the set $D \subseteq V(G)$ is a *connected eccentric dominating set (CED-set)*. If no proper subset D' of D is a CED-set, then the CED-set is a minimal connected eccentric dominating set. A minimum CED-set is the minimal connected eccentric dominating set with the smallest cardinality. The connected eccentric domination number, indicated by $\gamma_{CE}(G)$, is the cardinality of the smallest CED-set.

Theorem:2.8.[6] For any connected graph G, $\gamma_C(G) = n - \Delta(G)$.

Theorem:2.9.[6] For any connected graph G, $\gamma_C(G) \leq n + e(G) - \varepsilon_T(G)$, where $\varepsilon_T(G)$ is the maximum number of pendent edges in any spanning tree of G.

Connected Detour Eccentric Domination in Graph

Definition:3.1. If D is a DED-set of G and the induced subgraph $\langle D \rangle$ is connected, then D is called a connected detour eccentric dominating set (CDED-set), of G. A CDED-set$D$ is called a minimal CDED-set if there exists a subset $D' \subset D$ which is not a CDED-set. The *connected detour eccentric domination number(CDEDN)$\gamma_{CDE}(G)$* of G denotes a representation of the minimum cardinality of a CDED-set of G. The *maximumCDEDN$\Gamma_{CDE}(G)$* denotes the maximum cardinality of a CDED-set of G.

Example:3.2.

Consider the graph G given in Figure 1.
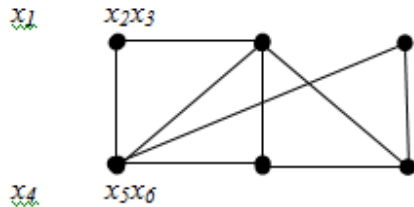
Figure 1: Graph G

The minimal DED-sets are $\{x_2, x_4\}$ and $\{x_1, x_3, x_5\}$.
Hence, $\gamma_{DED}(G)$ is 2 and $\Gamma_{DED}(G)$ is 3.
The minimal CDED-sets are $\{x_2, x_4\}$ and $\{x_3, x_5, x_6\}$.
Hence, $\gamma_{CDE}(G)$ is 2 and $\Gamma_{CDE}(G)$ is 3.

Note: 3.3.1. For any connected graph G,
$\gamma(G) \leq \gamma_{DE}(G) \leq \gamma_{CDE}(G)$ and $\gamma_C(G) \leq \gamma_{CDE}(G) \leq \gamma_C(G) + e(G)$.
Any CDED-set is also a DE-set, therefore$\gamma_{DE}(G) \leq \gamma_{CDE}(G)$. Since $\gamma_{DE}(G) = \gamma_{CDE}(G) = 2$, the sharpness of this inequality arises from the equation $G = K_{m,n}, m, n \geq 2$. The inequality, though, is extremely severe. For any connected graph G, for that instance, $\gamma_C(G) = n - \varepsilon_T(G)$, where $\varepsilon_T(G)$ is the maximum number of pendent edges in any spanning tree of G, $t_{DED}(C_n) = n/2$, when $n = 4m$ and m is odd, and $\gamma_{CDE}(C_n) = n - 2$ for all n, where $n \geq 4$.
2. D is a minimally CDED-set,if and only if at least one of the following conditions is true.

(i)   There is a vertex $w \in V - D$ such that w is uniquely dominated by v for every vertex $v \in D$.
(ii)   Every point v in D is a unique detour eccentric point of some point $w \in V - D$ in D that is all other detour eccentric points of $w \in V - D$ lie in $V - D$ only.
(iii) v is a cut point of $\langle D \rangle$, for all $v \in D$.

Observations:3.4.i). It is simple to see that the CDED-set only appears in connected graphs.
ii). Every DED-set is also anED-set, & every ED-set is a D-set. Therefore, we have $\gamma(G) \leq \gamma_{DE}(G) \leq \gamma_{CDE}(G)$.
iii). Every CDED-set is also aCD-set, and every CD-set is a D-set. Consequently, we have $\gamma(G) \leq \gamma_C(G) \leq \gamma_{CDE}(G)$.

Theorem:3.5. If H is a connected spanning subgraph of G, then
$\gamma_{CDE}(G) \leq \gamma_{CDE}(H)$.

Proof: Let G be a connected graph and H be any connected spanning subgraph of G. Then every CDED-set of H is also a CDED-set of G, and hence
$\gamma_{CDE}(G) \leq \gamma_{CDE}(H)$.

Theorem:3.6. If $G = K_n$ is a complete graph with n vertices, then $\gamma_{CDE}(K_n) = 1$.

Proof: The $diameter\ (diam)of\ G\ is\ 1\ and\ the\ radius\ (rad)of\ G\ is\ 1$ in K_n.
Since each vertex $u \in V$ is a DEV of other vertices of V, they are all near each other.
It follows that any vertex $u \in V$ dominates the other vertices of V and that it is the DEV of the remaining vertices, making it clear that every trivial graph is connected. Therefore, $D = \{u\}$ is a minimum CDED-set of G.
As a result, $\gamma_{CDE}(K_n) = 1$.

Theorem:3.7. If $G = K_{1,n}$ is a star graph, then$\gamma_{CDE}(K_{1,n}) = 2, n \geq 2$.
Proof: When $G = K_{1,n}$, the radius is 1 and the diameter is 2.

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Let $D = \{u, v\}$, with v as the central vertex. In $V - D$, the central vertex v dominates over all other vertices, and the DEVu is one of the vertices of $V - D$. The connected induced subgraph $\langle D \rangle$.

As a result, $\gamma_{CDE}(K_{1,n}) = 2, n \geq 2$.

Theorem:3.8. If $G = K_{m,n}$ is a complete bipartite graph, then$\gamma_{CDE}(K_{m,n}) = \begin{cases} 1, & m = n = 1 \\ 2, & otherwise \end{cases}$

Proof:$K_{m,n} = K_2$, if $m = n = 1$. By theorem A, if $m = n = 1$, then $\gamma_{CDE}(K_{m,n}) = 1$.

Consider the case $m \geq 1, \ n \geq 2 \ $ or $m \geq 2, \ n \geq 1$. $Rad(G) = 1, \ diam(G) = 2$ for $m = 1, \ n \geq 2 \ $ or $ \ m \geq 2, \ n = 1$. Consider the following equation: $G = K_{m,n}$, where $V(G) = V_1 \cup V_2, |V_1| = m$, and $|V_2| = n$, and each element of V_1 is adjacent to each vertex of V_2 and vice versa.

Let $D = \{u, v\}, u \in V_1$, and $v \in V_2$, where u dominates all V_2 vertices and is a DEV of all $V_1 - \{u\}$ vertices. Like this, v is a DEV that dominates all the vertices of V_1 and $V_2 - \{v\}$. The connected induced subgraph $\langle D \rangle$. Therefore, if either $m \geq 1, \ n \geq 2 \ $ or $m \geq 2, \ n \geq 1$, $\gamma_{CDE}(K_{m,n}) = 2$, is true.

Theorem:3.9. If C_n is a cycle graph with n vertices, then$\gamma_{CDE}(C_n) = n - 2, n \geq 3$.

Proof: When $G = C_n, r = rad \ (C_n) = n - 1$.

In $C_n, rad \ (C_n) = \ diam(C_n)$. Consider the cycle $C_n: v_1, v_2, v_3, \ldots, v_n, v_{n+1} = v_1$. Since in C_n, every vertex is $2 - $regular, each vertex $v(C_n)$ dominates exactly 3 vertices. The vertex v_1 dominates v_2, v_n and itself. Now include the vertex v_1 in set D. To form a CD-set D, we must introduce the next consecutive vertex either inv_2 or v_n in D, otherwise, we cannot form a CD-set. Suppose we select $v_2 \in D$, then we must choose the next consecutive vertex v_3 in D. This process is continued until we have $(n - 2)$ vertices of C_n in D. Therefore, $D = \{v_1, v_2, v_3, \ldots, v_{n-2}\}$. The vertices $v_{n-1} \in V - D$are dominated by v_{n-2} of D and the vertex $v_n \in V - D$ is dominated by $v_1 \in D$. D is the minimum CD-set of C_n. We know that C_n is a self–centered graph and radius $= r$.

The DEV of $v_i = \begin{cases} v_{i+1} \ if \ i \leq r \\ v_{i-r} \ if \ i > r \end{cases}$

When n is odd there exists another DEV of

$v_i = \begin{cases} v_{r+1} \ \ if \ i = 1 \\ v_{i-1} \ \ if \ i > 1 \end{cases}$

The eccentric point set is also a DED-set.

Therefore, the CDED-set $D = \{v_2, v_3, \ldots, v_{n-1}\}$.

Hence, $\gamma_{CDE}(G) = n - 2$.

Theorem:3.10. If $W_n$is a wheel graph with n vertices, then $\gamma_{CDE}(W_n) = \begin{cases} 1 \ \ if \ n = 3 \\ 2 \ \ if \ n = 4 \\ 3 \ \ if \ n \geq 5 \end{cases}$

Proof: If $G = W_3 = K_4$. Therefore,theorem 3.6,$\gamma_{CDE}(K_4) = 1$ implies that $\gamma_{CDE}(W_3) = 1$.

When $G = W_4$, consider $D = \{u, v\}$ where u and v are adjacent non-central vertices. D is a minimum CDED-set. Therefore, $\gamma_{CDE}(W_4) = 2$.

When $G = W_4, n \geq 5$. Consider $D = \{u, v, w\}$ where $v$the central vertex is, and u, w are there any two adjacent non—central vertices. D is a minimum CDED-set.

Therefore, $\gamma_{CDE}(W_n) = 3, n \geq 5$.

Theorem:3.11.$\gamma_{CDE}(G) \leq 1 + \delta(G)$, if Ghas a diameter of two.

Proof:$diam(G) = 2$. Suppose$w$is chosen so that$(G), deg \ w = \delta(G)$. Consider$D = \{w\} \cup N(w)$. This is a CDED-set of G. Hence, $\gamma_{CDE}(G) \leq 1 + \delta(G)$ for the connected induced subgraph $\langle D \rangle$.

Theorem:3.12.$\gamma_{CDE}(G) \leq deg(v) + 2$, if the tree T has a radius of two, a unique central vertex u, and $deg(v) \leq 2$ for every $v \in N(u)$.

Proof: Let$T$ be a tree with a radius 2 and a unique central vertex. $N[u]$ is then aCD-set for G.

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Case (i): If any vertex $v \in N(u)$ is a pendent vertex,then $N[u] - \{v\}$ is a minimum CD-set. If there are k pendent vertices in $N(u)$, then include every vertex in the collection D. $N[u] - \{D\}$ is the minimum CD-set for G. For any vertex w in $V - N[u]$, it is aDEV for all other vertices in $V - N[u]$ and D.

This leads to the minimally CDED-set$N[u] - \{D\} + \{w\}$.

$\gamma_{CDE}(G) = |N[u] - \{D\} + \{w\}|$
$\quad\quad = \deg(u) + 1 - k + 1$
$\quad\quad = \deg(u) + 2 - k$
$\quad\quad < \deg(u) + 2$

Case (ii):$N[u]$ is the minimum CD-set, if there is not a pendent vertex in$N(u)$. Any vertex w is aDEVfor all other vertices $V - N[u]$. For G, the resulting minimum CED-set is $N[u] + \{w\}$.

$\gamma_{CDE}(G) = |N[u] + \{w\}|$
$\quad\quad = \deg(u) + 1 + 1$
$\quad\quad = \deg(u) + 2$

$\gamma_{CDE}(G) \le deg(v) + 2$, where u is a unique central vertex with a radius of 2, following from cases (i) and (ii).

Theorem:3.13. If P_n is a path graph with n vertices, then$\gamma_{CDE}(P_n) = n - 1$.

Proof: Let P_n be a path with n vertices. In P_n,there are two pendent vertices, let us callu, v. It appears that the minimum CD-set is$D = V(P_n) - \{u, v\}$.To form the DED-set, we must add u or v in D.This is because the DEV of $u \in V(P_n) - D$ is $v \in V(P_n) - D$, and the DEV of $v \in V(P_n) - D$ is $u \in V(P_n) - D$.Assuming$D = V(P_n) - \{v\}$, Drepresents the minimum CDED-set and $|D| = n - 1$.

Hence, $\gamma_{CDE}(P_n) = n - 1$.

Theorem:3.14. For any graph G, then$\gamma_{CDE}(G) \ge d$,if d is the diameter of G.

Proof: Let G be a connected graph with a diameter d. Assume that there are two peripheral vertices,u and $v$separated by$d$. A diametral path joins$u$ and $v$is denoted by$P$. Let D be a CDED-set. When$u, v \in D$, $|D| \ge d + 1$. $|D| \ge d$,if any one of u, v is in D. Therefore, $\gamma_{CDE}(G) \ge d$.

Considering that$\gamma_{CDe}(G) = n - 1$ if G is a path on n vertices,this lower bound is likewise sharp.

Theorem:3.15. $\gamma_{CDE}(G) \le n + e(G) - \Delta(G)$, let G be a connected graph, then

Proof: Based on the theorem:2.8,$\gamma_C(G) = n - \Delta(G)$, for each connected graph G. The theorem follows as a result.

Theorem:3.16. For any connected graph G, then $\gamma_{CDE}(G) \le n + e(G) - \varepsilon_T(G)$, where $\varepsilon_T(G)$ is the maximum number of pendent edges in any spanning tree of G.

Proof: According to the theorem:2.9,$\gamma_C(G) = n - \varepsilon_T(G)$,for every connected graph G, where $\varepsilon_T(G)$ is the maximum number of pendent edges in any spanning tree of G. Furthermore,$D \cup S$ is a CDED-set of G, if D is a CD-set and S is a minimum DEP-set of G. Consequently, $\gamma_{CDe}(G) \le \gamma_c(G) + e(G)$. The theorem follows as a result.

Corollary:3.17. Let G be a connected graph, then $\gamma_{CDE}(T) \le n - \Delta(G) + 2$, for any tree T.

Proof:$e(G) = 2$, for any tree T.$\gamma_{CDE}(T) \le n - \Delta(G) + 2$ as a result.

Theorem:3.18.$\gamma_{CDE}(G) \le \lfloor (n + \gamma_C(G)) / 2 \rfloor$.

Proof: With $\gamma_C(G) + \lfloor (n - \gamma_C(G))/2 \rfloor$ vertices, we can form a γ_{CDE} – set S, if D is a γ_C - set of G. Given that the vertices of D and $V - D$are adjacent to $\langle S \rangle$ is connected.Because of this,$\gamma_{CDE}(G) \le \lfloor (n + \gamma_C(G)) / 2 \rfloor$.

Given that for$G = P_n$,$\gamma_{CDE}(G) = n - 1 = \lfloor (n + \gamma_C(G)) / 2 \rfloor$, this upper bound is sharp.

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Theorem:3.19. $\gamma_{CDE}(G) \le (n - t + 2)/2$ where t is the number of vertices with detour eccentric radius if G has a radius of one and a diameter of two.

Proof: Suppose $u \in V(G)$ and $() = 1$. For each vertex, let be the number of detour eccentricity of one. All other vertices are dominating to , and is a detour eccentric point for -1 other vertices. Consider the remaining $(-)$ vertices of . They are also dominated by , but does not dominate them detour eccentrically at their detour eccentric points; at most, $(-)/2$ vertices are required to dominate them and detour eccentrically. All other vertices are adjacent to since $() = 1$. $() \le 1 + \frac{-}{2} = (- + 2)/2$, as a result.

Theorem:3.20. $() \le 2 + \lceil(() -)/2\rceil$, where is the number of vertices with detour eccentricity one, holds if has a radius of one and a diameter of two.

Proof: $()$ can be divided as follows into two sets: $_1$ and $_2$. $_1 = \{ | () = 1\}$ and $_2 = \{ | () = 2\}$. Let be a vertex in $_2$ such that the degree of in $= \langle_2\rangle$ is minimum. Let $\deg_H = _2 = () - $. Then is detour eccentric to the remaining $- - _2$ vertices. Let be a subset of $()$ such that $() - $ vertices have detour eccentric vertices in . with $_1$ being a CDED-set of , $\{,\} \cup$. It follows that, $() \le 2 + \lceil(() -)/2\rceil$.
Additionally, this upper bound is sharp as $G = K_{1,n-1}$, $\gamma_{CDE}(G) = 2$.

Corollary:3.21 $\gamma_{CDE}(G) + \gamma_{CDE}(\bar{G}) \le n + \delta - \Delta + 1$, if G and $\bar{G}$ are self-centered of diameter 2.

Proof: $\gamma_{CDE}(G) \le 1 + \delta$ and $\gamma_{CDE}(\bar{G}) \le 1 + \delta(\bar{G}) = 1 + \bar{\delta}$ are found by Theorem 3.19.
Thus, $\gamma_{CDE}(G) + \gamma_{CDE}(\bar{G}) \le 1 + \delta + 1 + \bar{\delta} = 2 + \delta + (n - 1 - \Delta) = n + \delta - \Delta + 1$.

Theorem:3.22. $\gamma_{CDE}(G) \le 1 + \Delta(G)$, if G contains a pendent vertex v of detour eccentricity 3 and is of radius 2 and diameter 3.

Proof: If G support u has a detour eccentricity of 2 if its pendent vertex v has a detour eccentricity of 3. $N[u]$ is a CDED-set in this case. Consequently, $\gamma_{CDE}(G) \le 1 + \deg_G u \le 1 + \Delta(G)$.

Theorem:3.23. If G has a radius of 2 and a diameter of 3, then $\gamma_{CDe}(G) \le \min\left\{\frac{n + \deg_G u + 1}{2}\right\}$, where u is the minimum determined overall central vertices.

Proof: Assume that u is a minimum degree central vertex. Consider $N(u)$. All the vertices in $N_2(u)$ are detour eccentric to u, and $N(u)$ dominates all the vertices of G. Assume that S is a subset of $N_2(u)$ with minimum cardinality such that all vertices in $N_2(u) - S$ have detour eccentric vertices in S. In such a case, $|s| \le \frac{|N_2(u)|}{2} = (n - \deg_G u - 1)/2$. Here, $N[u] \cup S$ is a connected detour eccentric dominating set of G.
It follows that, $\gamma_{CDE}(G) \le 1 + \deg_G u + \frac{n - \deg_G u - 1}{2} = (n + \deg_G u + 1)/2$. Thus, the theorem is proved.

Corollary:3.24. For all n, $\gamma_{CDE}(P_n) = n - 1$.

Theorem:3.25. For all n, $\gamma_{CDE}(C_n) = n - 2$.

Proof: Let any two adjacent vertices, u, v of G. Then $V - \{u, v\}$ is a minimum CDED-set of C_n. Therefore, for any n, $\gamma_{CDE}(C_n) \ge n - 2$. Furthermore, $\gamma_C(C_n) = n - 2$ and $\gamma_C(C_n) \le \gamma_{CDE}(C_n)$. Consequently, for any n, $\gamma_{CDE}(C_n) = n - 2$.

Theorem:3.26. $\gamma_{CDE}(\bar{C}_5) = 3$ and $\gamma_{CDE}(\bar{C}_n) = \lceil n / 3 \rceil$, $n \ge 6$.

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Proof: We have $\gamma_{DE}(\bar{C}_5) = 3$ and $\gamma_{DE}(\bar{C}_5) = \lceil n / 3 \rceil, n \geq 6$. Also, $\gamma_{DE}(G) \leq \gamma_{CDE}(G)$. Hence, $\gamma_{DE}(\bar{C}_5) \geq \lceil n / 3 \rceil$. $\Gamma_{CDE}(\bar{C}_5) = 3$. Let us now assume $n \geq 6$. Form C_n with $v_1, v_2, v_3, \ldots, v_n, v_1$. Then $\bar{C}_n = K_n - C_n$, where every vertex v_i is adjacent to every other vertex in $\bar{C}_n$ except for v_{i-1} and v_{i+1}. Hence detour eccentric point of v_i in $\bar{C}_n$ is v_{i-1}, and v_{i+1} only. We can now consider the following CDED-set.

If $n = 3m$, then $\{v_1, v_4, v_7, \ldots, v_{3m-2}\}$;

If $n = 3m + 1$, then $\{v_1, v_4, v_7, \ldots, v_{3m+1}\}$;

If $n = 3m + 2$, then $\{v_1, v_4, v_7, \ldots, v_{3m+1}, v_{3m+2}\}$;

Consequently, $\gamma_{CDE}(\bar{C}_n) \leq \lceil n / 3 \rceil$. Therefore, for $n \geq 6$, it follows that $\gamma_{CDE}(\bar{C}_n) \leq \lceil n / 3 \rceil$.

Theorem:3.27. Let G be obtained by eliminating edges with a linear factor from the complete graph K_n, then, $\gamma_{CDE}(G) = n/2$, n is even.

Proof: Each vertex in $V - D$ is adjacent to at least one element in D, and each element in $V - D$ has a detour eccentric point in D. D is connected and has $n/2$ vertices. As a result, $\gamma_{CDE}(G) \leq n/2$. Additionally, we have $n/2 \leq \gamma_{DE}(G) \leq \gamma_{CDE}(G)$ because G is a unique detour eccentric point graph. As a result, $\gamma_{CDE}(G) \leq n/2$.

Theorem:3.28. Let G be a connected graph with $|V(G)| = n$. Then $\gamma_{CDE}(G \circ K_1) \leq 3n/2$.

Proof: Let $V(G) = \{v_1, v_2, \ldots, v_n\}$. For $i = 1, 2, \ldots, n$, let v_i' be the pendent vertex adjacent to v_i in $G \circ K_1$. A CD-set for $G \circ K_1$ is $D = \{v_1, v_2, \ldots, v_n\}$. Let S represent the eccentric minimum detour point set of G. Let S' be the corresponding subset of $\{v_1' v_2' \ldots, v_n'\}$. When $G \circ K_1$ and $|S' \cup D| \leq 3n/2$ are D-sets, $S' \cup D$ is a DE-set.

The following theorem defines graphs for which $\gamma_{CDE}(G) = 2$.

Theorem:3.29. Let G be a connected graph. If G is any one of the following:

(i) A connected graph, G, shall be. If G is any one of the following: $r(G) = 1, diam(G) = 2$, and $u \epsilon V(G)$ such that $e(u) = 2$ and $d(u, v) = 2$ for all $v \epsilon V(G)$ with $e(v) = 2$, then $\gamma_{CDE}(G) = 2$ is true.

(ii) G has a dominating edge that is not in a triangle and is self-centered, with a diameter of 2.

Proof: It is satisfied that $\gamma_{CDE}(G) = 2$ when any one of the above conditions is met for G Conversely, suppose that $\gamma_{CDE}(G) = 2$. Therefore, $\gamma(G) = 1$ or $\gamma(G) = 2$.

Case (i): $\gamma(G) = 1$ and $\gamma_{CDE}(G) = 2$. This implies G satisfies (i).

Case (ii): $\gamma(G) = 2 = \gamma_{CDE}(G)$.

Let D represent the minimum CDED-set (γ_{CDE}-set) of G. Let $D = \{u, v\} \subseteq V(G)$. Given that $\gamma(G) = 2$, $r(G) \geq 2$.

Since D is connected, the edges u and v are adjacent to each other and the edge uv is a dominating edge for G. As a result, $r(G) \geq 2$ and $2 \leq diam(G) \geq 3$.

Assuming $diam(G) = 3$, vertex x exists with detour eccentricity 3, and x is dominated by either u or v.

Suppose $xu \epsilon E(G)$. Now, D is a γ_{De} - set. Therefore, v must be an eccentric detour point of x. It suggests that $d(x, v) = 3$. However, the path xuv is a contradiction because $\Rightarrow d(x, v) = 2$. x must therefore be a vertex with an eccentricity of 2. This suggests that G is self-centered with diameter 2, or that $diam(G) = 2$. [Since w would not have a detour eccentric point in D in that case to $r(G) \geq 2$, no w is adjacent to both u and v.]

CONCLUSION

The connected detour eccentric dominating set (CDED-set) is described in this study along with its numbers. The connected detour eccentric domination numbers for several typical graphs are calculated. It might also be expanded to include the inverse CDED set and the totalCDED set and their numbers in further research.

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RESEARCH ARTICLE

Some New Families of Divisor Cordial Eccentric Graphs

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ABSTRACT

The eccentric graph of G= (V, E)is denoted by $ecc(G) = (V, E')$, where $E' = \{(u,v) : d_G(u,v) = ecc(u)$ or $d_G(u,v) = ecc(v)$ for $u,v \in V\}$. A graph that admits a divisor cordial labeling (dc-labeling) is called a divisor cordial graph (dc-graph). In this paper, we investigate some new families of the divisor cordial eccentric graphssuch as $ecc(P_n)$, $ecc(C_n)$, $ecc(P_n \odot K_1)$, and $ecc(P(C_n(2)))$.

Keywords: Eccentric graph, divisor cordial graph, path, cycle, comb graph.
AMS subject classification: 05C78.

INTRODUCTION

We start with an undirected, simple, finite graph. A graph G = (V, E), where V is the set of vertices with $|V| = p$ and E is the set of edges with $|E| = q$, is referred to as a (p,q) graph G. The origins of graph theory are attributed to Leonhard Euler's 1736 examination of the well-known Königsberg bridge problem. Graph labeling is an essential topic within the field of graph theory. Graph labeling is the process of giving vertices, edges, or both graph labels, which are often represented by integers. One of the fascinating and active subfields of graph theory is the labeling of graphs. The graph labeling techniques in graph theory originated with graceful labeling and harmonic labeling. Another significant labeling style that incorporates elements of both graceful and harmonious is called cordial, and it was first established by Cahit in [2]. The idea of divisor cordial labeling of graphs was first presented by Varatharajan et al. in [9]. Eccentric graphs are one type of eccentricity-related graph study; these studies of graphs are fascinating and amazing. Akiyama et al. defined the unique kind of graph operation known as the eccentric graph of the graph

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in [1], and they also provided several intriguing characterizations of these kinds of graphs.There is only one graph structure driven by any graph action. However, nearly every graph has an eccentric graph operation that leads to multiple fascinating and amazing graph structures. Kaspar et al. discovered and described such "intriguing graph structures of eccentric graphs of specific classes of graphs in [5]. Ghosh et al. in[6] look into a few families of prime cordial eccentric graphs. The graphs under discussion are undirected, simple, and finite. We refer to Harary [4] for terminology related to graph theory. We refer to Tom M. Apostol [8] for the standard terminology and notations in number theory, and to Gallian [3] for the literature on graph labeling. The purpose of this paper is" to look into the dc-labeling of $ecc(P_n)$, $ecc(C_n)$, $ecc(P_n \odot K_1)$, and $ecc(P(C_n(2)))$.

PRELIMINARIES

Definition "2.1graph labeling refers to the act of assigning distinct identifiers to the edges and vertices of a graph.

Definition 2.2 Assume that a and b are two integers. When an integer k is positive and a divides b, it indicates that b = ka exists. It is represented as a│b. If a does not divide b, then we represent this by denoting a $\nmid$ b.

Definition 2.3 Consider a simple graph G = (V(G), E(G)) and let f: V(G) → {1,2,…, |V(G)|} be a bijection. Assign the label 1 to each edge uv if either $f(u)|f(v)$ or $f(v)|f(u)$, and assign the label 0 otherwise. The function f is referred to as a divisor cordial labeling if $|e_f(0) - e_f(1)| \leq 1$, where $e_f(0)$, $e_f(1)$ are the number of edges having labels 0 and 1 respectively. A graph that can be labeled with a divisor cordial labeling (dc-labeling) is referred to as a divisor cordial graph (dc-graph).

Definition 2.4 Consider a graph G with a set of vertices V and a set of edges E. The eccentric graph of G is represented as $ecc(G) = (V, E)$, where $E' = \{(u,v): d_G(u,v) = ecc(u) \text{ or } d_G(u,v) = ecc(v) \text{ for } u, v \in V\}$.

Definition 2.5"[5] A double star is formed by "connecting the centers of two stars, which then become the centers of the double star $S_{m,n}$.

Definition 2.6 [7]Let $G_1, G_2, …, G_n$ be n(≥ 2) copies of a graph G. It is denoted by G(n) the graph obtained by adding an edge to G_i and G_{i+1}, i= 1, 2, …, n–1, and call G(n) the path-union of n copies of the graph G".

Result 2.1 [9] The cycle C_n is divisor "cordial.

MAIN RESULTS

Theorem 3.1$ecc(P_n)$ **is dc-graph, for n** $\geq$**3.**

Proof: The eccentric graph of path P_n is denoted as $ecc(P_n)$. P_n is a graph with n vertices and n–1 edges, where $v_1, v_2, …, v_n$ represent the vertices of P_n.

Case 1: when n is odd.

Then $ecc(P_n)$ is a graph containing" a cycle of three vertices v_1, $v_{\frac{n+1}{2}}$, v_n, and also both v_1 and v_n have $\frac{n-3}{2}$ pendent edges. Here v_1 has $\frac{n-3}{2}$ adjacent vertices $v_{\frac{n+3}{2}}$, $v_{\frac{n+5}{2}}$, …, v_{n-1}, and v_n has $\frac{n-3}{2}$ adjacent vertices v_2, …, $v_{\frac{n-1}{2}}$.

$|V(ecc(P_n))| = n$ and $|E(ecc(P_n))| = n$.Let p denote the largest prime number in the range of 1 "to n.

Define f : V(ecc(P$_n$)) $\rightarrow$ {1, 2, …, n} as follows.Label the vertices v$_1$,v$_n$and v$_{\frac{n+1}{2}}$ by 1, 2 and p. Also label the adjacent vertices of v$_1$ by even number from 4 to n–1 and label the adjacent vertices of v$_n$ by odd number from 3 to n other than p. Then the corresponding edge labeling will give e$_f$(0) = $\frac{n-1}{2}$ and e$_f$(1) = $\frac{n+1}{2}$. Thus ∣ e$_f$(0) – e$_f$(1) ∣ = 1. Hence the ecc(P$_n$) is a dc-graph, when n is odd.

Case 2: when n is even.

Then ecc(P$_n$) is" a double star $S_{\frac{n-2}{2},\frac{n-2}{2}}$ .ecc(P$_n$) has an edge v$_1$v$_n$ andalso both v$_1$ and v$_n$ have $\frac{n-2}{2}$ pendent edges.

Here v$_1$ has $\frac{n-2}{2}$ "adjacent vertices v$_{\frac{n+2}{2}}$, v$_{\frac{n+4}{2}}$, …, v$_{n-1}$,and v$_n$ has $\frac{n-2}{2}$ adjacent vertices v$_2$, …, v$_{\frac{n}{2}}$.

∣V(ecc(P$_n$))∣ = n and ∣E(ecc(P$_n$))∣ = n–1.

Define f:V(ecc(P$_n$)) $\rightarrow$ {1, 2, …, n} as follows.Label the vertices v$_1$ and v$_n$by 1 and 2. Also, label the adjacent vertices of v$_1$ by even number from4 to n and label the adjacent vertices of v$_n$ by odd number from 3 to n–1. Then the corresponding edge labeling will give e$_f$(0) = $\frac{n-2}{2}$ and e$_f$(1) = $\frac{n}{2}$. Thus ∣ e$_f$(0) – e$_f$(1) ∣ = 1.Hence ecc(P$_n$) is also dc-graph", when n is even. Therefore, the ecc(P$_n$)is a dc-graph, for n $\geq$ 3.

Illustration 3.1 (i).P$_6$ and dc-labeling ofecc(P$_6$)$_{are}$ shown in Figure 3.1(a).

Theorem 3.2ecc(C$_n$)is "dc-graph, for n $\geq$ 3.

Proof: Let ecc(C$_n$) be the eccentric graph of cycle C$_n$. C$_n$ has n vertices and n edges, where v$_1$,v$_2$,…,v$_n$ are the vertices of C$_n$.

Case 1: when n is even.

Then ecc(C$_n$) is $\frac{n}{2}$ P$_2$, where the vertices of each P$_2$ are v$_i$ v$_{\frac{n}{2}+i}$, i = 1,2,…, $\frac{n}{2}$. Also, ∣V(ecc(C$_n$))∣ = n and ∣E(ecc(C$_n$))∣

= $\frac{n}{2}$.

Define f:V(ecc(C$_n$)) $\rightarrow$ {1, 2, …, n} as follows.

Subcase 1(a): n $\equiv$ 0 (mod 4)

f(v$_i$) = 2i–1, for i = 1,2,…, $\frac{n}{4}$ and f(v$_{\frac{n}{2}+i}$) = 4i–2, for i = 1,2,…, $\frac{n}{4}$.

f(v$_{\frac{n}{4}+i}$) = 4i, for i = 1,2,…, $\frac{n}{4}$ and f(v$_{\frac{3n}{4}+i}$) = $\frac{n}{2}$ +2i–1, for"i = 1,2,…, $\frac{n}{4}$.

Then the corresponding edge labeling will "give e$_f$(0) = e$_f$(1) = $\frac{n}{4}$. Thus ∣ e$_f$(0)–e$_f$(1) ∣ = 0. Hence ecc(C$_n$) is also dc-graph, n $\equiv$ 0 (mod 4)

Subcase 1(b): $n \equiv 2 \pmod 4$

$f(v_i) = 2i–1$, for $i = 1,2,…, \dfrac{n+2}{4}$ and $f(V_{\frac{n}{2}+i}) = 4i–2$, for $i = 1,2,…, \dfrac{n+2}{4}$.

$f(V_{\frac{n+2}{4}+i}) = 4i$, for $i = 1,2,…, \dfrac{n-2}{4}$ and $f(V_{\frac{3n+2}{4}+i}) = \dfrac{n+2}{2} +2i–1$, for $i = 1,2,…, \dfrac{n-2}{4}$.

Then the corresponding edge labeling will give $e_f(0) = \dfrac{n+2}{4}$ and $e_f(1) = \dfrac{n-2}{4}$. Thus $\mid e_f(0) – e_f(1) \mid = 1$.

Hence ecc(C_n) is also dc-graph, when $n \equiv 2 \pmod 4$.
Therefore, ecc(C_n) is also a dc-graph, when n is even

Case 2: when n is odd.
Then ecc(C_n) is also acycle $C_n= v_1 V_{\frac{n+1}{2}} v_n V_{\frac{n-1}{2}} v_{n–1}… v_3 V_{\frac{n+5}{2}} v_2 V_{\frac{n+3}{2}} v_1$. By result 2.1, cycle C_n is a dc-graph for $n \geq 3$.

Therefore ecc(C_n) is also dc-graph" when n is odd. Hence, ecc(C_n) is dc-graph, for $n \geq 3$.

Illustration 3.2(i).$C_7$and dc-labeling of ecc(C_7)are shown in Figure 3.2(a).
(ii).$C_8$and dc-labeling of ecc(C_8)are shown in Figure 3.2(b).

Theorem "3.3 ecc($P_n \odot K_1$)is dc-graph, for $n \geq 3$.

Proof: Letecc($P_n \odot K_1$) be the eccentric graph of a comb $P_n \odot K_1$. P_n has n vertices and n–1 edges, where $v_1,v_2,…,v_n$ are the vertices of P_n. $w_1,w_2,…,w_n$ are the pendent vertices and $v_1w_1, v_2w_2, v_3w_3, …, v_nw_n$are the pendent edges of$P_n \odot K_1$.

Case 1: when n is odd.
Then ecc($P_n \odot K_1$) is a graph with $K_4– \{e\}$ of four vertices $w_1, V_{\frac{n+1}{2}}, w_n, W_{\frac{n+1}{2}}$ and $e = V_{\frac{n+1}{2}} W_{\frac{n+1}{2}}$. Also,both $w_1$and w_n haven–2 pendent edges. Here w_1 has n–2 adjacent vertices $V_{\frac{n+3}{2}}, V_{\frac{n+5}{2}}, …, v_{n–1}, v_n, W_{\frac{n+3}{2}}, W_{\frac{n+5}{2}}, …, w_{n–1}$and

$w_n$has n–2 adjacent vertices $v_1, v_2, …, V_{\frac{n-1}{2}}, w_2, …, W_{\frac{n-1}{2}}$. $\mid V(ecc(P_n \odot K_1)) \mid = 2n$ and $\mid E(ecc(P_n \odot K_1)) \mid =2n+1$. Let p be the largest prime number between 1 and 2n.

Define $f : V(ecc(P_n \odot K_1)) \rightarrow \{1, 2, …, 2n\}$ as follows. Label the vertices $w_1, V_{\frac{n+1}{2}}, w_n$,and $W_{\frac{n+1}{2}}$ by" 2, 4, p,and 6. Also,

label the adjacent vertices of w_1 by 1 and even number from 8 to 2n and label the adjacent vertices of w_n by odd number from 3 to 2n–1 other than p. Then the corresponding edge labeling will "give $e_f(0) = n+1$ and $e_f(1) = n$.
Thus $\mid e_f(0) – e_f(1) \mid = 1$. Hence ecc($P_n \odot K_1$) is a dc-graph, when n is odd.

Case 2: when n is even.
Then ecc($P_n \odot K_1$) is a double star $S_{n–1, n–1}$. ecc($P_n \odot K_1$) has an edge w_1w_n and also both w_1 and w_n has n–1 pendent edges. Here w_1 has n–1 adjacent vertices $V_{\frac{n+2}{2}}, V_{\frac{n+4}{2}}, …, v_n, W_{\frac{n+2}{2}}, W_{\frac{n+4}{2}}, …, w_{n–1}$, and w_n has n–1 adjacent

vertices $v_1,v_2, …, V_{\frac{n}{2}}, w_2, w_3, …, W_{\frac{n}{2}}$. $\mid V(ecc(P_n \odot K_1)) \mid = 2n$ and $\mid E(ecc(P_n \odot K_1)) \mid =2n–1$.

Define f:V(ecc($P_n \odot K_1$)) → {1, 2, …, 2n} as follows.

Label the vertices w_1 and w_n by 1 and 2. Also, label the adjacent vertices of w_1 by even number from 4 to 2n and label the adjacent vertices of w_n by odd number from 3 to 2n–1. Then the corresponding edge labeling will give $e_f(0)$ = n–1 and $e_f(1)$ = n. Thus | $e_f(0) – e_f(1)$ | = 1. Hence ecc($P_n \odot K_1$) is also dc-graph", when n is even

Therefore, ecc($P_n \odot K_1$)is also dc-graph, for n ≥ 3.

Illustration 3.3(i).$P_6 \odot K_1$and dc-labeling of ecc($P_6 \odot K_1$)are shown in figure 3.3(a).
(ii).$P_7 \odot K_1$and dc-labeling of ecc($P_7 \odot K_1$)are shown in figure 3.3(b).

Theorem 3.4"ecc(P($C_n(2)$)) is a dc-graph for n ≥ 3.

Proof: Let P($C_n(2)$) be a graph with 2n vertices and 2n+1 edges. The vertices of P($C_n(2)$)are $v_1,v_2,v_3,…,v_n$, $w_1,w_2,w_3,…,w_n$.

Case 1: when n is even.

Then ecc(P($C_n(2)$)) is $S_{n–1,n–1}$, the vertices of ecc(P($C_n(2)$)) have two centers $w_{\frac{n+2}{2}}$, $v_{\frac{n+2}{2}}$ and both $w_{\frac{n+2}{2}}$ and $v_{\frac{n+2}{2}}$ has n–1 pendent edges. Also, $w_{\frac{n+2}{2}}$ has n–1 pendent vertices $v_1,v_2,v_3,…, v_{\frac{n}{2}}, v_{\frac{n+4}{2}},…,v_n$ and $v_{\frac{n+2}{2}}$ has n–1 pendent vertices $w_1,w_2,w_3,…, w_{\frac{n}{2}}, w_{\frac{n+4}{2}},…,w_n$. Then, |V(ecc(P($C_n(2)$)))| = 2n and |E(ecc(P($C_n(2)$)))| = 2n–1.

Define f : V(ecc(P($C_n(2)$))) → {1, 2, …, 2n} as follows.

f($v_{\frac{n+2}{2}}$) = 2 and f($w_{\frac{n+2}{2}}$) = 1,

f(v_i) = 2i+2, for i = 1,2,…,$\frac{n}{2}$ and f(v_i) = 2i, for i = $\frac{n+4}{2}$, $\frac{n+6}{2}$,…,n.

f(w_i) = 2i+1, for i = 1,2,…,$\frac{n}{2}$ and f(w_i) = 2i–1, for i = $\frac{n+4}{2}$, $\frac{n+6}{2}$,…,n.

Then $e_f(0)$ = n – 1 and $e_f(1)$ = n. Thus, |$e_f(0) – e_f(1)$| = 1.

Therefore, ecc(P($C_n(2)$)) is dc-graph for n is even.

Case 2: when n is odd.

Then ecc(P($C_n(2)$)) is $\overline{K_{n-2}} + \overline{K_2} + \overline{K_2} + \overline{K_{n-2}}$, the "vertices of G are "$w_1,w_2,w_3,…, w_{\frac{n-1}{2}}, w_{\frac{n+5}{2}},…, w_n$ of $\overline{K_{n-2}}$, $v_{\frac{n+1}{2}}, v_{\frac{n+3}{2}}$ of $\overline{K_2}$, $w_{\frac{n+1}{2}}, w_{\frac{n+3}{2}}$ of $\overline{K_2}$ and $v_1,v_2,v_3,…, v_{\frac{n-1}{2}}, v_{\frac{n+5}{2}},…, v_n$ of $\overline{K_{n-2}}$. Let p_1 and p_2 be the largest and next largest prime numbers between 1 and 2n.Then, |V(ecc(P($C_n(2)$)))| = 2n and |E(ecc(P($C_n(2)$)))| = 4n–4.

Define f : V(ecc(P($C_n(2)$))) → {1, 2, …, 2n} as follows.

f($v_{\frac{n+1}{2}}$) = 1, f($v_{\frac{n+3}{2}}$) = 2, f($w_{\frac{n+1}{2}}$) = p_1 and f($w_{\frac{n+3}{2}}$) = p_2

f(w_i) = 2i+4, for i = 1,2,…, $\frac{n-1}{2}$ and f(w_i) = 2i, for i = $\frac{n+5}{2}, \frac{n+6}{2}$,…,n.

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$f(v_1) = 4$ and label the vertices $v_2, v_3,\ldots,$ $v_{\frac{n-1}{2}}$, $v_{\frac{n+5}{2}}$,…, v_n by odd number from 3 to $2n-1$ other than p_1 and p_2. Then

$e_f(0) = e_f(1) = 2n - 2$. Thus, $|e_f(0) - e_f(1)| \leq 1$. Therefore, $ecc(P(C_n(2)))$ is dc-graph for n is odd.
Hence, $ecc(P(C_n(2)))$ is a dc-graph for $n \geq 3$.

Illustration 3.4 $P(C_5(2))$ and dc-labeling of $ecc(P(C_5(2)))$ are shown in figure"3.4.

CONCLUSIONS

Several new families of eccentric graphs with interesting graph structures are derived, and it is confirmed that all of them are dc-graphs. The only dc-labeling that we provided was for $ecc(P_n)$, $ecc(C_n)$, $ecc(P_n \odot K_1)$ and $ecc(P(C_n(2)))$.

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Figure 3.1(a)	Figure 3.1(b)

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Figure 3.2(a)

Figure 3.2(b)

Figure 3.3(a)

Figure 3.3(b)

Figure 3.4

RESEARCH ARTICLE
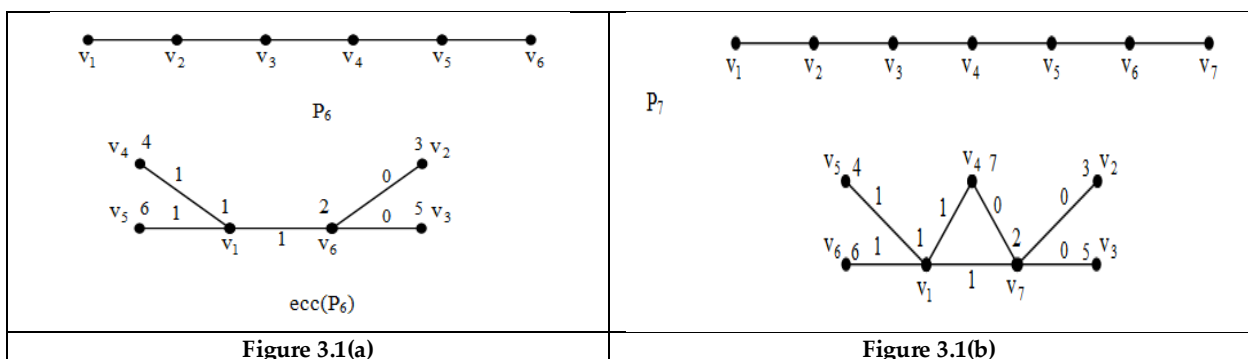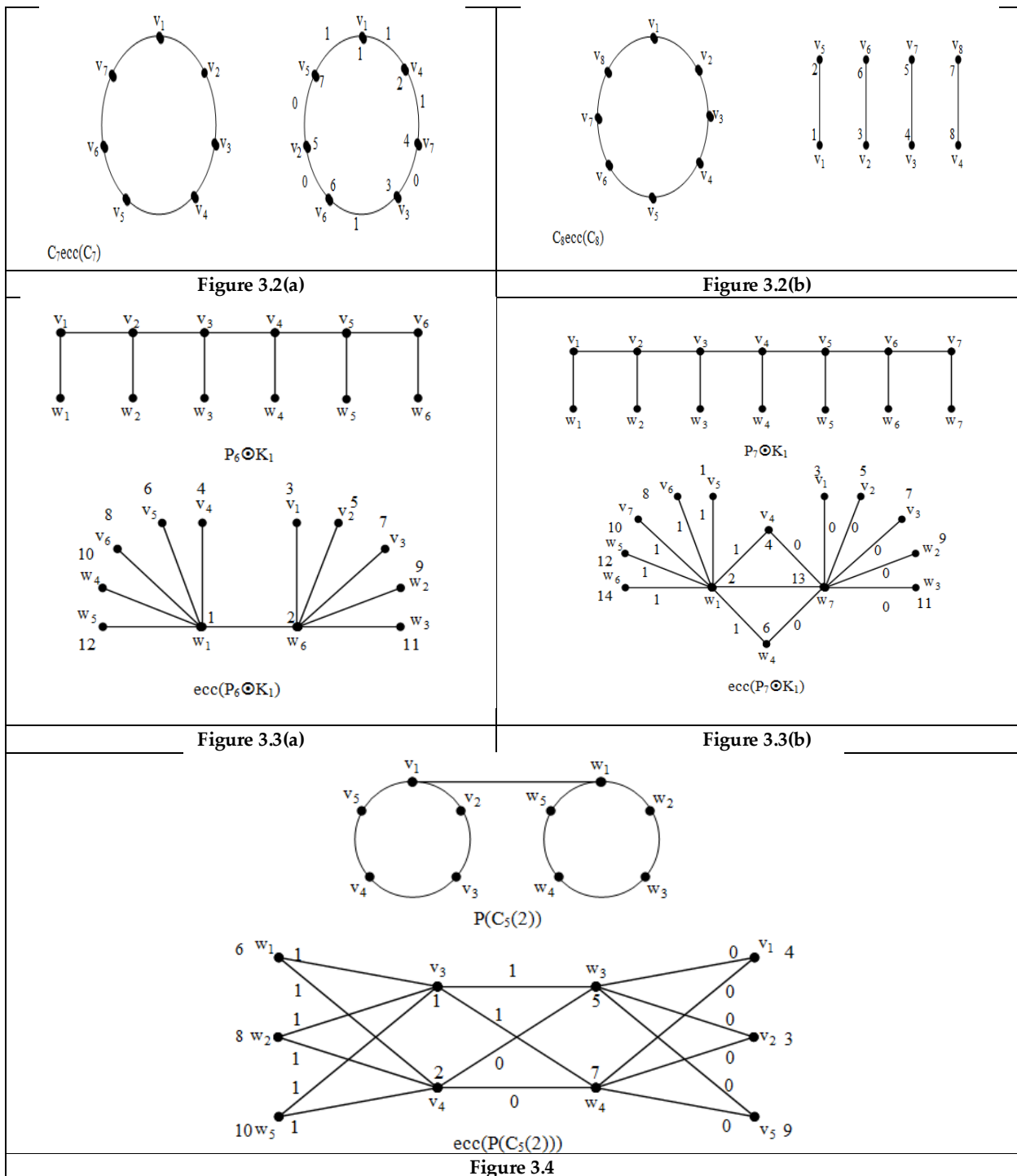
Algorithm for Shortest Path Problem using Pythagorean Fuzzy Trapezoidal Number

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ABSTRACT

An intuitionistic trapezoidal fuzzy shortest path problem in a network was developed into the network scheduling in this paper. These networks only hesitate to use ranking functions. $0 \leq \mu^2 + \lambda^2 \leq 1$ is a Pythagorean fuzzy value. The trapezoidal Pythagorean Fuzzy Shortest Path Problem is a fundamental problem in graph theory is now widely used in many practical applications, such as designing the most efficient computer network, figuring out the fastest route in a GPS navigation system, and optimising delivery routes for a logistics company. shortest path networks are calculated by applying the ranking function to identify Pythagorean trapezoidal fuzzy numbers that connect source nodes to destination nodes. Handle the Pythagorean fuzzy shortest path problem in a network where each weight is represented by a trapezoidal Pythagorean fuzzy number. The distance between the source node and the destination node is used by the proposed approach to determine the shortest path length. The contribution of an illustrative example demonstrates the applicability and efficacy of the suggested approach in the network.

Keywords: Pythagorean fuzzy number (PFN); Trapezoidal Pythagorean fuzzy number (TraPFNs); Score function; Shortest path problem (SPP).

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INTRODUCTION

A graph is composed of two sets, V and E., which represents the set of vertices, and E, which represents the set of edges that connect the pair of vertices. Numerous domains, including computer, social, and natural research, among others, use graph theory. Any mathematical, scientific, or engineering problem can be represented as a graph. Leonard Euler first introduced the idea of graph theory in 1736. In order to address the issue of the seven Konigsberg bridges constructed across the Pregel River in Prussia, he produced the first graph. The key factor contributing to graph theory's explosive growth is its application across a variety of disciplines. Even though graphs can be used to simulate events that happen in real-world problems, graph theory has become interesting. Graphs are useful for studying these issues. Shortest path (SP) problems lie at the heart of network flows. They arise often in practice since the aim of a broad variety of real-life problems is to send some goods between two stated nodes in a network as inexpensively as possible. Therefore, SP problems—finding a path with the least cost from the source node to the destination node—can be used to develop such real applications. Generally, it has been assumed that the traversal costs of arcs are expressed in terms of crisp numbers. Zadeh (1965) ⟨12⟩ developed the fuzzy set theory to address inaccurate data in SP problems.However, fuzzy sets can only represent membership functions; they cannot express non-membership functions. So, in this instance, the degree of non-membership is just the polar opposite of the degree of membership. After that, Atanassov (1986) ⟨11⟩ created intuitionistic FS(IFS) to incorporate the non-membership level into the study.The fuzzy shortest path problem (SPP) was first analysed by Dubois and Prade (1980). ⟨6⟩, using a fuzzy number instead of a real number assigned to each edge. Moreover defined Muhammad Akram, Mohammed M. Ali Al-Shamiri, Shaista Habib, Aqsa Majeed, and Muhammad Akram (2023) ⟨22⟩ Floyd-WARSHALL Algorithm Utilising Picture-Based Fuzzy Data. unveiled a novel maximal flow algorithm to address optimisation issues involving linguistic flows and capacities. Amna Habib, Tofigh Allahviranloo, Muhammad Akram, (2022) ⟨18⟩. The new consciousness of Pythagorean fuzzy sets was presented by Yager (2013)⟨20⟩, in which the set has the constraint that its square sum is less than or equal to 1. According to the definition of Pythagorean sets, Pythagorean fuzzy graphs have matured and are applied in many fields. The shortest path problem (SPP) is the basic network problem the membership and non-membership values are assigned to each edge. In this paper, we propose a Pythagorean fuzzy number instead of a fuzzy number. The proposed algorithm computes Euclidean distance for each path, identifying the shortest path for membership and non-membership values, and identifying the shortest length edge from all SPs.Guiwu Wei, Xiaofei Zhao, and Rui Lin (2010) ⟨7⟩, in the induced Aggregating Operators with Fuzzy Number Intuitionistic Fuzzy Information and Their Applications to Group Decision Making for the fuzzy aggregation. Lazim Abdullah and Pinxin Goh (2019) ⟨13⟩ define algebraic operations of Pythagorean fuzzy numbers in a decision-making method, while Xinfan Wang (2008) ⟨24⟩ developed fuzzy number intuitionistic aggregate operators for ranking functions. M. Muhammad Akram, Farwa Ilyasa, and Arsham Borumand Saeid (2019) ⟨16⟩, introduce certain notations of Pythagorean Fuzzy Graphs and also define group decision-making based on the Pythagorean fuzzy TOPSIS method from Pythagorean fuzzy graph. Zhang and Z In Xu (2014) ⟨23⟩ developed TOPSIS for multiple criteria decision-making using Pythagorean fuzzy sets. RR Yager (2014) ⟨21⟩ explored Pythagorean membership grades in decision-making for Pythagorean fuzzy numbers. Basha, Jabarulla, &Broumi (2023) ⟨4⟩ extracted for shortest path problem. M. Asim Basha and M. Mohammed Jabarulla (2023) ⟨5⟩ developed the extension of the algorithm approaches for the shortest path problem in an interval-valued triangular Pythagorean fuzzy network. The objective of this paper is to develop the shortest path concepts under the trapezoidal Pythagorean fuzzy shortest path (TraPFSP) in a network. A pythagorean fuzzy graph as an extension of intuitionistic fuzzy graphs has been presented to stem the uncertainty in real-world decision-making problems. In this paper, a trapezoidal ranking function for fuzzy environments is used to provide a method for network terminology, and the trapezoidal Pythagorean fuzzy shortest path problem (TraPFSPP) is discussed.

PRELIMINARIES

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Definition 2.1:-⟨15⟩Let U be a universe of discourse. Then the Pythagorean fuzzy set (PFS) $\wp$ on U is given by, $\wp = \{< u, \mu_\wp(u), \lambda_\wp(u) | u \in U >\}$, where the functions $\mu_\wp: U \to [0,1]$ and $\lambda_\wp: U \to [0,1]$represent the degree of member and non - membership functions the element $u \in U$ the set $\widetilde{P}$, respectively, $0 \le \left(\mu_\wp(u)\right)^2 + \left(\lambda_\wp(u)\right)^2 \le 1, \forall\, u \in U.$

Definition 2.2:-⟨9⟩A Pythagorean fuzzy graph (PFG) on a non-empty set X is a pair $G = (\wp, \mathbb{Q})$ with $\wp$ a PFS on X and $\mathbb{Q}$ a PFR on X such that,

$$\mu_\mathbb{Q}(uv) \le \mu_\wp(u) \wedge \mu_\wp(v)$$
$$\lambda_\mathbb{Q}(uv) \le \lambda_\wp(u) \vee \lambda_\wp(v)$$

where $\mu_\mathbb{Q}: X \times X \to [0,1]$ and $\lambda_\mathbb{Q}: X \times X \to [0,1]$ represent the membership and non-membership functions of $\widetilde{Q}$, respectively, with $0 \le \left(\mu_\mathbb{Q}(u)\right)^2 + \left(\lambda_\mathbb{Q}(u)\right)^2 \le 1, \forall\, u, v \in E.$

Example 2.3:-Consider the simple graph, $G = (\mathbb{V}, \mathbb{E})$, such that $\mathbb{V} = \{P, Q, R, S, T\}$ and $\mathbb{E} = \{PQ, QR, RS, ST, TP, RT, QS\} \subseteq \mathbb{V} \times \mathbb{V}.$

$$\wp = \langle \text{membership} \left(\frac{P}{.4}, \frac{Q}{.7}, \frac{R}{.6}, \frac{S}{.5}, \frac{T}{.6}\right), \text{non membership} \left(\frac{P}{.5}, \frac{Q}{.7}, \frac{R}{.6}, \frac{S}{.7}, \frac{T}{.7}\right) \rangle . \mathbb{Q}$$
$$= \langle \text{membership} \left(\frac{PQ}{.4}, \frac{QR}{.6}, \frac{RS}{.5}, \frac{ST}{.5}, \frac{TP}{.4}\right), \text{nonmembership} \left(\frac{PQ}{.7}, \frac{QR}{.7}, \frac{RS}{.7}, \frac{ST}{.7}, \frac{TP}{.7}\right) \rangle$$

The Pythagorean fuzzy edge and vertex sets, as described on $\mathbb{V}$ and $\mathbb{E}$, can be directly calculated using Fig. 1, proving $G = (\wp, \mathbb{Q})$ is a PFG.

Definition 2.4:-⟨9⟩ The degree of indeterminacy of x to $\wp$ is given by
$\pi_\wp(x) = \sqrt{1 - \mu_\wp^2(x) - \lambda_\wp^2(x)}.$ If $\wp = (\mu_\wp, \lambda_\wp)$ is a Pythagorean fuzzy number (PFN) then, degree of indeterminacy of element $x \in X$ is given as $\pi_P = \sqrt{1 - \mu_\wp^2 - \lambda_\wp^2},$ where $\mu_\wp, \lambda_\wp \in [0,1]$ and $0 \le \left(\mu_\wp\right)^2 + \left(\lambda_\wp\right)^2 \le 1.$

Trapezoidal Pythagorean Fuzzy Number and Algebraic Operators
The trapezoidal Pythagorean fuzzy value is a practical expression.
$$\mathcal{A}' = \langle (p, q, r, s), (u, v, w, x) \rangle$$
where, $\left(\mu_{\mathcal{P}_1}(u)\right)^2, \left(\mu_{\mathcal{P}_2}(u)\right)^2, \left(\mu_{\mathcal{P}_3}(u)\right)^2, \left(\mu_{\mathcal{P}_4}(u)\right)^2 = (p, q, r, s),$
$\left(\lambda_{\mathcal{P}_1}(u)\right)^2, \left(\lambda_{\mathcal{P}_2}(u)\right)^2, \left(\lambda_{\mathcal{P}_3}(u)\right)^2, \left(\lambda_{\mathcal{P}_4}(u)\right)^2 = (u, v, w, x).$

Definition 3.1:-A Trapezoidal Pythagorean fuzzy number (TraPFN) $\mathcal{A}' = \langle (p, q, r, s), (u, v, w, x) \rangle$ is said to be zero trapezoidal PFN if and only if, $(p, q, r, s) = (0,0,0,0);\ (u, v, w, x) = (1,1,1,1);$

Definition 3.2:- ⟨19⟩Let$\mathcal{A}' = \mathcal{A}_1, \mathcal{A}_2,$ then
$\mathcal{A}_1 \langle (p_1, q_1, r_1, s_1), (u_1, v_1, w_1, x_1) \rangle$and$\mathcal{A}_2 \langle (p_2, q_2, r_2, s_2), (u_2, v_2, w_2, x_2) \rangle$are two Trapezoidal Pythagorean Fuzzy Values (TraPFV) in the set of real numbers, and $\lambda > 0$, then operations rules are,

$$\text{(i)}\,\mathcal{A}_1 \oplus \mathcal{A}_2 = \left\langle \begin{array}{c} \sqrt{(p_1^2 + p_2^2 - p_1^2 p_2^2)}, \sqrt{(q_1^2 + q_2^2 - q_1^2 b_2^2)}, \sqrt{(r_1^2 + r_2^2 - r_1^2 r_2^2)}, \sqrt{(s_1^2 + s_2^2 - s_1^2 s_2^2)}, \\ (u_1 u_2, v_1 v_2, w_1 w_2, x_1 x_2) \end{array} \right\rangle$$

the grades of TraPFS. The TraPFS and concept paths can be ranked using these methods.

Definition 3.3:- ⟨6⟩Let $A_1 = \langle (p_1, q_1, r_1, s_1), (u_1, v_1, w_1, x_1) \rangle$ be a Trapezoidal Pythagorean fuzzy value (TraPFV) then, the score function $S(\mathcal{A}_1)$ and an accuracy function $H(\mathcal{A}_1)$ of TraPFV are defined as follows.
(i) $S(\mathcal{A}_1) = \frac{1}{4}[(p_1^2 + q_1^2 + r_1^2 + s_1^2) - (u_1^2 + v_1^2 + w_1^2 + x_1^2)],\ [-1,1],$
(ii) $H(\mathcal{A}_1) = \frac{1}{4}[(p_1^2 + q_1^2 + r_1^2, s_1^2) + (u_1^2 + v_1^2 + w_1^2 + x_1^2)],\ \ \ [0,1],$
The order relations between two TraPFVs are necessary for comparisons.

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Definition 3.4:- ⟨6⟩Let $\mathcal{A}_1 = \langle (p_1, q_1, r_1, s_1), (u_1, v_1, w_1, x_1) \rangle$ and
$\mathcal{A}_2 = \langle (p_2, q_2, r_2, s_2), (u_2, v_2, w_2, x_2) \rangle$ be two TraPFVs in the set of real numbers. Then, we define a ranking method as follows.
(i) If $S(\mathcal{A}_1) > S(\mathcal{A}_2)$, then $\mathcal{A}_1 > \mathcal{A}_2$, that is, $\mathcal{A}_1$ is superior to $\mathcal{A}_2$, denoted by $\mathcal{A}_1 > \mathcal{A}_2$.
(ii) If $S(\mathcal{A}_1) = S(\mathcal{A}_2)$, and $H(\mathcal{A}_1) > H(\mathcal{A}_2)$ then $\mathcal{A}_1 > \mathcal{A}_2$, that is $\mathcal{A}_1$ is superior to $\mathcal{A}_2$, denoted by $\mathcal{A}_1 > \mathcal{A}_2$.

Network Terminology
A directed network $P(V, E)$ is a set of m directed edges spanning a finite set of nodes $V = \{1,2,3, \dots, n\}$. Each edge is denoted is denoted by an ordered pair (i, j) where $i, j \in V$ and $i \neq j$. In this network, we consider two nodes, denoted by s and t, which are the source node and the destination node, respectively. We define a path
$P_{ij} = \{i = i, (i_1, i_2), i_2, \dots, (i_{l-1}, i_i), i_l = j\}$ of alternating nodes and edges. The existence of at least one path P_{S_i} in $P(V, E)$ is assumed for every $i \in V - \{S\}$.
d_{ij} denotes TPFN associated with the edge (i, j), corresponding to the length necessary to traverse (i, j) from i to j the Pythagorean distance along the path P is denoted as $d(P)$ is defined as, $d(P) = \sum_{(i,j \in P)} d_{ij}$.
The length required to traverse (i, j) from i to j is denoted by d_{ij}, which represents the TPFN associated with the edge (i, j). The Pythagorean distance along the path P is given by $d(P)$, which is defined as $d(P) = \sum_{(i,j \in P)} d_{ij}$.

Remark: - A node i is said to be pred, node j if,
        (i) Node i is directly connected to node j.
        (ii) The shortest route of the path is defined as the path that goes from node i to the node j.

Trapezoidal Fuzzy Pythagorean Path Problem
The paper discusses a network algorithm for shortest paths, using TrPFN as the edge length, which is executed in **6 steps**.
Step – 1: Assume $e_1 = \langle (0,0,0,0), (1,1,1,1) \rangle$ and label the source node (say node 1) as $[e_1 = \langle (0,0,0,0), (1,1,1,1) \rangle, -]$.
Step – 2: Find $e_j = \min\{e_i \oplus e_{ij}\}, j = 2,3,4, \dots, n$.
Step – 3: The minimum value of $i, i = r$, indicates a unique node j. If it occurs multiple times, it indicates multiple interval-valued Pythagorean paths between source nodes, but the trapezoidal fuzzy Pythagorean distance is e_j.
Step – 4: Let the destination node (node n) be labelled as $[e_n, l]$, then the Trapezoidal fuzzy Pythagorean shortest distance between source nodes is e_n.
Step – 5: If the destination node has the label $[e_n, l]$. Thus, examine node 1's label to determine the Trapezoidal Pythagorean fuzzy SP between the source and destination nodes. Assuming it is $[e_l, P]$, we next verify node P's label, and so forth. Continue in this manner until node 1 is reached.
Step – 6: Now the Trapezoidal Pythagorean fuzzy SP can be obtained by combining all the nodes obtained by the **Step – 5**.
Remark:- Let $\mathcal{A}_i = 1,2, \dots, n$ be a set of Trapezoidal Pythagorean fuzzy numbers, if $S(\mathcal{A}_K) < S(\mathcal{A}_i)$, for all i, the TraPFN is the min of $\mathcal{A}_K$. In this network each edge have been assigned to the TraPFN as follows: Above the values are defined as edges and TraPF distance at network (Fig.1).

Solutions
Since node 7 is the destination node, so $n = 7$.
Assume $e_1 = \langle (0,0,0,0), (1,1,1,1) \rangle$ and label the source node (say node1) as $[\langle (0,0,0,0), (1,1,1,1) \rangle, -]$, the value of $e_j; j = 2,3,4,5,6,7$ can be obtained as given below:

It 1: The predecessor nodes for node 2 are node 1, so put $i = 1$ and $j = 2$ in **Step – 2** of the given algorithm.
Then the path value of e_2 is,
$e_2 = \min \{e_1 \oplus e_{12}\}$
$= \min\{\langle (0,0,0,0), (1,1,1,1) \rangle \oplus \langle (0.3,0.5,0.6,0.5), (0.8,0.6,0.6,0.7) \rangle\}$
$e_2 = \langle (0.3,0.5,0.6,0.5), (0.8,0.6,0.6,0.7) \rangle$

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From the above calculation, min occurs corresponding to the node 1 and then label node 2 as
$[\langle(0.3,0.5,0.6,0.5), (0.8,0.6,0.6,0.7)\rangle, 1]$.

It 2: The predecessor nodes for node 3 are node 2, so put i = 2 and j = 3 in **Step – 2** of the given algorithm.
     Then the path value of e_3 is,
$e_3 = \min \{e_2 \oplus e_{23}\}$
$$= \min\{\langle(0.3,0.5,0.6,0.5), (0.8,0.6,0.6,0.7)\rangle \oplus \langle(0.6,0.5,0.4,0.2), (0.6,0.7,0.6,0.9)\rangle\}$$
$e_3 = \{\langle(0.628,0.688,0.702,0.53), (0.48,0.42,0.36,0.63)\rangle\}$
by using definition 3.3, (based on score function), the obtained value d_c is
$e_3 = \langle(0.628,0.688,0.702,0.53), (0.48,0.42,0.36,0.63)\rangle$
From the above calculation, min occurs corresponding to the node 2 and then label node 3 as
$[\langle(0.628,0.688,0.702,0.53), (0.48,0.42,0.36,0.63)\rangle, 2]$.

It 3: The predecessor of node 4 is node 1 and 3, so put the values of i = 1,3 and j = 4 respectively in **Step – 2** of the given algorithm.
     Then the path value of e_4 is,
$e_4 = \min \{e_1 \oplus e_{14}, e_3 \oplus e_{34}\}$
$$= \min \left\{ \begin{array}{c} \langle(0,0,0,0), (1,1,1,1)\rangle \oplus \langle(0.4,0.3,0.6,0.6), (0.7,0.8,0.7,0.8)\rangle, \\ \langle(0.628,0.688,0.702,0.53), (0.48,0.42,0.36,0.63)\rangle \\ \oplus \langle(0.3,0.4,0.5,0.6), (0.8,0.7,0.6,0.7)\rangle \end{array} \right\}$$
$$e_4 = \min \left\{ \begin{array}{c} \langle(0.4,0.3,0.6,0.6), (0.7,0.8,0.7,0.8)\rangle, \\ \langle(0.683,0.772,0.829,0.789), (0.384,0.294,0.216,0.441)\rangle \end{array} \right\}$$
$e_4 = \langle(0.4,0.3,0.6,0.6), (0.7,0.8,0.7,0.8)\rangle$
From the above calculation, min occurs corresponding to the node c and then label node d as
$[\langle(0.4,0.3,0.6,0.6), (0.7,0.8,0.7,0.8)\rangle, 1]$.

It 4: The predecessor of node 5 is node 2 and node 3, so put i = 2,3 and j = 5 in **Step – 2** of the given algorithm.
     The path value of e_5 is,
$$e_5 = \min \{e_2 \oplus e_{25}, e_3 \oplus e_{35}\}$$
$$= \min \left\{ \begin{array}{c} \langle(0.3,0.5,0.6,0.5), (0.8,0.6,0.6,0.7)\rangle \\ \oplus \langle(0.2,0.3,0.4,0.5), (0.9,0.8,0.7,0.7)\rangle, \\ \langle(0.628,0.688,0.702,0.53), (0.48,0.42,0.36,0.63)\rangle \\ \oplus \langle(0.2,0.4,0.5,0.6), (0.9,0.7,0.7,0.6)\rangle \end{array} \right\}$$
$$e_5 = \min \left\{ \begin{array}{c} \langle(0.336,0.568,0.702,0.688), (0.72,0.48,0.42,0.49)\rangle, \\ \langle(0.652,0.772,0.829,0.789), (0.432,0.294,0.252,0.378)\rangle \end{array} \right\}$$
by using definition 3.3, (based on score function), the obtained value e_5 is
$e_5 = \langle(0.336,0.568,0.702,0.688), (0.72,0.48,0.42,0.49)\rangle$
From the above calculation, min occurs corresponding to the node 2 and then label node 5 as
$[\langle(0.336,0.568,0.702,0.688), (0.72,0.48,0.42,0.49)\rangle, 2]$.

It 5 : The predecessor nodes for node 6 are node 4 and node 5, so put i = 4,5 and j = 6 in S**tep – 2** of the given algorithm.
     The path value of e_6 is,
$$e_6 = \min \{e_4 \oplus e_{46}, e_5 \oplus e_{56}\}$$
$$= \min \left\{ \begin{array}{c} \langle(0.4,0.3,0.6,0.6), (0.7,0.8,0.7,0.8)\rangle \\ \oplus \langle(0.4,0.5,0.6,0.3), (0.8,0.8,0.7,0.9)\rangle, \\ \langle(0.336,0.568,0.702,0.688), (0.72,0.48,0.42,0.49)\rangle \\ \oplus \langle(0.4,0.5,0.5,0.6), (0.7,0.8,0.7,0.8)\rangle \end{array} \right\}$$
$$e_6 = \min \left\{ \begin{array}{c} \langle(0.534,0.528,0.83,0.658), (0.56,0.64,0.49,0.72)\rangle, \\ \langle(0.478,0.737,0.829,0.878), (0.504,0.834,0.294,0.392)\rangle \end{array} \right\}$$
by using definition 3.3, (based on score function), the obtained value e_4 is
$e_6 = \langle(0.534,0.528,0.83,0.658), (0.56,0.64,0.49,0.72)\rangle$

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From the above calculation, min occurs corresponding to the nod e and then label node 6 as
[⟨(0.534,0.528,0.83,0.658), (0.56,0.64,0.49,0.72)⟩, 4].

It 6 : The predecessor nodes for node 7 are node 5 and node 6, so put i = 5,6 and j = 7 in S**tep – 2** of the given algorithm.

The path value of e_7 is,

$e_7 = \min \{e_5 \oplus e_{57}, e_6 \oplus e_{67}\}$

$$= \min \left\{ \begin{array}{c} \langle(0.336,0.568,0.702,0.688), (0.72,0.48,0.42,0.49)\rangle \\ \oplus \langle(0.3,0.4,0.6,0.7), (0.8,0.8,0.8,0.7)\rangle, \\ \langle(0.534,0.528,0.83,0.658), (0.56,0.64,0.49,0.72)\rangle \\ \oplus \langle(0.2,0.3,0.4,0.5), (0.9,0.9,0.9,0.8)\rangle \end{array} \right\}$$

$$e_7 = \min \left\{ \begin{array}{c} \langle(0.416,0.676,0.885,0.946), (0.576,0.384,0.336,0.343)\rangle, \\ \langle(0.563,0.592,0.88,0.799), (0.504,0.576,0.441,0.576)\rangle \end{array} \right\}$$

by using definition 3.3, (based on score function), the obtained value e_6 is

$e_7 = \langle(0.563,0.592,0.88,0.799), (0.504,0.576,0.441,0.576)\rangle$

From the above calculation, min occurs corresponding to the nod e and then label node 7 as
[⟨(0.563,0.592,0.88,0.799), (0.504,0.576,0.441,0.576)⟩, 6]. The shortest path and distance between source and destination nodes are determined by identifying the path

$1 \rightarrow 4 \rightarrow 6 \rightarrow 7 \langle(0.563,0.592,0.88,0.799), (0.504,0.576,0.441,0.576)\rangle$

By using the given proposed algorithm, shortest path for all nodes from source node and labelling is given:

CONCLUSION

The idea of a trapezoidal Pythagorean fuzzy shortest path in a network is defined in this study. We explore some mathematical procedures, including the trapezoidal Pythagorean fuzzy number. The suggested approach for utilising the trapezoidal Pythagorean path to solve SPP on a network makes use of this study. Next, we deduced the technique for the TraPFN shortest path issue within a pentagonal fuzzy setting.

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Table 1. Weights of the TraPFN.

Nodes	TraPFN
1 - 2	$\langle(0.3,0.5,0.6,0.5),(0.8,0.6,0.6,0.7)\rangle$
1 - 4	$\langle(0.4,0.3,0.6,0.6),(0.7,0.8,0.7,0.8)\rangle$
2 - 3	$\langle(0.6,0.5,0.4,0.2),(0.6,0.7,0.6,0.9)\rangle$
2 - 5	$\langle(0.2,0.3,0.4,0.5),(0.9,0.8,0.7,0.7)\rangle$
3 - 4	$\langle(0.3,0.4,0.5,0.6),(0.8,0.7,0.6,0.7)\rangle$
3 - 5	$\langle(0.2,0.4,0.5,0.6),(0.9,0.7,0.7,0.6)\rangle$
4 - 6	$\langle(0.4,0.5,0.6,0.3),(0.8,0.8,0.7,0.9)\rangle$
5 - 6	$\langle(0.4,0.5,0.5,0.6),(0.7,0.8,0.7,0.8)\rangle$
5 - 7	$\langle(0.3,0.4,0.6,0.7),(0.8,0.8,0.8,0.7)\rangle$
6 - 7	$\langle(0.2,0.3,0.4,0.5),(0.9,0.9,0.9,0.8)\rangle$

Table 2. TraPF distance and Shortest Path

Node	d_i	TPFSP between jth and 1st node
2	$\langle(0.3, 0.5, 0.6, 0.5), (0.8, 0.6, 0.6, 0.7)\rangle$	$1 \rightarrow 2$

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3	⟨(0.628, 0.688, 0.702, 0.53), (0.48, 0.42, 0.36, 0.63)⟩	$1 \to 2 \to 3$
4	⟨(0.4, 0.3, 0.6, 0.6), (0.7, 0.8, 0.7, 0.8)⟩	$1 \to 4$
5	⟨(0.336, 0.568, 0.702, 0.688), (0.72, 0.48, 0.42, 0.49)⟩	$1 \to 2 \to 5$
6	⟨(0.534, 0.528, 0.83, 0.658), (0.56, 0.64, 0.49, 0.72)⟩	$1 \to 4 \to 6$
7	⟨(0.563, 0.592, 0.88, 0.799), (0.504, 0.576, 0.441, 0.576)⟩	$1 \to 4 \to 6 \to 7$
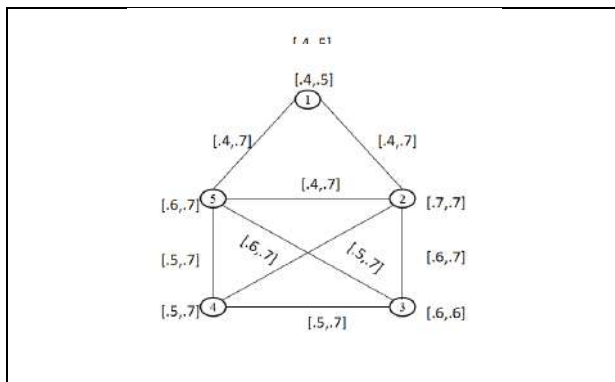
| Fig. 1. Pythagorean Fuzzy Graph. | Fig.2 Pythagorean Trapezoidal Fuzzy Directed Graph. |
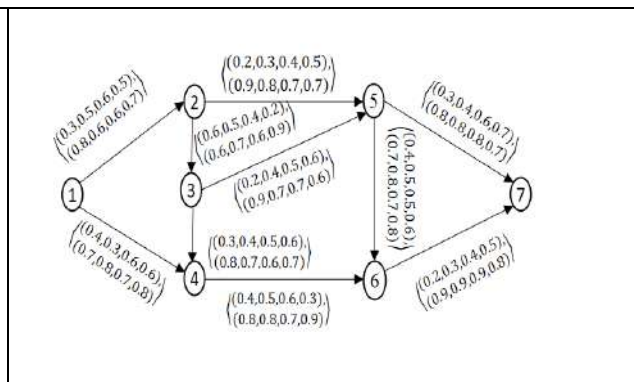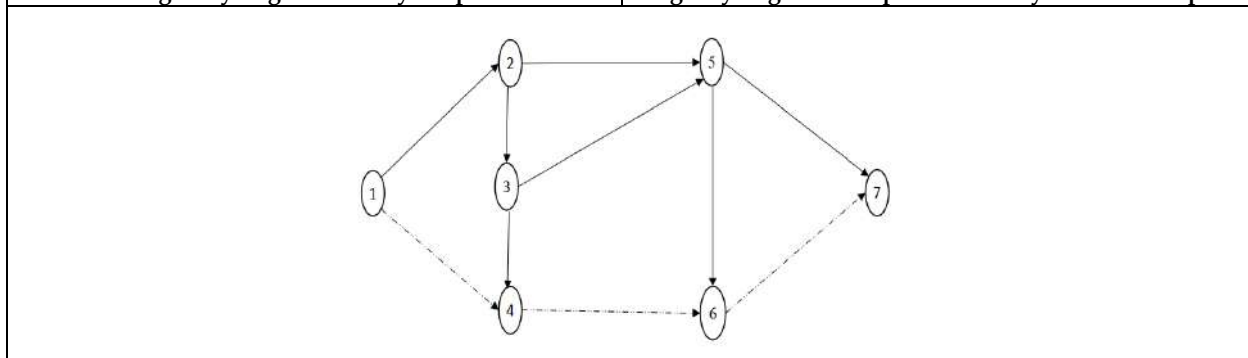
Fig.3 Pythagorean Trapezoidal Fuzzy Directed Graph with SP

RESEARCH ARTICLE

Optimized Inventory Control for Seasonal Demand: A Comprehensive Model Addressing Deterioration and Shortages

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ABSTRACT

In this paper, we developed an inventory model that accounts for seasonal demand rates, and linear deterioration rates, and allows for shortages with partial backlogging. We solved the model for a finite period and identified its potential applications in various real-world scenarios. The primary objective of this study is to minimize the total cost of the system while determining the optimal order quantity. Additionally, we conducted a sensitivity analysis on several related parameters and included a numerical example to illustrate the model and its critical features.

Keywords: Seasonal items demand rate, Deterioration rate, Backlogging.

INTRODUCTION

In real-world situations, it is observed that many products in life have a seasonal demand pattern. So the models with seasonal demand are prevalent because of their extensive application in the inventory management of products with short life cycles. When it comes to juices that are in stock, seasonal demand is a term used to describe how customer purchasing patterns for juices vary by season. Demand patterns are predictable as a result of this variation, which is frequently linked to seasonal events or holidays. For instance, the demand for some juice varieties could increase during the summer or around the holidays and decrease at other periods of the year. Demand forecasting, inventory optimization tools, and efficient

supply chain management techniques are frequently used by enterprises to control seasonal demand for juices in stock. Inventory is mostly based on the demand pattern; it may be deterministic or probabilistic. Shortages or stockouts result when demand exceeds the supply of products in stock. There are two types of shortages. The first is called backorder or backlogging, and it occurs when shops fail to meet customer demand. For example, a consumer can choose to wait for a while to purchase if there are study materials available, and he can depend on the shopkeeper to get them as quickly as possible. So long as there is a partial backlog, shortages are permitted. The second type of shortage is called full backlog or lost sales case where the demand is completely lost. For example, electronic equipment and gadgets, etc. have very short life spans due to innovative changes in the models and technology. In reality, a client can be willing to delay buying certain items, such as trendy clothing electronics, etc. However, for some products, like food or medicines, customers are not willing to wait and will buy them from other suppliers. The impact of inflation on a two-storage inventory model with time-dependent degrading items and stock-dependent demand was examined by Sharma et al. (2020). In traditional inventory models, we think items stay the same in storage. But things like fruits, vegetables, and liquids can go bad over time. This spoilage, called deterioration, is important to consider when making inventory plans. Deterioration means a drop in quality, which can include changes, decay, obsolescence, or spoilage over time. It leads to a decrease in the usefulness or value of goods. Deterioration is always considered over time.Pervin et al. (2018) developed an inventory model for stochastic deterioration with time-dependent demand. They use a method that considers how demand changes over time to ensure our model stays current and relevant. The paper aims to find the most effective way for retailers to replenish perishable items, considering changes in demand over time.

This demonstrates how these strategies apply in real-world scenarios using typical inventory management approaches. Bandaly and Hassan (2020) devised an inventory model that integrates Postponement strategies into production and inventory plans, considering the impact of deterioration. The study's objective was to devise a production and inventory strategy tailored for a producer of fresh apple juice. Singh et al. (2016) developed an inventory model for deteriorating items with stock-dependent and seasonal pattern demand. Tayal et al. (2014) presented an inventory model of seasonal products for deteriorating items in which they applied a preservation technology cost to reduce the product's rate of deterioration. In this model, the occurring shortages are partially backlogged.Tayal et.al (2015) developed an inventory model for deteriorating items with seasonal products in which they examined a model for managing inventory of seasonal products with a Weibull rate of deterioration, looking at two possible markets: the primary and an alternative one. Keeping inventory until the next season leads to higher total costs. Soysal and Krishnamurthi (2012) developed an inventory model focused on seasonal goods. The objective of their paper is to establish and assess a dynamic model of consumer choice behavior within markets for seasonal goods, where products are sold during a finite season with limited availability. Banerjee and Sharma (2010) investigated an inventory model for seasonal demand in which they introduced the idea of selling products in a different market. If there's demand, the distributor can sell them there for the same or higher price, which helps save on storage and product quality costs. Normally, products get worse over time. Their investigation centered on two significant markets: the primary market and an alternative market, accounting for the time lag in demand seasons between these markets. Hamilton et al. (2024) developed an inventory model for spatial procurement of farm products and the supply of processed foods which they investigated that shows how a food processor buys farm products. This model is meant to understand how supply chain problems affect where farms get their products for making food. Ihwah and Viandini (2020) created an

inventory model specifically for predicting the procurement quantity of Manalagi apples for the production of apple juice drinks at PT XYZ Malang. The primary goal of this study was to forecast the procurement volume of Manalagi apples, which serve as the primary raw material in the apple juice drink production process. Kandemir (2022) introduced an inventory model that focuses on clustering items with seasonal and non-seasonal demand patterns to improve inventory management. The investigation into the seasonality effect initially targeted products with short-lived demand. Groebner and Merz (1990) specifically examined items like winter sporting goods. This approach was further pursued by Giri et al. (1996) in their study of an EOQ model for deteriorating items. Subsequent research delved into seasonal demand, as illustrated by Gupta et al.'s work (2003), which focused on items characterized by fixed selling seasons. Singha et al. (2024) designed an inventory model specifically for Market Basket Analysis within the context of a Health Food Store. Their article includes a case study that applies market basket analysis to a transactional dataset from a health food store based in Thailand. Alnahhal et al. (2021) formulated an inventory replenishment model that focuses on optimizing inventory management for seasonal demand while considering discrete delivery times. This study aims to find a better way for companies to restock their inventory when demand changes throughout the year. They want to suggest a new method for suppliers and warehouses to work together effectively, especially for products that are in high demand during certain seasons.

This study takes inspiration from a case study of a German drinks company, conducted by Alnahhal et al. (2021), focusing on the manufacturing and distribution of beverages. In this model, we utilize data sourced from Alnahhal et al. (2021). Table 1 illustrates both the monthly actual demand and the expected demand. Various drinks are manufactured in-house or acquired from other businesses and distributed to retail retailers. Unit prices are generally constant, but summertime demand usually goes higher. Because suppliers cannot make every kind of product daily, some product types may only be available on specific days of the week, which means two days.This research aims to suggest a fresh approach for organizing the replenishment procedure between the supplier and the warehouse of any business with a seasonal need while maintaining a decent level of forecast accuracy regarding the demand for the final product. When used in real-world business situations, an integrated inventory model that takes deterioration and shortages into account for seasonal demand products can result in cost savings, enhanced supplier relationships, better customer service, and an overall gain in operational efficiency. This study examines Alnahhal et al.'s (2021) study, exploring seasonal demand items with linear deterioration rates and allowing shortages with partial backlogging. Our research introduces an inventory model tailored for seasonal demand items with linear deterioration rates and shortages allowed with partial backlogging. The main objective of this study is to propose a new approach to managing the replenishment process between suppliers and warehouses in businesses with seasonal demand while maintaining a reasonable level of demand forecast accuracy for the final product. This model has wide applicability across industries such as retail, consumer goods, fast-moving consumer goods, agriculture, food and beverage, as well as event planning. We provide numerical illustrations to demonstrate the practical implementation of this model in various realistic scenarios.

METHODOLOGY

Figure 1: The overview outlines the study's procedural steps. Initially, it defines the unique problem characteristics. Subsequent sections investigate step-by-step discussions. Assumptions closely mirror

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real-world conditions. The inventory model achieves optimal solutions. The final stage emphasizes the necessity of monthly plan updates based on evolving demand and current inventory size. Following this, the results are discussed. Figure 2 is about, who gives stuff to the company and who buys from it first. To get drinks to stores, they go through two steps: from suppliers or the factory to the warehouse, and then from the warehouse to small shops. The company has its factory next to the warehouse where they make or buy drinks. They use different ways to restock between the company and the shops. This study looks at how drinks get from the suppliers to the warehouse.

Notations

- C_P is the purchase cost per unit time.
- C_h is the holding cost per unit per unit time.
- $I_1(t)$ is inventory level at a time t_1.
- $I_2(t)$ is inventory level at a time T.
- A is the inventory order cost per order.
- C_D is the deterioration cost per unit time.
- C_s is the shortage cost per unit time.
- L_S is the lost sales cost per unit.
- t_1 is stock exhausts time.
- T is the length of a process duration.
- I_b is the highest level of delay purchase.
- I_m is the maximum level of stock during the period [0, T].
- TC is the total inventory cost.
- Q is the total quantity of an order.
- SC is the shortage cost per cycle.
- PC is the purchase cost per cycle.
- LS is the cost due to lost sales per cycle.
- $R(t)$ is the deterioration rate.

Assumptions

- The replenishment rate is infinite.
- There is no lead time.
- D_t is the demand rate and it is of the form $D_t = D$ in which $D = B_t * S_t$; where B_t =actual demand, S_t= average seasonal index.
- The deterioration rate is linear at time t and its parameter is R(t)= θt.
- Shortage is allowed, with partial backlogging and the backlogging rate is $e^{-\lambda t}$ Unsatisfied demand is backlogged at a rate, the backlogging parameter λ is a positive constant.
  $\lambda > 0$ is the backlogging parameter and $t_1 \leq t \leq T$.

Mathematical Model

In Figure 3, we consider the deteriorating inventory model with seasonal items demand rate. Replenishment starts at time $t = 0$ when the inventory level attains its maximum, I_m. The inventory decreases due to demand and deterioration for the time $(0, t_1)$. At time t_1, the inventory level is equal to zero, the shortage starts during the time interval $[t_1, T]$, and the demand during this period is partially

backlogged. The stock exhausts during the period [0, t₁] due to cumulative effects from decay. In this sense, the differential condition represents the stock level at any given time during [0, t₁].

$$\frac{dI_1(t)}{dt} + R(t)I_1(t) = -D_t; \quad 0 \le t \le t_1 \qquad \qquad \dots (1)$$

$$\frac{dI_2(t)}{dt} = -D_t\, e^{-\lambda t}; \quad t_1 \le t \le T \qquad \qquad \dots (2)$$

Using the Deterioration rate $R(t) = \theta t$ and Demand rate $D_t = D$ with the condition $t = t_1, and\ I_1(t_1) = 0$ in equation (1)

By equation (1) we get,

$$\frac{dI_1(t)}{dt} + \theta t\, I_1(t) = -D_t; \quad 0 \le t \le t_1$$

$$I_1(t) = D\left\{t_1 - t + \theta\frac{t_1^3}{6} - \theta\frac{t_1 t^2}{2} + \theta\frac{t^3}{3}\right\} \qquad \qquad \dots (3)$$

Using the boundary condition $t = t_1, and\ I_2(t_1) = 0$ in equation (2), we get

By equation (2) we get,

$$\frac{dI_2(t)}{dt} = -D_t e^{-\lambda t}; \quad t_1 \le t \le T$$

$$I_2(t) = \frac{D}{\lambda}\left\{e^{-\lambda t} - e^{-\lambda t_1}\right\} \qquad \qquad \dots (4)$$

The maximum level of optimistic inventory is $I_m = I_1(0)$

$$I_m = D\left\{t_1 + \theta\frac{t_1^3}{6}\right\} \qquad \qquad \dots (5)$$

The maximum negative inventory (back-ordered unit) is $I_b = -I_2(T)$

$$I_b = \frac{D}{\lambda}\left(e^{-\lambda t_1} - e^{-\lambda T}\right) \qquad \qquad \dots (6)$$

Thus, the total quantity in the inventory [0, T] is

$$Q = I_1(0) + I_2(T)$$

$$Q = I_m + I_b$$

$$Q = D\left\{t_1 + \theta\frac{t_1^3}{6} + \frac{1}{\lambda}\left(e^{-\lambda t_1} - e^{-\lambda T}\right)\right\} \qquad \qquad \dots (7)$$

Now, the Ordering Cost is given by: -

$$OC = A \qquad \qquad \dots (8)$$

Holding Cost during the interval [0, T] is given by

$$HC = \int_0^{t_1} h(t)\, I_1(t)\, dt$$

$$HC = hD\left\{\frac{t_1^2}{2} + \theta\frac{t_1^4}{12}\right\} \qquad \qquad \dots (9)$$

Shortage Cost during the interval [t_1, T] is given by

$$SC = -C_S \int_{t_1}^T I_2(t)\, dt$$

$$SC = \frac{C_S D}{\lambda}\left\{\frac{e^{-\lambda T}}{\lambda} + e^{-\lambda t_1}\left(T - t_1 - \frac{1}{\lambda}\right)\right\} \qquad \qquad \dots (10)$$

Deterioration Cost is given by: -

$$DC = C_D\left\{I_1(0) - \int_0^{t_1} D(t)\, dt\right\}$$

$$DC = C_D D\left\{\theta\frac{t_1^3}{6}\right\} \qquad \qquad \dots (11)$$

Lost Sale Cost is given by: -

$$LS = L_S D \int_{t_1}^T \left(1 - e^{-\lambda t}\right) dt$$

$$LS = L_S D\lambda\left\{T - t_1 + \frac{1}{\lambda}\left(e^{-\lambda T} - e^{-\lambda t_1}\right)\right\} \qquad \qquad \dots (12)$$

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Purchase Cost is given by: -

$PC = C_P Q$

$PC = C_P D \left\{ t_1 + \theta \frac{t_1^3}{6} + \frac{1}{\lambda} \left(e^{-\lambda t_1} - e^{-\lambda T} \right) \right\}$ ... (13)

Total Cost

$$TC = \frac{1}{T} \{ HC + SC + DC + LS + PC + OC \}$$

$$TC = \frac{1}{T} \left\{ hD \left\{ \frac{t_1^2}{2} + \theta \frac{t_1^4}{12} \right\} + \frac{C_S D}{\lambda} \left\{ \frac{e^{-\lambda T}}{\lambda} + e^{-\lambda t_1} \left(T - t_1 - \frac{1}{\lambda} \right) \right\} + C_D D \left\{ \theta \frac{t_1^3}{6} \right\} \right.$$

$$\left. + L_S D\lambda \left\{ T - t_1 + \frac{1}{\lambda} \left(e^{-\lambda T} - e^{-\lambda t_1} \right) \right\} + C_P D \left\{ t_1 + \theta \frac{t_1^3}{6} + \frac{1}{\lambda} \left(e^{-\lambda t_1} - e^{-\lambda T} \right) \right\} + A \right\}$$

...(14)

The necessary condition to be reduced is

$\frac{\partial TC}{\partial t_1} = 0, \frac{\partial TC}{\partial T} = 0$ i.e., And $\frac{\partial^2 TC}{\partial t_1^2} > 0$, $\frac{\partial^2 TC}{\partial T^2} > 0$ And $\left(\frac{\partial^2 TC}{\partial t_1^2} \right) \left(\frac{\partial^2 TC}{\partial T^2} \right) - \left(\frac{\partial^2 TC}{\partial t_1 \partial T} \right) > 0$

Numerical examples

Values of parameters used in our Inventory Model are as follows:

A=$100, C_P=\$30, λ=0.01, Cs=\$4, C_D=\$30, Ls=\$5, θ=0.002, D=34 per day, and h=\$1 in appropriate units. We obtained the optimal value t_1=9.0974 days, T=10.1514 days, TC=916.2623, and Q=350.3928 units.

Sensitivity analysis

By changing the values of parameters used in our model and readout the effects on t_1 and TC. The rate of changes in values of parameters are taken -20%, -10%, +10%, and 20%.

CONCLUSIONS

We created an inventory model for a seasonal items demand rate with a linear deterioration rate and Shortages allowed with partially backlogged. Table 2 demonstrates the impact of the deterioration rate and backlogging parameter on the total cost, as depicted in Figure 4. A sensitivity analysis is conducted, to examine how shifting parameter values affect the solution. Table 3 illustrates the sensitivity analysis, which is visually presented in Figure 5.

From the analysis of the model, it has concluded that:

- The stock exhaust time (t_1) decreases marginally for θ, h, C_P, A, and C_D but it decreases significantly for Cs.
- The stock exhaust time (t_1)is increased significantly for Ls and increased marginally for λ.
- The length of a process duration (T) decreases marginally for θ, C_P, A, and C_D but it decreases significantly for Cs.
- The length of a process duration (T) increased marginally for h, and λ. But it increased significantly for L_S.
- The total inventory cost decreases marginally for θ. But it decreases significantly for A, C_S, and L_S.
- The total inventory cost increases marginally for C_D.
- The total inventory cost increased significantly for C_P, λ, and h.

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Table 1. The annual demand data for apple juice from the beverage company.

Month	Actual Monthly Demand	Expected Monthly Demand	Expected Per day Demand
1st	1019	1021	34.03
2nd	1090	1092	36.4
3rd	1427	1430	47.66

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4th	1269	1272	42.4
5th	1734	1737	57.9
6th	1382	1385	46.16
7th	1701	1704	56.8
8th	1687	1690	56.33
9th	1538	1541	51.36
10th	1217	1219	40.63
11th	1322	1325	44.16
12th	1175	1177	39.23

Table 2: Effect of Deterioration Rate and Backlogging Parameter on The Total Inventory Cost

θ λ	Total Cost	0.0016	0.0018	0.002	0.0022	0.0024
0.008	TC	914.152	912.979	912.363	912.174	912.309
0.009	TC	916.154	914.914	914.256	914.035	914.152
0.01	TC	918.290	916.972	916.262	916.006	916.100
0.011	TC	920.587	919.175	918.403	918.103	918.167
0.012	TC	923.081	921.560	920.708	920.357	920.387

Table 3: Sensitivity analysis of these Parameter's

Parameter	%	-20%	-10%	0%	10%	20%
A	t_1	9.322	9.211	9.097	8.980	8.859
	T	10.502	10.328	10.151	9.969	9.783
	TC	921.763	919.037	916.262	913.426	910.531
θ	t_1	9.645	9.349	9.097	8.878	8.684
	T	10.737	10.417	10.151	9.926	9.732
	TC	918.290	916.972	916.262	916.006	916.100
h	t_1	9.313	9.201	9.097	9.000	8.910
	T	10.019	10.082	10.151	10.226	10.307
	TC	887.001	901.772	916.262	930.504	944.534
C_S	t_1	10.369	9.661	9.097	8.624	8.215
	T	12.766	11.241	10.151	9.317	8.650
	TC	963.348	936.754	916.262	899.631	885.692
C_P	t_1	9.339	9.215	9.097	8.983	8.874
	T	10.249	10.198	10.151	10.107	10.065
	TC	712.645	814.476	916.262	1017.998	1119.686
C_D	t_1	9.292	9.192	9.097	9.007	8.921
	T	10.340	10.242	10.151	10.065	9.984
	TC	915.729	915.970	916.262	916.597	916.968
L_S	t_1	7.072	8.130	9.097	10.012	10.897
	T	7.624	8.937	10.151	11.318	12.470
	TC	923.534	920.065	916.262	912.857	910.320
λ	t_1	8.997	9.044	9.097	9.157	9.225
	T	9.847	9.993	10.151	10.322	10.508
	TC	912.363	914.256	916.262	918.403	920.708

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Figure 1: Study general steps

Figure 2. Drinks company supply chain

Figure 3: Inventory Level Over Time T

Figure 4: Graphical Representation of the Effect of Deterioration Rate and Backlogging Parameter on The Total Inventory Cost

Figure 5: Graphical representation of Sensitivity analysis of these Parameter's

RESEARCH ARTICLE
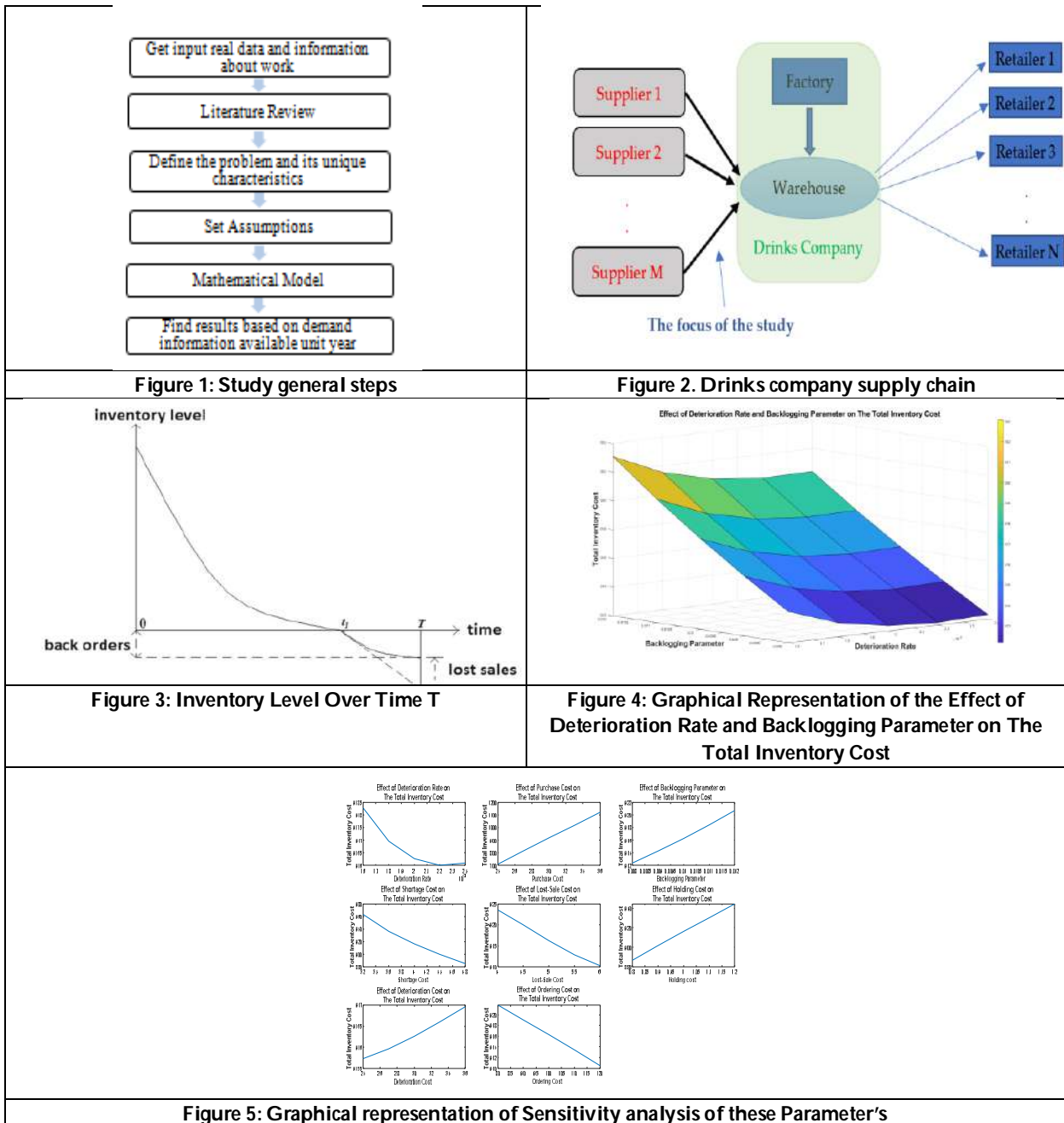
Post-COVID Educational Resilience Analysis (PCERA) for the Dadupur Community: A Detailed Study of a Small Village in India

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ABSTRACT

This study investigates the impact of the COVID-19 pandemic on the educational system in Dadupur, a rural community in Uttar Pradesh, India. The research aims to assess the pandemic's effects on educational progress, explore local responses to ensure continuity, and evaluate the effectiveness of digital learning and other innovations. Utilizing a mixed-methods approach, data was collected through surveys and interviews with school-aged children, teachers, administrators, parents, and community leaders. The findings reveal significant educational setbacks due to school closures, a notable pivot towards online learning, and community-driven educational programs highlighting remarkable resilience despite limited resources. However, the effectiveness of these strategies varies, underscoring gaps in digital infrastructure and support systems. This study contributes to understanding the educational impacts of COVID-19 in rural settings and underscores the need for targeted interventions and community-based solutions to build a more resilient educational framework.

Keywords: COVID-19, education, digital learning, rural resilience, Dadupur, educational continuity, socio-economic impacts.

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INTRODUCTION

The COVID-19 pandemic has precipitated unprecedented global disruptions, profoundly impacting various sectors, with education being one of the hardest hits. The sudden closure of schools and the shift to remote learning have highlighted and exacerbated existing systemic inequalities. The transition to digital education has underscored the urgent need for adaptable and resilient educational systems, especially in rural areas where technological infrastructure is often inadequate [1]. Dadupur, a village in Uttar Pradesh, India, with a population of 1406 as of the 2011 census, presents a unique case for examining the pandemic's impact on education [2]. This community, characterized by socio-economic challenges and limited access to technology, faced significant disruptions in its educational processes due to the pandemic. The pre-existing hurdles, such as low enrolment rates, high dropout rates, and poor quality of educational resources, were magnified during the crisis [3]. Education in rural India plays a critical role in the socio-economic development of the nation but is often plagued by challenges such as teacher absenteeism, lack of infrastructure, and gender disparities [4]. The pandemic has intensified these issues, creating a significant setback in educational progress. According to the Annual Status of Education Report (ASER) survey, two-thirds of rural children in India did not receive any learning materials or activities during the pandemic [5]. The objectives of this study are threefold: first, to assess the direct and indirect effects of COVID-19 on the education system in Dadupur; second, to explore the strategies adopted by educators, students, and the community to ensure educational continuity during the pandemic; and third, to evaluate the efficacy of these strategies, particularly digital learning initiatives, in mitigating the educational setbacks faced by students. By investigating these areas, the study aims to contribute valuable insights into the resilience of rural education systems during global health crises, offering lessons that can inform future educational policies and practices. The findings are expected to highlight the challenges and innovations within Dadupur's education system during the pandemic, emphasizing the broader implications for rural education globally [6]. This research adopts a mixed-methods approach, combining quantitative data from structured questionnaires and qualitative insights from open-ended responses. This methodology ensures a comprehensive understanding of the impacts of COVID-19 on education in Dadupur and the community's resilience strategies [7]. The significance of this study lies in its potential to bridge the research gap on the impact of COVID-19 on rural education in India, providing a nuanced understanding of the challenges and opportunities in enhancing educational resilience and equity in similar contexts worldwide [8].

MATERIALS AND METHODS

Topic Selection and Justification
The selection of "Post-COVID Educational Resilience Analysis in Dadupur Community" was motivated by the urgent need to understand the ramifications of the COVID-19 pandemic on education systems, particularly in rural settings. The pandemic underscored the fragility of educational infrastructures in the face of global crises, highlighting the need for resilience and adaptability. Dadupur, embodying the challenges faced by rural communities in India, including limited technological access, socio-economic barriers, and infrastructural deficiencies, provided a poignant backdrop for investigating these issues. This study aims to document the immediate impacts of the pandemic and explore the strategies employed by the community to navigate these challenges, thereby offering insights that could inform future policy and practice in rural education systems globally.

Village/Location Selection
Dadupur, a village in Uttar Pradesh, India, was chosen for its typical representation of rural Indian communities grappling with educational challenges exacerbated by the pandemic. Its small population and the existence of pre-pandemic data on its educational landscape allowed for a focused and deep investigation. The village's demographic diversity and socio-economic conditions also provided a microcosm through which to explore broader themes of resilience, adaptation, and innovation in rural education during and after the COVID-19 crisis.

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METHODOLOGY OVERVIEW

A mixed-methods approach was employed to capture a comprehensive picture of the pandemic's impact on education in Dadupur. The quantitative component, facilitated through structured questionnaires, was designed to gather data across various dimensions such as demographic details, educational status and impact, modes of learning adaptation during school closures, challenges encountered, and levels of community engagement. The qualitative component, through open-ended questionnaire responses, aimed to delve deeper into the lived experiences of participants, uncovering nuanced insights into the effectiveness of adopted strategies and the personal and communal implications of the pandemic on education.

Plan of Action

The research commenced with an extensive literature review to frame the study within the existing body of knowledge on rural education in the context of the pandemic. Following this, the questionnaire was meticulously designed to ensure comprehensive coverage of relevant themes and was piloted within a small segment of the target population to refine questions for clarity and relevance. The distribution of questionnaires was then conducted in person to accommodate the varied access levels within the community. Concurrently, participants answered the open-ended questions, with these discussions offering depth and context to the quantitative findings. Data collection was complemented by observational notes and secondary data from local educational authorities and reports.

Problems Faced in Execution and Solutions

Several challenges were encountered during the execution of the research, notably the digital divide, which limited access to online questionnaires. This was addressed by distributing physical copies of the questionnaires. Ensuring participant comfort and openness, particularly given the sensitive nature of the pandemic's impact on household education and income, was another challenge. This was mitigated through the use of empathetic questions, ensuring confidentiality, and building rapport with participants prior to data collection. Logistical issues, such as reaching remote parts of the village and coordinating the response times, were also faced and managed through careful planning and community engagement.

RESULT

The methodology yielded rich data, with over 40 questionnaires fully completed and analyzed, alongside open-ended questions that provided qualitative insights into the community's educational experiences during the pandemic. This comprehensive data collection facilitated a robust analysis of the direct and indirect effects of COVID-19 on education in the community, the resilience strategies employed, and the efficacy of digital and other innovative educational approaches under such crisis conditions.

RESEARCH METHODOLOGY

The methodology yielded rich data, with over 40 questionnaires fully completed and analyzed, alongside open-ended questions that provided qualitative insights into the community's educational experiences during the pandemic. This comprehensive data collection facilitated a robust analysis of the direct and indirect effects of COVID-19 on education in the community, the resilience strategies employed, and the efficacy of digital and other innovative educational approaches under such crisis conditions. The mixed-methods research methodology was instrumental in achieving the study's objectives. The quantitative data from questionnaires offered a broad overview of the pandemic's impacts and the demographic and educational landscape of Dadupur, allowing for the identification of trends and patterns. The qualitative data, on the other hand, brought to light the stories behind these trends, offering insights into the adaptive mechanisms, challenges, and successes experienced by individuals and the community at large. This approach ensured that the study's findings were grounded in both statistical evidence and

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human experience, providing a comprehensive understanding of the resilience of rural education systems in the face of unprecedented global challenges.

RESULTS AND DISCUSSIONS

RESULTS

The data collected from the structured questionnaires and open-ended responses provide a comprehensive overview of the educational impact of COVID-19 on the Dadupur community.

Demographic Insights
- **Age Group Distribution:** Under 18 (20%), 18-24 (20%), 25-34 (20%), 35-44 (17.5%), 45-54 (7.5%), 55+ (15%).
- **Gender Distribution:** Female (47.5%), Male (45%), Prefer not to say (7.5%).
- **Education Status:** Completed Education (40%), Currently Enrolled (25%), Never Attended School (25%), Dropped Out (10%).
- **Occupation Distribution:** Home worker (40%), Student (25%), Business/Trade (12.5%), Farmer (7.5%), Educator (5%), Retired (10%).

Impact of COVID-19 on Education
- **School Closures:** 85% of respondents indicated school closures for more than 3 months.
- **Reliance on Learning Methods:** 87.5% relied on online learning, 10% used other materials, and 2.5% used offline methods.
- **Satisfaction with Online Learning:** 42.5% very satisfied, 35% neutral, 20% dissatisfied.
- **Learning Gaps or Setbacks:** 35% reported significant learning gaps.
- **Financial Difficulties Impacting Education:** 42.5% faced financial difficulties.

Educational Resilience Strategies and Community Support
- **Strategies Used:** Online educational resources (35%), community support (35%), help from teachers/tutors (12.5%), peer support (12.5%), structured study schedules (5%).
- **Effectiveness of Strategies:** 55% found them somewhat helpful, 40% very helpful.
- **Emotional or Mental Health Support:** 22.5% received support; effectiveness was mostly neutral (72.5%).
- **Satisfaction with School Support:** 42.5% very satisfied, 17.5% dissatisfied, 17.5% very dissatisfied.
- **Community Programs:** 40% reported the presence of educational support programs; effectiveness varied with 32.5% finding them very helpful, 30% neutral, 30% not helpful.

Future of Education in Dadupur
- **Optimism about Future Education:** 42.5% neutral, 27.5% somewhat optimistic, 15% very optimistic, 15% somewhat pessimistic.
- **Willingness to Participate in Future Initiatives:** 80% very willing.

DISCUSSIONS

Digital Divide and Online Learning Challenges
The reliance on online learning (87.5%) underscores the shift towards digital education during the pandemic. However, the mixed satisfaction levels (42.5% very satisfied, 20% dissatisfied) highlight the challenges of online learning, including quality, engagement, and inclusivity issues. The significant digital divide impacted students' access and engagement, aligning with broader findings on rural education during the pandemic.

Educational Setbacks and Financial Difficulties

The pandemic resulted in substantial educational setbacks, with 35% of respondents reporting significant learning gaps. Financial difficulties further exacerbated these challenges, impacting 42.5% of the respondents. These findings emphasize the socio-economic barriers to educational continuity during crises, consistent with existing literature.

Resilience Strategies and Community Support

Community-driven strategies, including online educational resources and community support, were crucial in navigating educational challenges. However, the effectiveness of these strategies varied, indicating room for improvement. Mental health support was limited and often perceived as neutral in effectiveness, highlighting the need for better mental health resources.

School and Community Support

Mixed levels of satisfaction with school and community support programs underscore the importance of robust and effective support systems. The dissatisfaction reported by some respondents (17.5% dissatisfied) points to gaps in the support provided, emphasizing the need for more inclusive and accessible educational support programs.

Future Outlook and Community Engagement

Despite the challenges, there is a cautious optimism about the future of education in Dadupur, with a significant willingness (80%) to participate in future educational initiatives. This suggests a strong community commitment to improving educational resilience and quality post-pandemic. The results of this study underscore the importance of community and mental health support in enhancing satisfaction with online learning during the COVID-19 pandemic. The lack of significant differences in satisfaction levels between genders suggests that both male and female students faced similar experiences and challenges with online learning. The non-significant relationship between school closures and reliance on online learning may reflect the adaptability of students and their families in finding alternative learning methods regardless of school closures. This adaptability could be influenced by the availability of community resources and support networks. The regression analysis highlights the critical role of community support and mental health resources in ensuring educational resilience. These findings suggest that policies aimed at strengthening community support systems and providing mental health resources can significantly improve students' satisfaction and overall learning experiences during crises like the COVID-19 pandemic.

Policy Implications

1. **Enhancing Community Support:** Educational institutions and policymakers should invest in community support programs that facilitate learning continuity and provide a support network for students.
2. **Improving Access to Technology:** Efforts to bridge the digital divide by improving access to technology can potentially enhance satisfaction with online learning, as indicated by the positive trend in the regression analysis.
3. **Mental Health Resources:** Providing mental health resources is crucial for supporting students' emotional and psychological well-being, which, in turn, can positively impact their learning experiences.

STATISTICAL ANALYSIS RESULTS

Descriptive Statistics
Age Group Distribution

The age distribution among participants was varied, with equal representation from the under 18, 18-24, and 25-34 age groups (each with 8 participants). Participants aged 35-44 were slightly fewer (7 participants), followed by those aged 55+ (6 participants), and the smallest group was the 45-54 age group (3 participants).

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Gender Distribution
The gender distribution showed a slight majority of female participants (19), followed by males (18), and a small number preferring not to disclose their gender (3).

Current Education Status
Most participants had completed their education (16), while a significant number never attended school (10) or were currently enrolled (10). A smaller group had dropped out of their education (4).

Primary Occupation
Home workers formed the largest occupational group (16), followed by students (10), business/trade professionals (5), retired individuals (4), farmers (3), and educators (2).

Inferential Statistics
Chi-Square Test between School Closure and Learning Method
The Chi-Square test was performed to examine the relationship between school closures and the primary reliance on online learning during the pandemic. The test yielded a Chi2 value of 1.008 and a P-Value of 0.604, indicating no significant relationship between these variables. This suggests that school closures did not significantly influence the method of learning adopted by the students.

T-Test between Gender and Satisfaction with Online Learning
The T-Test was conducted to compare satisfaction levels with online learning between male and female participants. The results showed a T-Statistic of 0.292 and a P-Value of 0.772, indicating no significant difference in satisfaction levels between genders. This implies that both male and female participants had similar levels of satisfaction with online learning during the pandemic.

Regression Analysis

```
Regression Analysis:
                            OLS Regression Results
==============================================================================
Dep. Variable:                     Q3   R-squared:                       0.254
Model:                            OLS   Adj. R-squared:                  0.192
Method:                 Least Squares   F-statistic:                     4.081
Date:                Tue, 23 Jul 2024   Prob (F-statistic):             0.0136
Time:                        06:16:40   Log-Likelihood:                -58.599
No. Observations:                  40   AIC:                             125.2
Df Residuals:                      36   BIC:                             132.0
Df Model:                           3
Covariance Type:            nonrobust
==============================================================================
                         coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const                 -0.0552      0.844     -0.065      0.948      -1.766       1.656
Community support      1.0251      0.386      2.658      0.012       0.243       1.807
Access to technology   0.9699      0.536      1.810      0.079      -0.117       2.057
Mental health support  1.0569      0.436      2.424      0.021       0.172       1.941
==============================================================================
Omnibus:                        7.854   Durbin-Watson:                   1.466
Prob(Omnibus):                  0.020   Jarque-Bera (JB):                3.527
Skew:                           0.465   Prob(JB):                        0.171
Kurtosis:                       1.882   Cond. No.                         11.8
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
```

Predictors of Satisfaction with Online Learning
The regression analysis identified key predictors of satisfaction with online learning, including community support, access to technology, and mental health support.

- **Community Support:** The coefficient for community support was 1.025 (P = 0.012), indicating a significant positive effect on satisfaction with online learning. Participants who reported higher levels of community support were more likely to be satisfied with online learning.

- **Access to Technology:** The coefficient for access to technology was 0.970 (P = 0.079). Although this predictor was not statistically significant at the conventional 0.05 level, it showed a positive trend, suggesting that improved access to technology could enhance satisfaction with online learning.
- **Mental Health Support:** The coefficient for mental health support was 1.057 (P = 0.021), highlighting its significant positive impact on satisfaction with online learning. Participants who received mental health support were more likely to report higher satisfaction levels.
- **Model Performance:** The model explained approximately 25.4% of the variance in satisfaction with online learning (R-squared = 0.254), indicating a moderate level of explanatory power. The Durbin-Watson statistic of 1.466 suggested no significant autocorrelation in the residuals, while the Omnibus test (P = 0.020) and Jarque-Bera test (P = 0.171) indicated some deviation from normality but not severe enough to invalidate the model.

CONCLUSION

The COVID-19 pandemic has underscored the fragility of educational systems, particularly in rural settings like Dadupur, where socio-economic barriers and limited technological access exacerbate the impact of global crises. This study highlights the significant educational disruptions faced by the Dadupur community, including school closures, a reliance on online learning, and substantial learning gaps. Despite these challenges, the community's adaptive measures demonstrate remarkable resilience. Key takeaways from this research include the critical need for bridging the digital divide to ensure equitable access to education and the importance of integrating mental health support into educational frameworks. The findings suggest that targeted interventions, such as enhancing digital infrastructure, providing professional development for educators in digital pedagogies, and fostering robust community-school partnerships, are essential for building resilient educational systems. The strong community willingness to participate in future educational initiatives indicates a collective commitment to overcoming current challenges and improving the educational landscape post-pandemic. These insights can inform policy and practice, not only in Dadupur but also in similar rural contexts globally, contributing to the development of more adaptable, inclusive, and resilient educational models. Future research should explore long-term impacts on learning outcomes, effective models of blended learning, and strategies to integrate comprehensive mental health programs in educational settings. By addressing these areas, policymakers and educators can better support communities in navigating future crises, ensuring that education systems are not only resilient but also equitable and inclusive.

ACKNOWLEDGEMENT

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RESEARCH ARTICLE

Radio Mean Labeling of Graph and its Subdivision

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ABSTRACT

In the present investigation we applied radio mean labeling on arrow and the graph associated with arrow graphs by assigning non – negative numbers to the vertices and edges. A connected graph with injective mapping $g: V(I) \rightarrow N$ is Radio Mean labeling if for any vertices a and b of graph I, $d(a,b) + \left\lceil \frac{f(a)+f(b)}{2} \right\rceil \geq 1 + diam(I)$. By representing complex structures in a manageable form and providing quantitative measures of efficiency, these concepts contribute to advancements in algorithm design, network optimization, and problem-solving techniques.

Keywords: Eccentricity, Diameter of graph, Radio Mean Labeling, Radio Mean Number of Graph.

INTRODUCTION

In this paper, we will explore the Radio mean labeling of Arrow and its related graphs which can be applied in real world like wireless sensor networks, routing algorithms, network visualization and Internet of Things (IOT). Also, these concepts can be applied to ensure network connectivity by determining the minimum number of labels required to ensure connectivity in a network, can provide understanding into the fault tolerance of a network, can be utilized to optimize network performance in terms of energy consumption, resource allocation and many more. Graph theory is used to model and analyze complex networks such as social networks, computer networks, and biological networks. It helps in understanding the structure and behavior of these networks, and in developing algorithms for tasks such as routing, clustering, and community detection. Sekar [1] discussed the different applications of graph theory in computer science by using the concepts of list coloring, operation research, timetable scheduling, job scheduling, construction of algorithm, map coloring and GSM mobile phone network. These labeling

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can also be used in cryptography to achieve secure communication between two groups. This paper consists of simple, finite, undirected and connected graph. Chartrand et. al. [2] developed the concept of Radio Labeling in 2001. Aasi et. al. [3] discussed the concept of Radio labeling of Lexicographic Products of some graphs like path graph and also examine Radio Mean Labeling of Lexicographic Products of graphs. They also developed computer program for the same by using Python programming language. Sunitha et. al. [4] explored the concept of Radio Mean Labeling of Path and Cycle related graphs. Ponraj et. al. [5] explored the Radio Mean Labeling of some graphs like graph with diameter three, lotus inside circle, Helms and Sunflower graph. Palani et. Al. [6] analyzed the radio mean labeling of Path union of graphs. Kaneria et. al. [7] introduced the Arrow Graph and Double Arrow Graph in 2015 in their paper and also discussed the graceful labeling of arrow graphs and double arrow graphs. For basic terminologies, we refer Harary[8] and Gallian [9].

1.1 Definition
The maximum distance between a vertex to all other vertices of the graph is called as Eccentricity of a graph.

1.2 Definition
The diameter of a graph is the length of the longest shortest path between any two graph vertices $'p'$ and $'q'$.

1.3 Definition
Radio Mean labeling of a connected graph I is a one – to – one mapping from the set of vertices $V(I)$ to the set of natural numbers such that for any vertices p and q of I, $d(p,q) + \left\lceil \frac{f(p)+f(q)}{2} \right\rceil \geq 1 + diam(I)$. The Radio Mean Number of graph I, $rmn(I)$ is the minimum value allocated to any vertex of the graph I. The Radio Mean Number of function g, $rmn(g)$ is the maximum value allocated to any vertex of the graph I.

1.4 Definition
In a graph, $P_m \times P_n$ on mn vertices, $\{p_{11}, p_{21}, \dots \dots, p_{m1}\}$ and the vertices $\{p_{1n}, p_{2n}, \dots \dots, p_{mn}\}$ are known as Superior vertices from both the ends.

1.5 Definition
An Arrow Graph A_n^t with width t and length n is obtained by joining a vertex a with the Superior vertices of $P_m \times P_n$ by m new edges from one end.

1.6 Definition
A subdivision of a graph I is a new graph that is formed by adding vertices to the edges of I in such a way that each edge is replaced by a path of one or more edges connecting the newly added vertices.

RESULTS

2.1 Theorem: The diameter of an Arrow graph I with width t and length n is given as –
$$diam(I) = \begin{cases} n; & when\ t = 2 \\ n+1; & when\ t = 3\ and\ 4 \\ n+2; & when\ t = 5\ and\ 6 \end{cases}$$
Proof: To prove the above results we have following cases:

Case 1: Let I be an Arrow graph with width $t = 2$ and length n. We want to prove that any two vertices in graph I can be connected by a path of length at most n.
Let p be any vertex of the graph and consider any other vertex q in the graph I. Now, the distance between the vertex p and q of the graph I is at most n. Since q is an arbitrary vertex which means that the distance of p to any other vertex of the graph I is atmost n. Thus, $e(p) \leq n$.
Therefore, by the definition of diameter, the diameter of graph I is n.

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Case 2: Let I be an Arrow graph with width $t = 3$ and $t = 4$, and length n. We want to prove that any two vertices in graph I can be connected by a path of length at most $n + 1$.

Let p be any vertex of the graph and consider any other vertex q in the graph I. Now, the distance between the vertex p and q of the graph I is at most $n + 1$. Since q is an arbitrary vertex which means that the distance of p to any other vertex of the graph I is atmost $n+1$. Thus, $e(p) \leq n + 1$.

Therefore, by the definition of diameter, the diameter of graph I is $n + 1$.

Case 3: Let I be an Arrow graph with width $t = 5$ and $t = 6$, and length n. We want to prove that any two vertices in graph I can be connected by a path of length at most $n + 2$.

Let p be any vertex of the graph and consider any other vertex q in the graph I. Now, the distance between the vertex p and q of the graph I is at most $n + 2$. Since q is an arbitrary vertex which means that the distance of p to any other vertex of the graph I is at most $n + 2$. Thus, $e(p) \leq n + 2$. Therefore, by the definition of diameter, the diameter of graph I is $n + 2$. Example 2.1: The diameter of A_3^2 is 3. Example 2.2: The diameter of A_3^4 is 4.

2.2 Theorem: The Radio Mean Number of an Arrow Graph A_n^t is $nt + 2$.

Proof: Let I be an undirected Arrow graph having width t and length n and define the function $f: V(I) \to N$. Let $\{u_1, u_2, u_3, \ldots\ldots, u_n\}$ be the vertices of the grid graph and let a be the vertex joined by the superior vertices of the grid graph from one end. We will assign labels to the vertices of the graph I by $2(nt + 1)$ in the descending numerical order. Let u_m and u_n be the two vertices of the graph I which is satisfying the condition $d(u_m, u_n) + \left\lceil \frac{g(u_m) + g(u_n)}{2} \right\rceil \geq 1 + diam(I)$ as follows $-rmn(I) = nt + 2; \quad \forall\, t \geq 2, \forall\, n \geq 2$

As u_m and u_n are the arbitrary vertices of the graph I which is satisfying the condition of Radio Mean Labeling.

Thus, an Arrow graph A_n^t is a Radio mean graph.

The Radio mean number is the minimum value allocated to any vertex of the graph. Hence, the Radio mean number of an Arrow graph A_n^t is $nt + 2$.

Corollary 1: The number of vertices in an Arrow graph is $nt + 1$.

Corollary 2: The Radio Mean Number of the function g is twice the order of the graph i.e. $2(nt + 1)$.

Example 2.3: The radio mean number of A_5^5 is 27.

2.3 Theorem: The diameter of subdivision of an Arrow graph I with width t and length n is given as –

$$diam(I) = \begin{cases} nt + 1; & when\ t = 2 \\ nt + k; & when\ t = 3\ and\ k = n - 2 \end{cases}$$

Proof: To prove the above results we have following cases:

Case 1: Let I be a subdivided Arrow graph obtained by inserting a vertex in between every edge with width $t = 2$ and length n. We want to prove that any two vertices in graph I can be connected by a path of length at most $nt + 1$.

Let p be any vertex of the graph and consider any other vertex q in the graph I. Now, the distance between the vertex p and q of the graph I is at most $nt + 1$. Since q is an arbitrary vertex which means that the distance of p to any other vertex of the graph I is atmost $nt + 1$. Thus, $e(p) \leq nt + 1$.

Therefore, by the definition of the diameter, the diameter of graph I is $nt + 1$.

Case 2: Let I be a subdivided Arrow graph obtained by inserting a vertex in between every edge with width $t = 3$ and length n. We want to prove that any two vertices in graph I can be connected by a path of length at most $nt - k$, where $k = n - 2$.

Let p be any vertex of the graph and consider any other vertex q in the graph I. Now, the distance between the vertex p and q of the graph I is at most $nt - k$, where $k = n - 2$. Since q is an arbitrary vertex which means that the distance of p to any other vertex of the graph I is atmost $nt - k$, where $k = n - 2$. Thus, $e(p) \leq nt - k$.

Therefore, by the definition of the diameter, the diameter of graph I is $nt - k$, where $k = n - 2$.

Example 2.4: The diameter of subdivided Arrow graph A_2^2 is 5.

Example 2.5: The diameter of subdivided Arrow graph A_4^3 is 10.

2.4 Theorem: The Radio mean number of subdivision of Arrow graph A_n^t is $2(nt + 1)$.

Proof: Let I be a subdivision of Arrow graph obtained by inserting a vertex in between every edge with width t and length n. Define the function $f: V(I) \to N$ and let $\{u_1, u_2, u_3, \ldots\ldots, u_n\}$ be the vertices of the grid graph and let a be the vertex joined by the superior vertices of the grid graph from one end. Let $\{p_1, p_2, p_3, \ldots\ldots, p_n\}$ be the new added vertices between every edge. We will assign labels to the vertices of the graph I by $2(nt + 1)$ in the ascending numerical order. Let u_m and u_n be the two vertices of the graph I which is satisfying the condition $d(u_{m,}u_n) + \left\lceil \frac{g(u_m) + g(u_n)}{2} \right\rceil \geq 1 + diam(I)$ as follows – $rmn(I) = 2(nt + 1); \quad \forall\, t \geq 2, \forall\, n \geq 2$

Thus, a subdivision of Arrow graph A_n^t is a Radio mean graph and the Radio mean number is $2(nt + 1)$. Corollary 1: The number of vertices in a subdivision of Arrow graph is as follows – No. of vertices $= 3nt - k; \quad$ where $k = n - 1$
Corollary 2: The Radio Mean Number of the function g is as follows –

$$rmn(g) = \begin{cases} 4(nt + 1) + (n - t); & \text{when } t = 2 \\ 4nt + diam(I); & \text{when } t = 3 \end{cases}$$

Example 2.6: The radio mean number of subdivision of Arrow graph A_3^3 is 20.

CONCLUSION

The Radio mean labeling assigns a frequency to each base stations such that the distance between any two base stations can be determined by comparing their frequencies for ensuring smooth communication. It has several advantages in wireless communication networks, fault tolerance, network connectivity, routing and communication protocols etc. In this paper, we have investigated the radio mean labeling and radio mean number of Arrow graph. Also, we computed the radio mean number of subdivision of Arrow graph. Moreover, we can try to check radio mean labeling of these graphs by any programming language like Python, Java etc.

Open Problem
➢   Determining the diameter of an Arrow graph for $t \geq 7$.
➢   Determining the diameter of Subdivision of Arrow graph for $t \geq 4$.
➢   Finding Radio mean labeling of other families of graph.

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Figure 1: Superior vertices$P_m \times P_n$

Figure 2: Arrow Graph A_4^2

Figure 3: Subdivision of A_4^2

Figure 4: Arrow graph A_3^2

Figure 5: Arrow graph A_3^4

Figure 6: Arrow graph A_5^5

Figure 7: Subdivision of Arrow graph A_2^2

Figure 8: Subdivision of Arrow graph A_4^3
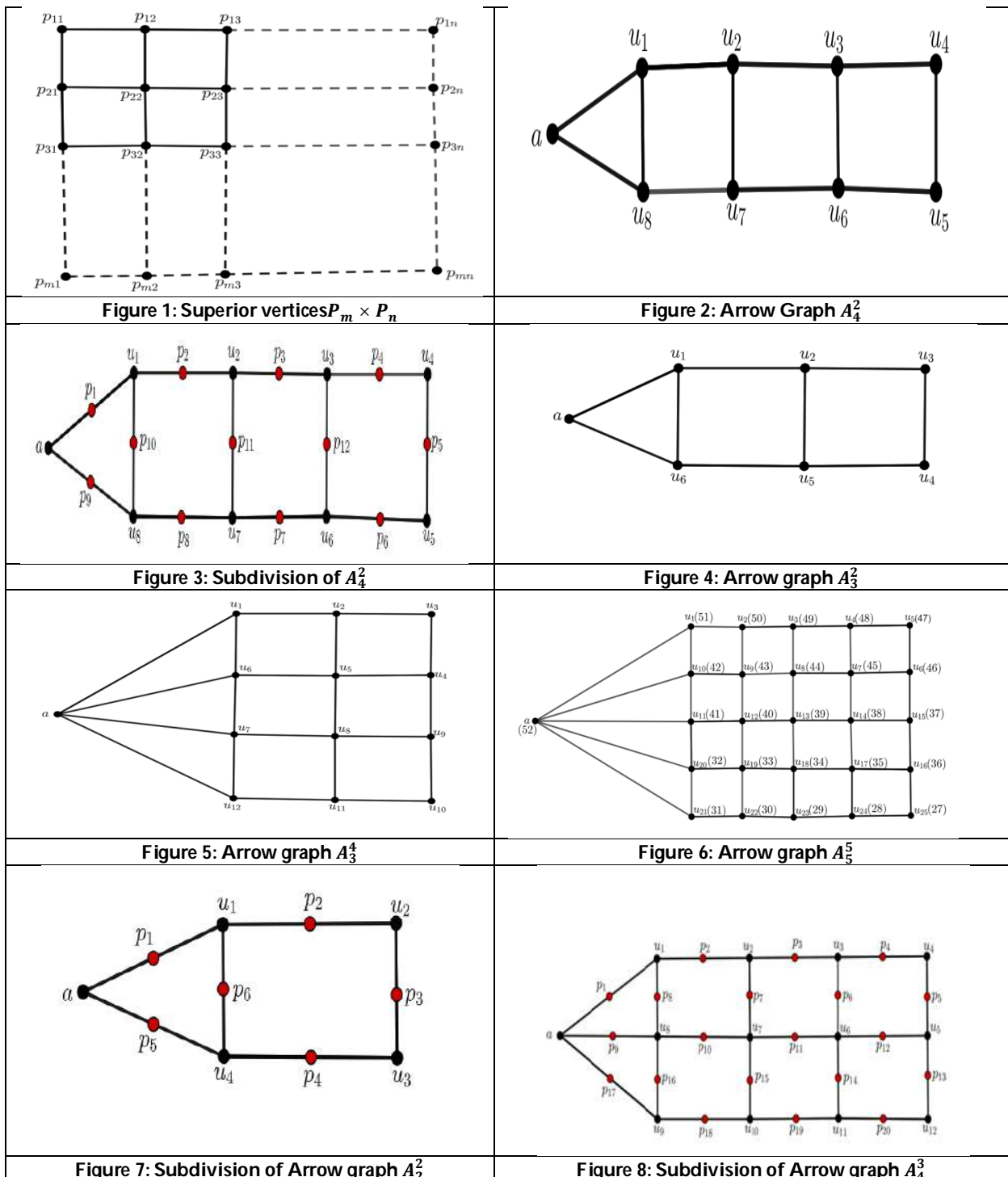
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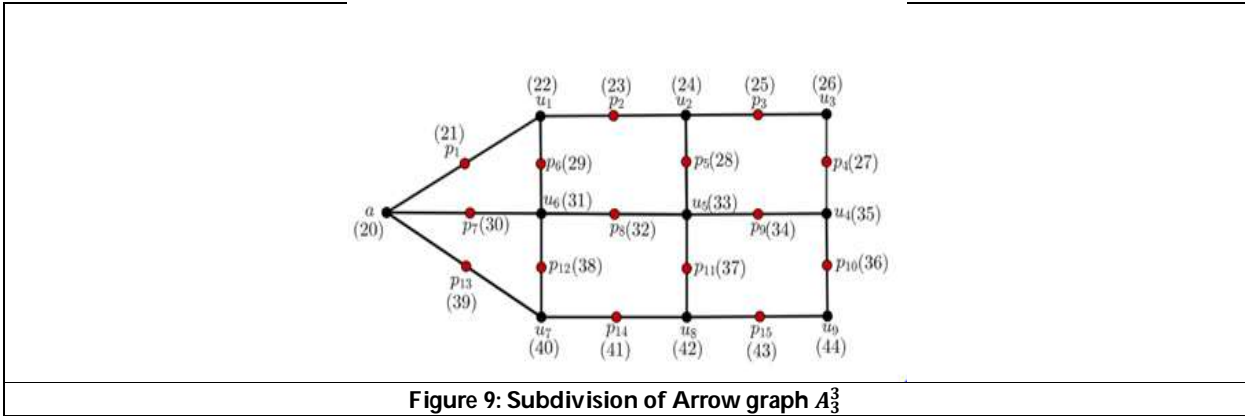
Figure 9: Subdivision of Arrow graph A_3^3

RESEARCH ARTICLE

Digital Media Dominance: Unveiling the Spatial Dynamics of Political Economy of Media

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ABSTRACT

The paper presents a brief critical review of major contributions to the theory of Political Economy of Communication and attempts to trace the history of classical Political economy in order to understand how and why such an approach has gained so much of popularity in social sciences. The research paper critically engages with the conceptual and thematic arguments, critiques developed by pioneering Political economists and focusses on the key challenges that emerged in the political economy of Media and Communication with the advent of Digital Media. The research paper is a systematic analysis of existing literature available in the field of Political economy and discusses the conceptual developments and key dimensions of Commodification, Spatialization and Structuration and how the notions of Spatialization have been reduced by the emergence and growth of digital media technologies.

Keywords: Political Economy, Structuration, Spatialization, Systematic- Analysis, Commodification.

INTRODUCTION

The Political Economy of Communication has emerged as a major field of inquiry in media studies over the decades that studies the relationship of economy and politics with reference to production, distribution and consumption of media content in relation to potential impact on audiences. This becomes imperative for communication scholars to study political economy of communication in order to understand who controls media, the production and distribution of messages and what relation do media have with other businesses and, most primarily, with the state. The initial days of emergence of Digital media platforms the focus of scholarship on Political Economy argued that the Digital media platforms are going to replace the existing media platforms like Radio, Television and Print. The

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results rather contradicted the notion as the platforms converged and old and new media began to collide (Jenkins, 2006) The paper briefly reviews the major work in the field of Political Economy of Media and Communication and emphasizes on the developments that occurred worldwide especially with the exponential growth of Digital Media technologies. The challenges to the field of Political economy with the emergence of Digital media technologies have increased the emphasis on the larger debates on corporatization, Commodification and Structuration. This makes it imperative to study and analyze the conceptual, critical and developmental synthesis of Political economy of Media.

Objectives of the Study
1.   To provide a critical insight in to conceptual and thematic approaches to Political Economy of Media and Communication with reference to digital media technologies.
2.   To unveil the spatial dynamics of digital media dominance with respect to political economy of Media.
3.   To discuss the Conceptual developments and key dimensions related to the field of Political Economy of Media.

Historical Foundation of Political Economy
The concept of Political economy of Communication traces its roots from philosophers like Smith, Mill and David Ricardo invoked from the 18th century Scottish enlightenment thinking (Wasko, 2005). Adam Smith has described political economy as the study of "wealth" that includes allocation of resources and how people allocate scarce resources to satisfy their certain needs. Political economists mostly understood and studied capitalism as a system of social production and according to Wasko (2005) the evolution of Capitalism and classical political economy evolves collectively. The growth of capitalism reinforced the need for political economy to be adopted as an approach to investigating the various facets of the consumerist system. The political economy gave philosophers not just an approach to study economic aspect of consumerism but also made them to investigate its moral consequences. The scholarship on Political economy draws its roots also from the works of Engels and Marx who added the perspectives of historical materialism in 19th Century. A major shift in the study of economic issues took place during the last half of the 19thcenturyas the focus shifted from macro to microanalysis (Wasko, 2005: 26). The emphasis of Political economy shifted from societal concerns to Individuals and the methods were drawn from social sciences rather than moral behavior. In his classic '*The Political Economy of Communication*', Mosco (1996)makes a detailed mention of four ideas at the foundation of political economy and these are Moral philosophy, social totality, Social Change and History, Praxis. Mosco argues that the focus of political economy has always been to understand the dynamics of Social Change and transformation where as classical Political economists like Mill, Ricardo and Smith considers it the great capitalist revolution. Social totality for Mosco is a fundamental element in political economy that looks at society at different vantage points to provide a deep and multi-dimensional insight of the societal changes that occur over the time and simultaneously an approach used by disciplines to investigate different aspects of consumerism.
Moral philosophy is the most important cornerstones of the classical political economy; the founding fathers used moral philosophy to indicate to social values and conceptions of appropriate social practices. They looked at the political economy to not only study the change vis-à-vis economy but also looked at the aspects of morality as to whether such a system cared about society's values or not; and if not, then to what extent does this phenomenon impact society and how to critically engage with such occurrences. In fact, Murdock and Golding (1991)argue that "political economy goes beyond technical issues of economic efficiency and engage with basic moral questions of justice and public good". The idea of moral philosophy was deeply close to classical political economists and as Mosco (1996) notes, Adam Smith considered '*The Theory of Moral Sentiments'* a much better work than his '*The Wealth of Nations'*. The fourth approach is praxis and relates to the free and creative activity by means of which people change the world. Mosco (1996) notes the idea of praxis has profound origins in the history of philosophy and that in ancient Greece, where the word originated, it referred to the business and political activities of free men. Praxis was used by Aristotle in his works and he was of the opinion that Political, ethical and economic studies are forms of practical knowledge to be differentiated from theory.

Development of Political Economy of Communication in North, Europe and in Third world
The political economy approach was first applied to communication during 1960sin North American academia by Dallas Smyth and Herbert Schiller, two founding figures who inspired a number of scholars to take political economy

as an approach to studying communication (Mosco, 1996). The larger part of their work has revolved around the assertion that communication industry has become a part of wider corporate order which they argue is exploitative and undemocratic and something which brings injustice to people. The North American scholarship is also concerned with interrogating the mainstream dominant media, influencing creation of alternatives and supporting the social movements that have made their presence felt in international for a like the United Nations. One of the most important contributions to the political economy of communication from North America, political economists acknowledge, has been the work of Herbert and Chomsky's *Manufacturing Consent*(1988) that initiates serious discussion on American print media and its functioning. So, the North American scholarship on political economy has mostly dealt with the concentration of power between the corporates and their relationship with the state.

The European scholarship of the political economy of communication dating back to late '70s is concerned with the study of movements for social change. It comes in open defense of the public service media system and calls for integration of communication research within various neo-Marxian theoretical traditions. Much of the European scholarship revolves around *class power*, the direction of which has been initiated by the contributions of Nicholas Garnham, GrahamMurdock and Peter Golding who draw on Frankfurt School tradition as well as Raymond Williams to document the integration of communication institutions within the wider capitalist economy.

The scholarship is also a significant documentation of resistance of subaltern classes and movements which opposed neo-conservative state practices prompting liberalization, commercialization and privatization of communication industries. The second stream of researchin the European scholarship foregrounds *class struggle*(Mosco, 1996: 20) that is prominently documented by Armand Mattelart. Hedraws from a range of traditions including Dependency Theory, Western Marxism and global experience of liberation movements to understand communication as one of the principal sources of resistance to power. The leading figure in the development of communication studies in Britain is James Halloran from whose Centre for Mass Communication Research Graham Murdock and Peter Golding and other scholars would later undertake substantial research on political economy of communication. It was from European academia that first debates on New World Information and Communication Order (NWICO) were initiated. The 'Third World' scholarship on political economy of communication involves a blend of interests and one of its major responses(Mosco, 1996) has been to the modernization or development paradigm that originated in the West. The 'Third World' political economists have challenged the West's model, its technological determinisms and questioned why it has omitted the interest in power relations that shape the West's economic and political relationship with the 'Third World'. The pattern of research in 'Third' World which Moscow calls it the 'developing' world has been different from its counterparts in developed world because of different situations they have grown from. Mosco (1996: 120) writes that the research in this region was forged during the 'hot wars' 1960s and that the academic inquiry took off into two directions. It, as Mosco notes, developed a critique of conservative and liberal developmentalist approaches that West launched in response to the anti-imperialist struggles.

The 'Third' World research also presented a new framework of dependency theory to understand global political economy in its own way. In India, critical political economy of communication is being seriously pursued by communications scholars who interrogate the news media from print to electronic to internet. Saeed (2013) initiates a thorough discussion on political economy of television in India and brings to fore the decadal changes in the media industries and how ownership patters are making a direct impact on the media content. In one of the compressive chapters in the book, *Ownership Patterns and Its Impact on News Values and Content,* Saeed traces the history of commercialization of media, the privatization of airwaves and reflect on the future of the public service broadcasting. The work of Thomas (2010)also maps the political economy in Indian communication scenario and the author reflects on the country's encounter with copyright, the burgeoning of audio-visual trade, community radio and the popularity of right to information movement. The scholars like Butt, A.A (2018) predicted the rise of digital media technologies in regional journalism as an alternate to national media. As Political Economy of Communication grew, many debates have taken place over the decades. In 1977, Dallas Smythsparked a debate when he wrote an article in which he argued that communication had been overlooked by Western Marxists who he noted were mostly interested in issues relating to ideology and argues that the 'main product of media was audiences which were sold by media to advertisers. It is because of the continued debates that political economy is being viewed through

different perspectives and applied to various levels of communication. And that's why, conscious of changing dynamics, political economists began to rethink the political economy of communication (Wasko, 2005).

Thematic Review: Commodification, Spatialization and Structuration

The application of political economy approach in communications research by Dallas Smyth and Herbert Schiller, major scholarly contributions (Murdock and Golding, 1974; Nicholas Garnham, 1979; Vincent Mosco, 1996 and others)have appeared in North America, Europe and the 'Third' World academia. The scholars have engaged with multiple issues facing the field of communication today and in so doing opened up new gates of inquiry into the field by their individual contributions. Academic inquiry into political economy of communication was largely influenced by the development of communication institutions into mammoth profit-maximizing industries.The need for a critical political economy of communication was felt because media are doubly significant (Thomas, 2010). Media are not only seen as industries which generate sizeable revenue but institutions which are actively involved in production and circulation of symbolic goods and services that make an impact on choices and opinions of consumers. But when these institutions that have the responsibility to circulate information to the consumers become just holders of capital and overlook their responsibilities vis-à-vis public service, they are certain to evoke academic response. Critical political economy of communication is a classic example. In 1996, Vincent Mosco published a significant book *The Political Economy of Communication*, a thorough synthesis of past contributions anda new addition to the existing body of knowledge on political economy of communication. Mosco's book is considered a significant reference point to the study of political economy of communication. Apart from giving a detailed overview of classical political economy and drawing an academic map of the field, Mosco has added three dynamic processes to the field which he argues are necessary to understand the social change. In his work, Mosco argues that social change is ubiquitous and can be understood from three dynamic processes that serve as entry or starting points to the field: commodification, Spatialization, structuration.

Commodification

The Political economists historically place the concept of commodification in the capitalist setting and explain the nature of industries which manufacture products and the processes of sale of those products in a market-driven milieu. Mosco identifies two important parameters which the classical political economists have sought to engage with: use value and exchange value. *Use value* of a product is something that satisfies a specific human want or need while *exchange value* is something whose value is based on what the product can command in exchange. Commodification of products begins when their production is organized through the process of exchange. Capitalism is seen to be an immense collection of commodities. So, commodification in political economy's perspective takes place when industries manufacture at large scale products to be sent to the market. And this interaction is based primarily on market-driven culture and products are not seen through the prism of *use value* but through *exchange value*. Mosco (pp. 143-144) defines commodification as "a process of turning use values into exchange values by transforming products whose value is determined by their ability to meet individual and social needs into products whose value is set by what can bring in the marketplace".

'Commoditization of media content' and Audience as a Commodity'

One of the main themes of Mosco's work and perhaps the best is his argument that when commodification is applied to communication, it is *media content* which is commodified by mass media industries (p. 146). The process of commodification in communication involves 'transforming messages, ranging from bits of data to systems of meaningful thought into marketable' products. The example of a newspaper reporter who works for a mass mediated commercially-driven newspaper and has the job to produce news reports that are fit to be marketed by the newspaper organization. The reporter, Mosco reasons, works on a specific wageoffered by the organization and has the responsibility to keep producing content which the newspa persells to increase profit and in so doing maximize capital or surplus which is the prime motive of any industry that manufactures products. In case of communication, information is termed as a commodity sold to customers against a sum in a market; the seller is the organization. So, when we refer to a newspaper organization, for example *Times of India or any news media group* should not be mistaken that the company is there to do any public good however few of its objectives might end eavorto attempt

so. As scholars suggest, the companies like these need scholarly attention because what they produce do influence individual choices so much so that even the perspectives of common people are shaped accordingly (Thomas, 2005).Drawing on Nicholas Garnham, Mosco mentions two dimensions of media commodification: the direct production of media products and the use of media advertising to perfect the process of commodification. The claim of Smythe (1977) that the audience is the primary commodity of the mass media. Mosco argues that mass media programming is used by advertisers to get access to audience and in so doing deliver audience to the advertisers. When media offer content to the audience, there is always something beyond or in-between it: the advertisements. Obsessed with the media content, the audience is left with no choice than to consume the advertisement. By doing this, advertisers one the one hand hold attention of audience to certain commodities and one the other hand get to know them, their likes and dislikes. The founding political economist, Dallas Smythe, was the first scholar who started the debate that mass media sell audience as commodities to advertisers. The debate is titled 'Blindspot' debate because Smythe argued that this issue was not getting enough attention in communication research.

Spatialization

Spatialization is a process of bridging time and space constraints between products and consumers by industries that sell them. The best example of this isof an Indiancitizen who wants to read *The New York Times* shortly after it is published. The persons need not necessarily be in the U.S. to read the newspaper and can access it through internet. In the light of this example, we can say that internet has the spatial characteristics that can transform messages to people anywhere in the world and at any time. This spatiality of facilitiesis what capitalism holds in the entire world and has the capacity to use it over to those who don't know a speck of it. The classic example of it is the recent revelation that National Security Agency (NSA) of the United States gathers personal information of millions of internet users in the world. Henri Lefebvre (cited in Mosco, 1996: 173) has defined Spatialization as overcoming the constraints of space and time in social life while Marxhas called it 'annihilation of space with time'. Since communications processes and technology are central to political economy of communication research, the idea of Spatialization interrogates discourse on how corporations bridge spaces in the world, manufacture products and ensure that the products are sold to consumers near and far from them, primarily seeking the help of technology. In the past, when technology was not so advanced and corporations had to move goods manually through transportation, the idea of Spatialization was still emerging. What we see now is a web-based facility that helps people make online sales and purchase goods sitting in their drawing rooms. This is what classical political economists called 'shrinking of space'. The Institutional extension of corporate power in the communication industry is what political economy of communication addresses chieflyas a prime manifestation of Spatialization (p. 175) and when institutional extension takes place, *corporate concentration* arises which results in big influential corporate companies buying other little industries and in so doing establishing a sort of oligopoly that aims to control the entire market to which consumers finally become subservient.

Corporates are powerful entities which influence political, economic, social and cultural interaction in a society; control on mass media gives them control over everything. Mosco calls this sort of development as *horizontal concentration*. "Horizontal concentration takes place when a firm in one line of media buys a major interest in another media operation, not directly related to original business, or when it takes a major stake in a company entirely outside of the media"(pp. 175-176). Vertical integration of corporate concentration takes place when a firm purchases another company in its own line of business. This institutional concentration indirectly shrinks the space among the corporates and gives them an endless power to influence and control both the base as well as superstructure of the society; base, because of the profit-maximization and the superstructure because of the control over production and distribution of the content which have the capacity to influence audience. Global changes in the capitalist market that continue to take place across the world today at a much higher pace than the past coupled with its impact on social life of common people are making modern day states jittery and their reaction to these changes comes in the form of regulation. That's what states do in line with their own constitutions to make their presence felt in a world where the pie chart of monitory growth is dominated by corporations and as Mosco (1996: 200) says, the role of a state in communication comes down to choose between regulation and de-regulation. However, as Mosco points out, the states have taken cue from the industrial changes and it has given rise to few phenomena directly constructed by the

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state. The phenomena include *commercialization, liberalization, privatization* and *internationalization*. As corporations continue to maximize revenue, states too are in a process of commercializing their institutions in order to get maximum profit. States givea free choice to stakeholders in a market and this is aimed to increase market competition, hence liberalization. Privatizationof institutions in a state takes place when the state itself intervenes to sell a state enterprise, e.g., a broadcaster or a telephone company. Internationalization happens when states create their own wide range of teaming arrangements or strategic alliances. This interstate coordination is always aimed at bridging the gap between states and settling down to a common minimum program where states proportionately grow, in capital and in politics.

Structuration

Drawing on the work of Anthony Giddens (1984), Mosco defines structurationasa process by which structures are constituted out of human agency, which means structures and action of individuals are interconnected. In this framework, the critique of Walt Disney Company by Wasko (2006) is a perfect analogy. In his critique, he traces the origin of the company and how efforts of a single man supported by a team– that remained mostly behind the curtain – made Disney one of the world's influential production houses. Mosco notes that structuration in coordination with the processes of commodification and Spatialization strikes a balance in the analysis of political economy of communication to feature structures and analyze them in relation with the ideas of human agency and social practice. Mosco argues that "structuration theory is an approach to social life that aims to address goal-oriented, reflexive human action, without giving up on the understanding the 'sutures' of power that mutually constitute social action". Mosco further breaks down the process of structuration into divisions to understand it from various vantage points like *social class, gender, race and social movements*. Together with these variables, the author tries to place the structuration as a main entry point to the field of political economy of communication. Mosco's work is a significant contribution to the field and would remain a main reference point to the debates on application of political economy to communication. Although academic literature on political economy of communication is expanding with the subject being pursued across the world, what follows in this paper is an overview of article-length contributions by authors who have tried their hands on the subject.

CONCLUSION

The emergence of political economy of communication in digital sphere has in fact favored the large media conglomerates. There was a sense of hope in the initial years of emergence of digital media and a possibility that it will allow emergence of alternate voices but the results indicate that digitalization has allowed further concentration of mainstream media. The notions of space and time have been eliminated by the emergence of digital media applications as all the major communication players have acquired digital platforms, social media sites, television channels, citizen journalism avenues or any other medium of communication. The political economy of digital media hardly changed any scenario instead allowed for convergence of digital technologies with Print, Radio, Television and other means of communication. There is an emergence of creation of larger digital ecosystem as these media conglomerates have branched in to digital business ventures. The concept of spatialization instead of acting as a hindrance rather provided a simplified tool to the major political economy players to reach out to each and every part of the globe and removed inhibitions of space and time. There was a time when technological advancement was not developed and manual transportation of goods and services emerged. The emergence of digital media technologies instead of providing a platform for marginal and hitherto voices rather led to the further shrinking of space and provided a improved opportunity for major political economy players to reach out to the places and cultures that were out of range for them there by creating a new hyper globalized societies and cultures where we have reached a stage where political economy of communication has become so dynamic that even states have felt a need to privatize and corporatize their institutions. The ease of access to geographies, demography's, cultures and societies is what digital political economy of communication has provided to the already dominant political economy structures. The political economy of digital media has in fact made the notions of structuration, commodification and spatialization more robust.

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RESEARCH ARTICLE

Exploring Differential Equations: Analyzing Transient and Steady-State Responses in Second-Order RLC Series Circuits

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ABSTRACT

Differential equations (DEs) are used in many engineering domains. In electrical engineering, differential equations are utilized to model various control systems and circuit problems. For analyzing and understanding electrical circuits, differential equations are essential, particularly in Resistor-Inductor-Capacitor (RLC) circuits. This research investigates the use of differential equations with an emphasis on the transient and dynamic characteristics of RLC series circuits. A second-order differential equation that models the RLC series circuit was derived, considering three cases, with the underdamped case being the main focal point of study, while the other two cases were briefly covered. The response of the current flowing through the circuit and the behavior of the oscillating current in an underdamped RLC series circuit, showing both exponential decay and sinusoidal oscillations, were analyzed, and conclusions were drawn based on the nature of the current derived from the circuit.

Keywords: Series connection, circuit model, Transient response, steady-state response, sinusoidal oscillations, transient analysis, steady state, amplitude.

INTRODUCTION

Across various fields, differential equations can be used to model real-life problems. The characteristics of such problems can be represented with the help of differential equations, extending their use to various disciplines. For

example, differential equations are employed in forensic science to estimate the time of death, in economics to analyze changes in Gross Domestic Product (GDP) over time, and in electrical engineering for the analysis and formulation of circuit models.

In electrical engineering, several key components include:
- **Capacitor**: An electronic component used in circuits for energy storage and filtering, storing energy in an electric field between two conductive plates separated by an insulator.
- **Inductor**: A passive component that stores energy in a magnetic field created by current flowing through a wire coil, frequently used in circuits for impedance matching and energy storage.
- **Resistor**: A passive component used in circuits to control voltage, limit current, and dissipate power by opposing the passage of energy.

Other important concepts include
- **Voltage Drop**: The decrease in voltage across a component due to impedance, resistance, or other factors, which is crucial for circuit design to ensure proper device performance.
- **Circuit Connection**: The physical or electrical linkage of electronic components within a circuit to form a complete path for current flow, established through methods like soldering or wire bonding.
- **Dampness**: The presence of moisture or humidity in electronic systems, posing risks of corrosion, short circuits, and component failure, necessitating protective measures for system reliability.

The demand for electrical power is increasing due to its essential role in powering machinery and appliances that make our lives easier. In electrical engineering, circuit analysis plays a vital role in various areas, such as transmission lines, radio receivers, and control systems. RLC (Resistor-Inductor-Capacitor) circuits provide a flexible framework for energy storage, filtering, and signal processing. Understanding the behavior of RLC circuits is crucial for developing reliable and efficient electronic systems. Solving electrical circuits can be tedious and lengthy work, but this is where differential equations come into play. Differential equations offer a mathematical framework for modeling voltage and current relationships over time, making them an effective tool for studying the dynamic behavior of RLC circuits. Using Kirchhoff's current law (the sum of all currents flowing in and out of a node is zero) and Kirchhoff's voltage law (the total voltage around a loop or mesh is equal to the sum of all the voltage drops across the components within the same loop), along with Ohm's law (the voltage drop across a resistor is equal to the product of the current and the resistance in the circuit), differential equations capture the interactions between resistive, inductive, and capacitive elements. This allows for the prediction of frequency characteristics, stability criteria, and transient responses. Engineers and researchers can study alternate circuit configurations, parameter values, and input conditions using differential equations, gaining insights into how an electrical system would behave in various situations. Differential equation-based analysis is further empowered by experimental validation, numerical or MATLAB simulations, and analytical solutions. In this report, a circuit analysis will be conducted, and a model will be introduced to determine the behavior of the circuit used, its state, and dampness, as well as the graph of the model using MATLAB dimensional plots.

Problem Statement
In the field of electrical engineering, undamped oscillation in resistor-inductor-capacitor (RLC) circuits is a basic yet intricate phenomenon. It is the central component of many electronic systems, including those that distribute power and process signals. Understanding the complexities of undamped oscillation is essential for improving the performance, stability, and dependability of circuits. In this report the undamped oscillation in RLC circuits is to be examined, focusing on its foundational ideas, difficulties, and consequences. The other two cases namely over damped and critically damped motions will be discussed in brief.

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METHODOLOGY
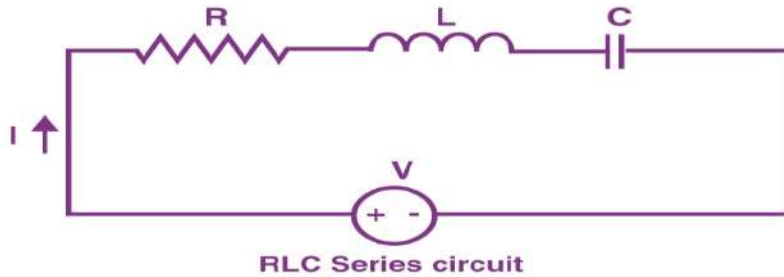
RLC circuit Diagram under any given time(t), the current I, will flow in every point of the circuit, this current is denoted by $I = I(t)$, since the current depends on time(t). We say $I(t) > 0$ if the current flows from positive terminal of the source to the negative terminal while the reverse of this case will be when $I(t) < 0$. Similarly, if $I(t) = 0$ then no current is flowing in the circuit at the given time(t) [9]. On the sides of every circuit component, we labelled it as positive(+ve) and negative(-ve). The voltage drops V_L, V_C, V_R across the circuit components is determined by taking the difference between the potential on the positive (+ve) side of the circuit component and the potential on the negative side. Thus, the voltage drops across resistor is given by

$$V_R = IR \tag{1}$$

The above equation is the representation of Ohm's law, the I describe in the equation above is the current and R is the resistance associated to the resistor. In the Induction coil, the voltage drop is given by

$$V_I = L\frac{dI}{dt} = LI' \tag{2}$$

where $I' = \frac{dI}{dt}$ and L is called the inductance of the coil which at the same time is a positive constant.

A capacitor is an energy storage component in a circuit that stores electrical charge $q = q(t)$, the relationship between the charge q and the current I is given by

$$q(t) = q_0 + \int_0^t I(\tau)\, d\tau \tag{3}$$

where q_0 denotes the charge at $t = 0$ on the capacitor. the voltage drop in this component is given by

$$V_C = \frac{q}{C}$$

Where C is the capacitance of the capacitor, which is a positive constant.

According to KVL "In any close loop network, the total voltage around the loop is equal to the sum of all the voltage drops within the same loop, which is also equal to zero.

Let V_t be the total voltage around the loop, then

$$
\begin{aligned}
V_t &= V_L + V_R + V_C \\
&= L\frac{dI}{dt} + IR + \frac{q}{c} \\
&= LI' + IR + \frac{q}{c} \\
V_t &= LI' + IR + \frac{q}{c}
\end{aligned} \tag{5}
$$

Those equation involves two unknown parameters; the current flowing in the circuit I and the charge q on the capacitor.

We can recall that from equation (3) we have

$$q(t) = q_0 + \int_0^t I(\tau)\, d\tau$$

by differentiating equation (3) we have

$q' = I \therefore I' = q''$ then equation (5) becomes

$$Lq'' + IR + \frac{q}{c} = V_t \tag{6}$$

the required current flowing in an RLC circuit can be obtained by solving equation (6) and differentiating the solution $q(t)$ to obtain the current.

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Free Oscillation

An RLC circuit is said to be having V_t for $t > 0$ is said to be in free oscilation. and thus equation (6) can be rewritten as

$$Lq'' + IR + \frac{q}{c} = 0 \tag{7}$$

This is a homogeneous system with characteristic equation $LS^2 + RS + \frac{1}{C} = 0$ having the root $S_1 = \frac{-R-\sqrt{R^2-\frac{4L}{C}}}{2L}$ and

$S_2 = \frac{-R-\sqrt{R^2+\frac{4L}{C}}}{2L}$ these yield three cases to consider.

Under damped

The oscillation is said to be under damped if $R < \sqrt{\frac{4L}{C}}$, where $s_1 \ and \ s_2$ from characteristic equation of (7) are complex

root which can be expressed as

$s_1 = \frac{-R}{2L} + \iota V_1$ and $s_2 = \frac{-R}{2L} - \iota V_1$ and

$V_1 = \frac{\sqrt{\frac{4L}{C}-r^2}}{2L}$ thus the general solution of equation(6) is now

$q = e^{\frac{-Rt}{2L}}(C_1 cos V_1 t + C_2 sin V_1 t)$

$$q = Ae^{\frac{-Rt}{2L}}cos(V_1 t - \psi) \tag{8}$$

where $A = \sqrt{C_1^2 + C_2^2}$, $A cos\psi = C_1$ and $A sin\psi = C_2$ When R=0, equation (8), becomes $q = A cos\left(\frac{t}{\sqrt{LC}} - \psi\right)$
An actual RLC circuits are mostly under damped, so this case is the most important

Over damped

The Oscillation is said to be over damped if $R > \sqrt{\frac{4L}{C}}$, Whereby the roots of the characteristic equation are both real

having $s_1 < s_2 < 0$, the general solution is

$$q = K_1 e^{s_1 t} + K_2 e^{s_2 t} \tag{9}$$

Critically damped

In critically damped case, we have $R = \sqrt{\frac{4L}{C}}$ thus $s_1 = s_2 = \sqrt{\frac{-R}{2L}}$ and so the solution of the equation (6) is

$$q = e^{\frac{-Rt}{2L}}(K_1 + K_2 t) \tag{10}$$

Suppose $R \neq 0$, the exponential in equation (8) in case 1, equation (9) in case 2 and lastly equation (10) in case 3 are negative, the solution of any homogeneous initial value problem (IVP)

$$Lq'' + Rq' + \frac{q}{C} = 0, \quad q(0) = q_0, q'(0) = I_0$$

approaches or tends to zero exponentially whenever $t \to \infty$. Thus, the solutions are transient in nature.

Example 1

An RLC circuit with resistance $R = 60$ ohm, inductance $L = 0.25$ henrys and a capacitance $C = 10^{-4}$farads have a current of 2 amperes flowing in at $t = 0$, if the capacitor has a 1 coulomb charge, find the circuit's current flowing at $t > 0$ for any $t > 0$, assume that $E(t) = 0$

Solution

The equation for charge q is

$$Lq'' + Rq' + \frac{q}{C} = 0$$

given L=0.25, R=60ohms and $C = 10^{-4}$

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$\frac{1}{4}q'' + 60q' + 10000q = 0$

which can be rewritten as

$q'' + 240q' + 40000 = 0$

to find the current flowing in the circuit, we have to solve the following initial value problem (IVP)

$q'' + 240q' + 40000 = 0,$

$q(0) = 1, q'(0) = 2$

The   required   current   is   the   derivative   of   the   solution   of   the   above   problem

Now the auxiliary equation of the above problem is

$s^2 + 240s + 40000 = 0$; so, the solution of the equation is

$$s = \frac{-240 \pm \sqrt{(240)^2 - 4(40000)}}{2}$$

$$= \frac{-240 \pm \sqrt{-102400}}{2}$$

$$= \frac{-240}{2} \pm \iota\frac{320}{2} = -120 \pm \iota160$$

$\therefore s_1 = -120 + \iota160q = e^{-120t}(C_1cos160t + C_2sin160t)$

$q' = -e^{120t}((120C_1 - 160C_2)cos160t + (120C_2 + 160C_1)sin160t)$

$and\ s_2 = -120 - \iota160$

which is complex root and thus the solution is

At the given initial $t = 0$

$q(0) = C_1 = 1\ and\ q'(0) = 120C_1 - 160C_2 = 2$

$\Rightarrow q = e^{-120t}(cos160t + \frac{3}{4}sin160t)$

$\therefore I = e^{-120t}(-160sin160t + \frac{3}{4}(160)cos160t) - 120e^{-120t}(cos160t + \frac{3}{4}sin160t)$

$\therefore I = -250e^{-120t}sin160t$

Example 2

An RLC circuit with resistance $R = 2$ ohm, inductance $L = 0.1$ henrys and a capacitance $C = \frac{1}{260}$ farads has a current of 2 ampere flowing in at $t = 0$, if the capacitor has a 1 coulomb charge, find the circuit's current flowing at $t > 0$ for any $t > 0$, assume that $Emf = 100sin60t V$

Solution

By using the equation that represent the relationship between current and charge; Given $L = \frac{1}{10}, R = 2ohms, C = \frac{1}{260}$ and $V = 100sin60t$ the differential equation of the form;

$\frac{d^2q}{dt^2} + 20\frac{dq}{dt} + 2600q = 1000sin60t$ is obtained.

since the given charge at $t = 0$ is 1 coulomb, and the initial current $I = 2$ then initial conditions

$q(0) = 1$; and $q'(0) = I_0 = 2$

so the auxiliary equation will be of the form $s^2 + 20s + 2600 = 0$

the roots of this equation are complex conjugates $s_1 = -10 + \iota50$ and $s_2 = -10 - \iota50$; which is in the form of $s = \alpha \pm \iota\beta$. the complementary function is

$q_c = e^{-\alpha}(C_1sin\beta t + C_2sin\beta t)$

$\Rightarrow q_c = e^{-10t}(C_1sin50t + C_2cos50t)$

So now we are going to apply the method of undetermined coefficient to find the particular integral, then we have

$q_p = (Asin60t + Bcos60t)$

$\Rightarrow A = \frac{-5}{122},\ \ B = \frac{-3}{61}$

The charge q is the solution of the differential equation, which has the form

$q = q_c + q_p$

$q(0) = 1 \quad q'(0) = 2$

$q = e^{-10t}(C_1 sin50t + C_2 cos50t) - \frac{5}{122}sin60t - \frac{3}{61}cos50t$

$q = e^{-10t}\left(\frac{381}{1525}sin50t + \frac{64}{61}cos50t\right) - \frac{5}{122}sin60t - \frac{3}{61}cos60t$

$I = q' = e^{-10t}\left(2cos50t - \frac{15238}{305}sin50t\right) - \frac{150}{61}cos60t + \frac{180}{61}sin60t$

CONCLUSION

The compliment function q_c is the term that determine the transient response and the term q_p is the term that determine the steady response of the circuit. An RLC circuit experiences a transient reaction when it is first turned on or when there is a quick change in input. The capacitor acts as a short circuit at first, letting a sudden increase in current flow through the circuit. Because the inductor resists changes in current, the current gradually increases. As the circuit approaches steady state, the oscillations in current and voltage are caused by the energy stored in the inductor and capacitor and gradually diminish. In an RLC circuit, damping is the term used to describe the gradual loss of energy that influences the transient response's oscillation decay. Under damped circuits show oscillations that amplify more slowly than over damped circuits, which show oscillations that decay slowly. In the shortest amount of time, critically damped circuits achieve steady state with little oscillation.

Amplitude: The oscillations in the current have an amplitude of 250 amperes in example 1. This is the circuit's current oscillation at their greatest magnitude.

Exponential Decay: With a decay constant of 120, the term denotes exponential decay. This exponential term is responsible for the circuit's dampening effect. The oscillations' amplitude decays exponentially with time signifying a decaying oscillation.

Sinusoidal Component: The current oscillations' sinusoidal component is denoted by the notation sin(160t). At a frequency of 160 cycles per second (Hz), the oscillatory behavior is introduced by this sinusoidal function.

Nature of Oscillation: The exponential term causes the current to fluctuate sinusoidally, albeit with a declining envelope. This pattern is characteristic of an under damped RLC circuit, in which the oscillations' amplitude decreases as a result of energy being progressively wasted over time. The circuit's transitory reaction is represented by the exponential decay, and its steady-state oscillations are represented by the sinusoidal component. Generally, I represent the behaviors of an RLC circuit.

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RESEARCH ARTICLE

Revolutionizing Digital Marketing: AI-driven Content Creation and Optimization Strategies

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ABSTRACT

As the digital landscape continues to evolve, marketers are increasingly turning to artificial intelligence (AI) to revolutionize their content creation and optimization efforts. This paper explores the transformative impact of AI technologies on digital marketing, specifically focusing on how AI-driven content creation and optimization strategies are reshaping the way brands engage with audiences online. Through an in-depth analysis of AI-powered tools, algorithms, and applications, this study examines the benefits, challenges, and best practices associated with leveraging AI for content creation, curation, and distribution in digital marketing campaigns. By exploring real-world case studies and industry trends, this paper offers valuable insights into how organizations can harness the power of AI to create more engaging, relevant, and personalized content that resonates with target audiences across various digital channels. Marketing around the globe utilizes digital technology to elevate customer service levels and improve operational efficiency. Artificial intelligence (AI) plays a pivotal role in marketing through advancements such as more intelligent search engines, smarter advertisements, refined content delivery, reliance on bots, ongoing learning capabilities, fraud prevention, data security measures, image and voice recognition, sales forecasting, language comprehension, predictive customer service, and customer segmentation. By harnessing AI, businesses can gain comprehensive insights into their customers' requirements, leading to enhanced sales and increased revenues.

Keywords: Marketing, Digitalization, Artificial Intelligence, Customer efficiency and electronic services.

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INTRODUCTION

In today's hyper-connected digital landscape, content has emerged as a cornerstone of successful digital marketing strategies. However, the sheer volume of content being produced and consumed online presents challenges for marketers seeking to capture and retain audience attention. In response to these challenges, many organizations are turning to AI-driven technologies to streamline and enhance their content creation and optimization efforts. By leveraging AI-powered tools and algorithms, marketers can gain valuable insights into audience preferences, automate content generation processes, and deliver personalized experiences at scale. This paper explores the transformative potential of AI in revolutionizing content creation and optimization in digital marketing, offering insights into emerging trends, best practices, and real-world applications. In today's digital age, content has become the cornerstone of successful marketing strategies. With the proliferation of digital channels and the rise of online consumerism, marketers are facing increasing pressure to produce high-quality, engaging content that resonates with their target audiences. However, the sheer volume of content being created and consumed online presents significant challenges for marketers seeking to cut through the noise and capture audience attention. In response to these challenges, many organizations are turning to artificial intelligence (AI) to revolutionize their content creation and optimization efforts.

Artificial intelligence refers to the technological advancements that allow computers or other devices with human-like intellect to carry out tasks like to those executed by the human brain. Nowadays, as technology develops, artificial intelligence (AI) is utilized in practically every facet of daily life. It has been used in conjunction with digital marketing to facilitate businesses' timely consumer outreach. "Marketers can process massive amounts of information and conduct customers' expectations," claims Jain (2020). With the aid of AI, it has been possible to guarantee consumer happiness (Jain & Aggarwal, 2020). AI-based digital marketing strategies include advanced analytics, machine learning, and industry-specific customer insights. Utilizing the internet in India is increasing, which enhance new opportunities for business growth.

The broad field of modern artificial intelligence (AI) uses cutting-edge methods to derive viewpoints from vast volumes of data. The core idea of artificial intelligence is to teach machines to understand, reason about, and solve problems that humans face on a regular basis. AI progress has surged since the early 20th century with the introduction of machine learning. The hardware and processing power of machine learning algorithms are to blame for this increase. The potential of processing power increases, but so does the field's advancement. Future developments in AI may include features that let computers learn and think more like people (Lake et al. 2016). Perhaps the productivity and efficiency of important decision making could be increased by implementing artificial intelligence (AI) at the organizational level (Knight 2015). In spite of the fact that studies show a various benefit to implement the changes in organisations. It also have additional challenges in adopting AI technologies (Chui and Malhotra 2018). One of the factors that cause behind the difficulty is organizations' lack of understanding where and how to incorporate artificial intelligence. Principal component analysis at the business level, which is necessary to properly implement the business strategy on AI adoption, is another potential reason why firms fail. It is necessary to take into account the underlying variables before deciding where to integrate technology at the enterprise level. In order to better understand the variables that may affect AI adoption at the corporate level, this study aims to comprehend AI from the viewpoint of the employee.

DIGITAL MARKETING

A variety of online databases and electrical appliances are utilized in digital marketing strategies to showcase, promote, and sell goods and services. Successful internet-based businesses have also benefited from these strategies. Websites, pages on social networking sites, targeted ads, and emails are commonly used to draw in new clients and retain existing ones. We must first examine the current status of scientific research in digital marketing and contrast it with the business sector in order to ascertain the crucial function that artificial intelligence (AI) plays in this field. Then, we'll be able to determine the extent to which academic digital marketing lags behind corporate advancements.

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ARTIFICIAL INTELLIGENCE (AI) ON DIGITAL MARKETING

We must first examine the key subfields of artificial intelligence (AI) in order to comprehend how AI seems to contribute to digital marketing strategies. Next, we look at each of those fields individually to see if any of them use digital marketing strategies. This would illustrate how research on digital marketing is impacted by artificial intelligence (AI). There has been discussion on various facets of artificial intelligence (AI) research. Among many other applications, artificial neural networks have been employed in time series prediction, brain modeling, and classification processes. Evolutionary computation includes techniques such as genetic algorithms and genetic programming. Examples of vision include object identification, conceptual image interpretation, and other image processing techniques. The term "robotics" refers to autonomous exploratory processes, intelligent control, etc. Skillful Systems encompass management information systems, instructional systems, and so on. Recognition system includes voice recognition, production process, etc. Machine translation referred to Planning, game play procedures, etc., are examples of planning. Data mining, decision tree learning, and other types of machine learning.

STATEMENT OF THE PROBLEM

We must first examine the key subfields of artificial intelligence (AI) in order to comprehend how AI seems to contribute to digital marketing strategies. Next, we look at each of those fields individually to see if any of them use digital marketing strategies. This would illustrate how research on digital marketing is impacted by artificial intelligence (AI). There has been discussion on various facets of artificial intelligence (AI) research. Among many other applications, artificial neural networks have been employed in time series prediction, brain modeling, and classification processes. Evolutionary computation includes techniques such as genetic algorithms and genetic programming. Examples of vision include object identification, conceptual image interpretation, and other image processing techniques. The term "robotics" refers to autonomous exploratory processes, intelligent control, etc. Skillful Systems mining,' or 'predictive modelling,' they always say 'artificial intelligence' to describe data analysis, smart systems, data extraction, or keyword searches. Computer scientists, on the other hand.

OBJECTIVES OF THE STUDY

- Identifying the Factors Influencing Artificial Intelligence in Digital Marketing
- Forecasting and Predicting the Future Potential of Artificial Intelligence
- Analysing the Impact of Artificial Intelligence on the Marketing Landscape

FACTORS INFLUENCING ARTIFICIAL INTELLIGENCE ON DIGITAL MARKETING:

Customized experience

Personalized gifts, notes, or exclusive deals are appreciated by all customers. Every company wants to satisfy its clients by giving them exactly what they desire. It is, in fact, imperative to support the acquisition of consumer data for this reason and to make investments in artificial intelligence. Businesses can tailor their own products as needed by using machine learning to analyze customer behavioral trends.

Real-Time Reaction

Businesses that use artificial intelligence can better keep their customers' loyalty. Consumers favor goods and services that promptly assist in resolving their problems. AI chatbots, for instance, let users respond and solve problems quickly. Certain chatbots possess additional senses, like speech or touch. Customers enjoy this since it gives them an almost direct encounter and makes them feel as though they are speaking with a human rather than a machine. The majority of the time, these chatbots are available around-the-clock, which can increase client satisfaction.

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Customer Behavior Prediction

In addition to personalizing client pleasure, artificial intelligence has the ability to forecast the behavior of both current and potential customers. Through the use of data management platforms, artificial intelligence may compile user information from all over the internet (DMP). This isn't just about one person visiting your website. This will enable the business to target future clients, create more successful marketing campaigns, and tailor its services to meet the needs of its current clientele. AI's process for gathering, analyzing, interpreting, and assessing data is constantly changing. Over time, its precision will make it possible for businesses to forecast their sales and return on investment and succeed in their endeavors.

Increasing the Return on Investment:

The capacity to recognize image quality is known as return on investment, and artificial intelligence helps to increase ROI. Consequently, this raises the company's revenue. In addition, it facilitates the settlement of numerous security issues and guarantees prompt and effective payment processing. feasible. After a user's behavioral patterns are recognized by the machine learning technology, a customized campaign is created for the destination. AI uses personal data to power business, enabling companies to personalize their offerings. Additionally, it helps the organization avoid wasting a lot of time and money on disengaged clients.

Enhance the Search Sessions

Users have also benefited immensely from the advancement of technology, as evidenced by the fact that they appear smarter! Consumers are searching for a range of instruments or programs that can connect them to superior goods and services. Consequently, companies need to incorporate AI into their plans. AI is useful for deciphering customer behavior trends. These days, an essential component of every AI technology is voice recognition.

Advertising:

Businesses mostly rely on advertising to promote their goods and services, both online and off. This appears to be a significant factor, especially considering that it can be utilized to eliminate most manual labor entirely. In example, customer data is quite helpful for producing distinctive marketing. The AI technology determines the consumers' areas of interest by analyzing all the data that has been gathered from them. This gives a company's marketing a structure so they may readily match the needs of their potential clients. Businesses benefit from this by having an advantage over rivals in the market.

Search Engine Optimization (SEO)

SEO suggests possessing one of the best potential scientific editions. Many scientific studies related to search engine marketing, or SEO, focus on fuzzy intelligent systems, machine learning, evolutionary computations, and web crawlers for the purpose of reading, gathering, and analyzing website data. The ultimate goal of these studies is to improve website page rankings in search engine results by integrating ranking factors through an intelligent learning model.

Social Media Marketing:

The quantity of research articles on social media marketing, which primarily focus on customer behavior, intentions, image comprehension processes, social media data analysis, and the application of machine learning models and data mining techniques, reveals the field's sluggish development. Digital marketing, content creation, and prescriptive marketing are scientific fields of study that employ data mining techniques, particularly deal procedures, text mining, and machine learning-based techniques like extractive summarization, expert systems, customer decision support systems, text analysis, and predictive analysis, to examine data extracted from blogs, websites, e-commerce sites, and social media.

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Pay-Per-Click (PPC) and Ad Targeting:

Machine learning is used extensively in scientific research for bidding and ad targeting through the use of optimized advertising models. It analyses criteria that allow one to assess the importance of the various factors on the probability of clicks and conversions. Machine Learning provide new information and reveal hidden trends.

Chatbots:

Digital marketing is now more successful thanks to chatbot research when compared to other strategies. There appears to be a significant ongoing research effort to develop automated robotic simulation software that interacts with humans by utilizing AI subfields like decision support systems, neural networks, autonomous exploratory procedures, etc. This effort spans health care, education, digital counseling, and insurance.

Semantic search

A large number of scientific publications pertaining to search engines, information retrieval, websites worldwide, data mining, social networking, the internet, learning algorithms, machine learning, information analysis, natural language processing systems, query processing, information management, decision support systems, user interfaces, web searches, etc., which is related to web development, show how far beyond comparable business sector aspects the scientific research is. Web technology and optimized versions have been used to explain over 2000 publications. Artificial intelligence (AI) is being used to optimize web development processes, ranging from online design and development to web applications, web services, mobile-friendly websites, and data representation.

Voice search

The majority of study focuses on voice search, and there is little to no research on digital marketing. Nonetheless, notable advancements are made in other scientific domains. The most significant research in marketing is on speech recognition and personal voice assistant technologies, which offer flexible methods of engagement where users and systems participate on an equal footing and can help provide clear and accurate responses to online searches.

Applications of Artificial Intelligence in Digital Marketing

Earlier Digital Marketers were reluctant regarding the usage of AI in Digital Marketing but with the growth of AI and its results of AI has proved that it will bring dynamic changes in the marketing world.

Generating Content

Machines can now create content from scratch based on data fed in coding. These can be helpful to save time and resources. AI can write reports and news based on data and information. Automated Journalism is now used by many leading news giants like BBC news, The New York Times, Washington Posts and more. Also, Facebook uses AI to remove fake news.

Product Recommendation and Content Curation

Not just creating content but helping recommending products and services based on the user's search, interest and behavior. Artificial intelligence can rightfully understand the behavior of the targeted audience and what is better than finding the right products or services that you are already looking at. Netflix recommends you content based on your interest. Artificial Intelligence technology is commonly used to make personalized content recommendations that the user may find interesting, such as the if people buy X product, they might like Y product too, similar products just like Amazon.

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Use of AI Chatbots

We are aware of automated responses used by businesses to solve customer queries and also used in data collection, keeping the audience updated about products and services. They can serve clients 24/7 and retain their data for future use. Also, the applications of chatbots are huge and the amalgamation of Chatbots with Artificial Intelligence and Machine is the new game changer.

Web Design

Without the help of a programmer or a designer, you can still have your website through the use of Grid, that uses Artificial Intelligence to do the work for you based on the information provided like images, text, calls-to-action, etc. they can make the website look professional in much less time and at affordable price.

Predictive Analysis

Artificial Intelligence uses data to make probable future projections. Predictive analysis is just the use of data, statistical algorithms, and machine learning.

Digital Advertising

Artificial intelligence is being used extensively in digital advertising to guarantee optimum success. It is being employed on platforms such as Facebook, Google, and Instagram to deliver optimal user experience. examining user data, including gender, age, interests, and other details, to display advertising that are appropriate for them. Marketers may anticipate trends and even identify micro trends with the use of AI technology. As a result, they can make strategic decisions; firms may cut down on wasteful digital advertising expenditures and make sure their investment yields the most returns.

Online Search engine

Marketers must produce and modify content in accordance with the evolving nature of content searching. Google's algorithm, voice search, and other AI advancements are examples of recent improvements. Additional developments include Google Home, Apple's Siri, Microsoft's Cortana, and Amazon Echo, which can all conduct searches with just a button push or voice command

Email Marketing

Using AI, brands are personalizing emails to connect with their intended audience. They can now tailor material to the interests and behaviors of their customers. Through the analysis of millions of data, machine learning, also known as autonomous learning, can now determine the optimal time of day and recommended frequency of contact with the user. They can now tell which titles and subjects generate the most clicks, as well as which material grabs the most attention.

Future Artificial Intelligence on Digital Marketing

In future, marketers can expect the following impacts from artificial intelligence on digital marketing

Smarter searches

As technology solutions become wiser and more perfect, it is essential to mention that the public's requirements become more sophisticated. People can find what they need quickly thanks to social media and fast search engines like Google. Artificial intelligence and big data can analyze these search models and assist marketers in identifying the key areas where they should concentrate their efforts.

Smarter Ads

Marketers are still looking to attract customers with smart advertisements today, but using artificial intelligence allows them to do so faster and more efficiently. Online ads are becoming smarter and more effective as a result

of big data. For human solutions, artificial intelligence can delve deeper into data, social networks, Profiles as well as other online content.

Relying on Bots

A further area where artificial intelligence can play a vital role in the evolution is consumer care and retention. Conversation functions and other direct-to-consumer engagement will be handled by artificial intelligence bots very soon. Businesses will save time for employees and cut costs in this manner. The artificial intelligence bots will also have access to the entire internet's information and search history, allowing them to outperform humans.

Continuous Learning

Using artificial intelligence, it will not only reveal some hidden data, but it will also instruct them and integrate them in to the new promotion strategy, as well as optimize the messages to the most relevant users. Artificial intelligence solutions will become more intelligent as well as effective over time, promoting real-time decision making.

RESEARCH METHODOLOGY

The present research study was descriptive and empirical in nature for this study empirical analysis used which is based on a quantitative approach to interpret the link between the variables such as Artificial Intelligence, Technology, social networking, profit maximization and Decision Making through the research instrument. Both primary data (through an online questionnaire to collect demographic information) and secondary data (journal articles, publications and other sources) have been used.

Convenience sampling method were used to filter participants, which are digital marketing customers. The data collected were subjected to pilot study to explore the reliability and validity of the instrument and Cronbach's Alpha Reliability Coefficient value of 0.899 proves that the scale is more consistent and highly reliable in nature. Questionnaires were distributed to 400 respondents, and only 370 completely concise questionnaires were returned by the respondents. Structured Questionnaires with three different sections were finalized for the survey method among the digital marketing customers in the Delhi city. Section one deals with the personal profile of the respondent such as, age, gender, marital status, educational qualification, designation of employees, gross annual income experience of consumers is measured in the appropriate nominal and interval scales. The responses of the participants were collected on the basis of 5 point Likert's scale applied for section 2 and 3 which consists of ten questions regarding perception of consumer regarding Artificial Intelligence Variables Due to the emerging trends of AI application in the digital marketing, the aim of this paper is to review the AI implementation in the field of digital marketing. The goal of the research is to assess the scope of AI application with digital marketing (voice, text, image recognition, decision-making, technology and robots) find application in marketing; (The first step was a focus on review the marketing portals (www.marketingweek.com, www.adweek.com, www.warc.com) to gather AI application in marketing.

The table 1 state that the personal profile of the respondents. The majority of the respondents are female 59.4%. The age group of the major respondents are 30 and below are 74%. The major respondents were graduate in Arts 45%. The majority of the respondent's gross income is 5lakhs and below are 84%.

The Structural Model

The SEM technique was used to examine the structural model so the effects among the four latent constructs were tested. The model included 15 items describing 4 latent constructs: Artificial Intelligence, Digital Marketing, Profit Maximization, and social networking. The various goodness-of-fit statistics are shown in

Table.2. and present a good fit between the data and the proposed measurement model. The goodness-of-fit value of 0.90 shows that the measurement model has a good fit with the data.

HYPOTHESES

H1. Artificial Intelligence has a direct effect on Digital Marketing.

The data indicates that Artificial Intelligence has a direct effect on Digital Marketing (H1: β= - 0.12, $p < 0.05$). Hence the hypothesis is accepted.

H2. Technology has direct effect on Digital Marketing.

The data indicates that Technology has a direct effect on Digital Marketing (H2: β= - 0.62, $p < 0.05$). Hence the hypothesis is accepted.

H2b. Social networking has a direct effect on Digital Marketing.

The data indicates that social networking has direct effect on Digital Marketing. (H3: β= - 0.07, $p < 0.05$). Hence the hypothesis is accepted.

CONCLUSION

The technology landscape for businesses is already being revolutionized by artificial intelligence thanks to big data, machine learning, and ideal solutions. Organizations modify their operational procedures to enhance their agility, efficiency, and competitiveness. New marketing opportunities have always been generated by technological improvements. Artificial intelligence will change how people connect with information, technology, businesses, and services, just as the advent of television marked a new era of really mass advertising and attainment, and the Internet and mobile phones heralded a new level of targeting and backdrop. Marketers are made aware of the possibility for personalization and relevance by artificial intelligence. Reach billions of people every day using search engines, Facebook, YouTube, and Google. Utilizing digital ad platforms, it facilitates large-scale communication. decided in addition to a customizability made feasible by artificial intelligence means that companies will soon be able to tailor personalized campaigns in real time. The world of the future is in the application of Artificial Intelligence. It's important to understand that integrating AI into a firm does not mean that workers are no longer required for certain tasks. Artificial Intelligence is a technological advancement that streamlines numerous intricate and time-consuming procedures, resulting in substantial financial and time savings for enterprises. AI-powered technologies may be trusted to provide a prompt solution because they are very accurate and dependable. It makes it possible for an organization to quickly and easily develop a plan. AI has a lot of potential in digital marketing these days. It links companies with possible clients. It significantly enhances a business's comprehension of both current and potential clients. This helps businesses create goods and services that satisfy the needs of their clients.

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Table. 1 Personal profile of the respondent

Particular	Items	Frequency (n=370)	Percentage
Gender	Male	170	45.6
	Female	200	54.4
Age	30and below	125	33.7
	31-40	89	24.5
	41-50	85	22.9
	50and above	71	19.1
Education Qualification	Engineering Technology PG- Arts PG-Science	135	36.47
		120	32.7
		55	14.86
		60	16.21
Experience	Below–5Years	75	44.11
	5 to 10 years	52	30.58
	11to20years	30	17.64
	Above20years	13	7.64
Gross Income	5lakhs and below 5 to 10 lakhs	84	49.411
		53	31.17
	Above10 lakhs	33	19.41

Table.2 – Model evaluation overall fit measurement

Fit indices	Recommended value	Value
χ^2	N/A	16.40
d.f.	N/A	28
χ^2/d.f.	≤3.00	3.57
Goodness of fit index (GFI)	≥0.9	0.80
Normed fit index (NFI)	≥0.9	0.79
Non-normed fit index (NNFI)	≥0.9	0.58
Comparative fit index (CFI)	≥0.9	0.69
Root Mean Square Error of Approximation (RMSEA)	≤0.05	0.044

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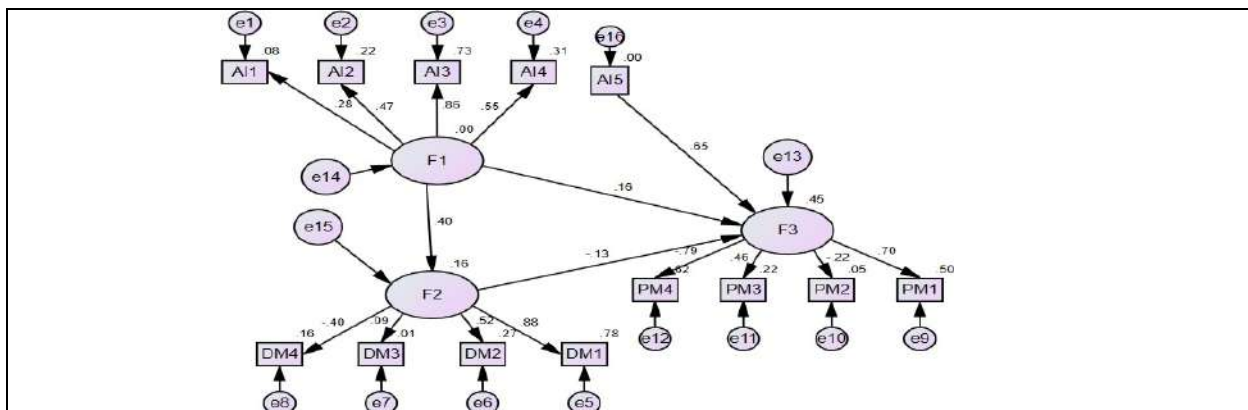
Optimizing Inventory Management for Electronics Materials: Incorporating Price Sensitivity, Time-Varying Holding Costs, Inflation Dynamics, and Payment Flexibility

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ABSTRACT

This study presents an inventory management framework for electronics materials, acknowledging the impact of price-sensitive demand. We account for potential shortages, allowing partial backlogging, alongside permissible payment delays and inflation considerations. Backlogging rate is depicted as an exponentially decreasing function over time. Furthermore, we integrate a constant deterioration rate to optimize overall inventory costs. Through parameter variation analysis, we explore the model's sensitivity to changes, supported by numerical examples. Graphical representations elucidate the relationships between different parameters and the total inventory cost, enhancing comprehension of the inventory models' outcomes.

Keywords: price-dependent demand, time-depending holding cost, partially backlogging, Inflation, permissible delay in payment

INTRODUCTION

Items kept in storage to use them later on or sell them make up an inventory. A company's inventory will run out very rapidly if it orders just a few things. Because replenishments will need to be made more frequently, this increases the ordering cost. But if the company orders a lot of goods, the higher the required storage/holding costs

will be. To minimise costs and maximise profits, inventory models are essential for assisting companies in determining the quantity and timing of their orders. In reality, a lot of factors influence inventory. One illustration would be the possibility for the items in the inventory to deteriorate or diminish in quality. Market yards, warehouses, assembly lines, manufacturing facilities, transportation, and other locations are just a few of the real-world settings where inventory systems are used extensively. Inventory management is an essential component of operations research that helps determine the best practices for controlling and managing inventories. Inventory models offer the fundamental structure needed to examine various production processes. The two general categories of inventory models are: (i) Economic Order Quantity (EOQ) models and (ii) Economic Production (EPQ) models. Physical resources, raw materials, and completed commodities are all included in the inventory. Inventory theory uses information technology to help make decisions and investigates the best way to allocate resources. Costs related to storage and maintenance are important considerations. Product damage is one of the challenges that inventory management faces. Inventory models have been the subject of many research articles during the last 20 years. Many topics are covered in these studies, including linear and quadratic demand functions as well as demand patterns including ramp, time, selling price, and combinations of time and demand.

Demand is important for creating a realistic model in inventory research. Demand was taken to be constant at the beginning of inventory modelling. As time has gone on, scholars have begun to focus on various demand patterns in inventory modelling. Price-dependent demand has distinguished itself from other demand patterns in inventory modelling. It has been observed that the product's price-dependent demand has an impact on the delivery of the goods. Customers are encouraged to purchase more goods by the products' appealing prices, which raises the demand for the goods. This circumstance suggests the store places larger orders, which increases their profit margin and increases sales. When the inventory starts to deteriorate, the situation gets more complicated. One of the key components of every manufacturing and inventory system is the deterioration of the goods. Rekha and Vikas [2] solved a model for weibull deteriorate items with price dependent demand rate and inflation. Jyoti et al. [7] studied deteriorating items inventory model having price dependent demand with inflation and learning effect. Pujari and Anil [15]discussed an Inventory Model with Deteriorating Items having Price Dependent Demand and Time Dependent Holding Cost under Influence of Inflation. According to traditional inventory models, goods preserve their physical characteristics while being held in storage. But in actuality, it is evident that foodstuffs such as fruits, vegetables, volatile liquids, etc., have a short storage period. To choose an inventory control model, it is important to consider the term deterioration. Deterioration is a process that takes place over time, according to Ghare and Scharder [3]. In recent years, several researchers have focused on inventories with deteriorating products because most physical goods deteriorate with time. A model is created for an inventory that depreciates exponentially. Wee presented a deterministic lot-size inventory model that deteriorates with shortages and an expanding market.

For perishable inventory with a stock-dependent rate and a non-linear holding cost, deterministic models are recommended. Deterioration is always considered over time. The deterioration rate is almost negligible for items like toys, hardware, glassware, and steel; however, it is highly effective for goods like fruits, vegetables, pharmaceuticals, volatile liquids, blood, high-tech products, and others. Harris [5] created the first economic quantity model. Wagner and Whitin [18] looked at the inventory model of a deteriorating item at the end of a period of shortage. Deterioration functions can therefore take on an extensive variety of patterns and factors, including constant and time-dependent functions. Magfura Pervin et al. [10] proposed an inventory model for estimation of deterioration with time dependent demand and storage cost. Singh et al. [16] proposed an inventory model for deteriorating items with time- dependent deterioration rate, ramp-type demand rate and shortages. When necessary items are either completely lacking or difficult to obtain in sufficient quantities, it is referred to as a shortage. To provide additional information on the subject, consider the following scenario: a business produces certain necessities whose demand rises sharply or suddenly, and the business is unable to meet the demand because of unexpected factors. During that time, customers are experiencing shortages of this specific product. For many models, especially when payment delays are considered, shortages are crucial. Customers may place more orders from a business if there is a shortage but it allows for a payment delay. Therefore, shortages can profit much from allowing a payment delay. It's commonly assumed that insufficient demand in inventory models with shortages is either totally lost or backlogged.

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There are, however, a few circumstances in which some clients depart while others are prepared to hold off until their demands are satisfied. Considering one particular business as an example, let's assume a consumer has a strong preference for a specific retailer and that, in the meantime, the customer notices that a certain product is in low supply. However, the client is unwilling to purchase from another business. The consumer in this instance will have to wait for further supplies of the specific product. As a result, shortages in inventory systems exist and have a big impact on things. Goyal [4] Suggested Economic order quantity under conditions of permissible delay in payments. Pal et al. [9] have studied an inventory model for deteriorating items with permissible delay in payment and inflation under price dependent demand. Nabendu et al. [13] presented an inventory model with price dependent demand under permissible delay in payment. Lakshmana et al.[8] introduced an inventory model with exponential deterioration and shortages for several levels of production. Sathishkumar and Iswarya[12]formulated an EOQ Model with price dependent demand and partially backlogging shortages with salvage cost.

A traditional inventory model assumes that holding costs are fixed and well-known. However, in real life, inventory is typically kept in warehouses to satisfy client demand or for later use. Due to the importance of inventory maintenance, variable holding costs have attracted the attention of the majority of relevant studies. For perishables like fruits, vegetables, medications, or volatile liquids, the cost of holding is also relatively significant and entirely depends on the period of time. For this reason, variable holding costs are crucial to maintain relevant with the state of the market. As a result, the holding cost is never a constant function. It changes based on the passing of time. Many researchers have taken consideration of different functions defining holding cost in the generalization of EOQ models. Yadav and Vats [19] discussed deteriorating inventory model for quadratic demand and constant holding cost with partial backlogging and inflation. Ichwanto [6] suggested analysis of inventory control model with shortage under time-dependent demand and time-varying holding cost including stochastic deterioration. In today's business environment, inflation has become a probable scenario. As a result of a decline in the purchasing power of money, inflation is the general level of price increases for goods and services over an extended period of time within an economy. A high rate of inflation causes many businesses' purchasing power to significantly decrease. Therefore, while developing any inventory model, the impact of inflation cannot be ignored. First, the inflation rate was first established by Buzacott [1] in inventory modelling with various pricing strategies. Saha and Sen [11] studied an inventory model for deteriorating items with time and price dependent demand and shortages under the effect of inflation. Udayakumar et al. [17] explained Economic ordering policy for non-instantaneous deteriorating items with price and advertisement dependent demand and permissible delay in payment under inflation. Geetanjali and Anamika [14]introduced effect of Inflation on a deteriorating inventory model with non-linear holding cost and non-linear demand. In this paper, we developed an inventory management framework for electronics materials, recognizing the influence of price-sensitive demand while considering delayed payment to minimize overall costs. This research work considered constant deteriorating items under the effect of inflation where shortages are permitted and partially backlogged. the model is illustrated with the help of sensitivity analysis and numerical example.

Assumptions and Notations
To develop the mathematical model, we use the following assumptions and notations:

Assumptions
1) Demand rate is considered as Price dependent demand.
2) Time-dependent holding cost
3) Shortages and partial backlogging are allowed.
4) Permissible delay in payment
5) It is assumed that the inflation rate, r, is also considered
which is defined as $f(t) = e^{-rt}$ $r > 0$
6) The Deterioration rate is constant.
7) Replenishment rate is infinite that is lead time is zero.
8) The backlogging rate is an exponentially decreasing function of time.

Notations

The demand rate is a function of the selling price or is dependent on the selling price i.e.,

$$D = (a - bp^m), \qquad 0 \le p \le \left(\frac{a}{b}\right)^m$$

Where $a > 0$ and a is the initial demand units/ year. And $b, m > 0$

$p(t)$: selling price/unit at time t.

r: inflation rate.

$h(t)$: h.t, is the time-dependent holding cost, where h is the holding cost parameter and is greater than zero.

A= Ordering Cost

T= Cycle time.

θ = Deterioration rate and $0 < \theta < 1$.

Q_1= The initial inventory level

Q_2= Maximum Backorder

C_1= Deterioration cost

C_2= Shortage cost

C_3= Opportunity cost

I_e= The interest earned per rupee in a year

M = The permissible delay in setting the accounts

$I(t)$ = The inventory level at time t

$e^{-\gamma t}$ = Unsatisfied demand is backlogged at rate, the backlogging parameter γ is the positive constant

I_p= The interest payable per rupee in a year

Mathematical model: In this model, the Inventory level is Q, initial at t=0. The inventory level decreases during the interval $(0,t_1)$ as a result of deterioration and demand. When t = T, it becomes zero. The amount of inventory during the partially backlogged shortage period (t_1, T) is dependent upon demand. The demand determines the inventory level during the partially backlogged shortage period (t_1, T). Our mathematical model is illustrated in picture (1). The following are the differential equations that describe the inventory level:

$$\frac{d}{dt}I(t) + \theta I(t) = -D$$

$$\frac{d}{dt}I(t) + \theta I(t) = -(a - bp^m) \qquad 0 \le t \le t_1 \qquad \text{... (1)}$$

$$\frac{d}{dt}I(t) = -(a - bp^m)e^{-\gamma t} t_1 \le t \le T \qquad \text{... (2)}$$

With boundary conditions $I(0)=I\_0= Q\_1$

$$I(t) = \frac{(a-bp^m)}{\theta}\left(e^{\theta(t_1-t)} - 1\right) \qquad \text{... (3)}$$

With condition $I(0) = Q_1$

$$I(0) = \frac{(a - bp^m)}{\theta}\left(e^{\theta t_1} - 1\right)$$

Initial inventory level

$$Q_1 = \frac{(a-bp^m)}{\theta}\left(e^{\theta t_1} - 1\right) \qquad \text{... (4)}$$

For Eq.(2)

$$I(t) = \frac{(a-bp^m)}{\gamma}\left(e^{-\gamma t} - e^{-\gamma t_1}\right) \qquad \text{... (5)}$$

Ordering Cost = A

Holding Cost

$$HC = \int_0^{t_1} hte^{-rt} I(t)dt$$

$$HC = \int_0^{t_1} \frac{(a - bp^m)}{\theta} h\, te^{-rt} (e^{\theta(t_1-t)} - 1)dt$$

$$HC = \frac{h\,(a-bp^m)}{\theta r^2(\theta+r)^2}\left[\theta e^{-rt}(r\theta t_1 + r^2 t_1 + \theta + 2r) + r^2 e^{\theta t_1} - (\theta + r)^2\right] \qquad \text{... (6)}$$

Maximum Backorder $Q_2 = -\int_{t_1}^{T} I(t)dt$

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$$= -\int_{t_1}^{T}(a - bp^m)e^{-\gamma t}\,dt$$

$$= \frac{(a - bp^m)}{\gamma}(e^{-\gamma T} - e^{-\gamma t_1}) \qquad \qquad \dots (7)$$

Deterioration Cost

$$DC = C_1\left[I(0) - \int_{0}^{t_1}e^{-rt}D(t)dt\right]$$

$$= C_1\left[\frac{(a - bp^m)}{\theta}(e^{\theta t_1} - 1) - (a - bp^m)\int_{0}^{t_1}e^{-rt}\,dt\right]$$

$$= \frac{C_1(a - bp^m)}{\theta r}\left[r(e^{\theta t_1} - 1) + \theta(e^{-rt} - 1)\right] \qquad \dots (8)$$

$$\text{Shortage Cost} = C_2\int_{t_1}^{T}e^{-rt}I(t)dt$$

$$SC = C_2\int_{t_1}^{T}e^{-rt}\frac{(a - bp^m)}{\gamma}(e^{-\gamma t} - e^{-\gamma t_1})dt$$

$$= \frac{C_2(a - bp^m)}{\gamma r(r + \gamma)}\left[e^{-rT}(\gamma e^{-rt_1} - re^{-T\gamma}) + e^{-\gamma t_1}(re^{-\gamma T} - \gamma e^{-rt_1}\right] \qquad \dots (9)$$

$$\text{Opportunity Cost} = C_3\int_{t_1}^{T}e^{-rt}(1 - e^{-\gamma t})(a - bp^m)$$

$$\frac{C_3(a - bp^m)}{r(r + \gamma)}\left[e^{-rT}(-\gamma - r + re^{-T\gamma}) + e^{-rt_1}(r + \gamma - re^{t_1\gamma})\right] \qquad \dots (10)$$

Permissible delay in payment
For permissible delay in payment there arise two cases. When inventory has become depleted the trade credit duration is shorter in the first case. The trade-credit period is greater than the inventory end date in the second case.

Case(1):$0 \le M \le t_1$
The retailer can continue to collect revenue and earn interest at an annual rate I_e for the remainder of the cycle if the length of time with positive inventory stock of the items is greater than the credit period. Consequently, the interest earned per cycle by

$$IE_1 = PI_e\int_{0}^{M}(a - bp^m)te^{-rt}dt$$

$$= \frac{PI_e(a - bp^m)}{r^2}\left[1 - e^{-rM}(rM + 1)\right] \qquad \dots(11)$$

However, the products that are still in stock must be financed at an annual rate I_p after the fixed credit period has passed. The total amount of interest due per cycle is

$$IP_1 = PI_p\int_{M}^{t_1}I(t)e^{-rt}dt$$

$$= PI_p\int_{M}^{t_1}\frac{(a - bp^m)}{\gamma}(e^{\theta(t_1 - t)} - 1)dt$$

$$= \frac{PI_p(a - bp^m)}{\theta^2}\left[e^{\theta(t_1 - M)} - 1 - \theta t_1 + \theta M\right] \qquad \dots(12)$$

Case (2):$t_1 \le M \le T$
$IP_2 = 0$, This policy assumes that the account will be settled during the shortage of time, and the store will pay interest on the account of each cycle.
The interest earned per cycle by

$$IE_2 = PI_e\left[\int_{0}^{t_1}(a - bp^m)te^{-rt}dt + (M - t_1)\int_{0}^{t_1}(a - bp^m)e^{-rt}\,dt\right]$$

$$= \frac{PI_e(a - bp^m)}{r^2}\left[Mr - e^{-rt_1} + 1 - Mre^{rt_1} - rt_1\right] \qquad \dots(13)$$

Total average cost of the system

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Case (1): Thus, the total average cost per unit time of the system is determined by

$$TC_1 = \frac{1}{T}[ODC + HC + DC + SC + OC + IP_1 - IE_1]$$

$$= \frac{1}{T}\left[A + \frac{h\,(a-bp^m)}{\theta r^2(\theta+r)^2}\left[\theta e^{-rt}(r\theta t_1 + r^2 t_1 + \theta + 2r) + r^2 e^{\theta t_1} - (\theta+r)^2\right] + \frac{C_1(a-bp^m)}{\theta r}\left[r\left(e^{\theta t_1} - 1\right) + \theta(e^{-rt} - 1)\right] + \right.$$

$$\frac{C_2(a-bp^m)}{\gamma r(r+\gamma)}\left[e^{-rT}(\gamma e^{-rt_1} - re^{-T\gamma}) + e^{-\gamma t_1}(re^{-\gamma T} - \gamma e^{-rt_1}\right] + \frac{C_3(a-bp^m)}{r(r+\gamma)}\left[e^{-rT}(-y - r + re^{-T\gamma}) + e^{-rt_1}(r + \gamma - re^{t_1\gamma})\right] +$$

$$\left. \frac{PI_p(a-bp^m)}{\theta^2}\left[e^{\theta(t_1-M)} - 1 - \theta t_1 + \theta M\right] - \frac{PI_e(a-bp^m)}{r^2}\left[1 - e^{-rM}(rM + 1)\right]\right] \qquad \dots (14)$$

Case (2): Thus, the total average cost per unit time of the system is determined by

$$TC_2 = \frac{1}{T}[ODC + HC + DC + SC + OC + IP_2 - IE_2]$$

$$= \frac{1}{T}\left[A + \frac{h(a-bp^m)}{\theta r^2(\theta+r)^2}\left[\theta e^{-rt}(r\theta t_1 + r^2 t_1 + \theta + 2r) + r^2 e^{\theta t_1} - (\theta+r)^2\right] + \frac{C_1(a-bp^m)}{\theta r}\left[r(e^{\theta t_1} - 1) + \theta(e^{-rt} - 1)\right] + \right.$$

$$\frac{C_2(a-bp^m)}{\gamma r(r+\gamma)}\left[e^{-rT}(\gamma e^{-rt_1} - re^{-T\gamma}) + e^{-\gamma t_1}(re^{-\gamma T} - \gamma e^{-rt_1}\right] + \frac{C_3(a-bp^m)}{r(r+\gamma)}\left[e^{-rT}(-y - r + re^{-T\gamma}) + e^{-rt_1}(r + \gamma - re^{t_1\gamma})\right] -$$

$$\left. \frac{PI_e(a-bp^m)}{r^2}\left[Mr - e^{-rt_1} + 1 - Mre^{rt_1} - rt_1\right]\right] \qquad \dots (15)$$

The Necessary condition for the total cost per unit time to be minimized is

$$\frac{\partial TC_1(t_1, T)}{\partial t_1} = 0 \; and \; \frac{\partial^2 TC_1(t_1, T)}{\partial t_1} > 0$$

Numerical Examples

The process for solving the model using numerical examples for getting optimal values for an inventory model is discussed in this section.

Case (1): we consider the following values of the parameters are given as:

A=1000, h=15, a=100, b=0.01, p=25, m=1.8, r=0.05, $\theta = 0.06, \gamma = 0.5, C_1 = 20, C_2 = 0.4, C_3 = 0.05, I_e = 0.35, I_p = 0.3$, M=60/365 year, T=1year we obtained the following optimum values

$t_1 = 0.1567$ and TC=1051.1777

Case (2): we consider the following values of the parameters are given as:

A=1000, h=15, a=100, b=0.01, p=25, m=1.8, r=0.05, $\theta = 0.06, \gamma = 0.5, C_1 = 20, C_2 = 0.4, C_3 = 0.05, I_e = 0.35$, M=120/365 year, T=1year we obtained the following optimum values

$t_1 = 0.2787$ and TC=1020.7968

Sensitive Analysis

In this section, the following tables show the sensitivity analysis to determine the effects of changing various parameter values on optimal values. The rate of changes in values of parameters are taken -20%, -10%, +10% and +20%.

CONCLUSION

In this paper, we have developed an inventory management framework specifically for electronics materials, acknowledging the significance of price-sensitive demand and integrating delayed payment to optimize overall costs. Shortages are allowed and partially backlogged. Inflation is also considered in this model. The backlogging rate is modelled as an exponentially decreasing function of time. The model is illustrated through numerical examples and sensitivity analyses.

For Case (1)

➢ When increasing in the Parameters A, a, b, p, m andC_3 then the total inventory cost increases significantly.

➢ When increasing in the parameters h, θ C_1, C_2andI_p then the total inventory cost increases marginally.

➢ When increasing in the Parameters $I_e$and γ then the total inventory cost decreases significantly.

➢ When increasing in the parameter r then the total inventory cost decreases marginally.

For Case (2)

➢ When increasing in the Parameters A, a, b, p, m and C_3then the total inventory cost increases significantly.

➢ When increasing in the parameters h,θ, $C_1$and C_2then the total inventory cost increases marginally.

➢ When increasing in the Parameters γ and I_e then the total inventory cost decreases significantly.

➢ When increasing in the Parameter rthen the total inventory cost decreases marginally.

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Table 1: Variation in system parameters of Case (1)

Parameters	%	-20%	-10%	0%	10%	20%
A	TC	851.1777	951.1777	1051.1777	1151.1777	1251.1777
h	TC	1050.9846	1051.0830	1051.1777	1051.2690	1051.3570
a	TC	1040.9888	1046.0833	1051.1777	1056.2722	1061.3666
b	TC	1039.4979	1045.3436	1051.1777	1057.0005	1062.8117
p	TC	1034.1023	1042.2283	1051.1777	1060.9359	1071.4891
r	TC	1052.3963	1051.7813	1051.1777	1050.5853	1050.0038
θ	TC	1051.1766	1051.1772	1051.1777	1051.1783	1051.1789
Υ	TC	1063.9539	1056.9112	1051.1777	1046.4249	1042.4255
C_1	TC	1051.1764	1051.1771	1051.1777	1051.1784	1051.1790
C_2	TC	1050.4618	1050.8217	1051.1777	1051.5298	1051.8779
C_3	TC	1039.5459	1045.3672	1051.1777	1056.9775	1062.7667
I_e	TC	1053.4520	1052.3149	1051.1777	1050.0406	1048.9034
I_p	TC	1051.1727	1051.1754	1051.1777	1051.1797	1051.1814
m	TC	1010.9179	1025.4358	1051.1777	1096.5751	1175.8242

Table 2: Variation in system parameters of Case (2)

Parameters	%	-20%	-10%	0%	10%	20%
A	TC	820.7968	920.7968	1020.7968	1120.7968	1220.7968
h	TC	1019.6968	1020.2610	1020.7968	1021.3067	1021.7930
a	TC	1016.8648	1018.8308	1020.7968	1022.7628	1024.7288
b	TC	1009.6951	1015.2500	1020.7968	1026.3357	1031.8665
p	TC	1011.2576	1015.6376	1020.7968	1026.7322	1033.4400

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r	TC	1022.0168	1021.4004	1020.7968	1020.2058	1019.6270
θ	TC	1020.7902	1020.7935	1020.7968	1020.8002	1020.8035
ϒ	TC	1033.6487	1026.5707	1020.7968	1016.0007	1011.9563
C_1	TC	1020.7927	1020.7948	1020.7968	1020.7989	1020.8010
C_2	TC	1019.6830	1020.2407	1020.7968	1021.3513	1021.9042
C_3	TC	1009.9234	1015.3639	1020.7968	1026.2222	1031.6402
I_e	TC	1029.6247	1025.2190	1020.7968	1016.3614	1011.9152
I_p	TC	1020.7968	1020.7968	1020.7968	1020.7968	1020.7968
m	TC	982.5785	996.3443	1020.7968	1064.0558	1139.9769

Table 3: Effect of Permissible delay in payment (M) and Inflation (r) for case (1)

M \ r	20 days	30 days	40 days	50 days	60 days
0.04	1062.58	1060.87	1058.59	1055.76	1052.40
0.045	1061.99	1060.27	1057.98	1055.15	1051.78
0.05	1061.41	1059.68	1057.39	1054.55	1051.18
0.055	1060.84	1059.11	1056.81	1053.96	1050.59
0.06	1060.28	1058.54	1056.23	1053.38	1050.00

Table 4: Effect of Permissible delay in payment (M) and Inflation (r) for case (2)

M \ r	80 days	90 days	100 days	110 days	120 days
0.04	1044.16	1039.31	1033.99	1028.23	1022.22
0.45	1043.53	1038.69	1033.37	1027.61	1021.40
0.05	1042.93	1038.08	1032.76	1027.00	1020.80
0.055	1042.93	1037.48	1032.17	1026.41	1020.21
0.06	1041.74	1036.89	1031.58	1025.82	1019.63

Table 5: Effect of Permissible delay in payment (M) and Deterioration rate (θ) for case (1)

M \ θ	20 days	30 days	40 days	50 days	60 days
0.048	1061.41	1059.68	1057.39	1054.55	1051.18
0.054	1061.41	1059.68	1057.39	1054.55	1051.18
0.06	1061.41	1059.68	1057.39	1054.55	1051.18
0.066	1061.41	1059.68	1057.39	1054.55	1051.18

| 0.072 | 1061.41 | 1059.68 | 1057.39 | 1054.55 | 1051.18 |

Table 6: Effect of Permissible delay in payment (M) and Deterioration rate (θ) for case (2)

M θ	80 days	90 days	100 days	110 days	120 days
0.048	1042.92	1038.07	1032.76	1026.99	1020.79
0.054	1042.92	1038.08	1032.76	1027.00	1020.79
0.06	1042.93	1038.08	1032.76	1027.00	1020.80
0.066	1042.93	1038.08	1032.77	1027.00	1020.80
0.072	1042.93	1038.08	1032.77	1027.01	1020.80
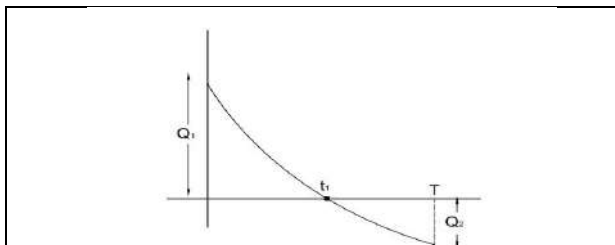
Figure:1 Mathematical model
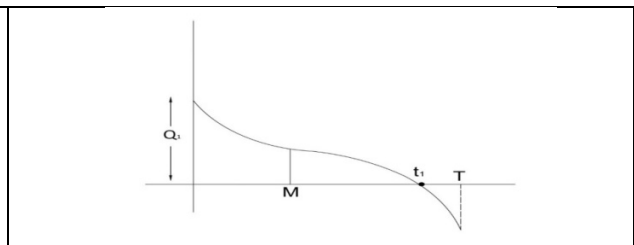
Figure: 2 Mathematical model for permissible delay in payment of case (1)
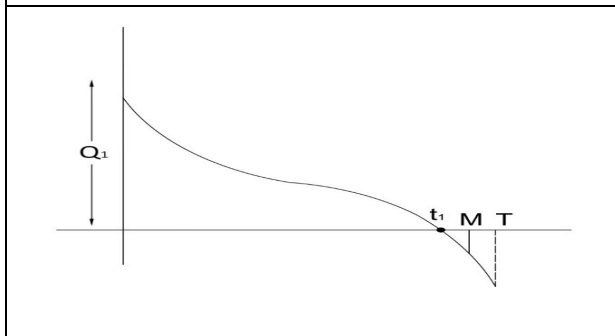
Figure:2 Mathematical model for permissible delay in payment of case (2)
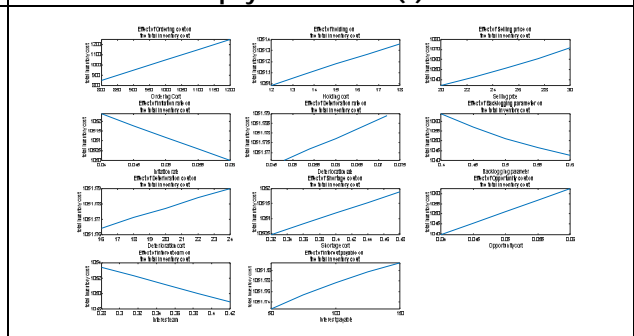
Figure 3: Variation in system parameters of Case (1)
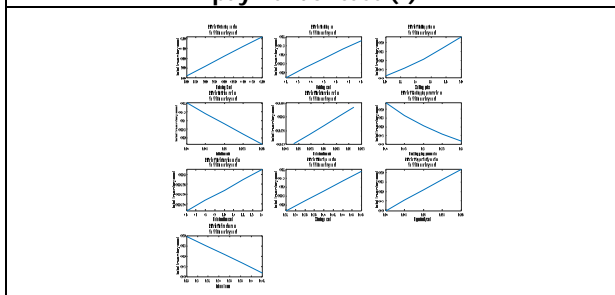
Figure 4: Variation in system parameters of Case (2)
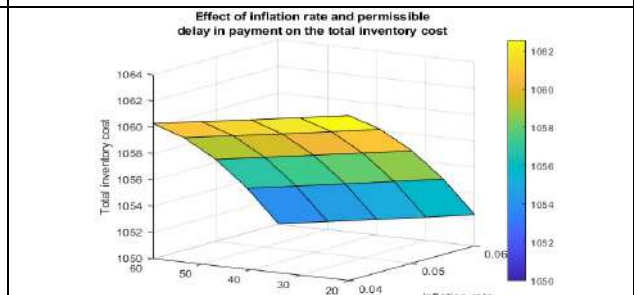
Figure 5: Effect of Permissible delay in payment (M) and Inflation (r) for case (1)

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Figure 6: Effect of Permissible delay in payment (M) and Inflation (r) for case (2)

Figure 7: Effect of Permissible delay in payment (M) and Deterioration rate (θ) for case (1)

Figure 8: Effect of Permissible delay in payment (M) and Deterioration rate (θ) for case (2)

REVIEW ARTICLE
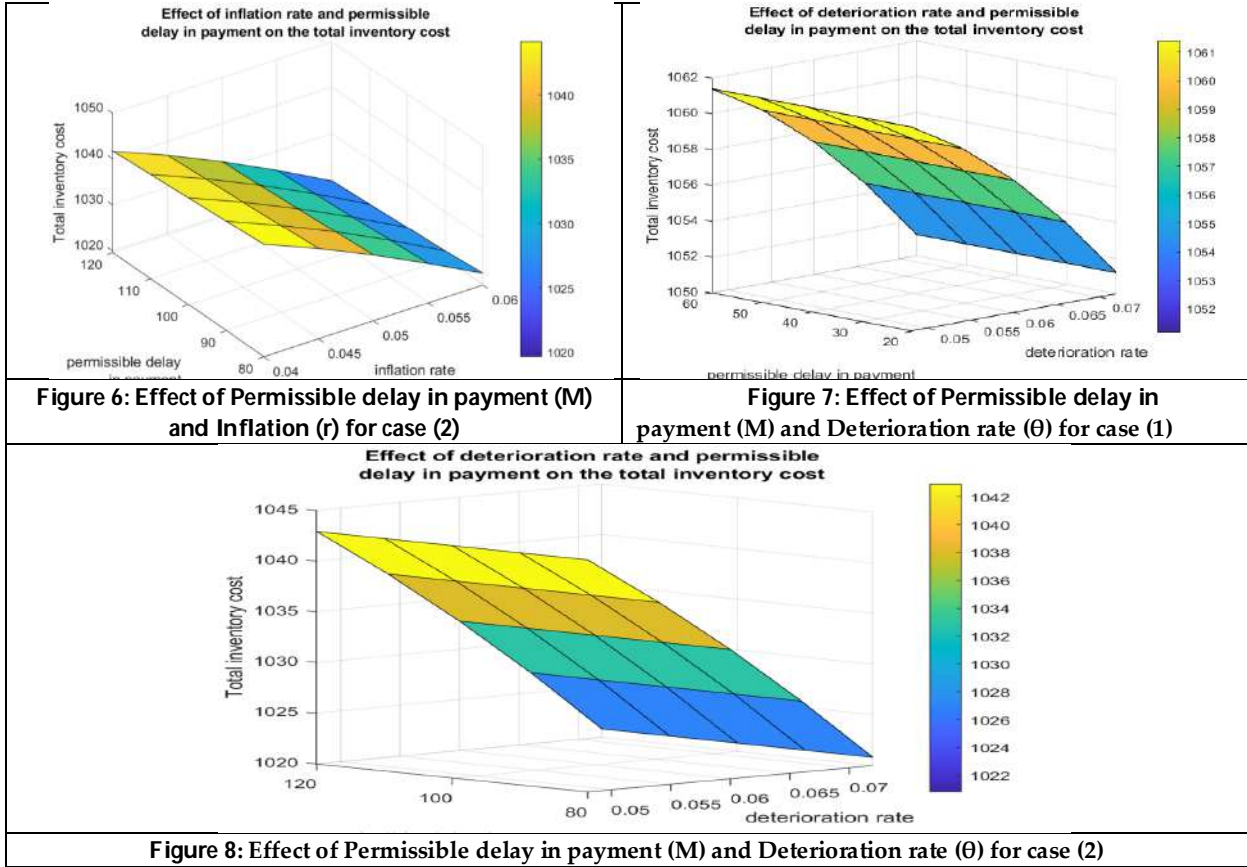
Historical Image Colorization using Advanced Deep Learning Models: A Review Approach

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ABSTRACT

This paper explores how advanced deep learning, particularly Generative Adversarial Networks (GANs) and diffusion models, are transforming the landscape of historical image colorization. GANs, masters of deception, learn to generate realistic colors by fooling a discerning discriminator. Diffusion models, on the other hand, unveil hidden colors by reversing a noise-adding process. We delve into both approaches, contrasting their strengths and weaknesses. While GANs excel at capturing complex color distributions, diffusion models offer superior noise reduction and detail preservation. This review celebrates the progress made, acknowledges remaining challenges like historical accuracy and diverse color palettes, and charts future directions like multi-modal data integration and historical context awareness. Deep learning paves the way for unlocking the narratives within historical images, fostering a deeper connection with the past.

Keywords: Historical image colorization, Deep learning, GANs, Diffusion models, Image restoration, Cultural heritage, Color distribution, Noise reduction, Historical context.

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INTRODUCTION

Historical photographs, black and white, can convey historical information but lack the emotional impact and style of color. Advances in deep learning are changing this process, making it possible to colorize historical images. The two main approaches are generative adversarial networks (GANs) and diffusion models. The creation of real data is made possible by GAN through the generator and the discriminator while transcription models eliminate noise to reveal veiled colors. Both methods are good and bad. GANs are good at capturing complex color distributions but sometimes struggle to preserve detail. The new potential of inverse interpretation models builds on the fundamentals of diffusion models by learning to reverse the noise addition process, potentially enabling accurate and meaningful interpretation.

Image colorization techniques

Image colorization is a technique that we can trace from the old days where it basically translates black and white images into color-based images. There have been many kinds of approaches that we can see in image colorization.s

Rule-based methods
Rule-based methods are some of the early techniques like K-means clustering assigning colors based on predefined rules and image features like brightness, offering limited flexibility.

Learning-based methods
Train on paired grayscale and color images, allowing them to "learn" how to colorize new grayscale pictures. This type of method is majorly used in predicting the colors based on the train data.

Color palette transfer
This is a type of technique that transfers color palettes from similar content reference images. It is limited to existing palettes and it has an easy implementation.

Deep Learning with CNNs
Utilizes convolutional neural networks to analyze image features and predict colors based on learned patterns. These kinds of techniques have a huge disadvantage in that they should have a large dataset to train.

Generative Adversarial Networks (GANs)
Utilize two competing neural networks: one generates   colorized images, and the other critiques them. This adversarial process refines colorization over time. GAN is famous that it has the ability that generates diverse and realistic color palettes.

Auto encoders
"Learns" a compressed representation of the image (latent space) and then reconstructs it in color, potentially capturing subtle details. This can potentially preserve details well, efficient encoding.

Diffusion Models
Adds noise to an image and then learns to reverse the process step-by-step, gradually revealing hidden colors. These Achieves more accuracy, and potentially preserves details well.

Attention-based Models
Focus on specific image regions based on attention mechanisms, allowing for targeted colorization based on local features like skin tones or clothing which enables more nuanced and context-aware colorization. The major cons of this technique can be it may require pre-trained attention models, computational cost can be higher.

Multi-modal Approaches

Incorporates additional information like historical records or surrounding text to guide colorization and ensure historical context. The major pros can can be seen in this approach are it promotes historically accurate color choices, adds richness and context.

Colorization with Semantic Segmentation and Style Transfer

Segmenting the image into semantically meaningful regions (e.g., sky, skin, clothes) and then applying different style transfer algorithms to each region based on pre-trained models trained on historical photographs.

Collaborative Colorization with User Guidance

Incorporates user feedback directly into the colorization process, allowing humans to guide the model towards historically accurate choices. This could involve selecting color palettes from reference images or directly marking specific regions with appropriate colors.

Colorization with 3D Scene Understanding

Analyzes the image content in 3D, understanding the spatial relationships between objects and estimating scene lighting. This information can then be used to guide colorization in a way that respects object geometry and light distribution.

LITERATURE SURVEY

In this section discussed about the researches carried out in the area of "Historical image colorazation". The evolution of colorization techniques spans from initial rule-based methods to advanced learning-based approaches, characterized by significant progress in recent years. Early methods like K-means clustering [1] relied on simplistic rules to assign colors based on basic image features such as brightness. However, these approaches struggled to capture the complexities of real-world color distributions, leading to limitations in their effectiveness. The introduction of learning-based techniques, exemplified by Richard et al. [2], marked a significant advancement by leveraging paired grayscale and color image datasets to understand their underlying relationships. By employing machine learning algorithms, these methods achieved more realistic colorizations, though challenges such as encoding historical context and mitigating biases from training data remained prevalent. The emergence of Convolutional Neural Networks (CNNs) represented a paradigm shift in colorization capabilities. Works like that of Isola et al. [3] demonstrated CNNs' ability to capture intricate color distributions and contextual information from surrounding pixels. Despite their success, CNNs faced challenges in preserving fine details and ensuring historical accuracy, highlighting the need for further refinement. Following CNNs, Generative Adversarial Networks (GANs) and auto encoders brought about new possibilities in colorization. GANs, as illustrated by Iizuka et al. [4], engaged in a competitive process where one network generated colorized images while another critiqued them, leading to diverse and realistic outcomes. Similarly, auto encoders, as proposed by Jiang et al. [5], reconstructed images from compressed representations, promising detail preservation at the cost of computational complexity. The advent of diffusion models introduced by Ho et al. [6] offered a novel approach by adding noise to images and learning to reverse the process incrementally. While diffusion models showed promise in revealing hidden colors with accuracy, challenges in handling complex color distributions persisted. Hybrid models, such as GAN-diffusion models pioneered by Liu et al. [7], sought to combine the strengths of GANs and diffusion models. These hybrid architectures aimed to leverage diverse color palettes while maintaining precision, although challenges in model interpretability and computational complexity remained. Looking forward, attention-based models [8] and multi-modal approaches [9] hold promise in targeted colorization and contextual accuracy, respectively. Additionally, advancements in temporal information and 3D scene understanding are expected to enhance colorization accuracy and historical coherence [10; 11]. These emerging directions offer exciting opportunities for further advancements in colorization techniques across various domains.

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Challenges in developing historical image colorization
There are many advantages to fully developed image colorization techniques, on the other hand it also faces many challenges in both developing stage and also after developed.

Accuracy and Fidelity
Ensuring color choices align with the depicted era and location requires incorporating historical knowledge and avoiding a chronisms. Balancing colorization with preserving fine details, textures, and noise patterns crucial for historical authenticity.

Bias and Inclusivity
Training data bias can lead to colorization reflecting and perpetuating social biases present in historical records..Ensuring diverse and inclusive color palettes that accurately represent different individuals and communities across history.

Computational and Technical Limitations
Some advanced models, like GANs and diffusion models, require significant computational resources, limiting accessibility and scalability. Dealing with degraded images affected by time, weather, and improper storage, which can impact colorization accuracy.

Ethical considerations
Determining the degree of artistic freedom versus historical accuracy in colorization. And also considering user Preferences and control where Integrating user feedback and allowing customization of colorization style and level of detail.

Temporal Consistency and Context
Capturing color trends and shifts over time, fashion, technology, and cultural norms have influenced color palettes throughout history. Models need to adapt to these changing trends without introducing anachronisms.

Data Scarcity and Quality
Limited access to accurate historical color references like many historical periods lack readily available color documentation, making it difficult to verify the accuracy of colorizations. Some of the data might be unevenly distributed and color references might be heavily skewed towards specific demographics, locations, or social classes, potentially leading to biased colorization outcomes.

CONCLUSION

Towards a Robust Ensemble Approach for Historical Image Colorization, fueled by advancements in deep learning, holds immense potential for enriching our understanding of the past. Yet, achieving accurate and historically consistent results necessitates addressing various challenges. This review explored individual algorithms such as GANs, diffusion models, and their hybrid versions, highlighting their strengths and limitations. While single algorithms have undoubtedly achieved impressive results, their inherent limitations call for a more robust approach. By combining the diverse palette generation prowess of GANs with the detail-preserving noise removal of diffusion models, ensemble approaches offer a compelling path forward. Furthermore, incorporating attention-based models for targeted colorization, leveraging multi-modal information for historical context, and utilizing temporal data alongside 3D scene understanding unlock further avenues for refinement.

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FUTURE WORK

As for the powerfulness in making the historic image more colorful, future research should actively explore ensemble approaches that combine the strengths of different algorithms. Such combinations could leverage GANs' ability to generate diverse color palettes with the detail preservation potential of diffusion models, particularly reverse diffusion. Additionally, incorporating information from historical records and surrounding text through multi-modal approaches can further enhance historical context and accuracy. Furthermore, addressing issues like data bias, computational cost, and limited access to historical data requires collaborative efforts involving computer scientists, historians, and archivists. By developing responsible and data-driven colorization techniques, we can unlock the hidden stories within historical images, fostering a deeper connection with the past.

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Table 1: Comparison of different image colorization algorithms based on three common metrics: Mean Squared Error (MSE), Peak Signal-to-Noise Ratio (PSNR), and Structural Similarity Index Measure (SSIM).

Algorithm	MSE	PSNR (dB)	SSIM	Advantages	Disadvantages
Rule-based	Moderate	Moderate	Low	Simple, fast	unrealistic colors
Deep Learning with CNNs	Low	High	High	State-of-the-art performance	computationally expensive
Generative Adversarial Networks (GANs)	Very Low	Very High	High	Highly realistic results	Complex training process
Auto encoders	Moderate	Moderate	High	Efficient encoding	May struggle with complex color relationships
Diffusion Models	Low	Very High	High	High accuracy	Slower training compared to some methods

RESEARCH ARTICLE

Restrained Star Coloring of Graphs and its Application in the Graph Operation : Cartesian Product

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ABSTRACT

The "restrained star vertex coloring" of graphs is termed proper if all the trichromatic subgraphs consist solely of disjoint unions of galaxies and triangles. Its minimum requirement is termed the "restrained star chromatic number" of the graph and is denoted using χ_{rs}. In this paper, we examine the proposed coloring and its application using the graph operation, "Cartesian Product" and then provide the definite value of the χ_{rs} by applying the operation to certain standard graphs. Their coloring is explained exclusively through the rendition of pertinent illustrations. This encompasses the corresponding χ_{rs}, for ladder graph, prism graph, grid graph, stacked prism graph.

Keywords: vertex coloring, restrained star coloring, chromatic number, cartesian product, path
MSC 2020 Classification: 05C15, 05C38, 05C76

INTRODUCTION

Graph theory is a universally applicable field that encompasses all areas of existence, whether directly or indirectly, in which a path is a sequence of edges and unique vertices. A vertex coloring of a graph is deemed to be "proper" if no neighboring vertices are colored with identical colors. And it is a "proper star coloring" if no P_4 in the graph has a

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2-coloring. This coloring developed by Grünbaum [1]along with the "acyclic coloring" was observed to have subgraphs resembling galaxies by Fertin et al.[2]. Subsequently, several outcomes[3,4] emerged from the said coloring and its impact on various graph operations. The "Cartesian product" [5], additionally referred to as the box product is a graph operation involving V(G) × V(H) vertices.And Joseph A. Gallian's [6]dynamic survey rendered further insights on the structure of the resulting graphs. The "star-vertex" coloring of such graphs observed in references [7,8] greatly influenced the results in this paper. Having restrained its conditions, the "restrained star vertex" coloring [9], abbreviated to RSV coloring is defined as follows: A coloring $\sigma_{rs}$is a proper RSV coloring if no P_3 in the graph is 2-colored and all its trichromatic subgraphs are composed of disjoint union comprising only of galaxies and triangles. And the minimum requirement for a proper RSV coloring is termed as the "restrained star chromatic number" of the graph G and is represented using χ_{rs}. The edge version of the same is also defined and can be observed in [10]. In this paper, we attempt to find similar results as that of star coloring in the RSV coloring particularly by considering the graph operation: "Cartesian Product". Furthermore, we discuss the potential for its application in agriculture.

PRELIMINARIES
This section comprises of essential preliminary definitions and results that are required for proving the subsequent sections. It is emphasized that all the graphs considered here onwards are both connected and simple. Thus, in this paper the term 'graph' is equivalently used to refer to a connected graph.

Definition 2.1.[5] The "Cartesian product" of graphs G and H expressed by G □ H composes of $V(G) \times V(H)$ vertices and there exists edges between$(u_b, v_c)$and(u_a, v_d) if and only if either$u_b$is adjacent to $u_a$in G and $v_c = v_d$ (or) $u_b = u_a$and $v_c$is adjacent to $v_d$in H.

Definition 2.2. [9] A graph coloring$\sigma_{rs}: V(G) \to \{c_1, c_2 \dots, c_k\}$ where $k \leq n$ is said to be a proper RSV coloring if it satisfies the following conditions.
- No path of the graph G whose length is 2 is bichromatic.
- Every trichromatic subgraph of G consists of disjoint union composing only of S_n and K_n; $n \leq 3$

Definition 2.3.[9] The minimum k for which there exists a proper RSV coloring is the "restrained star chromatic number" of the graph and it is denoted as χ_{rs}.

Lemma 2.4. A path graph $P_n$with $n > 4$; $\chi_{rs} = 4$ and cycle graph C_n; $\chi_{rs} = \begin{cases} n & \text{if } n = 3,7 \\ 6 & \text{if } n = 6,11 \\ 4 & \text{if } n = 4|n \\ 5 & \text{otherwise} \end{cases}$

RSV COLORING OF CARTESIAN PRODUCT OF GRAPHS
This section explains the RSV coloring of the "Cartesian Product" of certain standard Graphs.

Remark 3.1. For any graphs G and H, $\chi_{rs}(G \square H) \geq \chi_{rs}(G) + \chi_{rs}(H)$.
Proof. It is evident from the definition of the "cartesian product" of graphs, that the resultant graph is substantially larger than G and H, as it contains $V(G) \times V(H)$ vertices thus, consequently requiring extra colors to satisfy the requirements for a proper RSV coloring.

Remark 3.2. For any graphs G and H, $\chi_{rs}(G \square H) \leq \chi_{rs}(G) \cdot \chi_{rs}(H)$.
Proof. Supposing m and n to be the order of the graphs G and H, the RSV coloring of the graph G □ H cannot be greater than mn as the total coloring cannot exceed the order of the resultant graph.

Remark 3.3. For any well-defined graph G and path graph P_n, $\chi_{rs}(G \square P_n) \leq 4\chi_{rs}(G)$

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Proof. Lemma 2.4 reveals that a path graph with $n > 4$ can be properly colored using 4 distinct colors. Thus, the RSV coloring for any resultant graph of "cartesian product" of G and path graph cannot surpass 4 times the coloring of G.

Theorem 3.4. The χ_{rs} of a ladder graph, L_n with order n is $\chi_{rs}(P_2 \square P_n) = \begin{cases} 2n & \text{if } n \leq 2 \\ 6 & \text{if } n > 2 \end{cases}$

Proof. The proof is achieved by pondering a few cases on the order. Let $C_{rs} = \{c_i | 1 \leq i \leq n\}$.

Case 1. Suppose $n \leq 2$, then the resulting graph is a P_2 and C_4 when $n = 1$ and 2 respectively which can evidently be colored properly using 2 and 4 distinct colors. Thus, $\chi_{rs}(L_1) = \chi_{rs}(L_2) = 2n$.

Case 2. Suppose $n > 2$, then L_n consists of $2n$ vertices composing of two set of path graphs with each vertex sharing an edge with its corresponding vertex on the other set. Let $s(1,j)$ and $s(2,j)$ be the vertices of the 1st and 2nd path of L_n respectively. The vertices of the 1st path is assigned the color c_i if $j \equiv i \pmod 6$ and the vertices of the 2nd path the same color c_i if $j \equiv (i + 3) \pmod 6$ where $1 \leq i \leq 6$ and $1 \leq j \leq n$. Thus $\chi_{rs}(L_n) = 6$. Conversely supposing $\chi_{rs}(L_n) < 6$, results in a contradiction to the conditions of a proper RSV coloring.

Theorem 3.5. The χ_{rs} of a grid graph, $G(n,m)$ with $n, m \geq 3$ is $\chi_{rs}(P_n \square P_m) = \begin{cases} 7 & \text{if } n = m = 3 \\ 8 & \text{otherwise} \end{cases}$

Proof. Consider the grid graph $G(n,m)$ with $n \geq 3$ and $m \geq 3$, consisting of $n \times m$ vertices. Let $C_{rs} = \{c_1, c_2, \ldots, c_n\}$. The proof is by contemplating a few cases on its order.

Case 1. Suppose $n = m = 3$, then the resulting graph will consist of 3 sets of path graph in which each vertex of the center path is adjacent to the corresponding vertices of the path on either of its sides. The first two sets can be colored as the coloring defined for a ladder graph L_3 using 6 distinct colors. The remaining vertices of the third set of the path can be colored using the colors $\{c_3, c_7, c_1\}$ such that the conditions of a proper RSV are obtained using a minimum of 7 colors (Refer Figure 2).

Case 2. Suppose n (or) $m > 3$, then the resulting graph will consist of m sets of path graph in which each vertex of the ith set is adjacent to the corresponding vertices of the $(i+1)^{th}$ and the $(i-1)^{th}$ sets where $2 \leq i \leq m - 1$. From Lemma 2.4 it is evident that $\chi_{rs}(P_n) = 4$. Let $\{p_j | \text{Where } j = 1, 2, \ldots, m\}$ represent the set of vertical paths in the resulting graph and $v_{j,k}$ represent the vertices. Then the graph can be colored distinctly using 8 colors as follows,

Remark 3.6. Let G be any acyclic graph and P_m the path graph, $\chi_{rs}(G \square P_m) \leq 2\chi_{rs}(G) + 2$
Proof. The proof is achieved by examining three cases on the nature of the graph.

Case 1. Suppose G is a path graph P_n, then it is obvious from Theorem 3.4 and Theorem 3.5 that the graph can be colored with a minimum of 8 colors, which satisfies the inequality.

Case 2. Suppose G is in the form of a star graph S_{n+1}, then as the center vertex is adjacent to all the other vertices, $\chi_{rs}(S_{n+1}) = n + 1$. When we take two copies of the star graph, since they would be connected by at least one edge the coloring used to color these two graphs ought to be distinct. But when the copies increase, so does the distance between them resulting in the avoidance of usage of additional colors. In other words, they can be colored properly by interchanging these colors while maintaining a distance greater than 4 among them. But the central vertex must be uniquely colored along the path, thus requiring a total of $2\chi_{rs}(G) + 2$ colors satisfying the inequality.

Case 3. Suppose G is in the form of a tree, then it is a combination of the first two cases, which would imply that the inequality is satisfied in this case as well.
It can be noted that the converse of this theorem need not be true.

Proposition 3.7. The χ_{rs} of the prism graph, D_n with $n > 5$ is $\chi_{rs}(C_n \square P_2) \leq 7$ iff the order of the graph can be represented as sum of multiples of 6 (or) 7 (or) a combination of both 6 and 7.

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Proof. A proper RSV coloring of a prism graph can be obtained with a minimum of 7 colors (or) less if it is possible to partition the vertices into sets of size less than 7, which would imply that the graph can be represented as sum of multiples of 6 (or) 7 (or) a combination of both and vice versa. (Since, $n > 5$)

Proposition 3.8. The χ_{rs} of the prism graph, D_n is $\chi_{rs}(C_n \square P_2) = \begin{cases} 2n & \text{if } n \leq 5 \\ n & \text{if } 5 < n < 11 \end{cases}$

Proof. Let us examine two cases on the order of the graph along with the usage of Lemma 2.4.

Case 1. Let $n \leq 5$, then it is evident from the structure of the graph that n colors are required to color the inner cycle and another n colors for coloring the outer cycle to avoid any trichromatic subgraphs from becoming connected and in turn failing to satisfy the conditions of a proper RSV coloring.

Case 2. Let $5 < n \leq 11$, then it is evident from the structure of the graph the inner cycle can be colored in n colors (not necessarily) and in this case the same n colors can be permutated and used for coloring the outer cycle while satisfying the necessary condition for a proper coloring. If we follow the coloring said in Lemma 2.4, then we would be using $\lfloor n/2 \rfloor$ to color the inner cycle and another $\lfloor n/2 \rfloor$ to color the outer cycle, which again brings us to the total requirement of *n* colors.

Theorem 3.9. Let D_n be a prism graph with order $n > 11$ that can be represented as multiples of 6(or) 7 (or) a combination of both then $\chi_{rs}(C_n \square P_2) = \begin{cases} 6 & \text{if } 6|n \\ 7 & \text{otherwise} \end{cases}$

Proof. The proof can be obtained by taking two cases on the order of the graph.

Case 1. Suppose $6|n$, then vertices of the graph can be separated into equal sets of length 6. Then each of these sets can be colored using the same 6 colors, and even if the colors are repeated a distance of at least 3 is maintained between any two colors.

Case 2. Suppose $6 \nmid n$, then the vertices of the graph can be divided into sets of length 6 and 7. Since, the order of the graph can be represented as sum of multiples of 6 (or) 7 (or) a combination of both 6 and 7. Thus these 7 colors can be permutated to attain a proper RSV coloring.

Proposition 3.10. The χ_{rs} of the stacked prism graph, $Y_{n,m}$ with $n > 8$ and $m > 2$ is $\chi_{rs}(C_n \square P_m) \leq 9$ iff the order of the graph can be represented as sum of multiples of 9 (or) 8 (or) a combination of both 9 and 8.

Proof. A proper RSV coloring of a stacked prism graph can be obtained with a minimum of 9 colors (or) less if it is possible to partition the vertices into sets of size less than 9, which would imply that the graph can be represented as sum of multiples of 8 (or) 9 (or) a combination of both and vice versa. ($\because n > 8$)

Remark 3.11. The χ_{rs} of the stacked prism graph, $Y_{n,m}$ with $n \leq 7$ and $m > 2$ is $\chi_{rs}(C_n \square P_m) = n$.

Theorem 3.12. Let $Y_{n,m}$ be a stacked prism graph with order $n > 7$ that can be represented as (multiples of 7 or) 9 (or) a combination of both then $\chi_{rs}(C_n \square P_m) = \begin{cases} 8 & \text{if } 8|n \\ 9 & \text{otherwise} \end{cases}$

Proof. The proof can be obtained two cases on the order of the graph.

Case 1. Suppose $8|n$, then vertices of the graph can be segregated into equal sets of length 8. Then each of these sets can be colored using the same 8 colors. Thus, requiring a minimum of 8 colors.

Case 2. Suppose $8 \nmid n$, then the vertices of the graph can be secluded into sets of length 8 and 9. Since, the order of the graph can be represented as sum of multiples of 8 (or) 9 (or) a combination of both 8 and 9. Thus these 9 colors can be permutated to attain a proper RSV coloring.

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RESULTS AND DISCUSSIONS

The RSV coloring and its corresponding $\chi_{rs}$is ascertained to be an intriguing concept with limitless possibilities. In this paper, the RSV coloring in terms of the "Cartesian-product" of some graphs are examined. Furthermore, the process of finding the exact value of the chromatic number is found to be quite a tedious task, especially when we ponder graphs of complex structure. Also, the "cartesian product of graphs" is a graph operation having numerous real-world applications including in machine learning, genetics and in geographical mapping. In such instances, the bounds and exact values of such graphs can assist in gaining a deeper comprehension of the resultant graphs and its characteristics. In this context, we discuss a potential application of said coloring in the field of agriculture. Farmers can implement this coloring to strategically plan their crop rotations while consequently managing soil health and mitigating the proliferation of pests and infections. This would also facilitate the effective optimization of the layouts. Here, the fields are converted into a graph with the vertices signifying the corner of the fields. A crop is represented using a combination of four exclusive colors. It is crucial to avoid cultivating the same crops in consecutive seasons on two neighboring land areas that share a border to avert transmission of diseases and pest crises. By computing the proper RSV coloring, farmers can ensure a diversified crop rotation that maximizes land utilization while minimizing risks. While also considering the varying factors such as irrigation scheduling, pesticide treatment and harvest scheduling. In similar manner, this technique can be applied to in evenly distributing equipment and in optimizing data collection operations. For instance, if the field is partitioned into either 4 (or) 20 segments, then the graph would resemble that of $G(3,3)$ and $G(6,5)$ respectively [refer figure 2]. The allocation of crops to the fields allows for a rotation procedure where 4 crops and 8 crops can be cultivated. It should be emphasized that the application is not exclusively restricted to agriculture. But due to the resemblance of most graphs created using the "Cartesian Product" to agricultural land, this application has considerable significance to the operation. And since it is feasible to transform intricate structures into a graph, this approach can be effectively employed.

CONCLUSION

Thus, the RSV coloring and the $\chi_{rs}$of the "Cartesian-product" of some graphs including ladder graphs, grid graphs, prism graphs and stacked prism graphs were explained exclusively with the usage of appropriate illustrations. It is also found that $\chi_{rs}(G) + \chi_{rs}(H) \le \chi_{rs}(G \square H) \le \chi_{rs}(G) \times \chi_{rs}(H)$ holds for the "Cartesian product" of graphs. In addition, the upper bound for the "Cartesian-product" of a well-defined graph with the path graph is also examined.

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Figure 1: The RSV coloring of the Ladder graph L_2, L_3 and L_6

Figure 2: The RSV coloring of the Grid graph $G(3,3)$ and $G(6,5)$

Figure 3: The RSV coloring of G and G □ P_2

Figure 4: The RSV coloring of the Prism graph D_3 and D_5

Figure 5: The RSV coloring of the Stacked Prism graph $Y_{10,3}$ and $Y_{4,3}$

Figure 6: The crop rotation plan using RSV coloring for $G(3,3)$ and $G(6,5)$
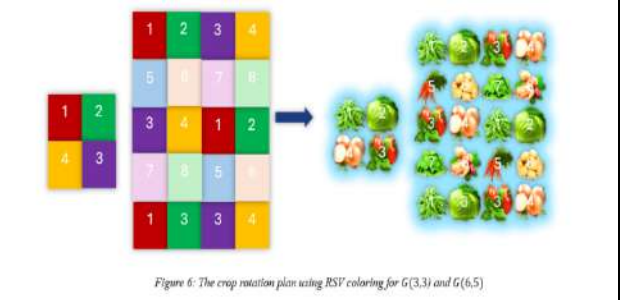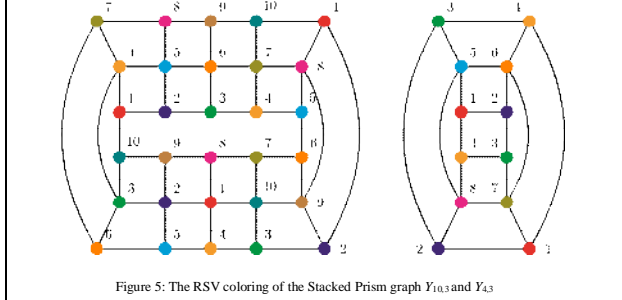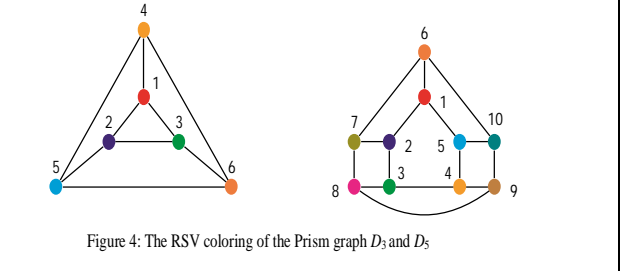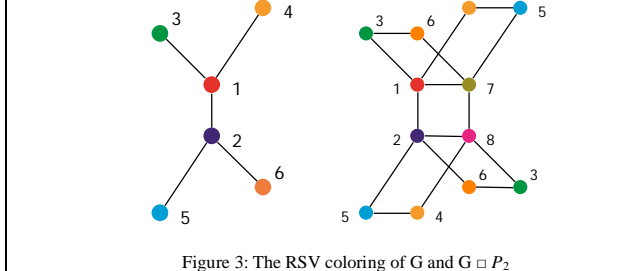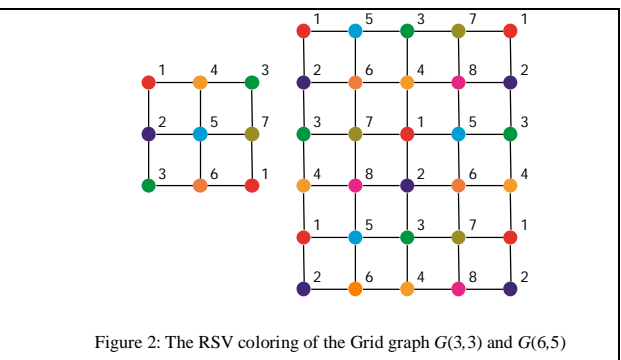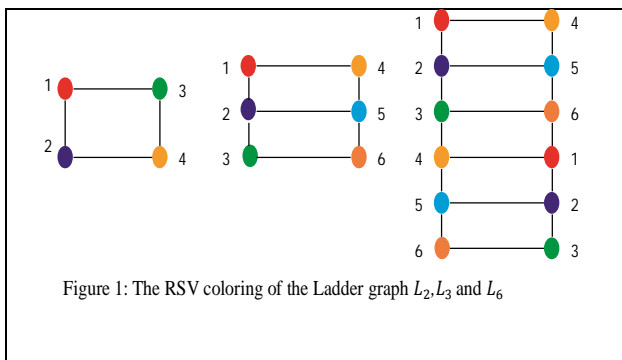
RESEARCH ARTICLE

Impact of Manual Guidance and Knowledge of Performance on Fall Efficacy and Balance in Stroke.

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ABSTRACT

Falls becomes a very common complication in stroke patients, where nearly 50% to 70% experiences it within a year of post discharge from hospital and rehabilitation center. There are various risk factors associated with fall after stroke, among which balance and gait deficit stands as the major reasons. The proposed study aims to determine the effect of manual guidance and knowledge of performance on reducing the fear of fall and improving the balance in stroke survivors. The study is of experimental (comparative) design and was conducted for duration of 3 years comprising of 3 groups. 72 subjects were finalized to participate in the study based on the selection criteria. Subjects were divided into conventional therapy group, manual guidance group and knowledge of performance group. After completion of 4 weeks of practice session the post values of FES and BBS was recorded from the subjects.

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Pre and post test score analysis with BBS and FES by using paired t test showed that p value is less than 0.05 in conventional therapy group, manual guidance group and knowledge of performance group indicating significant difference. Between group analyses by using one way ANOVA showed significant difference in result with p value less than 0.05 with berg balance and fall efficacy scale. The present study concludes that all the three inventions utilized in the study are effective in reducing the fear of fall and improving balance in stroke patients. However knowledge of performance proved to be comparatively more efficient in enhancing fall efficacy and balance in stroke.

Keywords: Stroke, Fall-efficacy scale, Berg-balance scale, Manual Guidance, Knowledge of Performance.

INTRODUCTION

Stroke is defined by the World Health Organization (WHO) as "a clinical syndrome consisting of rapidly developing clinical signs of focal (or global in case of coma) disturbance of cerebral function lasting more than 24 hours or leading to death with no apparent cause other than avascular origin" and it is a leading cause of death and disability in many Western nations (1). Each year around the globe 5.5 million demises and around 116.4 million disability accounts for stroke (2). Stroke marks as one of the major cause of disability in United States with more than 7 million people affected (3, 4). In India 6, 94,144 people die every year due to stroke (2). India's annual incidence of stroke suggests it to be higher than other developed countries (5). Falls becomes a very common complication in stroke patients, where nearly 50% to 70% experiences it within a year of post discharge from hospital and rehabilitation center(6).Chronic stroke patients have an increased tendency of fall for about 36% compared to same aged and gender peers which is about 24% (7). There are various risk factors associated with fall after stroke, among which balance and gait deficit stands as the major reasons (8). A fall is a result of unintentional loss of equilibrium (9). Patient displays a fear of fall because he enters unknowingly into a cycle of deteriorating self worth and limiting independency in physical activity that renders the individual reliant on the caregiver (10). Individuals who have experienced a stroke at least once throughout their sickness are afraid of falling. Even if they do not fall, they are aware of the condition, which is inadequate to maintain body's balance and ultimately result in fall (11) The risk of fall gets exponentially increased in patient with hemiplegia since the lateral and vertical balance maintenance capacity gets highly compromised due to deficits in weight bearing capacity in affected limb (12). Falls even increases the risk of hip fracture and decreased physical activity in such patient which is due to the fear of fall (8). These factors impose functional limitation on the patient making him more vulnerable and affecting him socially by impeding his community participation thus affecting the quality of life (12).

Quality of life is extremely correlated to risk of fall and balance (13, 14, 15) The motor learning programme (MRP) is one among the rehabilitative strategies used fundamentally with the post stroke patients (16). Feedback plays a vital role in retraining skills using MRP and motor control. Feedback is a sensory guidance which is offered during or once the action has been completed. Feedback includes information associated with the sensations related to the movement itself, likewise as information associated with the results of action with relation to the environmental goal. These sources of feedback are described an extrinsic and intrinsic feedback (17). Internal feedback is inherent to an action. Extrinsic feedback is presented by external cues that does not generally received within the task and it always contributes towards intrinsic form of feedback and so it's designated as augmented feedback (18**).** Several studies have incontestable supply of extraneous feedback which induces higher conditions for motor learning in individuals with stroke (19, 20, 21). Extrinsic feedback consists of knowledge concerning movement from external supply. This information are often characterized into two types: Knowledge of results (KR) that refers to information provided concerning the results of individuals action in respect to the outside environment goal and Knowledge of performance (KP) that refers to information provided to the subject relating to the execution pattern of the movement to attain a particular goal (22). In spite of the significant effect of fear of fall on stroke rehabilitation it has been considered of secondary importance in most of the studies. Moreover there are no studies which have investigated

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the effect of augmented form of feedback like manual guidance and knowledge of performance on fear of fall and balance in stroke patient. Therefore the proposed study aims to determine the effect of manual guidance and knowledge of performance on reducing the fear of fall and improving the balance in stroke survivors

MATERIALS AND METHODS

The study is of experimental (comparative) design and was conducted for duration of 3 years comprising of 3 groups. In this study at the initial phase 86 stroke subjects were assessed for eligibility. Among which 8 subjects didn't meet the selection criteria and were not included to participate in the study. In the subsequent phase of study following the pre assessment of the measures 5 subjects showed their unwillingness to be the part of the study and 1 subject due to change of address were withdrawn from the study. Finally 72 subjects were finalized to participate in the study. The study was approved by the institutional ethical committee of Assam Down Town University, Kamrup, Assam. Prior the conductance of the study, subjects read and signed the informed consent form approving their willingness to participate in the study after being provided with the knowledge about the procedure, purpose and the potential discomfort which might be faced during the course of the study. Purposive sampling technique was utilized to select the samples at par with the selection criteria. The study received its ethical clearance from the institutional ethical committee (adtu/ethics/PhD Scholar/ 2019/009).

Criteria for sample selection
Inclusion criteria
subjects aged from 30 to 75 years old who were diagnosed with stroke and was confirmed by the Physiotherapist, both ischemic and hemorrhagic type of stroke etiology, subjects having an FES score of 20-64, subjects diagnosed of stroke at least 6 months ago so to rule out spontaneous recovery, Brunnstrom recovery stage III or higher, subjects able to walk minimum 6 meter independently with or without assistive devices, subjects without unilateral neglect of paretic limb, homonymous hemianopsia and those who were medically stable and able to understand simple verbal command were included for the study.

Exclusion criteria
subjects with major musculoskeletal problems (eg: recent joint replacement surgery or arthritis) affecting musculoskeletal performance, other neurological disorders in addition to stroke, And subject who are uncooperative or unable to comply with instructions were excluded from participation.

Outcome Measures
- Measurement of fall : Fall Efficacy Scale International (FES-I)
- Measurement of balance : Berg Balance Scale (BBS)

Fall efficacy scale international measures "concern or fear of falling" in adult population during social and physical activities of daily living with chronic medical conditions (23). The scale includes 16 article self reported questionnaire and each item involves the participant to score himself on a 4 point likert scale 1= not at all concerned, 2= somewhat concerned, 3=fairly concerned and 4=very concerned depending upon their fall botherance (24). The rating of lowest, moderate and highest risk of falling ranges from 16-19, 20-27 and 28-64 respectively out of 64 points. Minimum of 16 point score suggests lowest risk of falling and maximum of 64 score denotes highest risk of falling (24, 25) Berg balance scale (BBS): it's a widely used clinician rated scale to determine the patient's ability to soundly maintain his/her balance throughout a series of determined static and dynamic useful tasks. The scale comprises a list of 14 items and every item consisting of a 5- point ordinal scale ranging from 0 (least possible performance) to 4 (finest performance) with a most total of 56 score. A score $\leq$ 45 indicates need for assistance, 41-44 suggest minimal risk of fall, 21*40 suggest high risk of fall and a score of 0-20 suggest maximum risk of injury or fall (26, 27)

METHODOLOGY

The study comprised of 3 parallel groups (Group A, Group B, Group C). Purposely selected samples were randomly allocated to three different groups. Prior to start the interventions, pre assessment of fall efficacy scale and berg balance scale scores were recorded for all the patients. Following to this the baseline measurements were also recorded and were randomly allocated to one of the conventional group (Group A) or experimental groups (Group B or Group C). Group A (Conventional therapy group): subjects in this group received conventional balance exercises for 3 days per week for 4 weeks. Group B (Experimental group): subjects received manual guidance training for duration of 3 days per week for 4 weeks. Group C (Experimental group): subjects received knowledge of performance training for duration of 3 days per week for 4 weeks. All patients received their regular treatment protocol pertaining to their condition apart from the prescribed program in which only the balance related interventions were altered. Material utilised to conduct the study involved two bathroom scales (weighing machines), consent form, web camera, laptop.

Conventional Therapy
The Conventional Therapy group training program based on traditional stroke rehabilitation programme (1, 28). CT session included: (a) progressive stretching of the shoulder, elbow, forearm, wrist, hamstrings, and calf; (b) active-assisted range of motion for the affected upper and lower limbs, including the hip, knee, ankle, shoulder, elbow, forearm, and wrist; (c) strengthening exercises of the hip abductors, quadriceps, and hamstrings;(d) reaching activities in sitting and standing (e) gait training (29).

Manual guidance and Knowledge of performance
Manual guidance and knowledge of performance are the types of augmented feedback used in the study to teach the patient symmetrical weight bearing. To make the goal more practical the task assigned to the subjects was to learn bearing 50% of their body weight on their paretic foot and distribute the weight between their feet at 50:50 ratios. The subjects were initially weighed on analogue bathroom scale. Body weight was divided by two to get a single limb bearing weight. During the acquisition phase of the intervention the subjects of both the groups performed 5 blocks of 12 trials for a period of 3 days / week for 4 week. Between each trial five second rest was given and similarly between each trial blocks 30 second rest was given. Subjects from Knowledge of Performance group received the visual feedback through the monitor of laptop placed before them and had to correct the error based on this visual feedback, while subjects in the Manual Guidance group were moved to the position required to generate 50% weight on the paretic foot. During the experiment on knowledge of performance group, the trainer (1) sat beside the subject. A webcam was fixed ahead of the bathroom scale and was connected to the laptop which was kept in the level of the direct view of the subject. The subject was then asked to perform 5 sets of 12 trails and receive the visual feed back through the monitor and correct the error themselves. In manual guidance group throughout the experiment the trainer(1) remained seated behind the subject, with his/ her hands on either aspect of the subject's pelvic girdle, by moving the pelvis laterally and positioning the subject symmetrical to regulate the error. Subject wasn't provided with any reading. Trainer did corrections through his/ her hands, gave the feedback over the pelvis, so that 50 % of the body's weight was leaning on the dominant foot. The position in each trail was held minimum for 5 seconds. Another trainer (2) sat in front of the subject to record the reading of the scale. After 12 trials the reading was recorded. After completion of 4 weeks of practice session the post values of FES and BBS was recorded from the subjects of all three groups (30).

RESULTS

The obtained data of FES and BBS of conventional therapy group, manual guidance group and knowledge of performance group was analyzed using Statistical package for social sciences (SPSS 21.0 version), $p<0.05$ was considered significant and $p<0.01$ was considered highly significant. The data for berg balance scale and fall efficacy scale was obtained from all the three groups. The pre and post analysis was done by using paired "t" test. Between

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group analysis was done by using one way ANOVA. Specificity of differences among each pair of group was further analyzed by using Post Hoc Test. To determine the strength of a correlation, the Pearson correlation coefficient between the dependent variables is used. The Pearson correlation coefficient ranges from -1 to 1, with -1 being the negative correlation, 0 representing no correlation, and 1 representing positive correlation. The average pre test score with the berg balance scale in case of conventional therapy group was 38.65 and in case of post test were 39.96 The average pre test score with the berg balance scale in case of manual guidance group was 39.22 and in case of post test was 41.00. The average pre test score with the berg balance scale in case of knowledge of performance group was 38.44 and in case of post test was 43.12. Pre and post test score analysis with berg balance scale score by using paired t test showed that p value is less than 0.05 in conventional therapy group, manual guidance group and knowledge of performance group indicating significant difference in result. The average pre test score with the fall efficacy scale in case of conventional therapy was 34.73 and in case of post test was 34.26 The average pre test score with the fall efficacy scale in case of manual guidance group was 33.33 and in case of post test was 26.77. The average pre test score with the fall efficacy scale in case of knowledge of performance group was 38.24 and in case of post test was 23.56. Pre and post test score analysis with fall efficacy scale score by using paired t-test showed that p value is less than 0.05 in conventional therapy group, manual guidance group and knowledge of performance group indicating significant difference in result. Between group analyses of conservative therapy group, manual guidance and knowledge of performance group by using one way ANOVA showed significant difference in result with p value less than 0.05 with berg balance and fall efficacy scale.

DISCUSSIONS

Motor disablement becomes an unavoidable companion for almost 80% of stroke survivors (31). In stroke survivors, impaired balance is a major risk factor for falls. A fear of fall following stroke can eventually result in poor quality of life by increasing disability, sedentary habits, and the chance of a recurrence (32). Studies on individuals with chronic stroke with a period of more than 6 months post stroke have revealed fall incidence rates ranging from 23% to 50% (33). The purpose of the present study was to determine the effect of manual guidance and knowledge of performance on reducing the fear of fall and improving the balance in stroke survivors. 72 subjects were finalized to participate in the study after evaluating them for the selection criteria. The pre and post analysis of conventional therapy group, manual guidance group and knowledge of performance group with berg balance scale revealed significant improvement in the score with p value 0.029, 0.000 and 0.000 respectively. This result shows that conservative treatment technique, manual guidance and knowledge of performance technique is equally effective in improving balance in stroke patient. Similar satisfying result was observed where conservative therapy group, manual guidance group and knowledge of performance group showed significant difference with fall efficacy scale with p value 0.000, 0.000 and 0.000 respectively. This result proved that all the three treatment strategies are equally effective in reducing the score of fall efficacy scale, thereby improving the confidence by reducing the fear of fall and accelerates the process of regaining of independence of movement among the stroke patients.

From the ANOVA analysis it has been observed that the effect of conventional therapy, manual guidance technique (MG) and knowledge of performance technique on reducing the fear of fall (fall efficacy scale, FES) and improving the balance (BBS) in stroke survivors is significant as in both within group and between group analysis the calculated p-value is less than 0.05. Thus it can be said that the conventional therapy, manual guidance technique (MG) and knowledge of performance technique (KP) has impact on reducing the fear of fall (fall efficacy scale, FES) and improving the balance (Berg Balance Scale, BBS) in stroke survivors. In post hoc comparison analysis the BBS results showed significant difference of p value being 0.002 between conventional therapy and knowledge of performance group, on contrary insignificant differences were observed when conventional therapy with manual guidance group and manual guidance group with knowledge of performance group were compared with p value being 0.110 and 0.100 respectively. Further analysis of mean values suggests knowledge of performance group proved to be highly effective in improving berg balance score with mean value of 43.120 compared to conventional therapy group with mean value of 38.961. FES score analysis suggests that there was significant difference in result

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with p value 0.000 when conventional therapy group was compared with manual guidance and knowledge of performance group but conversely when manual guidance group was compared with knowledge of performance group it yielded insignificant difference with p value 0.006. the mean values of the groups suggests that manual guidance group with mean value 26.77 and knowledge of performance group with mean value of 23.560 was comparatively more efficient in reducing the FES score when compared with conventional therapy group with mean value 34.260. In a study done by Amer Ghrouz et al on 63 subacute stroke patients aimed to evaluate the efficacy of Motor relearning programme for enhancing balance and postural control. After 8 weeks of 24 rehabilitation session the researcher concluded that MRP group showed significantly improved BBS and posturography assessment compared to conservative physical therapy group. Researcher explained that MRP intervention's included more of functional and task specific exercises which resulted in improved effectiveness of the treatment (34). The Pearson correlation coefficient was used to examine the association and direction of the link between the dependent variables—the fall effectiveness scale and the berg balance scale—between the groups. A low positive correlation of 0.212 and an insignificant p value of 0.2999 were discovered in the group receiving conventional treatment. The group that was given manual guidance showed a statistically insignificant p value of 0.242 along with a modest negative correlation coefficient of -0.233. Once more, a very weak positive correlation of 0.069 and a statistically insignificant result with a p value of 0.745 was found in the knowledge of the performance group. This result shows that there is a very low correlation between fall efficacy scale and Berg balance scale score among all the three groups. In a study conducted by Prakash Brade et al on subacute and chronic stroke patients found a significant and negative correlation on berg balance scale and fall efficacy scale variables , where one is increasing the other is decreasing and the two variables are in variance with one another. The research showed that when FES score increased in these kinds of patients the BBS score reduced suggesting the stroke patient with fear of fall are even low on balance, thus this study proved a close correlation among the variables (35).The present study showed a conflicting result as the FES and BBS scores obtained was post treatment and the interventions didn't have any effect in establishing a relation between FES and BBS.

CONCLUSION

Patients with stroke experience frequent fear of fall which can have potential implications. The present study concludes that all the three inventions utilized in the study that is conventional therapy, manual guidance and knowledge of performance are effective in reducing the fear of fall and improving balance in stroke patients. However knowledge of performance proved to be comparatively more efficient in enhancing fall efficacy and balance in stroke.

LIMITATION OF STUDY& SUGGESTION

There are certain limitations in the present study that needs to be addressed. The stroke patients fatigue level was not taken into consideration during the experiment which might have influenced the result. The subject's age, gender, hand dominance and side affected were not taken into account which would have yielded better analysis of the effect of treatment. Berg balance scale is an appealing tool to assess balance for its ease to administer. However it's suggested to utilize an additional balance measuring tool in conjunction with berg balance scale to address its floor and ceiling effects.

AUTHOR CONTRIBUTION
Moushami Purkayastha and Dr. P.C Sarma conceptualized the study. Data collection was done by Moushami Purkayastha and Dhivakar Murugan. Abhijit Kalita contributed in drafting of manuscript. Debajyoti Bora conducted the analysis of data. Sankar Sahayaraj Muthukaruppanand. Abhijit Dutta reviewed and revised the manuscript for clarity, coherence and accuracy.

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CONFLICT OF INTEREST
Conflict of interest declared none.

List of abbreviations
WHO: World Health Organization
MRP: Motor Relearning Programme
FES: Fall Efficacy Scale
BBS: Berg Balance Scale
MG: MANUAL GUAIDANCE
KR: Knowledge of results
KP: Knowledge of performance
TIA: Transient Ischemic Attack

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Table 1: Comparison of Pre and post test average with berg balance scale.

Berg balance scale		Conventional therapy group	Manual guidance group	Knowledge of performance group
Pre test	Mean	38.653	39.222	38.440
Post test		38.961	41.000	43.120

Table 2: Comparison of pre and post analysis with berg balance scale of conservative therapy group, manual guidance group and knowledge of performance group.

Pairs	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
CTPRE-CGPOST	-0.308	.679	0.133	-.582	-0.033	-2.309	25	.029
MGPRE-MGPOST	-1.778	1.311	0.252	-2.296	-1.259	-7.048	26	.000
KPPRE-KPPOST	-4.680	1.749	0.350	-5.402	-3.958	-13.377	24	.000

Table 3: Comparison of Pre and post test average with fall efficacy scale.

Fall efficacy scale		Conventional therapy	Manual guidance group	Knowledge of performance group
Pre test	Mean	34.730	33.333	34.240
Post test		34.269	26.777	23.560

Table 4: Comparison of pre and post analysis with fall efficacy scaleof conservative therapy group, manual guidance group and knowledge of performance group.

Pairs	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
CT PRE-CT POST	.462	.582	.114	.227	.697	4.045	25	.000
MGPRE-MGPOST	6.556	3.816	.734	5.046	8.065	8.926	26	.000
KPPRE-KPPOST	10.680	6.296	.259	8.081	13.279	8.481	24	.000

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Table 5: ANOVA Analysis. Comparison between the groups with berg balance scale and fall efficacy scale.

		Sum of Squares	df	Mean Square	F	Sig.
BERG BALANCE SCALE	Between Groups	220.398	2	110.199	5.239	0.007
	Within Groups	1577.602	75	21.035		
	Total	1798.000	77			
FALL EFFICACY SCALE	Between Groups	1550.430	2	775.215	20.091	0.000
	Within Groups	2893.942	75	38.586		
	Total	4444.372	77			

Table 6: Post Hoc Comparison Analysis

Dependent Variable			Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
BERG BALANCE SCALE	CT	MG	-2.03846	1.26019	0.110	-4.5489	0.4720
		KP	-4.15846*	1.28468	0.002	-6.7177	-1.5992
	MG	CT	2.03846	1.26019	0.110	-0.4720	4.5489
		KP	-2.12000	1.27297	0.100	-4.6559	0.4159
	KP	CT	4.15846*	1.28468	0.002	1.5992	6.7177
		MG	2.12000	1.27297	0.100	-0.4159	4.6559
FALL EFFICACY SCALE	CT	MG	7.49145*	1.70680	0.000	4.0913	10.8916
		KP	10.70923*	1.73997	0.000	7.2430	14.1754
	MG	CT	-7.49145*	1.70680	0.000	-10.8916	-4.0913
		KP	3.21778	1.72411	0.066	-0.2168	6.6524
	KP	CT	-10.70923*	1.73997	0.000	-14.1754	-7.2430
		MG	-3.21778	1.72411	0.066	-6.6524	0.2168
*. The mean difference is significant at the 0.05 level.							

Table 7: Pearson Correlation Analysis for berg balance scale and fall efficacy scale.

Group (post analysis)	N	Correlation coefficient (BBS & FES)	p value
Conventional therapy	26	0.212	0.299
Manual guidance	27	-0.233	0.242
Knowledge of performance	25	0.069	0.745

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Graph 1: Comparison of Pre and post test average with berg balance scale

Graph 2:Comparison of Pre and post test average with fall efficacy scale

RESEARCH ARTICLE
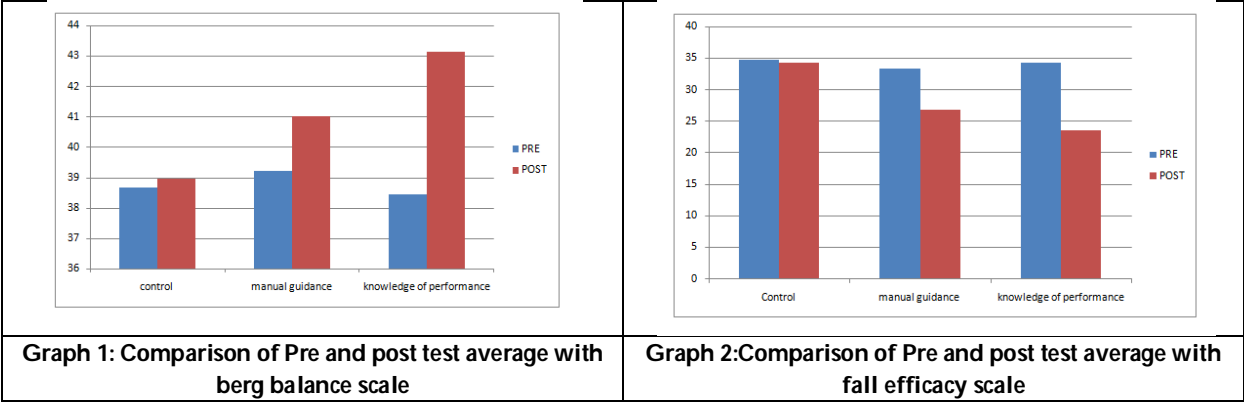
UV Spectrophotometric Determination of Tinidazole in Bulk and Tablet Dosage form by using Single Point Standardization Method

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ABSTRACT

A novel analytical method was developed and validated for the estimation of Tinidazole in bulk and tablet dosage form by using UV- Visible spectroscopy. The method involved optimization of various experimental parameters to achieve maximum sensitivity, specificity, and precision. Validation studies were conducted in accordance with International Conference on Harmonisation (ICH) guidelines, encompassing linearity, accuracy, precision, specificity, robustness, and stability. The proposed method demonstrated excellent linearity over a wide concentration range (2,4,6,8,10µg/ml)with correlation coefficient of 0999. Accuracy was confirmed by recovery studies, yielding results within acceptable limits99.5%,99.5%,101.7%.Precision studies exhibited low % relative standard deviations (%RSD), indicating good repeatability and intermediate precision with less than 2%. Specificity was confirmed by analyzing placebo samples, demonstrating the absence of interference from excipients. The robustness of the method was assessed by deliberate variations in experimental conditions, affirming its reliability under different circumstances. Moreover, stability studies revealed that the tinidazole solution remained stable throughout the analysis period and % RSD values are less than 2%. The developed method offers a reliable, cost-effective, and rapid approach for the quantitative determination of tinidazole in pharmaceutical formulations, thus holding significant potential for routine quality control analysis.

Keywords: Tinidazole, UV-Visible spectroscopy, Method development, Method validation,Pharmaceutical analysis.

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INTRODUCTION

Pharmaceutical analysis is the branch of science which deals with identification of substances and determination of amount present in particular sample. Pharmaceutical analysis covers the bulk materials, dosage forms and more recently, biological samples in support of biopharmaceutical and pharmacokinetic studies.Analysis can be divided into areas called qualitative and quantitative analysis. Pharmaceutical products synthesized and identified using instrumental techniques. Tinidazole is a widely used antibiotic medication known for its effectiveness in treating various bacterial and protozoal infections. Ensuring the accuracy and consistency of its dosage is crucial for maintaining its therapeutic efficacy and minimizing potential adverse effects. Single Point Standardization is a method employed in pharmaceutical quality control to ascertain the concentration of active ingredients in a drug formulation accurately [1,2,3].

AIM AND OBJECTIVE OF WORK
➢ To develop a UV Spectroscopic method which is simple, rapid, accurate, sensitive and selective
➢ To validate the proposed analytical method as per ICH guidelines.
➢ To estimate the drug in formulation by
➢ Single point standardization method

PLAN OF WORK
The proposed study was progressed as follows.
➢ Literature survey
➢ Procurement of standard drug
➢ Selection of solvent
➢ Performing UV spectra for selection of detecting wavelength
➢ Determination of wavelength
➢ Estimation of drug by single point standardization method
➢ Optimization of developed method
➢ Validation of optimized method as per ICH guidelines
➢ Application of method for the estimation of drug in formulation

MATERIALS AND EQUIPMENTS

INSRTUMENTS USED
• Electronic weighing balance – SHIMADZU, model- ELB300
• Sonicator- Ultra Sonicator, model- 2200MH
• UV-Visible Spectrophotometer, Model NO:3000 with detection wave length of 200 nm-800 nm.

SOLVENTS USED
• Methanol- AR grade
• Distilled water

EXPERIMENTAL WORK
METHODS DEVELOPMENT
Selection of solvent:
Solubility of the drug was performed with different solvents. Tinidazole was freely soluble in methanol. The drug showed good spectrum and was stable in methanol, hence methanol was selected as a solvent.[4]

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Preparation of standard stock solution:
Weighed accurately about 100 mg Tinidazole reference standard was transferred into 100 ml volumetric flask. Then dissolved and diluted up to the mark with methanol to give a stock solution having strength 1mg/ml or 1000µg/ml.[5,6]

Determination of absorption maxima:
The above stock solution was further diluted with distilled water to get a concentration of 10µg/ml and scanned under UV between 200-400 nm by taking distilled water as a blank. The maximum absorbance wavelength of Tinidazole was found at 318 nm.

Calibration curve:
Working standard solutions of the drug having concentrations 2, 4, 6, 8 and 10µg/ml were prepared by diluting the standard stock solution with distilled water. The absorbance of resulting solutions was measured against solvent blank and a calibration curve was plotted to get the linearity and regression equation.

Single point standardization:
Measurement of absorbance of sample solution and standard solution of a reference substance was done. The concentration of standard solution should be close to that of sample solution. The concentration of a substance in the sample can be calculated from the proportional relationship that exists between absorbance and concentration.[7,8,9]

$$C_{Test} = (A_{Test} / A_{std}) \times C_{std}$$

METHOD VALIDATION
Specificity
By diluting the stock solution 10µg/ml concentration solution was prepared and the absorbance was measured at 318 against the blank.[10]

Precision
Precision is defined as "the closeness of agreement between a series of measurements, multiple sampling of homogenous samples under the prescribed condition".[11]
Precision is of two types:
       1. Repeatability
       2. Reproducibility

Repeatability (Intraday precision): 2, 4 and 6 µg/ml concentration solutions of Tinidazole were prepared whose absorbance was measured six times at 318nm at different time intervals and the relative standard deviation was calculated.

Reproducibility (Interday precision): Six individual preparations of Tinidazole were prepared with different concentrations of 2, 4 and 6 µg/ml and the absorbance were measured at 246nm. The relative standard deviation was calculated[12,13]

Accuracy
Accuracy of method is the closeness of the measured value to the true value for the sample. It is usually determined by recovery studies. A known quantity of the standard drug was added to the preanalyzed sample formulation at 50%, 100% and 150% levels and the contents were reanalyzed by the proposed method. [14]

% Recovery= Amount of drug found after— amount of drug found before
Addition of standard drug   addition of standard drug   *100

Amount of standard drug added

Limit of detection

The detection limit of individual analytical procedure is the lowest amount of analyte in a sample which can be detected but not quantitated as an exact value. It is performed by based on visual evaluation method. It is determined by the analysis of samples with known concentration of analyte and by establishing the minimum level at which the analyte be reliably detected. [15]

Limit of quantitation

Limit of quantitation of an individual analytical procedure is the lowest amount of analyte in a sample which can be quantitatively determined with suitable precision and accuracy. The quantitation limit is a parameter of quantitative assays for low levels of compounds in sample matrices and is used particularly for the determination of impurities and or degradation product. It is performed by based on visual evaluation method. It is determined by the analysis of samples with known concentration of analyte and by establishing the minimum level of which the analyte can be quantified with acceptable accuracy and precision. [16,17]

Robustness

Robustness of the method is its ability to remain unaffected by small changes in parameter such as changes in wavelength, changes in temperature etc. Robustness examines the effect of operational parameter on the analytical method. 10µg/ml concentration of Tinidazole was prepared whose absorbance was measured in three different wavelengths like 316, 320 nm closer to the λmax of the drug. [18,19,20]

RESULTS AND DISCUSSIONS

Method Development Parameters
Solubility studies: Tinidazole was freely soluble in methanol, dil.Hcl. Partially soluble in butanol and insoluble in water.

Determination of absorption maxima:
The stock solution was further diluted with distilled water to get concentration of 10µg/ml and scanned under UV between 200nm-400nm. The absorption maximum of Tinidazole was found at 318 nm.

Calibration curve:
Calibration curve was performed in the concentration range of 2 - 10µg/ml. Regression coefficient (R2) was found to be 0.999.

Single point standardization method:
10 µg/ml concentration containing standard solution and by crushing the tablets powder equivalent to 10 µg/ml sample solution were prepared and the absorbance of both solutions measured at 246nm. From this the sample concentration was found as 10.02µg/ml.

By substituting the concentration of sample solution in the formula which was given in methodology the amount was found as follows.

Validation Parameter
Specificity: Table-4: Specificity of tinidazole

Precision
Intra-day Precision
Intraday precision studies were performed at 2, 4 and 6μg/ml concentrations and the relative standard deviation was found to be within limits i.e. less than 2%. Hence the performed parameter was validated.

Inter-day Precision
Interday precision studies were performed at 2, 4 and 6μg/ml concentrations and the relative standard deviation was found to be within limits i.e. less than 2%. Hence the performed parameter was validated.

Accuracy
Accuracy studies were performed at 50%, 100% and 150% levels by spiking 2, 4 and 6 μg/ml standard solutions to a pre analysed sample solution. The % Recovery was found to be within the limits i.e. in the range of 99.7 – 101.6

Limit of detection
Limit of detection of Tinidazole was performed by visual evaluation method and the result was found to be 0.1μg/ml.

Limit of quantitation
Limit of quantitation of Tinidazole was performed by visual evaluation method and the result was found to be 0.3μg/ml.

Robustness
Robustness of the method is its ability to remain unaffected by small changes in parameter such as changes in wavelength, changes in temperature etc. Robustness examines the effect of operational parameter on the analytical method. 2,4,6μg/ml concentration of Tinidazole was prepared whose absorbance was measured in three different wavelengths like 316,318nm closer to the λmax of the drug. The % relative standard deviation was found within the limits i.e. less than 2%

AT WAVELENGTH 316nm
Table-9: Robustness of tinidazole at 316nm

AT WAVELENGTH 318nm
Table-10: Robustness of tinidazole 318nm

SUMMARY AND CONCLUSION

A validated UV spectrophotometric method was developed for the estimation of Tinidazole in bulk and tablet dosage by using single point standardization method. Stock solution of Rupatadine Fumarate was prepared in methanol and distilled water used as a further diluent. The normal UVabsorption spectrum was recorded at maximum absorption wavelength (λmax) of 318nm. Linearity was checked in different concentrations. The calibration curve was obtained in the range of 2- 10μg/ml. The slope, intercept and correlation coefficient (R^2) values of Tinidazole were found to be 0.047, 0.0034 and 0.9995 respectively. The developed method was validated as per ICH guidelines. Intraday and inter-day precision studies were carried out and there % RSD values were found within limits i.e. less than 2%. The recovery studies were carried out by adding known amount of standard drug to preanalyzed formulation and % Recovery was found to be within 99.7- 101.6%. LOD and LOQ of Tinidazole were found to be 0.01μg / ml and 0.3μg / ml respectively. Robustness studies were performed at different wavelengths and the % RSD was found within the limits i.e. less than 2%.

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Table-1: Solubility profile of Tinidazole

S.NO	SOLVENT	SOLUBILITY
1	Methanol	Freely soluble
2	Ethanol	Insoluble
3	Butanol	Sparingly soluble
4	Dil.Hcl	Soluble
5	Dil.NH$_3$	Sparingly soluble
6	Water	Insoluble
7	dil.NaOH	Sparingly soluble

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Table-2: Calibration curve values of Tinidazole

S.NO	Concentration(µg/ml)	Absorbance
1	2	0.151
2	4	0.253
3	6	0.335
4	8	0.435
5	10	0.522

Table-3: Concentration of Tinidazole in sample

S.No	Concentration of Standard (µg/ml)	Absorbance of Standard	Absorbance of Sample	Concentration of Sample (µg/ml)
1	10	0.522	0.514	9.844

µg=Micrograms, ml= Millilitres

Table-4: Specificity of tinidazole

S.No	Wavelength(nm)	Concentration(µg/ml)	Absorbance	Mean	SD	%RSD
1	318	10	0.522 0.512 0.519	0.517	0.0041	0.79

µg=Micrograms, ml= Millilitres

Table-5: Intraday precision of Tinidazole

S.NO	Concentration (µg/ml)	Absorbance	Mean	SD	%RSD
1	2	0.101 0.103 0.101	0.102	0.00082	0.80%
2	4	0.175 0.172 0.171	0.172	0.0014	0.81%
3	6	0.267 0.265 0.262	0.264	0.0017	0.64%

µg= Micrograms, ml=Milli litres

Table-6:Inter day precision of tinidazole

S.NO	Concentration (µg/ml)	Absorbance	Mean	SD	%RSD
1	2	0.104 0.103 0.102	0.103	0.0006	0.58%
2	4	0.178 0.174 0.183	0.178	0.003	1.85%
3	6	0.274 0.272 0.268	0.273	0.0021	0.78%

µg= Micrograms, ml=Milliliters

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Table-7: %recovery of tinidazole

S.No	LeveL	Amount of drug in sample(µg/ml)	Amount of standard drug added (µg/ml)	Amount of drug recovered (µg/ml)	% Recovery
1	50%	4	2	3.419	99.55%
2	100%	4	4	5.41	99.5%
3	150%	4	6	7.532	101.7%

µg= Micrograms, ml=Milli litres

Table-8: LOD of Tinidazole

S.NO	LOD Value
1	0.882 µg/ ml

µg= Micrograms, ml=Milli litres

S.NO	LOQ
1	2.673 µg/ ml

µg= Micrograms, ml=Milli litres

Table-9: Robustness of tinidazole at 316nm

S.No	Wavelength (nm)	Concentration (µg/ml)	Absorbance	Mean	SD	%RSD
1	316	2	0.103 0.102 0.103	0.102	0.000147	0.144%
2	316	4	0.181 0.182 0.184	0.182	0.00153	0.841%
3	316	6	0.235 0.232 0.238	0.232	0.0022	0.94%

µg=micrograms, ml=milli litres

Table-10: Robustness of tinidazole 318nm

S.No	Wavelength (nm)	Concentration (µg/ml)	Absorbance	Mean	SD	%RSD
1	318	2	0.113 0.115 0.111	0.113	0.00163	1.44%
2	318	4	0.181 0.185 0.187	0.184	0.0019	1.03%
3	318	6	0.234 0.230 0.230	0.231	0.0015	0.65%

µg=micrograms, ml=milli litres

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Table-11:Robustness of tinidazole at 320nm

S.NO	Wavelength (nm)	Concentration (µg/ml)	Absobance	Mean	SD	%RSD
1	320	2	0.112 0.116 0.114			
2	320	4	0.175 0.172 0.171	0.172	0.0014	0.81
3	320	6	0.274 0.272 0.268	0.273	0.0021	0.78
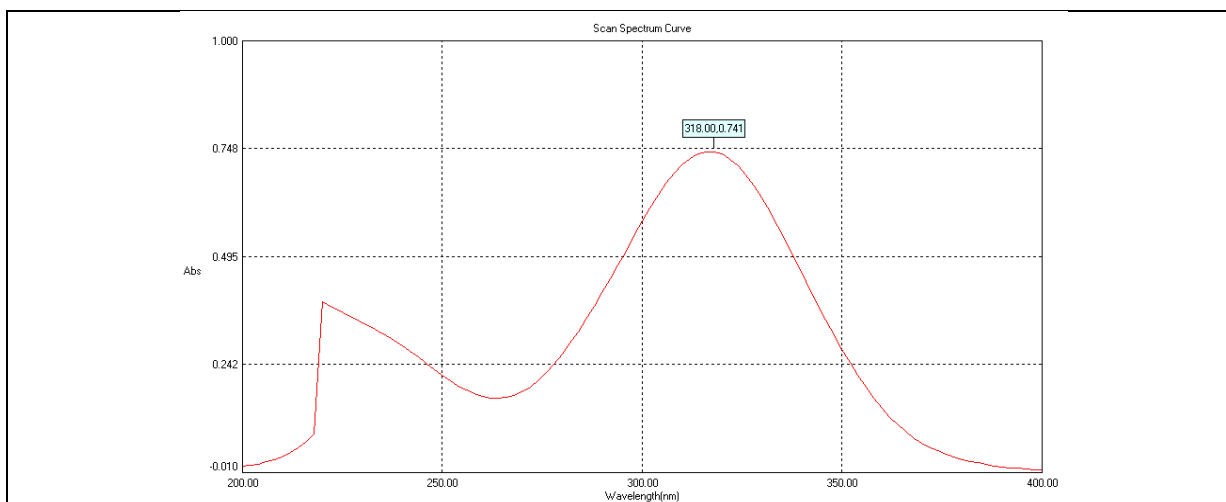
Figure-1: Absorption max of tinidazole drug
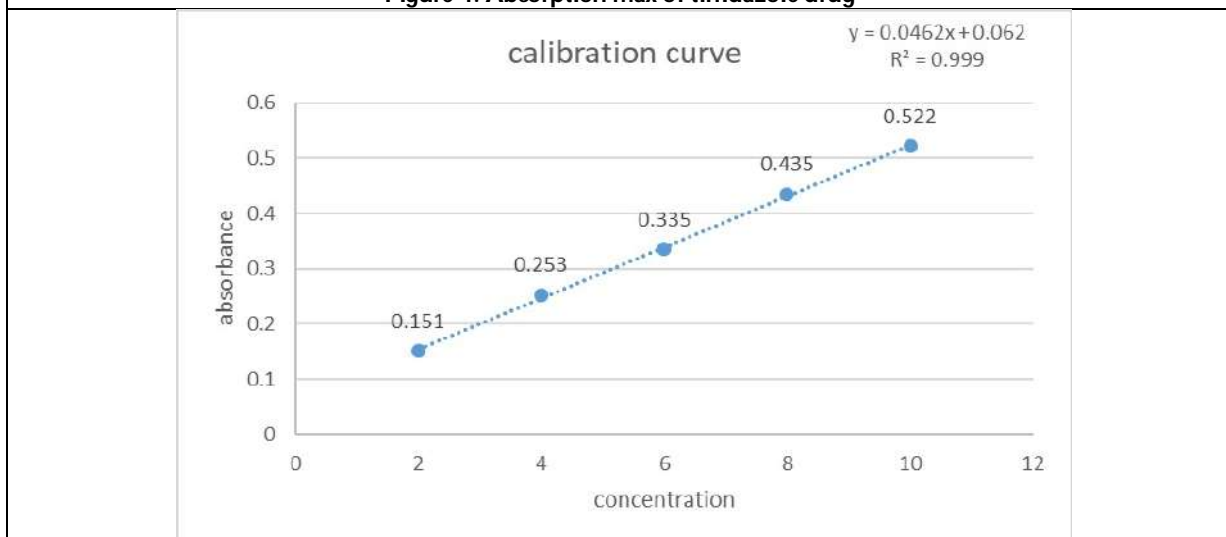
Figure-2: calibration curve of tinidazole

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RESEARCH ARTICLE

An Empirical Study Measuring the Impact of Perceived Inclusion on Job Satisfaction in the Indian Healthcare Sector

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ABSTRACT

The current research presents the connection between perceived inclusiveness and job satisfaction among healthcare practitioners in India. It highlights the significance of perceived inclusiveness in shaping job satisfaction within the healthcare industry, where working together as a team is essential. Perceived inclusion pertains to individuals' sense of being valued, respected, and integrated within their teams and organizations; it goes beyond mere participation to encompass a feeling of belonging and fair treatment. Job Satisfaction reflects the emotional fulfilment experienced by workers in their professional roles when organizational outcomes align with their expectations. This research aims to investigate how perceived inclusion contributes to an inclusive work environment and overall job satisfaction among staff members. The hypotheses propose a positive link between perceived inclusion and job satisfaction based on data gathered from 250 employees in the healthcare sector through an online survey. Statistical analysis conducted using IBM SPSS23.0 indicates a robust positive correlation between perceived inclusion and job satisfaction. In summary, this study emphasizes the importance of fostering perceptions of inclusion as an aspect that enhances employee happiness among healthcare professionals which thereby enhances patient care quality within the country's health delivery system.

Keywords: Perceived Inclusion, Job Satisfaction, healthcare, well-being, inclusive climate.

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INTRODUCTION

India faces various challenges in its healthcare system, such as limited resources, a shortage of medical personnel, and unequal access to care. In this complex environment, healthcare workers need to collaborate, adapt and be resilient. The well-being and contentment of these professionals are crucial for the quality of patient care in India's intricate healthcare delivery system. Within this dynamic environment, the idea of perceived inclusion becomes an important factor influencing job satisfaction among healthcare workers. It refers to how valued, respected, and included they feel within their teams and organizations in subjective terms.It extends beyond mere participation in decision-making processes to encompass a sense of belonging, appreciation for individual contributions, and equitable treatment [7,9]. Previous research conducted in Indian context has highlighted the importance of organizational factors, including leadership support and workplace culture, in shaping healthcare professionals' job satisfaction. However, the specific role of perceived inclusion in influencing job satisfaction remains an area ripe for exploration. In healthcare settings, where collaboration and teamwork are paramount, perceived inclusion fosters a sense of cohesion, trust, and mutual respect among healthcare professionals [7].

Perceived Inclusion
Perceived inclusion pertains to how individuals perceive themselves as belonging and being appreciated for their unique qualities within a particular group [9]. This perception of inclusion occurs when individuals feel they have influence in decision-making processes, can express their opinions, and are valued for their authentic selves [7,8,3]. It also involves participating in knowledge sharing and decision-making activities, which are associated with engagement in learning behaviours like dialogue and collaboration [7]. Additionally, perceived inclusion encompasses recognizing and respecting individual differences while working together towards shared goals [5], thus promoting a sense of social equality across various aspects of individual identity [4].

Job Satisfaction
Job satisfaction (JS) represents the emotional state in which workers experience a sense of fulfilment or enjoyment from their professional endeavours. It arises when the expectations of both the organization and the individual align; if there is harmony, job satisfaction thrives, but if there is discord, dissatisfaction arises [6]. In essence, when individuals perceive that their job expectations are fulfilled, receive fair treatment during work processes, and attain desired outcomes within the organizational framework, they are likely to experience high levels of job satisfaction [1].

Perceived inclusion and job satisfaction
According to the theory of social identity, when people in an organization feel acknowledged and esteemed, it fosters a feeling of unity among them. This perception of likeness promotes trust and approval among members of the organization, thus nurturing a sense of being included[9].Recognizing common ground among members within an organization is just one facet of fostering inclusivity. Another crucial aspect involves appreciating and valuing the distinct attributes each individual brings to the table, as highlighted by scholars such as [7,8.9].A climate conducive to inclusivity is established by striking a balance between belonging to a cohesive organizational unit and being recognized and respected for one's unique qualities [9]. When individuals within an organization feel included, it positively impacts their attitudes towards work, ultimately enhancing job satisfaction, as indicated by research [2,9].

METHODOLOGY

Objective
The major purpose of the study is to examine how perceived inclusion contributes towards an inclusive climate and overall job satisfaction of employees.

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Hypotheses

H_{a1}: There is a direct positive relationship between perceived inclusion and job satisfaction of employees.

H_{a2}: There is a significant effect of perceived inclusion on job satisfaction of employees.

Sample

Primary data was collected from employees working in healthcare sector via an online structured questionnaire which was administered on one-to-one basis through e-mail. The sample size was 250 individuals.

Procedure

Purposive sampling, a type of non-probability sampling was used to select the sample from the population. The corresponding data set which was finally obtained was analysed using statistical tools. Statistical software for analysis was IBM SPSS23.0

Instruments

Job satisfaction scale (Robbins and Judge, 2013)

Five items were considered under this scale. The test values of 0.84(Composite Reliability) and 0.921(Cronbach's alpha) indicates outstanding internal consistency reliability for the Job Satisfaction scale. Table 1 shows the results.

Perceived inclusion scale (Barak, 1999)

Fifteen items were considered under this scale. The test values of are above 0.70 which indicates good internal consistency reliability for the Job Satisfaction scale. Table 1 shows the results. The constructs were graded on a five-point Likert scale, with 1 denoting strong disagreement and 5 denoting high agreement.

RESULTS

Table 2 reveals the value of Pearson correlation to be r=0.833. This indicates strong positive relation between Perceived inclusion and Job satisfaction. Pearson correlation of Perceived Inclusion and Job satisfaction was found to be highly positive and statistically significant (r=0.832, p<0.01.ANOVA table 3 (b)gives us the variation in Job satisfaction. F-value is the ratio between explained and unexplained variation, here it is 54.39>> 1 i.e., explained variation is higher than Unexplained variation. Here, F-value is highly significant (p=0.00<0.05) at 5% level of significance. According to R-square values 68% of variation in Job Satisfaction is explained by Perceived Inclusion which indicates a good model fit.

DISCUSSIONS

The current research examines the importance of how healthcare workers in India perceive inclusion within their workplace. It stresses that for improving job satisfaction and patient care quality, it is crucial that healthcare workers feel valued, respected, and included in their teams and organizations. Perceived inclusion encompasses not only participation in decision-making but also a sense of belonging, recognition for individual contributions, and fair treatment. The positive connection between perceived inclusion and job satisfaction among healthcare professionals highlights the significance of support from leadership, workplace culture, and teamwork. This study involving 250 employees in the healthcare sector using a structured questionnaire revealed a strong positive correlation between perceived inclusion and job satisfaction. Conclusively this research emphasizes the necessity of promoting inclusivity within healthcare organizations to enhance employee well-being and which ultimately improve patient care outcomes.

LIMITATIONS AND FUTURE SCOPE

The present study has taken into consideration only two variables, future research can further introduce more variables as mediators and moderators to better explain the relationship between Perceived Inclusion and Job Satisfaction. Other outcomes of Perceived Inclusion such as organizational citizenship behaviour, employee retention, employee well-being can also be examined in future. As the present data is collected only from healthcare workers, further studies may capture interview data from employers to further validate the findings and get deeper insights into the phenomenon. A comparative study which compares outcomes of job satisfaction pre and post implementation of inclusive programs may also be undertaken in future. Further, other industries can also be targeted to better generalize the outcomes of the present study.

CONCLUSIONS

The present study will help the organisations to make their workplaces more equal, diverse, and inclusive, which would benefit workers and their satisfaction levels. Inclusion is more than a goal; it is a continual process that necessitates regular assessment and action. Thus, the study offers a perspective as to how healthcare organizations could leverage perceived inclusivity among workers to foster their job satisfaction and ultimately better organizational outcomes.

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Table 1: Reliability and Validity of scale

Variable	Items	Factor Loadings (FL)	Average Variance Extracted (AVE)	Composite Reliability (CR)	Cronbach Alpha
Job Satisfaction	JS1	.854			
	JS2	.901			
	JS3	.922			
	JS4	.831			
	JS5	.899	0.81	0.84	**0.921**
Perceived Inclusion	PI1	.828			
	PI2	.804			
	PI3	.890			
	PI4	.820			
	PI5	.834	0.76	0.899	**0.891**
	PI6	.701			
	PI7	.883			
	PI8	.738			
	PI9	.749			
	PI0	.671	0.66	0.910	**0.755**
	PI11	.793			
	PI12	.731			
	PI13	.907			
	PI14	.685			
	PI15	.918	0.73	0.901	**0.721**

Source: Self compiled by the authors using IBM SPSS23.0

Table 2. Pearson Correlation Coefficients

	PI	JS
PI	1	0.833
JS	0.833	1

Source: Self compiled by the authors using IBM SPSS23.0

Table 3 (A): Regression Analysis

Model Summary	
Multiple R	0.833
R Square	0.694
Adjusted R Square	0.681
Standard Error	0.401
Observations	209

Source: Self compiled by the authors using IBM SPSS23.0

Table 3: (B) ANOVA

	df	SS	MS	F	Significance F
Regression	1	8.757648	8.757648	54.39687	1.29E-07
Residual	207	3.86389	0.160995		
Total	208	12.62154			

Source: Self compiled by the authors using IBM SPSS23.0

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Table 3:(C) Coefficients

	Coefficients	Standard Error	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-0.257	0.564	0.652	-1.421	0.907	-1.421	0.907
X Variable 1	1.037	0.141	0.000	0.747	1.327	0.747	1.327

Source: Self compiled by the authors using IBM SPSS23.0

REVIEW ARTICLE

A Brief Review on Analytical Techniques in Bioequivalence Studies

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ABSTRACT

Bioequivalence studies are crucial in pharmaceutical development, ensuring that generic drugs are therapeutically equivalent to their brand-name counterparts. Analytical techniques play a pivotal role in assessing bioequivalence, encompassing a range of methods to measure drug concentrations in biological matrices accurately. This review provides a concise overview of key analytical techniques utilized in bioequivalence studies.It serves as a vital component in evaluating the equivalence of generic drugs with their reference counterpart's. The bioequivalence studies are the special type of studies where two drugs or two sets of formulation of the same drug are compared to show that they have nearly equal bioavailability and Pharmacokinetic/Pharmacodynamic parameters. These Bioequivalence studies mainly focused on interchangeability between generic and brand name medication depends heavily on a range of Analytical techniques to measure the presence of concentration of drug active pharmaceutical ingredient within the human body. The generic drug products are sometimes termed as "Super Generic" or "Therapeutichybrid". The generic drug products are cost-effective than their respective brand products. The bioequivalence studies are mainly divided into two types. They are "in vivo" and "in vitro". The analytical methods involved in the bioequivalence studies are used for the quantitative determination of drugs and their metabolism in biological samples play a significant role in evaluation and interpretation of Bioequivalence. This review highlights the role of analytical instrumentation and analytical methods in assessing the quality of drugs.

Keywords: Analytical Techniques, Bioequivalence studies, Bioavailability studies, Pharmacokinetic studies, Generic drugs.

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INTRODUCTION

Bioequivalence is the study of different brands of a same drug and its dosage forms. Two different formulations of a same drug are bioequivalent when their rate of dissolution and absorption is same. As there is an increase in production and consumption of generic drugs, the need for bioequivalence study is also rising. In pharmaceutical research and development, bioequivalence studies serve as vital component in evaluating the equivalence of generic drugs with their counterparts. The analytical technique applied in bioequivalence studies is Liquid Chromatography-Mass spectroscopy renowned for its precision. This method high sensitivity plays a pivotal role in accurately assessing the concentration of API's and it effectively separates and quantifies drugs and their metabolites in biological samples [1]. The bioequivalence studies are mainly based on generic drugs. Generic drug products are termed as super generic drugs [2]. In terms of active ingredients, strength, dosage forms, method of administration, quality, safety, performance characteristics, and therapeutic indication, bio-equivalence means that a generic drug product is virtually comparable to the originator products. generic drug products are cost - effective than their brand products [3]. Bioequivalence studies based on pharmacokinetics parameters and bioavailability of the drug. pharmacokinetics means how the body interacts with administration substances for the entire duration of exposure. The pharmacokinetic parameters are absorption, distribution, metabolism, and excretion [4]. Mainly the analytical techniques include liquid chromatography- mass spectroscopy, UVVisible spectroscopy, High performance liquid chromatography, gas chromatography, capillary electrophoresis [5].

METHODS

LIQUID CHROMATOGRAPHY AND MASS SPECTROSCOPY: [6-10]
Liquid Chromatography-Mass Spectrometry (LC-MS) is a powerful analytical technique commonly used in bioequivalence studies to quantify drug concentrations in biological samples. [Fig1]

Principles
Liquid Chromatography-Mass Spectrometry (LC-MS) combines the separation capabilities of liquid chromatography with the detection and identification capabilities of mass spectrometry. LC separates analytes based on their interaction with a liquid mobile phase and a stationary phase, typically packed in a column, while MS detects and analyzes ions produced from the separated analytes. The principle behind LC-MS involves the ionization of analytes in the mobile phase, followed by their separation based on mass-to-charge ratio (m/z) in the mass analyzer, and subsequent detection and quantification.

Advantages
High Sensitivity: LC-MS offers high sensitivity, enabling the detection and quantification of compounds at low concentrations, often in the femtogram or attogram range.
Selectivity: LC-MS provides excellent selectivity, allowing the differentiation and identification of analytes even in complex matrices, owing to the unique mass spectra of individual compounds.
Versatility: LC-MS can analyze a wide range of compounds, including small molecules, peptides, proteins, lipids, and metabolites, making it suitable for various applications in pharmaceuticals, environmental analysis, metabolomics, proteomics, and lipidomics.

Structural Information: LC-MS provides valuable structural information about analytes, including molecular weight, fragmentation patterns, and chemical composition, facilitating compound identification and characterization.
High Throughput: Modern LC-MS systems are highly automated, offering increased efficiency, reproducibility, and throughput in analysis, especially when coupled with high-performance liquid chromatography systems.

Limitations

Cost: LC-MS instrumentation and maintenance can be expensive, particularly for high-end systems and specialized detectors, which may pose a barrier to widespread adoption.

Complexity: LC-MS analysis requires specialized training and expertise in method development, operation, data interpretation, and troubleshooting, which may limit access for inexperienced users.

Matrix Effects: LC-MS analysis in complex matrices such as biological samples may suffer from matrix effects, including ion suppression or enhancement, leading to variability and inaccuracies in quantification.

Sample Preparation: Sample preparation for LC-MS analysis can be time-consuming and labor-intensive, often requiring extraction, purification, and derivatization steps to improve sensitivity and remove matrix interference.

Sensitivity to Contaminants: LC-MS systems are highly sensitive to contaminants in samples, solvents, and reagents, which can lead to interference, background noise, and false positives or negatives in analysis.

HIGH PERFORMANCE LIQUID CHROMATOGRAPHY: [11-15]

High performance Liquid Chromatography is another employed in Bioequivalence studies. This analytical technique is mainly used to separate the complex mixtures of molecules into the Carbohydrates, fattyacids, peptides, proteins etc. The Normal phase HPLC is used for polar compounds and reverse phase for hydrophobic drugs. The HPLC shows better accuracy, precision and High specificity etc. [Fig2]

High-Performance Liquid Chromatography (HPLC) is a versatile analytical technique used for the separation, identification, and quantification of compounds in complex mixtures.

Principles of HPLC

HPLC separates compounds based on their differential interaction with a stationary phase (solid or bonded to the support) and a mobile phase (liquid solvent), flowing through a packed column. The components of the mixture are eluted from the column at different rates, depending on their affinity for the stationary phase. Detection of separated compounds is typically achieved using UV-visible, fluorescence, or mass spectrometric detectors.

Advantages of HPLC

High Sensitivity: HPLC can detect compounds at very low concentrations, making it suitable for trace analysis in complex samples.

Versatility: HPLC can analyze a wide range of compounds, from small molecules to large biomolecules, making it applicable across various industries, including pharmaceuticals, environmental science, and food analysis.

High Resolution: HPLC provides excellent resolution, allowing for the separation of closely related compounds.

Automation: HPLC systems can be automated, enabling high-throughput analysis and improving reproducibility.

Quantitative Analysis: HPLC allows for accurate quantification of analytes, essential for pharmaceutical quality control and pharmacokinetic studies.

Limitations of HPLC

Complexity of Method Development: Developing an HPLC method can be time-consuming and requires expertise in selecting appropriate columns, mobile phases, and detection techniques.

Cost: High-performance liquid chromatography systems and consumables can be expensive, limiting accessibility for some laboratories.

Sensitivity to Matrix Effects: HPLC analysis of complex samples, such as biological fluids, may be susceptible to matrix effects, leading to interference and reduced accuracy.

Limited Mobile Phase Compatibility: Some compounds may not be sufficiently soluble or stable in commonly used mobile phases, necessitating method optimization.

Sample Preparation Requirements: Prior to analysis, samples often require extensive preparation, including extraction, filtration, and derivatization, which can increase analysis time and introduce variability.

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GAS CHROMATOGRAPHY: [16-19]

GAS Chromatography is a work horse of Analytical method in these studies. Gas chromatography is mainly used to separate the complex mixture into individual compounds. [Fig 3]

Principles

Gas Chromatography (GC) is a chromatographic technique used for separating and analyzing volatile and semi-volatile compounds in a mixture. The principle behind GC involves the distribution of sample components between a stationary phase (typically a liquid or solid coated onto a column) and a mobile phase (inert gas such as helium or nitrogen), leading to differential migration rates and separation based on their chemical properties such as volatility, polarity, and affinity for the stationary phase.

Advantages

High Resolution: GC offers excellent separation efficiency and resolution, enabling the analysis of complex mixtures with high precision.

Sensitivity: GC provides high sensitivity, allowing the detection and quantification of compounds at trace levels, often in the parts-per-billion or parts-per-trillion range.

Speed: GC analysis is typically fast, with run times ranging from a few minutes to less than an hour, facilitating high throughput analysis.

Wide Applicability: GC can analyze a broad range of compounds, including volatile organic compounds, small molecules, fatty acids, and gases, making it suitable for various applications in environmental analysis, food industry, pharmaceuticals, and forensic science.

Compatibility with Mass Spectrometry (GC-MS): GC can be coupled with mass spectrometry detectors, enhancing specificity and enabling compound identification based on their mass spectra.

Limitations:

Limited Analyte Stability: Some analytes may degrade or undergo chemical reactions under the high-temperature conditions used in GC analysis, leading to chromatographic artifacts or loss of analyte.

Sample Volatility Requirement: GC is suitable only for volatile or semi-volatile compounds that can be vaporized without decomposition under the operating conditions.

Sample Preparation: Sample preparation for GC analysis often involves extraction, derivatization, or concentration steps, which can be time-consuming and labor-intensive.

Stationary Phase Degradation: The stationary phase in GC columns may degrade over time, leading to reduced separation efficiency and column performance.

Complexity of Operation: GC instruments require specialized training and expertise for operation, method development, and maintenance, which may pose challenges for inexperienced users.

CAPILLARY ELECTROPHORESIS: [20-24]

Capillary electrophoresis is another method used in bioequivalence studies, mainly for ionic and polar compounds. It is recognized for delivering high resolution and swift analysis time. [Fig 4]

Principles

Capillary Electrophoresis (CE) is a separation technique based on the differential migration of charged analytes in an electric field. In CE, analytes are separated as they migrate through a narrow capillary filled with an electrolyte solution under the influence of an applied voltage. The separation is based on differences in the charge-to-size ratio of the analytes, with smaller or more highly charged molecules migrating faster than larger or less charged molecules.

Advantages

High Separation Efficiency: CE offers high separation efficiency, allowing the resolution of complex mixtures into individual components with sharp peaks, even for compounds with similar properties.

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Rapid Analysis: CE analysis is typically fast, with separation times ranging from seconds to a few minutes, facilitating high-throughput analysis and reducing analysis time compared to other separation techniques.

Small Sample Volume: CE requires only small sample volumes (nanoliters to microliters), making it suitable for applications where sample availability is limited or sample recovery is challenging.

Versatility: CE can separate a wide range of analytes, including small ions, organic molecules, peptides, proteins, nucleic acids, and pharmaceutical compounds, making it applicable to various fields such as pharmaceuticals, biomedical research, environmental analysis, and food industry.

Compatibility with Mass Spectrometry (CE-MS): CE can be coupled with mass spectrometry detectors, providing additional structural information and enhancing sensitivity and specificity for compound identification.

Limitations

Sensitivity: While CE offers high separation efficiency, its sensitivity may be lower compared to other techniques such as liquid chromatography-mass spectrometry (LC-MS), particularly for low-abundance analytes, which may limit its applicability in certain analyses.

Limited Sample Loading Capacity: CE has a limited sample loading capacity compared to other techniques, which may result in peak broadening or reduced sensitivity for high-concentration samples.

Lack of Universal Detection: CE lacks universal detection methods, and the choice of detector depends on the properties of the analytes, which may limit detection options for certain compounds.

Matrix Effects: CE analysis in complex matrices such as biological samples may suffer from matrix effects, including interference from sample components or electrolyte additives, leading to variability and inaccuracies in quantification.

Method Development Challenges: CE method development can be challenging due to the optimization of parameters such as buffer composition, pH, voltage, and capillary coatings, requiring expertise and time for optimization.

IMMUNOASSAYS: [25-29]

Immunoassays are antibody-based techniques utilized for the quantification of specific drugs or their metabolites. While less commonly employed in bioequivalence studies due to potential cross-reactivity issues and limited specificity, immunoassays offer rapid analysis and high throughput capabilities, making them suitable for screening purposes.

Principles of Immunoassays

Immunoassays are analytical techniques based on the specific interaction between an antigen (analyte) and an antibody. They rely on the principle of binding between antibodies and antigens to detect and quantify target molecules in a sample. There are various types of immunoassays, including enzyme-linked immunosorbent assays (ELISA), radioimmunoassays (RIA), fluorescence immunoassays (FIA), and chemiluminescence immunoassays (CLIA). In a typical immunoassay, the antigen in the sample binds to an antibody linked to a detectable marker (e.g., enzyme, radioisotope, fluorophore), allowing for the measurement of the signal generated, which is proportional to the concentration of the analyte in the sample.

Advantages of Immunoassays

High Specificity: Immunoassays offer high specificity, as they rely on the selective binding between antibodies and antigens, enabling the detection of target molecules even in complex biological samples.

Sensitivity: Immunoassays can detect target molecules at very low concentrations, often in the picogram to nanogram range, making them suitable for applications requiring high sensitivity.

Versatility: Immunoassays can be adapted to detect a wide range of analytes, including proteins, peptides, hormones, drugs, and infectious agents, making them widely applicable in various fields such as clinical diagnostics, pharmaceuticals, environmental monitoring, and food safety.

Quantitative Analysis: Immunoassays can provide quantitative measurements of analyte concentrations, allowing for the precise determination of biomarker levels in biological samples.

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Automation: Many immunoassay platforms are automated, offering high throughput and reproducibility, making them suitable for large-scale screening and analysis.

Limitations of Immunoassays
Cross-Reactivity: Immunoassays may exhibit cross-reactivity with structurally similar molecules, leading to interference and inaccurate results.
Matrix Effects: Complex biological matrices, such as serum, plasma, or tissue homogenates, may contain interfering substances that affect assay performance and accuracy.
Limited Multiplexing: Traditional immunoassays are often limited to the detection of a single analyte or a small panel of analytes, which may not be sufficient for comprehensive biomarker profiling.
Standardization Challenges: Immunoassays may suffer from variability between different assay kits and manufacturers, leading to challenges in standardization and comparability of results.
Development Time: Developing and optimizing immunoassays can be time-consuming and labor-intensive, requiring the production and validation of specific antibodies and optimization of assay conditions.

BIOANALYTICAL METHOD VALIDATION: [30-34]
Regardless of the analytical technique employed, rigorous method validation is essential to ensure the reliability and reproducibility of results in bioequivalence studies. Validation parameters include specificity, accuracy, precision, linearity, and sensitivity, among others, as outlined by regulatory guidelines such as those provided by the FDA or EMA.
Bioanalytical method validation is a critical process in pharmaceutical analysis to ensure the accuracy, precision, selectivity, sensitivity, and reproducibility of analytical methods used for quantifying drugs and their metabolites in biological matrices.

Principles of Bioanalytical Method Validation
Bioanalytical method validation involves demonstrating that an analytical method is suitable for its intended purpose and meets regulatory requirements. Key validation parameters include specificity, accuracy, precision, linearity, sensitivity, and stability.

Advantages of Bioanalytical Method Validation
Reliable Results: Validated methods provide reliable and reproducible results, ensuring the accuracy of drug concentration measurements in biological samples.
Regulatory Compliance: Validation ensures compliance with regulatory guidelines, such as those issued by the U.S. Food and Drug Administration (FDA) and the European Medicines Agency (EMA), facilitating drug development and regulatory approval.
Quality Assurance: Validated methods contribute to quality assurance in pharmaceutical analysis, enhancing confidence in analytical data and supporting decision-making in drug development and clinical studies.
Method Optimization: Validation includes optimization of critical parameters, leading to improved method performance and efficiency.
Risk Reduction: Validation helps identify and mitigate potential sources of error or variability in analytical procedures, reducing the risk of inaccurate results.

Limitations of Bioanalytical Method Validation
Resource Intensive: Method validation requires significant time, resources, and expertise to perform comprehensive studies and generate reliable data.
Complexity: Validation protocols can be complex, particularly for assays involving complex matrices or analytes with challenging properties.
Regulatory Compliance Burden: Meeting regulatory requirements for method validation can be demanding, necessitating thorough documentation and adherence to guidelines.

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Inter laboratory Variability: Method validation may exhibit variability between different laboratories, highlighting the need for standardized protocols and proficiency testing.

Evolution of Guidelines: Regulatory guidelines for method validation may evolve over time, requiring continuous monitoring and updates to ensure compliance.

BIOEQUIVALENCE STUDIES, BIOAVAILABILITY STUDIES, PHARMACOKINETIC STUDIES, GENERIC DRUGS: [35-45]

BIOEQUIVALENCE STUDIES

Bioequivalence studies are performed for new drugs to establish essential pharmacokinetic parameters like rate of absorption, extent of absorption, rate of excretion and metabolism, elimination half-life after single and multiple dose administration in the body.

The bioequivalence studies are mainly divided into two types. They are "in vivo" and "invitro" studies. In vivo bioequivalence studies mean research done on a living organism, while invitro means research done in a laboratory dish or test tube. (Tissues, cells or other parts of an organism are removed and placed in laboratory dishes. the

The main purpose of studies is to increase the production and consumption of generic drugs.

Bioequivalence studies are critical in pharmaceutical development to ensure the interchangeability of generic drugs with their reference products. These studies typically compare the pharmacokinetic parameters of the generic drug and the reference product to establish bioequivalence.

BIOAVAILABILITY STUDIES

Bioavailability is defined as the relative amount of drug from an administered dose which enters the systemic circulation and the rate at which the drug appears in the systemic circulation. The bioavailability studies are done by measuring the concentration of the drug in the plasma. These studies are helpful for clinical trials in early drug development. Bioequivalence studies were carried out to distinguish between pharmaceutical products containing the same active substance.

Bioavailability studies are crucial in pharmaceutical development to assess the rate and extent to which the active ingredient of a drug becomes available at the site of action or in the systemic circulation.

PHARMACOKINETIC STUDIES

Pharmacokinetic (PK) is the study of how the body interacts with administered substances for the entire duration of exposure. Pharmacokinetic studies are closely related to pharmacodynamics, which examine the drug's effect on the body more closely. pharmacokinetic studies based on four main parameters. They are absorption, distribution, metabolism, and excretion (ADME). Pharmacokinetic studies are fundamental in understanding how drugs are absorbed, distributed, metabolized, and eliminated in the body over time.

GENERIC DRUGS

Generic products are sometimes termed as "Super Generic" or "Therapeutic hybrid". The bioequivalence means that a generic drug product is virtually comparable to the originator product. Generic drug products are more cost effective than their respective brand products. Nowadays most of the pharmaceutical's countries focus on developing the generic drugs products due to their quality, safety characteristics.

Generic drugs are pharmaceutical products that contain the same active ingredient(s), dosage form, strength, route of administration, and intended use as their brand-name counterparts. They are marketed after the expiration of patents or exclusivity rights held by the original innovator company.

CONCLUSION

The concept of analytical techniques in bioequivalence studies has been adopted by pharmaceutical industries. It is mainly due to increasing the number of generic drugs and its formulations marketed after regulatory acceptance. So, the bioavailability and bioequivalence studies can be carried out by analytical techniques. The analytical methods are

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evaluated by the statistical methods to get accurate results to assure high quality interchangeable and affordable drugs.

ACKNOWLEDGEMENT

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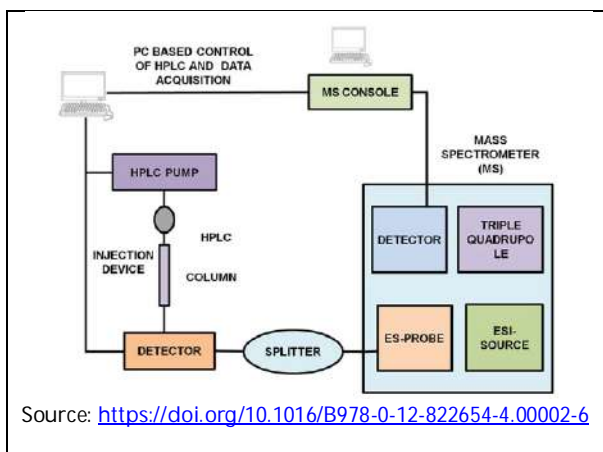
Figure 1: Liquid chromatography - Mass spectrometry.

Source:https://microbenotes.com/high-performance-liquid-chromatography-hplc/
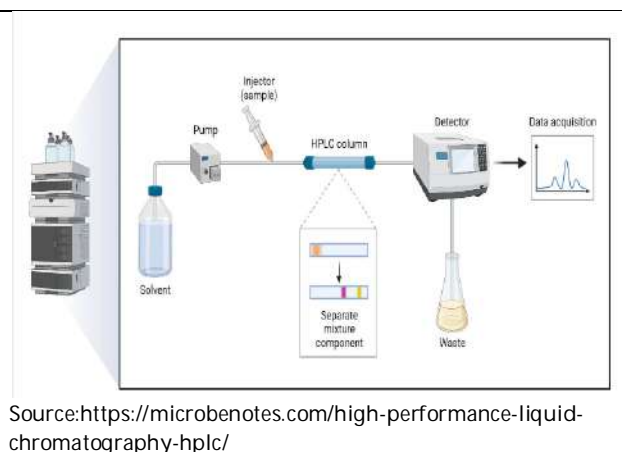
Figure 2: High performance liquid Chromatography (HPLC)

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Source: https://www.researchgate.net/publication/273134301

Figure 3: Gas Chromatography

Source:https://link.springer.com/protocol/10.1385/1-59259-870-6:095

Figure 4: Capillary Electrophoresis.

RESEARCH ARTICLE
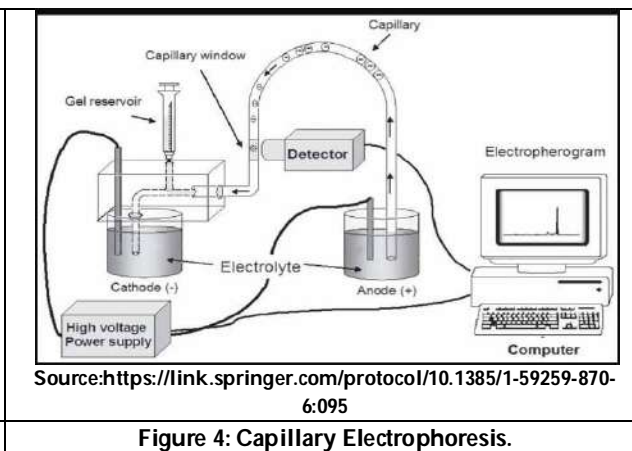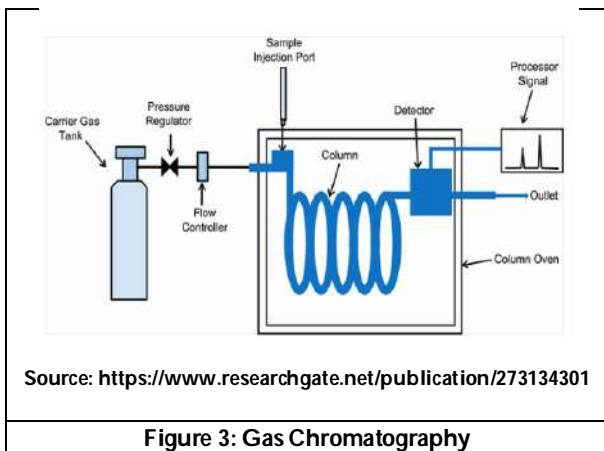
Intranasal Nanoemulsions for Neurodegenerative Disease

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ABSTRACT

Debilitating and virtually incurable, neurodegenerative illnesses are closely associated with aging. An estimated 50 million individuals worldwide suffer from Alzheimer's disease and associated conditions. As the population ages, this number is predicted to double every 20 years. The few treatments currently available for neurodegenerative disorders mostly target the symptoms rather than the underlying cause or the disease's progressive path. The two most prevalent neurodegenerative illnesses are Parkinson's and Alzheimer's diseases**.** In this paper we have foreground on nanoemulsions targeting delivery which have proven to show better results, comparatively as per the studies conducted. Studies have shown that many pathways were reported by Intradermal but the survey drew attention towards the intranasal route showing the highest and fastest absorption. We specifically focus on nanoemulsions targeting brain diseases and current approaches to overcome the barriers, method of preparation of nanoemulsions, and classification of nanocarriers, briefly we then highlight the intranasal route and various contributing pathways, followed by various neurodegenerative-related nanoemulsions.

Keywords: NDs , AD,PD, HD, Blood-Brain Barriers, Nano Carriers Nanoemulsions, Method Of Preparation, Intranasal Route, NEs loaded drugs.

INTRODUCTION

Neurological diseases currently impact 15% of the global population, neurological illnesses are the primary cause of both physical and cognitive disability worldwide (1Placeholder1). A major characteristic of a wide range of neurodegenerative diseases, including Alzheimer's disease (AD), Parkinson's disease (PD), amyotrophic lateral sclerosis (ALS), frontotemporal dementia (FTD), and Huntington's disease (HD), is proteotoxicity, which is defined as impairment of cellular function as a result of protein misfolding or aggregation. The etiology of these disorders is often shared by the fact that aberrant protein aggregation and deposition, which results in changed particular molecular processes leading to cell toxicity and degeneration, commonly causes neuronal damage.The primary risk factor for neurodegenerative illnesses is aging,and an increased risk factor that comes with aging is proteotoxicity. The ability of our body to maintain protein homeostasis significantly declines with age. Research has demonstrated that as we age, our ability to eliminate harmful protein aggregates is actively suppressed, which leads to their build-up and the early onset of neurodegeneration in later life. Toxic protein aggregates often form when soluble proteins progressively transform into insoluble filamentary polymers. The damaged brain cells' cytoplasm, extracellular space, or nucleus are where these filamentous formations eventually deposit and aggregate after accumulating as fibrils. Essential protein quality control (PQC) systems are present in eukaryotic cells.

These systems include the autophagy-lysosome system, which breaks down misfolded proteins, the ubiquitin-proteasome system (UPS), and chaperones, which protect proteins from aggregating. Neuronal impairment and cell death are the outcomes of these proteolytic systems being less active or saturated(2). During the previous 30 years, the total number of patients has increased significantly. Furthermore, during the next 20 years, it is anticipated that the burden of chronic neurodegenerative disorders would at least double. Keeping neurological care affordable for everybody will be extremely difficult in light of this evolution, which is mostly due to the growing aging population. Prominent organizations like the World Health Organization and the National Health Service of the United Kingdom have already made reference to these dangers by releasing the concerning statements that "neurological services are not sustainable in their current form and redesign is needed" and "available resources for neurological services are insufficient in most countries of the world compared with global need for neurological care (3).The extremely effective blood–brain barrier (BBB) nevertheless poses a significant obstacle to the proper management of NDs. Although numerous successful procedures and extremely evasive approaches have been established, their clinical adoption is limited because of differing concerns regarding their long-term value due to possible brain barrier injury. Nanotherapeutics having the ability to pass the blood-brain barrier (BBB) without causing damage to it have been suggested and shown to be a viable alternative for stopping or reversing neurodegeneration in many cases(4)(5)Even with this tremendous advancement, nanotherapeutics still require improvement to guarantee the best possible results. The pathophysiology of major NDs and their current therapeutic approaches are first described in this study. We also talk about the BBB's function and other difficulties with brain-targeted medication administration. We also examine the possible application of nanotherapeutics in the prevention and treatment of neurodegeneration. Lastly, we go over recent developments and discoveries in the field of nanotherapeutics to manage NDs and offer insights for potential future uses(6)

NEURODEGENRATIVE DISEASE

Neurons are essential to the human brain's healthy operation, Because they are essential for communication(7)(8).The majority of neurons are produced by neural stem cells throughout childhood; in contrast, adult neurons are much fewer in number. Neurodegeneration, the progressive loss of neurons, their structure, and/or their activities, is a major health problem and a key factor in the pathogenesis of various brain illnesses,despite the fact that neurons are not eternal. Dysfunction of the neuronal network, synapses, and the accumulation of physiologically modified protein variations in the brain are linked to neurodegenerationFIG 1. (9). Major and most common neurodegenerative diseases are: Alzheimer's disease, Ataxia, Huntington's disease, Parkinson's disease, Motor neuron disease, Multiple system atrophy, Progressive supranuclear palsy (10), Gerstmann –Sträussler– Scheinker disease, Familial British dementia, Familial British dementia, Primary age-related tauopathy, Pick's

disease, Corticobasal degeneration, Argyrophilic grain disease, Aging-related tau astrogliopathy, Lewy body disorders, Multiple system atrophy, Frontotemporal lobar degeneration, Amyotrophic lateral sclerosis, Primary lateral sclerosis, Progressive muscular atrophy(11). Common symptoms Breathing, Heart function, Memory and cognitive abilities, Mood,Bladder and bowel function, Blood pressure fluctuation, Speech, Mobility and balance, Abnormal movements, Swallowing, Sleep. The two most prevalent neurodegenerative disorders are Parkinson's and Alzheimer's. According to a 2022 forecast from the Alzheimer's Disease Association, there could be as many as 6.2 million Americans living with Alzheimer's.

ALZHEIMER'S DISEASE

Alzheimer's disease (AD) is becoming more common and society is getting older, there is a lot of interest in the disease from researchers. One of the most persistent types of neurodegenerative illnesses, AD gradually worsens over time, leading to brain atrophy and eventual death. Over 60 is the age at which most AD patients present, and it is also the age at which considerable brain mass loss   and age-related astrocyte death are linked(12).The latest research on AD's basic pathophysiology and neuropathology indicates that intracellular Tau neurofibrillary tangles (NFTs) and extracellular amyloid plaques are the main histopathologic lesions of the disease(13).The two neuropathological hallmarks of AD are intracellular Tau neurofibrillary tangles (NFTs) and external Aβ plaques. The primary component of the plaques is the neurotoxic peptide amyloid (Aβ), which is produced when two enzymes, β-secretase (also referred to as BACE1) and γ-secretase (which involves four proteins, including presenilin), sequentially cleave a big precursor protein, or APP. However, if α-secretase rather than β-secretase acts on APP first and cleaves it, then Aβ is not generated. Tau, a microtubule-associated protein (MAP) that binds microtubules in cells to support the neural transport system, makes up the majority of NFTs(14).The typical feature of AD has been identified as the development of Aβ-containing plaques inside the brain associated with hyperphosphorylated tau-based neurofibrillary tangles (NFTs)(15)(16)(17).AD is characterized by a large loss of neurons, abnormal synaptic connections, and impairment of the key neurotransmitter systems required for memory and other brain functions (18).

PARKINSON'S DISEASE

Parkinson's disease (PD) is a chronic, progressive and age-related neurodegenerative disease affecting seven million people globally it is the second most common neurodegenerative disorder after Alzheimer's disease (AD)(19).The main cause of Parkinson's disease is the progressive degeneration of brain cells in the substantia nigra. The generation of dopamine occurs in this region. Dopamine functions as a chemical messenger, facilitating the coordination of activity between two distinct brain regions. For instance, it links the corpus striatum to the substantia nigra to control muscular contraction. When dopamine levels in the striatum are low, the nerve cells in this area "fire" erratically. This renders the person incapable of controlling or directing their motions. This results in the onset of Parkinson's disease symptoms. A more severe mobility disorder results from the disease's progressive degeneration of other brain and nervous system regions. We Exactly don't know the precise reason for the cell loss. Environmental and genetic factors are also potential causes.

HUNGSTONDISEASE

Huntington's disease (HD) is an incurable neurological condition sometimes referred to as Huntington's chorea (20). The first signs are frequently mild issues with mood or cognitive/psychiatric functioning. An unstable walk and a general lack of coordination frequently ensue. It is also a condition of the basal ganglia that results in chorea, a hyperkinetic movement disorder. The uncontrollable, involuntary body movements associated with chorea become more noticeable as the illness worsens. The person's physical capabilities progressively deteriorate until they are unable to move with coordination and speak. Mental capacities typically deteriorate into impulsivity, despair, apathy, and dementia throughout time. The particular symptoms differ slightly from person to person. Although they can start at any age, symptoms typically appear around the age of 40. They typically start between the ages of 30 and 50. With every subsequent generation, the illness can manifest earlier. Juvenile HD cases, which make up around 8% of all cases, usually begin before the age of 20, and they are characterized by slow movement symptoms that are more common in Parkinson's disease than in chorea. The hunting tin gene mutation that causes HD is usually

inherited from an affected parent (HTT).Up to 10% of cases, nevertheless, are brought on by novel mutations.The huntingtin protein's genetic makeup is determined by the huntingtin gene (HTT).The huntingtin protein gene produces an aberrant mutant protein (mHtt) when the cytosine-adenine-guanine (CAG) repeats expand (a process referred to as a trinucleotide repeat expansion). This abnormal mutant protein causes progressive brain cell death through a variety of potential pathways.Genetic testing is used for diagnosis, and it can be done at any moment, even in the absence of symptoms.This fact brings up a number of moral questions, such as when a person is deemed mature enough to decide whether to undergo testing and whether parents should have testing their kids; maintaining test-taker privacy and results disclosure(21).

COMPLEXITIESOF THE DRUG ADMINISTRATION BECAUSE OF BBB

When it comes to interacting with the central nervous system, the blood-brain barrier (BBB) is crucial. It is widely recognized that the BBB, which prevents the central nervous system from receiving a range of potentially beneficial therapeutic and diagnostic compounds, is the main obstacle to effectively treating neurological illnesses. Additionally, it restricts the free movement of neurotransmitters among brain cells(22). The major BBB constituents (FIG 2)include endothelial cells, astrocytic end-foot connections, basal lamina, tight junctions, and pericytes (23) (24).By keeping peripheral circulation from the central nervous system intact, it is feasible to stop hazardous substances from getting into the brain. The blood-brain barrier (BBB) uses passive transport to carry out filtering functions and allow some substances—like water, nutrients, and hydrophobic compounds—to flow through. The blood-cerebrospinal fluid barrier (BCSFB) complicates the central nervous system and provides additional obstacle to treatment. Comprising ependymal cells, the choroid plexus acts as a barrier in the brain by keeping blood apart from cerebrospinal fluid (CSF). When it comes to inefficient medication absorption into the brain, the BBB and other efflux transporters are essential. Numerous ATP-dependent efflux transporters are present in the BBB. The over expression of tight junctions and active efflux mechanisms in the BBB also hinder medications from accomplishing their intended therapeutic goal. An ABC transporter called P-glycoprotein (P-gp) effectively excretes medications from the brain and pumps them bac into circulation (25)

MODERN TECHNIQUES FOR NEURODEGENERATIVE DISEASE DIAGNOSIS AND TREATMENT

The Assessment of Neurodegenerative Diseases

Timely identification of neurodegenerative illnesses is critical to the efficacy of a given therapy in slowing down their course. Treatment can be started before the onset of severe clinical symptoms and can be considerably delayed by early detection through screening. Pre-clinical evaluation has emerged as a key area of interest for neurodegenerative disease research in recent years (26; 27). Behavioral symptoms, biomarkers from blood and cerebrospinal fluid, neuroimaging data (PET and MRI), brain conductivity and electrical activity (TMS and EEG), and the outcomes of neuropsychological tests may all be considered in the evaluation. Differential diagnosis is frequently necessary for diseases such as depression that may lead to a potentially reversible deterioration in cognitive function.(28).As a result, there are a lot of markers and criteria that are determined instrumentally. The limited specificity of individual assessment techniques and markers is a characteristic shared by the majority of neurodegenerative illnesses. This frequently results in the difficulty to determine the accurate diagnosis without extensive and frequently expensive testing(29). Below we have enlisted the main diagnostic methods that are used for treatment as well as to monitor neurodegenerative disease (30).Biomarkers in Blood and Cerebrospinal Fluid, Psychological and Neuropsychological Assessment, Neuroimaging, Connectivity, Electrical Activity of the Brain, Pharmacological Therapy, Cognitive Training, Physical Exercises, Ergotherapy, Brain Stimulation, Prevention of the Associated Psychological Problems(30).

Drug delivery for CNS via nanocarriers

The finding that hydrophobic dyes diffuse through a silicone tube wall at a consistent rate by Folkman and Long spurred the development of synthetic polymers for the controlled release of medicinal medicines (31)(32). Among the methods used, nanotechnology has shown to be a secure and effective platform for targeted gene or medication delivery to the central nervous system(33,34). To create nanoparticles, a range of materials have been used, including

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inorganic minerals like cerium, silver, and gold, and synthetic materials like PLGA and PCL. Natural polymers like proteins and polysaccharides have also been used. It has been demonstrated that nanocarriers are excellent medication and gene carriers for the brain(35). Different sizes, characteristics, and purposes of nanoparticles have been produced for the delivery of drugs to the brain shows. However, the size, type, polarity, and surface chemistry of the nanocarriers determine how well they penetrate the BBB. Furthermore, the polysorbate surface coating can aid in avoiding transmembrane efflux systems like P-glycoprotein pumps (36). Here we have mentioned the classification of the nano carriers; (FIG 3) Thus, the creation of polymer therapies and nanomedicines that can get past CNS obstacles and be administered systemically would be a significant progress has been made in the diagnosis and treatment of brain cancer, trauma, and neurodegenerative diseases. Many polymer-based medicines include available for purchase or undergoing clinical testing for the treatment of cancer and other illnesses(37,38).

Novel self-assembled nanomaterials are being used by a new generation of nanomedicines to deliver drugs and genes . As an illustration, consider polymeric micelles , block ionomer complexes , DNA/polycation complexes (also known as "polyplexes") , nanogels , and other substances. Polymeric micelles have been used in human studies as one of these materials to deliver anti-cancer medicines . Polymeric micelles have been used in human studies as one of these materials to deliver anti-cancer medicines . The encouraging outcomes based on these experiments, polymeric micelles are probably going to be useful in medicine. Furthermore, new nanomaterials with distinct spatial orientations of chemical groups, such as dendrimers , star-polymers , and cross-linked polymer micelles , have been developed as a consequence of additional developments in polymer chemistry. Taking into consideration, nanomedicines have surfaced, helping to enhance medication and diagnostic agent delivery to disease target areas as well as trigger release.Furthermore, they can target a specific cell or even an intracellular compartment in addition to an organ or tissue. These systems have many features in common with natural carriers like viruses and serum lipoproteins, including size and structure, and they can be used to deliver therapeutic and imaging chemicals to the central nervous system. The following list includes some particular instances of nanomaterials that were tested for brain delivery or showed promise for such uses(39).

NANOEMULSIONS
An advanced delivery method for medications, biologically active chemicals, and genetic materials with release issues is nanoemulsion preparation. given that 40% of chemical compounds are inherently insoluble in water, making it difficult to transport these hydrophobic chemicals. A colloidal dispersion with an acceptable ratio of oil emulsified in the aqueous phase, surfactant, and co-surfactant is known as a nanoemulsion. Clear, thermodynamic, and kinetically stable nanoemulsion. It is employed in the pharmaceutical industry because it improves the solubility of lipophilic medications, which improves their bioavailability by reducing the particle size of powdered drugs and forming nano-sized droplets with a range of 10-100 nm(40). NEs are colloidal dispersions with scattered droplets that range in diameter from 20 to 500 nm, made up of two immiscible liquids stabilized by surface-active chemicals(41).
One or more emulsifiers are used to stabilize nanoemulsions, which are nano-sized emulsions made up of two immiscible phases (oil and water)(42,43,44). NEs are divided into two types based on their appearance and the dispersed phase diameter: milky (up to 500 nm) and transparent or translucent (50–200 nm). Furthermore, contingent upon constituents, both internal and exterior stages, Biphasic NEs (oil-in-water (O/W) or water-in-oil (W/O)) and multiple NEs (W/O/W) are the two primary forms of NEs. The NE droplet number and system stability are determined by the phase:volume ratio (F), which is the relative volumes of the internal and exterior liquids.

In general, the internal phase is the phase that is present at a smaller volume than the continuous phase. Phase inversion of a W/O NE to an O/W one might occur when F increases over 40%(45). A clear definition of nanoemulsions is not always clear in the literature, as they are sometimes confused with spontaneously forming thermodynamically stable microemulsions(46,47). (FIG 4) .illustrates, the primary distinctions between classical emulsions (also known as macroemulsions), nanoemulsions, and microemulsions are in the stability characteristics and droplet size range. Both macroemulsions and nanoemulsions exhibit thermodynamic instability, meaning that phase separation happens when enough time passes. On the other hand, nanoemulsions—also called "miniemulsions"—can be kinetically stable over extened periods of time due to their small size. The proximity to an

equilibrium state has no bearing on the metastability of nanoemulsions. However, microemulsions are sensitive to composition and temperature changes because they are systems that are thermodynamically stable in equilibrium. Since they are comparatively the least susceptible to changes in both physical and chemical properties, nanoemulsions are appealing for the aforementioned applications. The differences between nanoemulsions and microemulsions have been elucidated by two recent investigations, and These publications, which describe the distinctions between these two classes of liquid-in-liquid dispersions, are recommended reading for interested readers(48).

COMPONENTS OF NANOEMULSION (FIG 5)

OIL
Since the medication will be added as a droplet in the oily phase and distributed in the aqueous phase, the oil choice employed in the nanoemulsion formulation is thought to be a crucial component. In order to obtain a larger percentage of medicine loaded, the oil chosen needs to be compatible with the other components of the nanoemulsion as well as able to dissolve the compounds employed in the dosage form. The oil used in nanoemulsion might be synthetic, semi-synthetic, or natural(48).

Surface-active agent, or surfactant
Surfactants are compounds that act upon a solid-liquid interface to reduce surface tension and interfacial tension.Surfactants have several functions such as emulsifier, foaming agent, wetting agent, detergent, and dispersant, based on the value of the hydrophilic-lipophilic balance (HLB). Surfactant is used in the preparation of nanoemulsion to stabilize the system; the type of surfactant used depends on the type of nanoemulsion to be prepared. For o/w nanoemulsion, hydrophilic surfactants with an HLB value greater than 10 are utilized, whereas hydrophobic surfactants with an HLB value less than 10 are utilized for w/o nanoemulsions. the employment of surfactant combinations with high and low HLB values, which, when diluted with water, generate a stable nanoemulsion.(49).

Co-Surfactant
When the surfactant was unable to reduce the interfacial tension between oil and water, these components were added to the nanoemulsion formulation. Furthermore, it introduced some fluidity into the surfactant's high stiffness interfacial tension by infiltrating the surfactant's monolayer and upsetting its crystalline liquid phase; PEG 400, propylene glycol, and poly glyceryl oleate are examples of co-surfactant(50)

FORMATION
The preparation of nanoemulsions involves two steps: the first phase involves creating a macroemulsion, which is subsequently transformed into a nanoemulsion. This section outlines the several techniques that have been developed over the last ten or so years to prepare nanoemulsions and highlights the advancements that have been made in the prediction and control of nanoemulsion droplet size(51).

METHOD OF PREPARTION
One of two methods—high energy dissipation or low energy dissipation—can be used to prepare nanoemulsions. The energy requirements of these two approaches are different. Large disruptive forces are produced by mechanical devices in the high energy approach**.** Whereas, low energy method alters the physiochemical properties of the system to generate nanosized particles(52). Because temperature-sensitive components, such medicinal chemicals, are needed, low-energy technologies have recently gained popularity(53).

High-energy emulsification method
Since a nanoemulsion cannot form spontaneously and requires the application of chemical or mechanical energy to formulate, it is regarded as a non-equilibrium system. High-energy method of preparing nanoemulsion by employing mechanical energy input with high-pressure homogenizers, high shear stirring, and ultrasound

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generator(54). The high energy methods are most effective when applied to highly viscous and high molecular weight oils, although they can be used to generate nanoemulsions from any type of oil. This approach uses less surfactants and makes choosing a surfactant easier. However, because the components in this approach are heat sensitive, it appears to be inconvenient for drug delivery systems(55).

Low energy
The low energy approach is used to prepare nanoemulsions by harnessing the system's own chemical energy or the chemical potential of its constituent parts. The behavior observed with low energy methods is thought to be caused by the chemical energy produced during the emulsification process. This results from a shift in the surfactant molecules' spontaneous curvature, which can go from positive to negative (w/o) or from negative to positive (o/w)(56). This technique involves D phase emulsification, microemulsion dilution, phase inversion temperature, spontaneous emulsification, and phase inversion composition. The low-energy approach uses only a slower stirring speed (1600 rpm), which uses less energy. Low energy methods are categorized as thermal and isothermal methods in theory. Thermally sensitive bioactive substances are best suited for isothermal techniques(57).

NANOEMULSIONS ADMINISTRATION WITH VARIOUS ROUTES
Nanoemulsions may enter the body via different routes oral, parenteral, transdermal, intranasal. The transportation of the intended drug concentrations to the site of action is the main goal of these drug delivery mechanisms. Moreover, medications might have their metabolic breakdown reduced and their physical clearance reduced (FIG 5). provides an overview of drug transport. Because it avoids first-pass metabolism, has a large surface area, a porous endothelium membrane, and a high total blood flow, highly permeable nasal epithelium facilitates fast drug absorption to the brain. Numerous therapeutic substances (small and large molecules) can be administered to the central nervous system (CNS) via intranasal administration. Numerous medications have demonstrated superior CNS efficacy when administered nasally, requiring lower dosages to provide the desired therapeutic effects. Moreover, nasal medication distribution doesn't need any neither demands that the medication be combined with a carrier nor alter the therapeutic agent. Pharmaceutical and medical device companies have long prioritized the development of nasal medication delivery systems because they provide significant advantages over alternative drug administration methods(58). Over the past few decades, nasal drug delivery—in which the medication is directly given to the brain via the trigeminal and olfactory pathways—has attracted a lot of attention for brain targeting. Different innovative and promising formulation strategies have been investigated for nasal delivery of drugs that target the brain.(58). The nose-to-brain delivery method has been investigated as a potential treatment for central nervous system illnesses for the last 20 years(59). Because of its high vascularization, nasal medication administration was previously often utilized for both local and systemic therapy(60). Subsequently, researchers discovered that improved brain targeting of medications may be achieved by utilizing the direct link between the brain and nose cavity through olfactory and trigeminal neurons. W. H. Frey II discovered the idea of nose-to-brain medication delivery in 1989(61). (FIG 7) elaborates on the transport pathway from nose to brain.
Here we will see different pathways of intranasal drug delivery (FIG 6)

INTRANASAL ROUTE OF ADMINISTRATION
Finding the appropriate medical therapies for a variety of different neurological conditions can be greatly aided by an understanding of the mechanisms that regulate the blood-brain barrier during health and how they change during disease . A few scientists have accurately illustrated these differences in their findings. Neurodegenerative disorders are a group of major neurological pathologies that include infections of the nervous system, Parkinson's disease, Alzheimer's disease, multiple sclerosis, extended age-related neurological illnesses, cerebral ischemia, and others. According to health data, the frequency of CNS disorders is rapidly increasing worldwide, as are medical expenses. The drug can be infused intracerebrally with mini-pumps, administered via focused ultrasound, intra-cerebroventricular or intra-parenchymal infusions, catheter infusions, focused ultrasound approaches, or external magnetic field-based methods for direct brain delivery. However, considering the need for surgical therapy, all of these treatments are exceedingly intrusive and risky. and many of them are unsuitable in circumstances where several or ongoing therapies are involved. Owing to these reasons, several attempts have been made to create

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strategies for getting active substances where they need to go without using the blood-brain barrier. A strategy for brain targeting includes both the use of non-traditional administration methods and the development of drug formulations with properties optimal for the best possible administration through these channels. Intra-nasal drug administration is a pleasant, non-invasive way to deliver medication into the brain by getting beyond the blood-brain barrier. Such drug delivery system paths have a number of advantages, such as increased patient compliance, superior safety, remarkable simplicity of administration, rapid commencement of action, and less systemic exposure. Furthermore, when medications are delivered via the nasal mucosa, they can avoid the liver's first-pass processing. As a result, nasal dosages usually have 10 times lower potency than oral ones. Therefore, for delivering medications directly to the brain, nasal drug administration is more promising than oral or intravenous drug delivery.(62)

OLFACTORY PATHWAY
It is well known that the olfactory area, which is located on the nasal cavity's roof, may be used as a nose-to-brain drug delivery pathway to treat a variety of CNS disorders(63). It is well known that the olfactory area, which is located on the nasal cavity's roof, may be used as a nose-to-brain drug delivery pathway to treat a variety of CNS disorders(64). Drugs can be transferred by neurons, passive diffusion, endocytosis, or sluggish movement across the narrow interstitial space between cells to traverse olfactory epithelium cells. The majority of medicines that are deposited on the olfactory area go between cells extracellularly. A number of experimental in-vitro and in-vivo findings suggested that P-glycoprotein has a clinical role in the administration of intranasal drugs. In addition, tests of drug penetration efflux transporter substrates at the nasal barrier in RPMI 2650 cells and 3D MucilAirTM nasal models have been conducted in vitro. When taking drugs intranasally, olfactory neurons play a crucial role in directing the drug's delivery to the brain(65). Human olfactory axon diameter ranges from 0.1 to 0.7 μm, suggesting that chemicals or nanoparticles with similar dimensions can be easily transported via this channel(66). Compared to axonal transport, drug transport via the epithelial route is quicker. There are two ways that drugs are transported through olfactory pathways: extracellular and intracellular. medicines that are hydrophilic are transported through the paracellular pathway, but the majority of lipophilic medicines are carried by passive diffusion. Medicines' molecular weight and lipophilicity have a big impact on how they absorb medications. Drugs with extremely high lipophilicity are most relevant to the transcellular mechanism(67).

TRIGEMINAL SENSORY NERVE PATHWAY
There is less research on the trigeminal route for medication transfer from the nose to the brain. The trigeminal nerve's primary job is to transmit chemosensory and thermosensory data to the mucosa of the nose, mouth, and eyes (68,69). The dorsal nasal mucosa, which connects to the frontal brain and olfactory bulb, is innervated by the trigeminal nerve(70). As a result, one possible route for medication transport from the nasal cavity to the brain is the trigeminal nerve pathway. For example, the brain was supplied with a solution of insulin-like growth factor 1 via the olfactory and trigeminal pathways(71).

LYMPHATIC PATHWAY
Several extracellular routes, including lymphatic, perineural, and perivascular channels, can carry drugs from the submucosal region of the olfactory region. These extracellular routes connect to the olfactory nerves that enter the brain's olfactory bulb from the lamina propria(72,73).

SYSTEMATIC PATHWAY
The systemic pathway is an indirect transport system from the nose to brain, and it can be a promising approach for lipophilic drugs with low molecular weights(74,75). Following absorption by the vascular areas of the nasal mucosa's epithelial membrane and the lymphatic system, drugs are then transferred to the systemic circulation, evading first-pass metabolism. (76,77).

SIGNIFICANT FACTORS OF NANOEMULSIONS FOR NOSE-TO-BRAIN DELIVERY
Numerous studies have demonstrated that nasal epithelial cells (NEs) provide superior medication penetration to the brain compared to oral drug delivery methods. In addition to the surfactant and cosurfactant properties that enhance

drug absorption, NEs have other important characteristics that are specifically designed for brain targeting.(78). These are some of the main characteristics of the NEs.

Globule size

Drug penetration via the nasal cavity is significantly influenced by the globule size of the NE. As previously mentioned, the main pathways for nasal medication delivery to the brain are the olfactory and trigeminal transport routes. In many preclinical species, the typical diameter of an olfactory axon is about 200 nm; however, in humans, it can vary from 100 to 700 nm. Therefore, for optimal drug penetration, the globule size of new formulations should be less than 200 nm. According to Ahmad et al., through the olfactory route, NEs with an average globule size of 100 nm showed a higher rate and extent of drug absorption than NEs with an average globule size of 700 nm.(79). Furthermore, the length of time that the formulations remain on the nasal mucosa is influenced by the globule size of the NE. Compared to larger globule NEs that are easily eliminated during nasal clearance, formulations with smaller globule sizes have longer retention durations, which results in decreased drug absorption(80). For instance, NEs may show retention periods of up to 4 hours following intranasal delivery if their typical globule diameters are greater than 200 nm, although NEs with globule sizes of 80 and 200 nm have shown retention times of 16 and 12 h, respectively. Hence, globule sizes of nanoemulsions play a significant role for drug delivery to the brain through intranasal administration(81).

Zeta potential

The colloidal balance of NE is attached to the zeta ability of the advanced formulations. For any colloidal system, zeta potential values exceeding ±30 mV provide electrostatically stabilized systems(82). Moreover, numerous reviews have proven that the zeta ability has a giant function with inside the drug retention time of the NE formulations. Mucin found in the nasal mucosa bears a negative charge; hence, formulations carrying positive charges depict good attachment to the nasal mucosa(83).Several research have proven that, usually, maximum of the nasal NEs advanced for mind transport undergo bad charges. The values of zeta capacity better than −10 mV of the emulsion imply the instability of NEs. Therefore, zeta potential is also an important consideration in the development of NEs for nose-to-brain delivery(84).

Advantages

- Patient self-administration
- direct distribution from nose to brain
- non-invasive medication administration
- Quick start of action
- high adherence from patients
- Degradation of drugs is reduced
- elevated absorption rate

Disadvantages

- Drug eradication
- Low bioavailability
- Limited dose

Advancements in nasal medicine delivery systems, including nasal sprays, have made significant progress. However, these systems have drawbacks like incorrect dosage and inadequate administration depth. New drug delivery technologies like nanoparticles and nanofibers are being explored. This review provides an analysis of the benefits and drawbacks of these delivery methods (85)

CONCLUSION

Neurodegeneration is a complex, multifaceted process that causes neuronal death, which leads to damage and malfunction of the brain and spinal cord. This article provides an overview of neurological disorders, the difficulties in administering medications because of the blood-brain barrier, and methods for improving the delivery of nanomedicines to the brain using a variety of routes based on nasal targeting. Several studies have demonstrated that these nanomedicines, when delivered intranasally with appropriate procedures, exhibit good therapeutic efficacy. Nevertheless, nose-to-brain drug administration using nanotechnology delivery devices is still in its infancy as a therapeutic application. Formulations known as nanoemulsions are becoming more andmore significant in the field of nanomedicine. Their properties (high surface area nanodroplets) make them appropriate for transport from the nose to the brain. As per the reviewed data, the method of preparation suited for nanoemulsion is low energy methods. Since low-energy methods use less energy, are more efficient, and don't require complex apparatus, they should be chosen over high-energy methods. However high energy methods are more favorable for food-grade emulsions as they require lower quantities of surfactant than low energy methods. As shown by Table 1, there are many examples in the literature of recent years of nanoemulsion-loaded drugs with different therapeutic goals in brain diseases. The pathologies are all vital and serious; lots of those diseases, if now no longer handled effectively, can lessen the nice of lifestyles or maybe cause death. Nanoemulsions for nasal administration represent a promising strategy for nose-to-brain drug delivery and achieving CNS targeting for the treatment of neuro diseases. The major routes for the administration of drugs using these vehicles, viz., oral, parenteral, transdermal, and intranasal channels, have been reviewed here, where we concluded the intranasal route was more potent.

DISCUSSION

This article provides an overview of neurological disorders, the difficulties in administering medications because of the blood-brain barrier, and methods for improving the delivery of nanomedicines to the brain using a variety of routes based on nasal targeting. Several studies have demonstrated that these nanomedicines, when delivered intranasally with appropriate procedures, exhibit good therapeutic efficacy. Formulations known as nanoemulsions are becoming more andmore significant in the field of nanomedicine. Their properties (high surface area nanodroplets) make them appropriate for transport from the nose to the brain. As per the reviewed data, the method of preparation suited for nanoemulsion is low energy methods. Since low-energy methods use less energy, are more efficient, and don't require complex apparatus, they should be chosen over high-energy methods. However high energy methods are more favorable for food-grade emulsions as they require lower quantities of surfactant than low energy methods. .Nanoemulsions for nasal administration represent a promising strategy for nose-to-brain drug delivery and achieving CNS targeting for the treatment of neuro diseases. The major routes for the administration of drugs using these vehicles, viz., oral, parenteral, transdermal, and intranasal channels, have been reviewed here, where we concluded the intranasal route was more potent.

List of Abbreviation
WHO: World Health Organization
AD: Alzheimer's Disease
PD: Parkinson's Disease
ALS:Amyotrophic Lateral Sclerosis
FTD: Frontotemporal Dementia
HD: Huntington's Disease
PQC: Protein Quality Control
UPS: Ubiquitin-Proteasome System
BBB: Blood–Brain Barrier
Nds: Neurodegenrative Diseases

(Nfts): Neurofibrillary Tangles
MAP: Microtubule-Associated Protein
HTT: Huntingtin Protein
Mhtt: Mutant Huntingtin Protein
CAG: Cytosine-Adenine-Guanine
BCSFB: Blood-Cerebrospinal Fluid Barrier
(P-Gp): P-Glycoprotein
CSF: Cerebrospinal Fluid
PET: Positron Emission Tomography
MRI: Magnetic Resonance Imaging
TMS: Transcranial Magnetic Stimulation
EEG: Electroencephalography
PLGA: Poly Lactic-*Co*-Glycolic Acid
PCL: *Polycaprolactone*
DNA: Deoxyribonucleic Acid
HLB: Hydrophilic-Lipophilic Balance
O/W: Oil In Water
W/O: Water In Oil
W/O/W: Water Oil Water
NE: Nanoemulsions
PEG: Poly Ethylene Glycol
CNS: Central Nervous System

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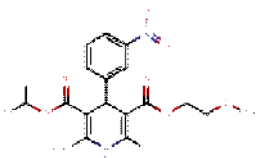
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Table 1: Intranasal Route Nanoemulsions (101,102)

Nanoemulsions (intranasal)	Structure	Target	Approval
Nimodipine		**Voltage-dependent L-type calcium channel subunit alpha-1C,1D,1F,1S; Voltage-dependent L-type calcium channel subunit beta-1,2,3,4; Mineralocorticoid receptor; Aryl hydrocarbon receptor**	• NIMODIPINE (NIMODIPINE) | ANDA #076740 | CAPSULE;ORAL | Prescription | BIONPHARMA • NIMODIPINE (NIMODIPINE) | ANDA #077067 | CAPSULE;ORAL | Discontinued | SUN PHARM INDS INC • NIMODIPINE (NIMODIPINE) | ANDA #077811 | CAPSULE;ORAL | Prescription | HERITAGE PHARMS • NIMODIPINE (NIMODIPINE) | ANDA #090103 | CAPSULE;ORAL | Prescription | THEPHARMANETWORK LLC • NIMODIPINE (NIMODIPINE) | ANDA #201832 | CAPSULE;ORAL | Discontinued | SOFGEN PHARMS • NIMODIPINE

			(NIMODIPINE)	ANDA #213409	SOLUTION;ORAL	None (Tentative Approval)	ALKEM LABS LTD
Resveratrol		Tyrosine--tRNA ligase, cytoplasmic; RAC-alpha serine/threonine-protein kinase; Carbonyl reductase [NADPH] 1; Prostaglandin G/H synthase 1; Prostaglandin G/H synthase 2	**Not regulated by FDA**
Selegiline		Amine oxidase (flavin-containing B , A)	• SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE)	NDA #019334	TABLET;ORAL	Discontinued	SOMERSET • SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE)	ANDA #074537	TABLET;ORAL	Discontinued	G AND W LABS INC • SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE)	ANDA #074565	TABLET;ORAL	Discontinued	CHARTWELL MOLECULES • SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE)	ANDA #074641	TABLET;ORAL	Discontinued	CHARTWELL MOLECULES • SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE)	ANDA #074672	TABLET;ORAL	Prescription	I3 PHARMS

			• SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE) | ANDA #074744 | TABLET;ORAL | Discontinued | COSETTE
			• SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE) | ANDA #074756 | TABLET;ORAL | Discontinued | COSETTE
			• SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE) | ANDA #074866 | TABLET;ORAL | Discontinued | DASH PHARMS NATCO
			• SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE) | ANDA #074871 | TABLET;ORAL | Prescription | APOTEX INC
			• SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE) | ANDA #074912 | TABLET;ORAL | Discontinued | BAYSHORE PHARMS LLC
			• SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE) | ANDA #075145 | CAPSULE;ORAL | Discontinued | LANNETT CO INC
			• SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE) | ANDA #075321 | CAPSULE;ORAL | Prescription | APOTEX
			• SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE) | ANDA
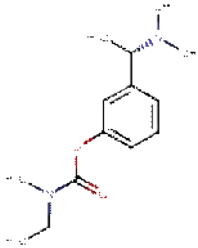
			#075352 | CAPSULE;ORAL | Prescription | NOVITIUM PHARMA • SELEGILINE HYDROCHLORIDE (SELEGILINE HYDROCHLORIDE) | ANDA #206803 | CAPSULE;ORAL | Prescription | RISING
Rivastigmine		**Acetylcholinesterase; Cholinesterase**	• RIVASTIGMINE (RIVASTIGMINE TARTRATE) | ANDA #077363 | SOLUTION; ORAL | None (Tentative Approval) | RANBAXY • RIVASTIGMINE (RIVASTIGMINE) | ANDA #204403 | FILM, EXTENDED RELEASE;TRANSDERMAL | Prescription | ALVOGEN • RIVASTIGMINE (RIVASTIGMINE) | ANDA #205622 | FILM, EXTENDED RELEASE;TRANSDERMAL | Prescription | MYLAN TECHNOLOGIES • RIVASTIGMINE (RIVASTIGMINE) | ANDA #206318 | FILM, EXTENDED RELEASE;TRANSDERMAL | Prescription | ZYDUS PHARMS • RIVASTIGMINE (RIVASTIGMINE) | ANDA #207308 | FILM, EXTENDED RELEASE;TRANSDERMAL | Prescription | AMNEAL PHARMS • RIVASTIGMINE (RIVASTIGMINE) | ANDA #209063 | FILM, EXTENDED RELEASE;TRANSDERMAL | Prescription | BRECKENRIDGE

Table:2 Neurodegenerative Disease-Related Nanoemulsions

Disease	Drug	Study model	Reference
Alzheimer disease	Memantine	Male SD rats	**(85)**
	Donepezil	In vitro drug diffusion study. Ex vivo drug permeation study. Tolerability study through in vitro and in vivo models.	**(86,87)**
	Rivastigmine	pharmacokinetic and biodistribution study in rat	**(88)**
Lactoferrin-modified Nanoemulsions	Huperzine A	Male Wistar rats	**(89)**
Parkinson's disease	Resveratrol	Wistar rat's brain.	**(90)**
Trimethyl chitosanmodified Nanoemulsion	Ropinirole-dextran Sulfate	Female Swiss albino mice	**(91)**
	Selegiline	Behavioral activities of Parkinson's disease in Wistar rats.	**(92)**
Epilepsy	Letrozole	In vitro and ex vivo drug release study. A behavioral seizure; biochemical and histopathological studies were performed.	**(93)**
Antiepileptic	Amiloride	Wistar rats	**(94)**
Migraine	Zolmitriptan	In vitro mucoadhesion study. Ex vivo drug permeation studies. In vivo pharmacokinetic and biodistribution studies.	**(95)**
	Rizatriptan	In vitro drug diffusion study. Nasal irritation study on sheep nasal mucosa. In vivo brain-targeting potential.	**(96)**
Neuroprotective	Cyclosporine-A	In vitro drug diffusion study. In vivo brain uptake study.	**(97)**
Neuroprotective and anti-tumor	Kaempferol	Ex vivo diffusion study. In vivo drug biodistribution study in Wistar rats.	**(98)**
Antipsychotic	Ziprasidone hydrochloride	Ex vivo diffusion study. In vivo pharmacodynamic study in Wistar rats. Nasal ciliotoxicity studies in goat nasal mucosa.	**(99**)
Antipsychotic	Quetiapine	In vitro dissolution study. In vivo drug distribution study in Wistar rats.	**(100)**

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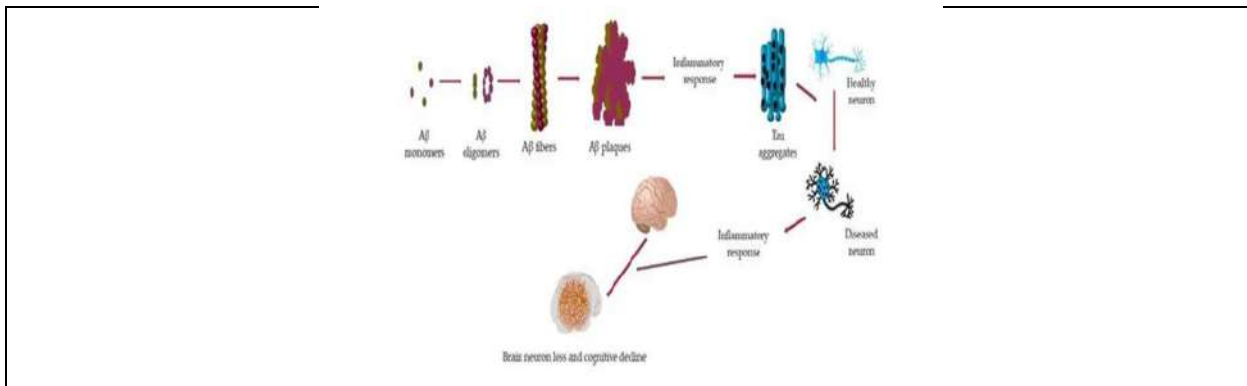
FIG 1. Path to cognitive decline in neurodegeneration. Amyloid-beta (Aβ) monomers clump together to form oligomers of variant structures. Subsequently, the oligomers aggregate to form Aβ fibers, which misarrange to form Aβ plaques. Plaque formation induces an inflammatory response which includes the formation of tau aggregates leading to the conversion of healthy neurons to diseased neurons. The presence of more diseased neurons triggers another inflammatory response leading to more neuron loss and a subsequent loss in brain function as well as cognitive decline.
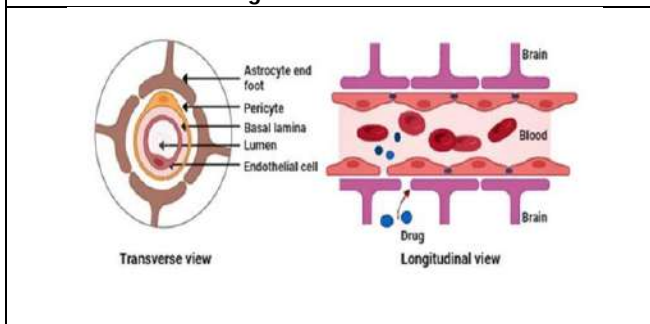
FIG 2. The constituents of blood brain barrier

FIG 3. Classification of nanocarriers

FIG4. The figure compares the size, shape, stability, preparation method, and polydispersity of macroemulsions, nanoemulsions (also known as miniemulsions), and microemulsions. Because of their smaller size, macroemulsions have a lower surface area per unit volume than do nanoemulsions and microemulsions. Furthermore, nanoemulsions have a high degree of kinetic stability, which makes them less susceptible to chemical and physical changes.

FIG 5. Components of nanoemulsion

FIG 6. Pathways of intranasal drug delivery

FIG 7. Transport pathways of drugs from nose-to-brain

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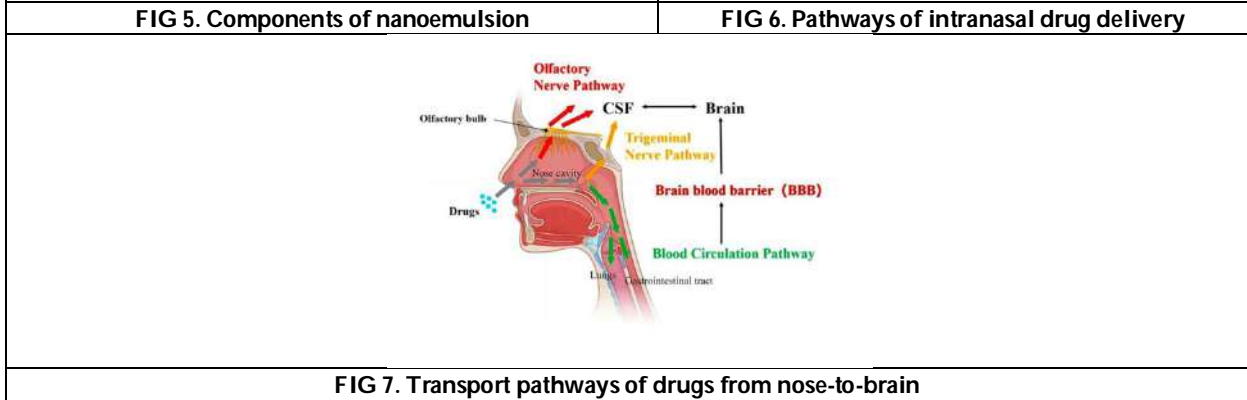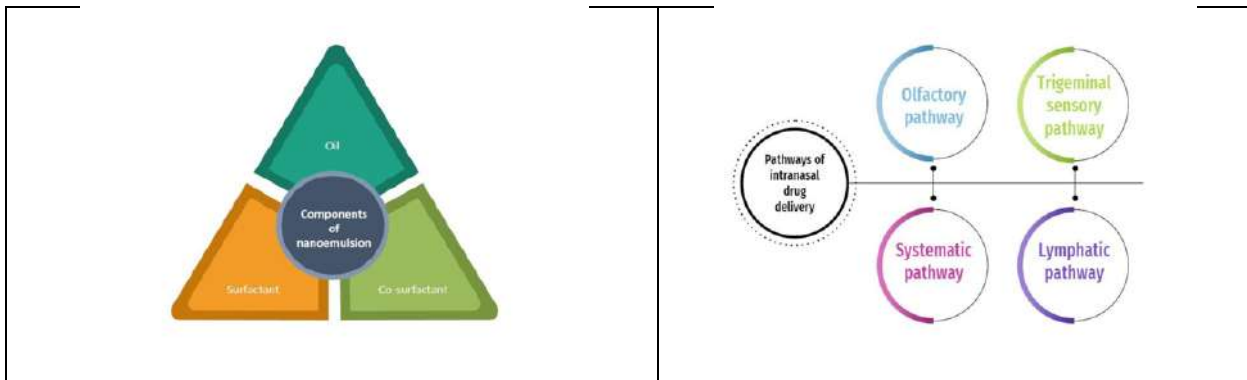
Adsorption Isotherm Studies on the Polymeric oxadiazole Adsorbents for the Removal of Methylene Blue Dye

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ABSTRACT

New heterocyclic aromatic polymers containing oxadiazole group has been investigated as adsorbents for the Methylene Blue (MB) dyes using the adsorption isotherm studies. Adsorption isotherm models such as the Freundlich (1906), Langmuir (1918) and Redlich-Peterson (1959) were used to fit the experimental data. FTIR spectra of before and after dye treated polymeric adsorbents were carried out to evaluate the efficacy of the polymers. The adsorption capacity of the polymers was found to be high.

Keywords: Polymers, Adsorption, Isotherm, Methylene Blue Dye solution, FT-IR

INTRODUCTION

Clean and safe water is becoming scarcer in many parts of the world due to pollution [1,2]. Wastewater discharged in many industries, such as metallurgy, mineral processing, tanning, chemical manufacturing, and battery manufacturing, contains one or more toxic metal ions [3]. If the wastewater is not treated in time, heavy metals, dyes will circulate with the water, immerse into the groundwater or be exposed to the air, and may result in causing various diseases. [5,6]. Therefore, the recovery of dyes and heavy metals from wastewater has high economic and environmental significance. In this work, a new polymeric adsorbent was developed to selectively adsorb MB dyes from wastewater.

METHODS AND MATERIALS

Adsorption isotherm studies

Batch adsorption experiments were carried out by contacting 50 mg of the polymer with 20 mL of the dye solution of different initial concentrations (100-500 mg/L) at pH 6.8 taken separately at a temperature of 30 °C. The contents were shaken for 180 min at a speed of 150 rpm and then filtered. The filtrates were analyzed for the residual dye concentration using the UV-Vis spectrophotometer. The amount of dye adsorbed onto the adsorbent at equilibrium, q_e (mg/g) was calculated by the following relationship:

$$q_e = \frac{(C_o - C_e)\,V}{m}$$

(1)

Where, C_o and C_e (mg/L) are the initial and equilibrium dye concentrations respectively. It is important to find out the best fitting isotherm model to evaluate the efficiency of the prepared adsorbent.

The structure of the polymers are given in the following table.

RESULTS AND DISCUSSION

Adsorption isotherm studies

Adsorption isotherms are basic requirements for the design of the adsorption processes. These equilibrium data give information on the capacity of the adsorbent or the amount of adsorbent required, for removing the metal ions under system conditions. The adsorption equilibrium experiments were performed, and a plot of metal ions adsorbed onto the adsorbent (q_e, mg/g) against the equilibrium concentration of metal ions (C_e, mg/L) in solution at 30 °C, was made. Though there are several models available to describe adsorption isotherms, the most widely used adsorption isotherm models are the Langmuir, Freundlich and Redlich-Peterson. The adsorption equilibrium data of methylene blue dye onto polymeric adsorbents (P1, P2, P3, P4 and P5) were analyzed with all the four isotherm equations. A plot of q_e versus C_e for the adsorption isotherms of dye removal onto synthesized polymeric adsorbents at 30°C. These curves were found to be convex upward throughout, and were designated as favourable types. The parameters of the adsorption isotherm equations for this process were calculated by the nonlinear regression analysis.

Langmuir adsorption isotherm

The Langmuir treatment (Langmuir, 1918) is based on the assumptions that the maximum adsorption corresponds to a saturated monolayer of solute molecules on the adsorbent surface, that the energy of adsorption is constant, and that there is no transmigration of the adsorbate in the plane of the surface. [7,8]. The non-linear form is represented by,

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e}$$

(2)

Where q_e is the amount of dye adsorbed (mg g^{-1}), and C_e is the equilibrium concentration of the solution (mg L^{-1}). q_m and K_L are the Langmuir constants indicating the adsorption capacity and energy, respectively. According to the Hall et al (1966) the essential feature of the Langmuir model can be expressed in terms of a dimensionless constant separation factor (R_L) given by the following equation:

$$R_L = \frac{1}{1 + K_L C_o}$$

(3)

Where K_L is the Langmuir constant (L mg^{-1}) and C_o is the initial concentration (mg L^{-1}). It has been established that for favorable adsorption, $0 < R_L < 1$; for unfavourable adsorption, $R_L > 1$; for linear adsorption $R_L = 1$; and the adsorption process is irreversible if, $R_L = 0$.

Freundlich adsorption isotherm

The Freundlich isotherm (Freundlich 1906) is an empirical equation, and can be employed to describe heterogenous systems. The heterogeneity arises from the presence of different functional groups on the surface, and the various adsorbent – adsorbate interactions. This isotherm is derived from the assumption that the adsorption sites are distributed exponentially with respect to the heat of adsorption. It also assumes that the stronger adsorption sites are occupied first and the binding strength decreases with increasing binding site occupation. [9,10]. The non-linear form is expressed as follows:

$$q_e = K_F C_e^{1/n}$$

(4)

Where K_F is the Freundlich constant $((mg.g^{-1})(L.mg)^{1/n})$ related to the bonding energy. 1/n is the heterogeneity factor and n $(g.L^{-1})$ is a measure of the deviation from the linearity of adsorption. This value indicates the degree of non-linearity between the solution concentration and adsorption as follows: if n = 1, the adsorption is linear; if n < 1, adsorption is a chemical process; and if n > 1, adsorption is a physical process.

Redlich – Peterson adsorption isotherm

Redlich – Peterson isotherm is a hybrid isotherm featuring both Langmuir and Freundlich model (Redlich and Peterson, 1959) which incorporates three parameters into an empirical equation and can be applied either in homogeneous or heterogeneous system due to its versatility (Foo and Hameed, 2010). It approaches Freundlich isotherm model at high concentrations and is in accordance with the low concentration limit of the ideal Langmuir condition (Foo and Hameed, 2010) [11,12].The equation is given as:

$$q_e = \frac{K_R C_e}{1 + \alpha_R C_e^{\beta}}$$

(5)

Where q_e is the amount of adsorbate in the sorbent at equilibrium (mg/g), C_e is the equilibrium concentration (mg/L); K_R is the Redlich - Peterson isotherm constant (L/g), α_R is the Redlich - Peterson isotherm constant (L/mg), and β is the exponent which lies between 0 and 1. The Redlich - Peterson isotherm exponent which lies between 0 and 1has two limiting behaviour: Langmuir form for β=1 and Freundlich form for β=0. The obtained experimental results were made to fit with non-linear isotherm model using MATLAB 7.0 to find the best fit model for the adsorption process and to predict the pathway of the reaction. The adsorption capacity (q_m) values were found to be good and in agreement with the obtained experimental results. The co-relation coefficient (R^2) value were also found to be closer to 1, predicting that the dye molecules were attached to the pores of the polymeric adsorbents. Since these polymers were macroporous, physical interaction between the dye molecules and polymeric adsorbents play a significant role in the adsorption process. But even the correlation coefficient values were found to be less when compared with langmuir isotherm, Freundlich isotherm showed that there was some chemical interaction also between the polymeric adsorbents and the dye molecules. The n values of Freundlich isotherm were found to be greater than 1, suggesting physical adsorption as the predominating step in the adsorption process.

This is justified and concluded with the β value of Redlich-Peterson value which was nearing to 1, suggesting that physical adsorption is the predominating in the adsorption mechanism. However, the FTIR spectra of before and after treated polymeric adsorbents showed major changes which indicates that the donor atoms nitrogen and oxygen present in the polymeric chain actively took part in the adsorption process. When the FTIR spectra of pure and spent polymeric adsorbents were observed, there was a considerable decrease in the intensity of the spectrum with specific changes in various zones. When observed closely, it was evident in all the FTIR spectra, that there was a new peak formed between 2800cm^{-1} to 3000 cm^{-1}, it was due to the interaction between the dye molecule and the polymeric adsorbent. The broad peak obtained above 3000 cm^{-1} is also diminished. This broad peak corresponds to the free hydroxyl group or the oxygen linkages which are interconnecting each monomeric repeating unit. This oxygen effectively takes part with the interaction between the dye molecule resulting in effective binding between the dye molecules and the polymeric adsorbents. When compared closely, it will be evident, that the adsorption capacity of the P5 and P4 polymers was found to be high. This is due to the absence of substituted methyl group in the

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polymeric backbone. But in polymers P1, P2 and P3 the presence of methyl group in the polymeric main chain hinders the binding between the dye molecules and polymeric adsorbent due to steric effect. Hence the binding will be only on the walls of the adsorbent resulting in lower adsorption capacity.

CONCLUSION

This study was focused on the evaluation of oxadiazole polymeric material as potential adsorbent for the removal of MB dyes from dye solution. Preliminary studies demonstrates that the adsorbent prepared is effective in the removal of MB dyes. Adsorption isotherm studies revealed that the oxygen present in the oxadiazole moiety effectively bind between the dye molecules and the polymeric adsorbents. FT-IR studies showed a formation of new peak which confirms the interaction between the dye molecules and the polymeric adsorbents. Hence, all the polyesters effectively acts as adsorbents. In future studies, these polymers can be used as corrosion inhibitors and as an adsorbent for the removal of heavy metal ion from industrial effluent waste water.

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Table 1:Adsorption isotherm parameters and constants for the removal of MB dye with synthesized polymeric adsorbents.

Isotherm model	Parameters	P1	P2	P3	P4	P5
Langmuir	q_m	463	482	484.2	491	495
	k_L	0.018	0.025	0.019	0.038	0.049
	R^2	0.9851	0.9949	0.9841	0.992	0.999
Freundlich	K_f	31.2	40.8	31.7	55.8	66.9
	N	2.10	2.16	2.10	2.33	2.45
	R^2	0.9657	0.9752	0.9868	0.9810	0.955

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Redlich-Peterson	K_R	8.60	13.4	16.4	26.7	23.3
	α_R	0.0210	0.0310	0.1630	0.1310	0.0145
	B	0.9772	0.933	0.704	0.8220	1.0
	R^2	0.9851	0.9950	0.9911	0.9960	0.9999

Table:2

Symbols used	Structure of the polymer
P1	
P2	
P3	
P4	
P5	

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Fig 1: Non-linear adsorption isotherm for MB dye onto P1 adsorbent	**Fig 2: Non-linear adsorption isotherm for MB dyeonto P2 adsorbent**
Fig 3:Non-linear adsorption isotherm for MB dyeonto P3 adsorbent	**Fig 4: Non-linear adsorption isotherm for MB dye onto P4 adsorbent**
Fig 5: Non-linear adsorption isotherm for MB dye onto P5 adsorbent	**Fig 6: FTIR spectra of before and after dye treated polymeric adsorbents (P1,P2 and P3).**

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Fig 7: FTIR spectra of before and after dye treated polymeric adsorbents (P4 and P5)

RESEARCH ARTICLE

Vulnerability of Human Blood Groups to Various Diseases Concerning Age and Sex

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ABSTRACT

Research on association of blood groups with diseases and disorders is less informative and further in relation to age and sex is very limited. Hence to study the vulnerability of blood groups of human population to diseases and disorders concerning their age and sex. Human individuals were divided into '10' groups according to their age (between 1 to 100 years) & sex. Serum samples were also collected. Hospital based case control study has been done in determining how the blood groups of human individuals are vulnerable to various diseases and disorders in relation to their age and sex. DMR test, where values are means (n=6) which do not share common superscript differ significantly at $p < 0.05$. This study finds that the blood group B+ is associated more with occurrence of diseases, disorders followed by blood groups A+, O+, AB+ proportionately in human individuals in relation to age groups between 41 & 70 years and 51 & 80 years of males and females respectively.

Keywords: Age, Blood groups, Disease, Sex, Vulnerability.

INTRODUCTION

Antigens on the surface of red blood cells represent the blood groups. Establishment of antibodies and antigens as inherited characteristics was done after the discovery of blood groups by the Landsteiner in the early 1900s, classification of the ABO blood groups and subsequent research by others[1]. Red blood cells, platelets, leukocytes, plasma proteins, certain tissues and various cell surface enzymes are the sites on which the blood group antigens exist and also in soluble form in body secretions such as breast milk, seminal fluid, saliva, sweat, gastric secretions, urine and amniotic fluid[2]. Rh blood group system is the most complex and indeed the second most studied blood group system[3]. Kaipainen and Vuorinen first hypothesized the association of blood groups and disease in 1960[4] and the gene involved in different blood groups was discovered in 1990[5]. However, lack of antigens in certain

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blood groups rise contentious issues between the ABO blood group and vulnerability to infectious and noninfectious diseases. Presence or absence of these both ABO and Rh blood groups systems throughout the body/on RBCs have been associated with number of diseases[6,7]. Large epidemiological studies involving connectivity between the human ABO blood group and occurrence of various diseases were broadly postulated in the years 1960 and 1970[8]. ABO blood types were found in conjunction with various infectious[9,10] and noninfectious diseases[11]. Haemolytic transfusion reactions and/or haemolytic disease of the newborn (HDN)[5] are the resultant of incompatibilities among other blood groups. Various diseases like hematologic disorders, cognitive disorders, circulatory diseases, metabolic diseases, cancer, cardiovascular diseases and malaria have been associated with ABO blood groups. Irrespective of geographical region, age, race and gender an increased risk of cognitive impairment was mainly observed in blood group AB individuals. Earlier etiological studies indicated that people with blood type O are associated with increased incidence of cholera, plague, tuberculosis infections and mumps; blood type A with increased incidence of smallpox and *Pseudomonas aeruginosa* infection; blood type B with increased incidence of gonorrhea, tuberculosis and *Streptococcus pneumoniae*, *E. coli* and *Salmonella* infections; blood type AB with increased risk of smallpox, *E. coli* and *Salmonella* infections. People with blood type A has higher incidence of cancers in the stomach, ovaries, salivary glands, cervix, uterus and colon/rectum than in O type people. Most of the affected human individuals in the present study experienced majority of the said diseases[12]. The chemistry of blood, its classification, structure, Lewis determinants and respective inducing enzymes is linked to the occurrence of the diseases and is evidential[8]. Further research is required to identify differences in biochemical composition of blood group antigens to risks for disease and their relationship for the identification of targets in the development of nutritional intervention strategies or druggable targets[2]. However, the studies to show the relationship between occurrence of various diseases and disorders, their severity and A, B, AB and O blood groups, especially in relation to age and sex is very limited. Hence we thought that there could be a significant relationship between A, B, AB, O, Rh blood groups, age and sex and occurrence of various diseases and disorders, their severity and studied them in the selected human population.

MATERIALS AND METHODS

Pasupala with geo-coordinates (15.7735° N, 78.0723° E) is located in Kurnool, Andhra Pradesh with a population of around 2900 inclusive of both educated and uneducated individuals. Diversity of occupations is more along with various health issues and is the reason for selection of this village for this study. Human individuals and were divided into '10' groups according to their age (between 1 to 100 years). Serum samples were also collected. This study was done for 12 months i.e. from October 2022 to September 2023. Diagnosis for the diseases and disorders was carried out by standard clinical methods and these procedures were followed in accordance with ethical standards as per the guidelines laid down by central ethical committee of Indian Council of Medical Research (ICMR). This study and the collection of data were carried out with the approval of Institutional Review Board (IRB). Statistical analysis of the data was analyzed by 'DMR test' and observed that the individuals with blood groups of the order B>A>O>AB in the age groups 1 to 100 years distinguishing males and females suffering from respective diseases, disorders with p<0.05 considered as significant. Individuals of disease free are treated as controls in the respective sample size and also in total sample size.

RESULTS

Of the total male and female individuals **(Table – 1)** around 14.51% and 12.97% respectively were affected with certain diseases, disorders **(Table – 2)**. This study found that males with the age groups (in years) 51-60, 41-50, 61-70 were more affected in proportion to the blood groups (B>A>O>AB) followed by the age groups (in years) 31-40, 71-80 with greater significant values indicating p<0.05. Age groups (in years) 0-10, 11-20, 21-30, 81-90 were less prone to diseases. Where as in females, the age groups (in years) 51-60, 61-70, 71-80 were more affected in proportion to the blood groups (B>A>O>AB) followed by the age groups (in years) 41-50, 31-40 with greater significant values indicating p<0.05. Age groups (in years) 0-10, 11-20, 21-30, 81-90 were less prone to diseases. Blood groups with

affected % is in the order of B+, A+, O+, AB+, B-, A-, AB-, O- in the male individuals and in females it is in the order of B+, A+, O+, AB+, B-, A-, O-, AB- **(Table – 3)**.

DISCUSSION

Oligosaccharide structures confirming the blood type is the reason for biochemical profile differences of individuals leading to differences in blood type, antigens and secretor status[2]. Human ABO blood type antigens located on the red cell surface which exhibit alternative phenotypes and genetically derived glycoconjugate structures exert vital role in the cells physiology and pathology[13]. Metabolomics studies have revealed the differences in the biochemical profiles and blood type distribution differences among different ethnicities. ABO antigens are thought to be evolutionarily beneficial in conferring resistance against pathogens[14]. Human leukocyte antigens (HLAs) present on every nucleated cell in the human body have been grouped into major histocompatibility complex (MHC) classes. Nucleated cells generate MHC molecules needful for their immunogenic functions. HLAs and other surface markers found on nucleated cells help in fighting disease[15]. One of the notable differences between HLA antigens and human blood group antigens is the association of only one phenotype with HLA antigens, while three phenotypes with blood group antigens. But the most important difference may be that mature RBCs are non-nucleated; all of the blood group antigens are generated prior to maturation, when RBCs lose the ability to generate new antigens[16]. Hence, RBCs do not function as antigen-presenting cells. Thus the association of blood group antigens with disease risk is far more refined than the association of HLA antigens with diseases. Disease risk is clearly multifactorial and causation is not implied by association but blood group antigens may be one of the predisposing factors that contribute to or prevent disease processes. Mostly A and B antigens are secreted by the cells and are found in human blood circulation. Therefore, non secretors are at risk to a variety of infections[17]. The likely pathogenesis for this vulnerability is binding to polysaccharides by many organisms on the cell surface, but soluble blood group antigens may not entertain[10,18]. Carbohydrate as a receptor in the species can resist a pathogen in ABO alternative phenotype. Alternatively, ABO polymorphism leads to a polymorphic production of anti-A and anti-B natural antibodies prevent individuals from several infectious agents expressing A and B motifs[19].

ABO blood group system is highly polymorphic with more than 20 distinct sub-groups; study findings are usually related to ABO phenotype, but rarely to the ABO genotype, secretor status and Lewis phenotype. Animal models are unsatisfactory because their antigen glycosylation structure is different from humans[20]. However, yet to know the exact mechanisms elucidating the associations between blood group antigens and disease in adhesion molecules. But an unexpected number of these structures contribute to normal RBC development; some act as cell adhesion molecules (CAMs) and some play a role in human disease[21]. The ABO, Hh, Sese (secretor) and Lele (Lewis) genes play different roles in the final ABO antigen structure of an individual's body tissues/secretions. This basic evidence can be revised as new information was obtained[1,9]. Several studies explaining the possible mechanisms did not confirm the relation between ABO blood types and diseases due to inconsistent results. Nevertheless, evidences were collected here to make this supposition sound. ABO may influence the risk of different diseases by different known and unknown mechanisms and now it is clear that ABO not the exact cause of diseases and susceptible to disease and health problems. In general, non-O blood types are more susceptible to diseases than O blood type. Genetically determined human ABO blood groups were correspondingly linked with an increased risk of various infectious and noninfectious diseases and our study further related this with age and sex. Ageing is accompanied by decline in immune system function and alteration which increases susceptibility to infections with meagre distinctive variation in males and females[22] as is evident from this study. It can be useful to increase the knowledge of persons in this aspect because individuals with high risk blood types could be screened and trained for modifying their lifestyles, health behavior and environment and other attempts that may increase public health. In addition, blood type can also influence the personality of humans such as creativity, social tendencies and temperament which is again an interesting phenomenon in psychological research[23]. The importance of human blood types is clearer in the context of population movement and the persistent combat between the humans and infectious diseases. However,

further investigations are needed particularly at the molecular level of ABO blood groups and their association with various diseases.

CONCLUSION

Blood group B+ is associated more with occurrence of diseases followed by blood groups O, A, AB proportionately in human individuals in relation to age groups between 41 & 70 years and 51 & 80 years of males and females respectively.

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Table – 1: No. of male and female human individuals of different blood groups according to the age group in the study area.

Age group [in years]	Males									Females								
	Blood groups									Blood groups								
	O+	O-	A+	A-	B+	B-	AB+	AB-	Total	O+	O-	A+	A-	B+	B-	AB+	AB-	Total
0-10	75	05	15	04	115	06	05	02	227	69	02	29	02	87	01	06	01	197
11-20	85	02	34	05	125	07	12	05	275	78	02	43	03	98	01	11	03	239
21-30	87	06	37	03	125	02	15	04	279	84	04	55	05	117	02	16	01	284
31-40	86	03	33	04	127	08	14	02	277	65	01	21	01	93	0	04	0	185
41-50	66	01	18	02	86	01	08	0	182	39	02	19	02	53	01	07	01	124
51-60	47	01	16	01	57	01	03	0	126	38	01	21	02	61	0	06	0	129
61-70	42	0	11	0	58	0	02	0	113	30	0	09	01	44	01	05	01	91
71-80	23	0	08	0	32	0	01	0	64	14	01	05	0	18	02	02	01	43
81-90	04	0	03	01	04	0	02	0	14	07	0	03	01	10	01	04	0	26
91-100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	515	18	177	20	732	25	62	13	1557	424	13	205	17	581	09	61	08	1318

Sample size 'N' = 50, for each age group of males and females;

Table – 2: Blood groups and no. of affected individuals (suffering from various diseases, disorders) along with the age group.

Blood group	Males										Females									
	Age group [in years]										Age group [in years]									
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	Total	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	Total
O+	02	02	02	05	05	05	06	02	0	**29**	02	01	02	02	05	06	02	03	01	**24**
O-	0	0	0	01	01	0	0	0	0	**02**	0	0	0	0	02	0	0	0	0	**02**
B+	07	11	06	09	24	28	20	15	05	**125**	05	07	05	08	10	14	24	19	02	**94**
B-	01	01	02	01	01	0	0	01	01	**08**	0	01	0	0	01	01	0	0	0	**03**
A+	01	02	0	03	08	09	06	04	02	**35**	01	03	04	06	02	02	04	04	02	**28**
A-	01	01	0	01	01	0	0	0	01	**05**	0	0	0	01	01	0	0	0	01	**03**
AB+	01	0	0	02	04	05	03	01	03	**19**	01	02	03	04	02	02	01	01	01	**17**

AB-	0	01	0	01	01	0	0	0	0	**03**	0	0	0	0	0	0	0	0	0	**0**
Total	**13**	**18**	**10**	**23**	**45**	**47**	**35**	**23**	**12**	**226**	**09**	**14**	**14**	**21**	**23**	**25**	**31**	**27**	**07**	**171**

No individuals found in the age group 91-100.

Table – 3: Blood groups with affected % of male and female individuals.

Blood group	Males	Affected %	Females	Affected %
O+	29[f]	12.83	24[f]	14.03
O-	02[a]	0.88	02[b]	1.16
B+	125[h]	55.30	94[h]	54.97
B-	08[d]	3.53	03[c]	1.75
A+	35[g]	15.48	28[g]	16.37
A-	05[c]	2.2 1	03[cd]	1.75
AB+	19[e]	8.40	17[e]	9.94
AB-	03[b]	1.32	0[a]	0.00
Total	**226** [1557]		**171** [1318]	

Number in the parentheses is the total no. of individuals tested;

Controls are the unaffected individuals from respective sample size;

Values are means [n=6] which do not share common superscript differ significantly at $p < 0.05$.

RESEARCH ARTICLE

Advanced Lightweight AI Model for Indian Fruit Quality Evaluation using Computer Vision

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ABSTRACT

This study underscores the critical role of advanced technology in modern agricultural practices. By harnessing AI and computer vision techniques, the fruit quality assurance system offers a robust solution to ensure compliance with standards. This investigation focuses on the detailed analysis of five fruit varieties: Apple, Banana, Guava, Lime, and Orange. The study examines fruit images captured under various environmental conditions and backgrounds to ensure robustness and accuracy in different scenarios. This research investigates the effectiveness of multiple feature extraction techniques for classifying images of fruit. Histogram of Oriented Gradients (HOG), Gabor filters, Wavelet transforms, and Zernike Moments feature extraction techniques are employed for unique image characteristics. The extracted features are then fed into various classification algorithms to assess their suitability for achieving comprehensive fruit image analysis. Furthermore, to address the issue of loss and enhance classification performance, we have developed a novel, lightweight, and robust algorithm tailored specifically for this application. Our developed model achieves a notable accuracy rate of 94.86% and an impressive inference time of 1.32 milliseconds per fruit. These results demonstrate the efficacy of the model for real-time applications, particularly in resource-limited agricultural settings. This comprehensive approach aims to significantly contribute to enhancing quality assurance measures in the agricultural sector.

Keywords: CNN, Image Processing, Fruit, Deep learning, Machine Learning.

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INTRODUCTION

Agriculture remains the predominant source of livelihood in India, with a70% of rural households relying primarily on it for their sustenance[1]. According to the Food and Agriculture Organization (FAO) of the United Nations, India ranks second globally in terms of both production of fruits and vegetables in 2019[2]. India has consistently recorded higher output in fruit production. India is the biggest producer of Banana, Guava, Papaya, Mango, and many other fruits &vegetables [1]. There is a huge potential for the export of fruits and vegetables from the country. Due to a lack of adequate processing facilities, labor shortage, cold chain, and proper storage facilities, as well as exports, transportation, and marketing fruit, a wastage problem arises[3].Annually, India generates 86.602 million metric tons of fruits and vegetables, leading to approximately 5.6 million tons of waste[4]. The study report suggests that a strong and dynamic processing sector plays a vital role in stopping post-harvest loss in India[5].The classification of fruits involves handling image uncertainties, image preprocessing, data handling, and seasonal effects, which are major challenges in sorting and grading fruits. Image processing techniques such as preprocessing and segmentation, combined with feature extraction methods, are instrumental in fruit sorting and grading applications [6] [7]. These techniques are integrated with machine learning models for effective classification purposes, enabling the automated assessment of fruit quality based on various visual attributes. The area under fruit crops during 2021-22 (3rdAdvance Estimate) is 7.05 million hectares, with a total production of 107.24 million tones [8]. During the Period 2011-12 to 2021-22 (3rd Adv. Est.), the production of fruits increased by about 40.3%, while the area increased by about 5.1%. Comparative details of the area, production, and productivity of fruit crops are given in Figure 1.

The significant contributions of this paper are as follows:

- This work proposes state-of-the-art Machine Learning models for the classification of fruits with various feature extraction methods like Histogram of Oriented Gradients (HOG), Gabor filters, Wavelet transform, and Zernike Moments.
- The Classifiers evaluated are Random Forest, Logistic Regression, Support Vector Machine (SVM),and K-Nearest Neighbour(K-NN).
- Developed a Novel, lightweight, and robust model for fruit classification, which is specially designed for Indian fruit with different backgrounds.
- The proposed model integrates depth-wiseseparable convolution and inception modules, enhancing feature extraction and representation. This combination optimizes image classification, particularly in challenging datasets with diverse backgrounds, and environmental conditions are common.
  The rest of the paper summarizes the Literature survey, materials and methods, results and discussion, conclusion, and future scope.

LITERATURE SURVEY

Key attributes of agricultural goods include size, color, shape, texture, and defects. Automating food inspection via computer vision systems offers unbiased, reliable, and non-invasive assessment, replacing manual methods effectively[7]. The author investigated fresh and rotten fruits from images of apples, bananas, and oranges using a Convolutional Neural Network (CNN) and Soft Max classification. Evaluation on a Kaggle dataset yields an accuracy of 97.82%[9]. The study compares six CNN-based architectures for rice disease classification and localization, addressing the scarcity of comprehensive comparative analyses in this domain. Results indicate that an ensemble approach achieves 98% accuracy, with transfer learning enhancing accuracy by 17% compared to Seresnext101. The research underscores the potential of CNN models in real-time plant disease detection, offering timely insights for farmers to safeguard agricultural productivity and quality[10]. Lightweight deep learning model, merging MobileNetV2 with an attention module to mitigate storage and computational demands of heavy-weight architectures in fruit classification. Leveraging transfer learning, the method outperforms four recent approaches across three benchmark datasets, offering superior classification accuracy with fewer trainable parameters. Its

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potential for automating fruit identification holds promise for industries involved in fruit production and processing[11]. The classification results from three stages: Tomato/Non-Tomato, Good/Defective, and specific defect type for defective fruitsare transmitted to the microcontroller. This enables the activation of the corresponding motor, facilitating the sorting and collection of classified fruits into their designated bins[12]. Authors have developed a meticulously curated image dataset focusing on Indian fruits with a keen emphasis on quality parameters crucial for both consumption and export purposes. The dataset encompasses six commonly consumed fruits: Apple, Banana, Guava, Lime, Orange, and Pomegranate, meticulously categorized into good quality fruits, Bad quality fruits, and Mixed quality fruits over 19,500 processed images[13]. Recent advancements in machine learning technology have revolutionized agricultural practices, offering farmers valuable insights and recommendations to minimize losses and optimize crop yields[6]. The author investigated several transfers learning architectures, including a proposed and established models like Nas Net Mobile, InceptionV3, Inception ResNet V2, ResNet50V2, MobileNetV2, VGG16, DenseNet 121, and Xception. Among these, Xception showed the most promising results. After 15 epochs, the proposed modelachieved a training accuracy of 98.82% with a loss of 0.0386. Subsequent testing yielded an accuracy of 98.04% and a loss of 0.0679. These findings underscore the effectiveness of transfer learning in various architectural contexts[14].

MATERIALS AND METHODS

Data Acquisition and Preprocessing

The dataset is obtained from mandely[13]. The dataset comprises images obtained under diverse environmental conditions, including variations in lighting, backgrounds, and viewing angles. The images contain good and bad quality images of Apple, Banana, Guava, Lime, and Orange. Figure 2 shows sample images of dataset.

A total of 11323 images are used, out of which 9056 training images and 2269 testing images are used for evaluation. Images are resized to 200x200x3 for performance evaluation. Total 10 classes namely Apple bad, Apple good, Banana bad, Banana good, Guava bad, Guava good, lime bad, lime good, Orange bad and, Orange good.

METHODOLOGY

Machine Learning Approach

For fruit classification tasks, traditional machine learning with feature extraction offers interpretability by identifying key discriminative features like shape, texture, and color, aiding in understanding the underlying factors that distinguish between various fruit types. This method facilitates domain-specific insights integration and robust model development, particularly beneficial in scenarios with limited data availability.

HOG Feature

HOG is a feature descriptor that represents the local gradient information in an image by dividing it into small cells, computing histograms of gradient orientations within each cell, and then normalizing them. It captures edge and texture information, making it robust to changes in illumination and viewpoint. HOG is suitable for fruit feature extraction because it effectively captures shape and texture information, allowing for discriminative features to be extracted from images of fruits. Its robustness to variations in lighting and viewpoint makes it ideal for fruit classification tasks. The parameters passed to the hog function control the configuration of the HOG descriptor. Orientations9 specifies the number of orientation bins, pixelspercell (8, 8) determines cell size for gradient computation, and cells perblock(2, 2) sets the normalization block size. Additionally, Visualizing False determines whether to return the visualized HOG image, but here, it's set to False for efficiency as only the feature vector is required.

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GABOR Feature

Gabor features are texture descriptors derived from Gabor filters, which are used to analyze local spatial frequency content in images. They capture both the texture patterns and their orientations, providing a rich representation of textures across different scales and orientations. Gabor features are advantageous for fruit feature extraction due to their ability to capture fine texture details, such as surface patterns and irregularities, which are often discriminative for differentiating between fruit types. Their multi-scale and multi-orientation nature enables the detection of textural variations in fruits, enhancing the robustness of classification models. Additionally, Gabor features are less sensitive to variations in illumination and shading, making them suitable for analysing fruit images captured under different lighting conditions. Gabor filters were applied at various 8 orientations and scales. It computes the real part of the filtered images and constructs a feature vector by concatenating them. Finally, it returns an array containing the feature vectors for all images in the dataset.

Wavelet Feature

The wavelet feature extraction technique, implemented here using the Haar wavelet transform, offers a sophisticated method to capture both local and global image characteristics. By decomposing images into different frequency bands and directional components, wavelet analysis facilitates the extraction of diverse features, including texture, edges, and patterns, at multiple scales. This approach enhances the discriminative power of feature representations, enabling more comprehensive image analysis compared to traditional methods. Moreover, wavelet features possess the inherent ability to preserve both spatial and frequency information, thereby offering a richer representation of image content. Such versatility and robustness make wavelet feature extraction invaluable for various applications, including image classification, object recognition, and medical image analysis, where capturing intricate image details is crucial for accurate decision-making and analysis.

Zernike Moments

Zernike Moments, a set of orthogonal moments, capture the shape information of an object by representing its spatial distribution. Each moment corresponds to a specific shape characteristic, such as area, centroid, and elongation, providing a concise description of object morphology. By quantifying shape features invariant to translation, rotation, and scale, Zernike Moments offer robustness in object recognition and classification tasks across various domains. Moreover, their orthogonality property enhances computational efficiency and reduces feature redundancy, facilitating effective feature extraction and analysis. Leveraging Zernike Moments enables accurate and efficient representation of object shapes, contributing to advancements in image processing, pattern recognition, and computer vision research.

Support Vector Machine (SVM)Classifier

SVMs excel in handling high-dimensional data, making them well-suited for processing image features commonly encountered in fruit classification tasks[15]. They are effective even with limited training data and can delineate complex decision boundaries. SVMs can be a suitable choice for fruit classification tasks, particularly with datasets containing moderate numbers of images per fruit class[16]. Their capability to handle image data effectively may lead to robust performance.

Random Forest Classifier

Random Forests are adept at handling large datasets, robust to noise and outliers, and provide insights into feature importance[17]. Their ensemble nature makes them resilient to variations in lighting, backgrounds, and viewing angles within the data. It can handle non-linear relationships and intricate patterns present in datasets comprising images of Indian fruits with different backgrounds and lighting conditions.

K-nearest neighbours (KNN)Classifier

KNN is simple to implement and effective with high-dimensional data, making it a straightforward baseline model for initial exploration[18]. It works well for tasks where local data patterns are important. KNN may be helpful in providing initial insights or baseline performance comparisons in fruit classification tasks. This makes it applicable to

datasets containing Indian fruit images with different backgrounds and environmental conditions, as it relies on local data patterns rather than global assumptions.

Proposed lightweight and robust model approach

Deep learning, specifically Convolutional Neural Networks (CNNs), offers the advantage of automatically learning hierarchical representations from raw data, eliminating the necessity for manual feature engineering. Moreover, CNNs adeptly capture spatial hierarchies in data, rendering them highly effective for tasks such as image recognition and object detection. Figure 3 depicts the proposed lightweight and robust model. The model begins with an input layer of specified image dimensions 200x200x3, representing RGB images. The initial convolutional layer consists of 8 filters of size (3, 3) with a stride of (2, 2) and 'same' padding followed by Rectified Linear Unit (ReLU) activation.

Subsequent layers include a depth-wise separable convolution block, comprising a Depth wise convolution layer with (3, 3) kernel size and 'same' padding, followed by a pointwise convolution layer with 32 filters of size (1, 1) and ReLU activation. MaxPooling2D layer with a pool size of (2, 2) is applied after the Depth-wise separable block to downsample feature maps. A skip connection is implemented by preserving the output of a layer and skip connection to be concatenated with the output of subsequent layers. The model incorporates an inception module that consists of parallel convolutional branches to enhance feature representation[19]. Each branch includes convolutional layers with different filter sizes (1x1, 3x3, 5x5), followed by ReLU activation. Additionally, a max-pooling layer with (3, 3) pool size and (1, 1) strides is included, followed by a 1x1 convolutional layer. The outputs from all branches of the inception module are concatenated along the channel axis to form a single feature map.The concatenated output is flattened and passed through fully connected layers for classification. The dense layers consist of 128 and 64 neurons, respectively, with ReLU activation. Dropout regularization with a dropout rate of 0.2 is applied between the dense layers to prevent overfitting. The final output layer comprises a dense layer with SoftMax activation, producing probabilities for each class in the dataset. 10 neurons in the output layer correspond to the number of classes.

RESULTS AND DISCUSSION

Evaluation with various feature extraction techniques is crucial as different methods capture distinct aspects of data, aiding in selecting the most effective approach for a given task. By comparing performance, through performance comparison, strengths, weaknesses, and optimal methods can be identified, enabling informed decision-making and enhancement strategies. Various classifiers facilitate the identification of the most suitable model for a specific task, enhancing the overall effectiveness of the machine learning system. Furthermore, it provides valuable insights into the dataset's characteristics and the performance of different algorithms, aiding in informed decision-making during model selection. This comprehensive approach contributes to the development of a more reliable and robust machine learning system capable of handling diverse datasets and real-world challenges with greater efficacy. Performance evaluation results obtained from Feature extraction and classification using various classifiers are shown in Table 1.

The mentioned feature extraction techniques, including HOG, Gabor feature, Wavelet transform, and Zernike moments, are pivotal in capturing distinctive visual attributes from images for subsequent analysis. HOG delineates object shapes by quantifying local intensity gradients, Gabor filters highlight texture patterns through frequency and orientation analysis, while Wavelet transform captures multi-scale information. Zernike Moments encode shape characteristics, offering robustness to geometric transformations and facilitating comprehensive image representation for diverse applications in computer vision and pattern recognition research. HOG excels as a feature extractor by effectively capturing object shapes and textures, while Random Forest stands out as a top-performing classifier, showcasing robustness and accuracy in handling complex feature representations. Our proposed model designed for the Indian fruit dataset demonstrates remarkable performance superiority over conventional feature extraction and classifier methods. The model in corporate depth wise separable convolution offers computational efficiency by decoupling spatial and channel-wise convolutions, resulting in fewer parameters and reduced computation, and is

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suitable for resource-constrained environments[20]. Inception architecture leverages multiple parallel convolutional pathways, allowing the network to capture features at different scales and complexities efficiently, enhancing representation learning and model performance. Figure 4 shows the learning curve of our proposed lightweight and robust model with the percentage of correctly predicted samples represented by the Accuracy metric and by measuring the difference between expected and actual values, the Loss metric model's train during progress. Our proposed model achieves exceptional results, boasting a maximum training accuracy of 97.12% and a testing accuracy of 94.86% with a minimal loss of 0.02 over 10 epochs with a batch size of 32.

Notably, the training process demands a mere 84.69 seconds, while the model comprises a modest 5.2 million parameters, rendering it highly suitable for deployment in resource-constrained environments such as embedded systems or mobile applications. Figure 5 and Figure 6 show the confusion matrix and classification results of our proposed model.

CONCLUSION AND FUTURE SCOPE

Our study comprehensively evaluated the effectiveness of diverse machine learning classifiers for fruit classification tasks, integrating various feature extraction techniques such as HOG, Gabor filters, Wavelet transform, and Zernike moments. Moreover, we introduced a novel lightweight and robust model incorporating an Inception block and Depth-wise separable convolution, achieving exceptional accuracy of 94.86% and demonstrating superior performance compared to traditional machine learning algorithms, with a minimal inference time of 1.32 milliseconds per fruit. Our findings highlight the significance of employing diverse classifiers and innovative model architectures to enhance classification accuracy, particularly in scenarios with variable backgrounds and lighting conditions. Our proposed approach shows promise for fruit classification accuracy and robustness, especially in practical software applications and embedded systems. Future research endeavours could focus on leveraging more extensive datasets comprising additional fruit species and a diverse range of images, including both authentic and synthetic representations, to enhance the system's robustness and generalization capabilities.

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Table 1 showcases the Accuracy results obtained from Feature Extraction and classification using a variety of classifiers

Accuracy of Various Machine Learning Classifiers				
Feature Extraction Techniques	Random Forest	Logistic Regression	SVM	K-NN
Hog Feature	85.98	85.54	88.01	87.17
Gabor Feature	82.54	64.83	71.00	66.89
Wavelet Feature	88.67	66.59	72.23	86.11
Zernike moments features	81.13	64.50	69.17	78.97

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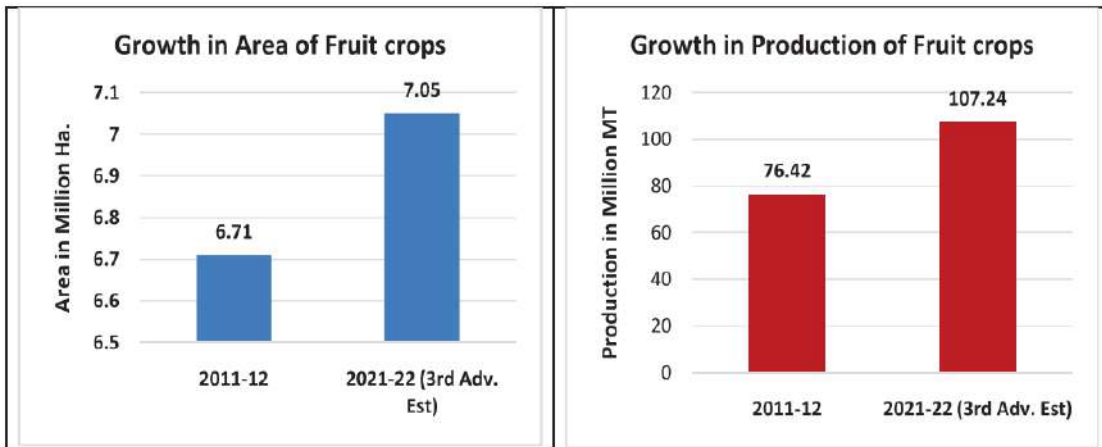
Figure 1 Comparative analysis of Growth in fruit and fruit production in India[8]

Figure 2 Sample images from the dataset containing different background and lighting conditions
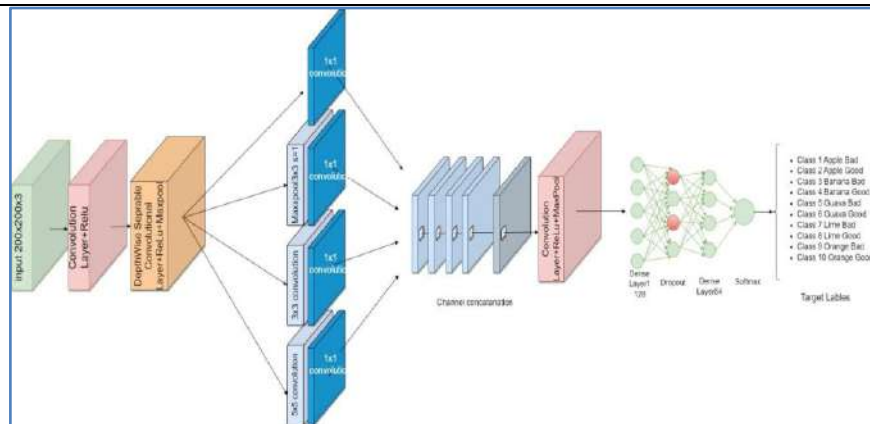
Figure 3 Proposed lightweight and robust model illustrates the fusion of inception and depth-wise convolution blocks, showcasing an innovative architecture aimed at enhancing efficiency and performance in deep learning-based image classification

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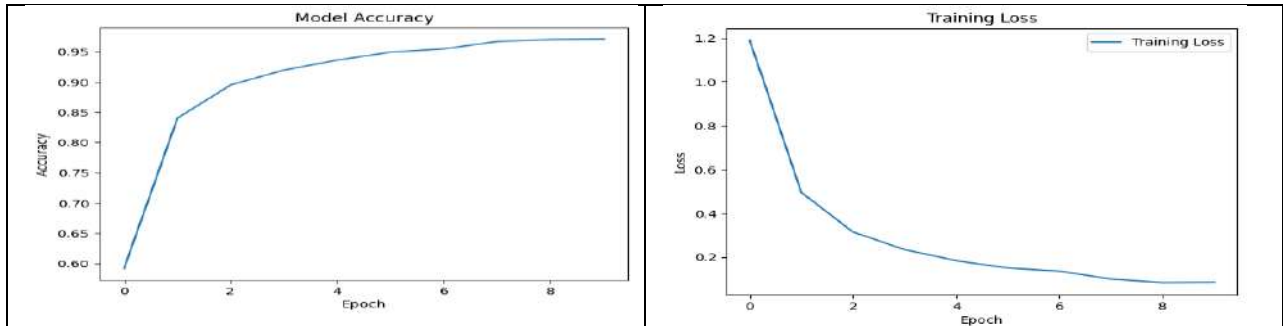
Figure 4(a) depicts the learning curve of our proposed lightweight and robust model, showcasing the Accuracy metric. Figure 4(b) illustrates the Loss metric throughout the model's training phase
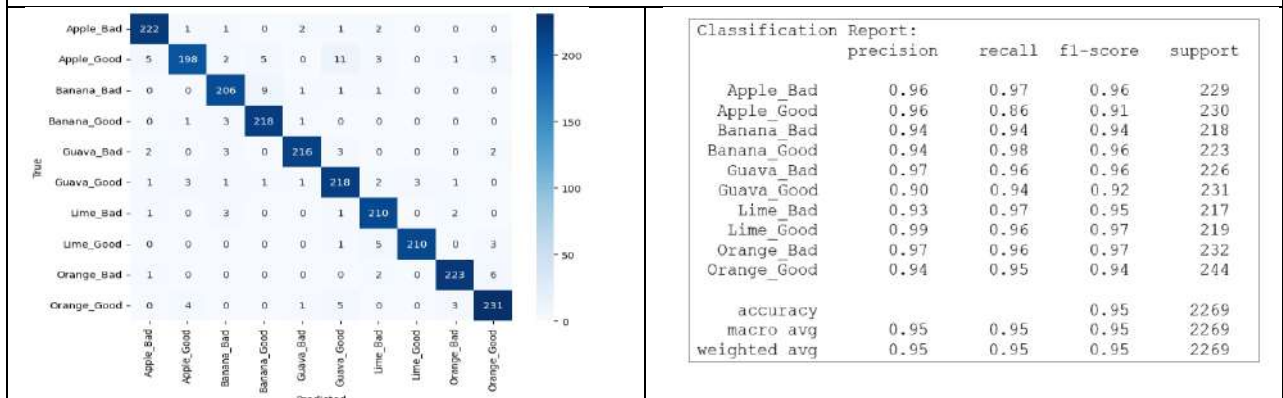
Figure 5 illustrates the confusion matrix of our proposed lightweight and robust model

Figure 6 illustrates the Classification report of a proposed lightweight and robust model

RESEARCH ARTICLE

Optimal Feature Selection using Integration of Firefly Optimization with Random Forest Method

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ABSTRACT

Heart disease, a broad term encompassing various cardiovascular conditions, stands as a formidable global health challenge, representing a leading cause of morbidity and mortality. To increase the efficacy of disease prediction earlier, it is necessary to identify the most relevant subset of features in a given domain. In this paper, the integration of the Firefly Optimization Algorithm (FOA) with Random Forest (RF) is proposed and used to select the optimal feature subset for prediction of Heart disease. The hybridization makes use of the advantages of both FOA and RF methods. Initiating with the data pre-processing step by employing a matching pursuit imputation method to handle missing values, followed by Z-score normalization for feature scaling, and Bray–Curtis feature learning vector quantization is then employed for feature extraction to reduce dataset dimensionality. After that Optimal feature selection is carried out using the Firefly Optimization Algorithm with Random Forest (FOA-RF) method, which minimizes both time and space complexity in disease prediction and then applies the proposed algorithm in five different heart disease datasets to select the best features. The effectiveness of the selected feature set is analyzed using a Support Vector Machine and the experimental results confirm the efficiency of the proposed feature selection approaches rather than the original Firefly Optimization and Random Forest algorithm by way of searching the feature space and selecting the most informative attributes for prediction tasks. Accuracy, Sensitivity, and Specificity have been measured to evaluate the results. Our experimental result demonstrates that the SVM-based model with the FOA-RF achieves a better result than the other feature selector algorithms.

Keywords: Firefly Optimization Algorithm, Random Forest, Support Vector Machine, Heart disease, feature selection, vector quantization, Z-score normalization

INTRODUCTION

Heart Disease is a severe condition that significantly impacts human life, emerging as one of the leading causes of death worldwide. To prevent further damage to patients, accurate diagnosis and early identification of heart disease are essential for effective rehabilitation and treatment. A machine learning model has been trained on medical data to enable efficient heart disease diagnosis, conserving resources while improving accuracy. During the training process, the medical datasets contain both relevant and redundant features about the patients. These unnecessary features do not contribute meaningful information to the disease detection task and lead to the curse of dimensionality. Therefore, significant feature selection techniques are required in heart disease prediction. Feature selection is a crucial step in machine learning and data analysis, particularly in the domain of medical diagnosis such as predicting heart disease. It involves identifying the most relevant features or variables from a dataset that contribute the most to the predictive performance of a model. By selecting the right features, we can improve model accuracy, reduce overfitting, and enhance interpretability. In heart disease prediction, the significance of feature selection cannot be overstated. With a multitude of potential risk factors and diagnostic indicators, identifying the most influential features can lead to more accurate and efficient predictive models. By focusing on relevant features, we can streamline the diagnostic process, potentially leading to earlier detection and intervention, ultimately saving lives.

The integration of Firefly Optimization (FO) and Random Forest (RF) algorithm for feature selection presents a promising approach to addressing the complexity of feature selection problems. Firefly Optimization is a metaheuristic algorithm inspired by the flashing behavior of fireflies, which seeks to optimize solutions in a search space. When combined with Random Forest, a powerful ensemble learning technique known for its robustness and flexibility, this hybrid approach aims to leverage the strengths of both algorithms for more effective feature selection. Several feature selection algorithms exist, each with its strengths and weaknesses. Commonly used methods include Recursive Feature Elimination (RFE), Genetic Algorithms (GA), and Principal Component Analysis (PCA). When compared to these methods, the FO-RF hybrid approach offers distinct advantages. While RFE may struggle with large feature sets and GA can be computationally expensive, the FO-RF hybrid method aims to strike a balance between efficiency and effectiveness. Additionally, the ensemble nature of Random Forest helps mitigate the risk of overfitting, which can be a concern with some feature selection techniques. The hybridization of Firefly Optimization and Random Forest brings several benefits. Firstly, Firefly Optimization enhances the search process by efficiently exploring the feature space, potentially leading to more optimal solutions. Secondly, Random Forest provides robustness and generalization ability, ensuring that the selected features are relevant across different datasets and scenarios. By combining these strengths, the hybrid approach aims to improve feature selection performance, resulting in more accurate and interpretable predictive models for heart disease diagnosis. The subsequent sections of this paper are organized as follows: Section II discusses the related research on feature selection techniques for heart disease prediction and highlights the limitations. Section III briefly explains FO and RF algorithms, and then details how they are integrated for feature selection in the proposed FO-RF approach. Emphasize how FO addresses redundancy issues and how RF contributes to robustness and generalizability. Section IV describes the experimental setup, including data selection, evaluation metrics, and comparison with existing methods. This section should demonstrate the effectiveness of the FO-RF approach in improving model performance. Section V summarizes the findings, emphasizing how the proposed method addresses the initial problem of redundant features and contributes to more accurate heart disease prediction models.

LITERATURE REVIEW

In recent studies aiming to improve heart disease diagnosis accuracy, various feature selection techniques have been employed. Zheng et al. [1] introduce the MPMDIWOA algorithm, which merges the MPMD filter algorithm with the IWOA wrapper algorithm, effectively addressing local optimal values through concepts like maximum value without change (MVWC) and thresholds, resulting in superior classification accuracy and feature subsets. Tubishat et al. [2] present the Dynamic Butterfly Optimization Algorithm (DBOA), an enhanced version of BOA, which resolves

limitations by enhancing solution diversity and mitigating local optima issues. Tested on 20 benchmark datasets, DBOA outperforms other optimization algorithms. Abdel-Basset et al. [3] propose a novel approach by integrating the grey wolf optimizer algorithm with a two-phase mutation strategy, improving feature selection efficiency. The study contributes to optimization methods by leveraging metaheuristic algorithms. Abdelhamid et al. [4] introduce bSCWDTO, a hybrid binary meta-heuristic algorithm for feature selection, showing superiority over existing methods on 30 datasets. A hybrid approach [5] utilizing LGP and BA generates candidate chromosomes and performs neighborhood search, followed by SVM classification, yielding promising results. Another study [6] focuses on a three-step method involving feature selection, clustering, and classification, achieving superior results through various hybrid optimization algorithms. Xiang *et al.* [7] propose a hybrid system merging IGSA with k-NN, enhancing IGSA with PWL and SQP, and extending it to binary space, resulting in superior computational performance. Three hybrid algorithms [8] integrating SOA and TEO are introduced, showing promising results on 20 benchmark datasets. Nemati et al. [9] propose a hybrid feature selection algorithm merging GA and ACO, with low computational complexity and competitive performance. Xi e *et al.* [10] propose IFSFS, a hybrid method merging filter and wrapper methods, yielding optimal feature subsets from the original set. Another framework [11] integrates SACI with SVM, showing promising results in feature selection and model selection. A hybrid FFPSO technique [12] for BBB detection combines Firefly and Particle Swarm Optimization, enhancing classifier performance through optimized features. TRSFFQR [13] combines TRS and FA for feature selection in MRI brain images, addressing the limitations of basic models. HGAWE [14] combines a genetic algorithm with wrapper-embedded feature selection, outperforming existing methods in feature selection and classification accuracy. FCBF is used in conjunction with PSO and recursive FA [15], demonstrating robustness in classification accuracy. In a study on CAD [16], seven feature selection techniques are explored, achieving a classification accuracy of 88.15%.Kabir et al. [17] propose a hybrid ACO algorithm that efficiently explores feature spaces.Yu et al. [18] integrate PSO and GA for feature selection, offering a promising solution for enhancing machine learning model performance, particularly in cyber security applications. A proposed method [19] combines PSO exploration with GWO exploitation, yielding superior performance in feature selection and classification tasks.

DATASET
To evaluate the performance of various feature selection methods, we utilized five benchmark datasets from the Kaggle repositories focusing on cardiovascular health. These datasets serve as representative samples of real-world clinical data collected for heart disease prediction. Table 1 summarizes the datasets, including the number of attributes (features) and instances (data points) in each.

DATA PREPROCESSING
Data preprocessing plays a crucial role in ensuring the reliability and generalizability of machine learning models, particularly in the domain of heart disease prediction. Inconsistent data formats, missing values, and outliers can significantly impact model performance. To address these challenges, a comprehensive preprocessing pipeline is essential.

Missing Value Imputation
Missing entries within the datasets require careful handling to minimize their influence on model performance. We employ Matching Pursuit imputation, a machine learning-based approach for robustly imputing missing values. This method leverages the existing data to estimate the conditional statistical mean for each feature (column) with missing values. Here's the formula for calculating the mean:

$$\mu\left(\beta_{fv_i}\right) = \frac{\sum \beta_{fv_i}}{n} \tag{1}$$

Following the mean calculation, Matching Pursuit identifies the optimal value to impute by minimizing the absolute difference between the estimated value and its neighboring entries in the same feature. Essentially, the method seeks the value that creates the least disruption to the existing data pattern within the feature. The formula for absolute difference minimization can be represented as:

$$F = min\left|\beta_{fvD} - \beta_{fv(N)}\right| \tag{2}$$

By minimizing this absolute difference (often referred to as Least Absolute Deviation), Matching Pursuit aims to impute a value that seamlessly integrates with the surrounding data points within the feature.

Feature Scaling

Feature scaling is crucial for ensuring that all features contribute equally to the model's learning process. This is particularly important when dealing with datasets containing features measured in different units. We utilize standardized Z-score normalization for feature scaling. This technique transforms each feature value by subtracting the mean of the feature and then dividing it by its standard deviation. This results in a standardized dataset with a mean of 0 and a standard deviation of 1.

Categorical Feature Encoding

Many real-world datasets, including those used for heart disease prediction, contain categorical features. These features need to be converted into a numerical format suitable for machine learning algorithms. One-hot encoding is employed for this purpose. This technique creates a new binary feature for each unique category within the original categorical feature. The value of each new feature is set to 1 for the corresponding category and 0 for all other categories. For instance, a categorical feature "gender" with values "male" and "female" would be transformed into two new binary features: "gender_male" (1 for male, 0 for female) and "gender_female" (0 for male, 1 for female).

FEATURE EXTRACTION

Following data preprocessing the Bray–Curtis feature learning vector quantization is utilized for feature extraction, aiming to reduce the dataset's dimensionality. This process enhances computational efficiency and mitigates the curse of dimensionality, transforming the original dataset into a lower-dimensional representation for modeling. Feature learning vector quantization employs winner-take-all training algorithms, identifying significant features based on the Bray–Curtis index and mapping input features to a smaller set through quantization. For each feature in the vector 'β_{fi}' and β_{fj}, find the closet features using the Bray-Curtis Similarity Index.

$$\omega_{ij} = 1 - \frac{2\,(M_{ij})}{|\beta_{fi}| + |\ \beta_{fj}|} \tag{3}$$

In (3), ω_{ij} denotes a Bray-Curtis Similarity coefficient, M_{ij} denotes a mutual dependence between the two features, $|\beta_{fi}|$ and $|\ \beta_{fj}|$ represents the cardinalities of the two sets (i.e. number of values in each feature)**.** The Bray–Curtis similarity coefficient is bounded between 0 and 1. The winner-take-all training algorithm is exploited in learning vector quantization to identify winning features in the vector (i.e. high similarity).

$$H = \begin{cases} 1, & winning\ features\ in\ vector \\ 0, & otherwise \end{cases} \tag{4}$$

FEATURE SELECTION

After the feature extraction, feature selection is performed to choose a subset of optimal relevant features from extracted features. The main aim of feature selection is to improve model performance and reduce error, by focusing on the most informative and discriminative features. Therefore, the integration of the firefly optimization algorithm with random forest is introduced for optimal feature selection.

Proposed Hybrid FOA-RF Algorithm

Firefly Optimization [20] is a metaheuristic algorithm inspired by the flashing light behavior of fireflies. Fireflies are generally unisexual. Each firefly is attracted to others based on its light intensity, as the attractiveness of a firefly is directly proportional to its brightness. Fireflies with lower intensity are attracted to other fireflies that emit brighter light. Here the firefly is related to the number of features in the given dataset. The population of fireflies (i.e., features) $\beta_{fi} = [\beta_{fv_1}, \beta_{fv_2}, \dots, \beta_{fv_n}]$ is initialized in the search space. For every firefly, the fitness value is calculated based on the objective function.

$$f(x) = arg\,max\,Acc\,(DD) \tag{5}$$

Where $f(x)$ denotes a fitness function, $arg\,max$ denotes an argument of the maximum function, $Acc(DD)$ denotes an accuracy of the disease diagnosis (i.e. target output). The attractiveness of a firefly is determined by its fitness

value. Fireflies are attracted to other fireflies with higher fitness values and move towards them. In other words, the firefly 'ff_i'with less fitness is moved towards to fireflies with high fitness. Otherwise, the fireflies move in a random position. The position of the firefly is updated as follows,

$$X_{t+1} = X_i^t + a_{ij}e^{[-\rho D_{ij}^2]}(X_i^t - X_j^t) + q_t\epsilon_t \tag{6}$$

From (11), X_{t+1} represents an updated light intensity of the firefly,X_i^t denotes a current light intensity of firefly 'i', X_j^t denotes a current light intensity of firefly 'j', a_{ij} attractiveness of the firefly, q_t denotes a parameter controlling step size and ϵ_t represents a vector drawn from a Gaussian or other distribution, 'ρ' denotes a light absorption coefficient, D_{ij} distance between the fireflies 'i' and 'j'. Then the fitness is again computed based on the updated position of the firefly. Followed by, the fireflies are ranked to determine the more optimal solution with the help of a random Forest decision tree.   Random Forest is an ensemble learning algorithm that utilizes multiple decision trees to find more optimal features. The proposed ensemble learning technique first constructs the set of the weak learner as a decision stump to find the optimal features through the ranking process. The Random Forest ensemble technique utilizes a multi-iterative decision tree for weak learners and gives the input of fireflies with the fitness value. A decision stump is a basic decision tree comprising a root node directly linked to a leaf node, employing a decision rule. The root node performs decision-making by establishing the decision rule. Based on the decision-making process, optimal features are identified, and results are obtained at the leaf nodes. The root node makes a rule as given below

$$R = if\ (f_i(x) > (f_j(x))\quad where\ i = 1,\quad j = 2,3,4,5\dots n \tag{7}$$

Where R denotes a rule, $f_i(x)$ denotes the fitness of one firefly, $f_j(x)$ denotes the fitness of other fireflies.   If the fitness of the 'i^{th}' firefly is greater than the fitness of the other 'j^{th}' fireflyf_j, then the root tree node rank the features. Followed by, other features are ranked.

$$Q = \sum_{i=1}^{n} W_i \tag{8}$$

From (13), Qdenotes strong output results by combining all the weak learner results 'W_i'. Finally, the preferential voting scheme is applied to find the final optimal results.

$$Z = arg\ max\ \vartheta(W(ff_i)) \tag{9}$$

From (14), 'Z' denotes the final random forest decision tree result. '$arg\ max\ \vartheta(W(ff_i))$' represents the majority votes of weak learner results are obtained as a final result. In this way, optimal features are selected for disease diagnosis to minimize complexity and improve accuracy.

// Algorithm Integration of Firefly optimization with Random Forest for feature selection
Input: Number of fireflies (i.e. number of features) $\beta_{fi} = \beta_{fv_1}, \beta_{fv_2}, \dots, \beta_{fv_{n'}}$
Output: Optimal feature selection

Begin
   Generate an initial population of fireflies i.e. number of features $\beta_{fi} = \beta_{fv_1}, \beta_{fv_2}, \dots, \beta_{fv_n}$
  For each firefly
   Compute fitness '$f(x)$'
  while($t < terminationismet$)
  for$i = 1:n$ (all n fireflies)
  for$j = 1:n$ (all n fireflies)
  if $(f(X_i) < f(X_j))$**then**
  Move firefly ff_itowards firefly ff_j
  Evaluate new solutions and update light intensity using (11)
   End if
  end for$j$
  end for$i$
   Go to step 3
  for eachfirefly with the fitness value
  Construct a set of weak classifiers
   End for
      if $(f_i(x) > f_j(x))$ **then**
   Rank the features with a high position

> **End if**
> Combine all weak classifiers
> **for each** weak classifier
> Assign the voting scheme
> Find weak learner resultswith majority votes
>   Return (optimal k features)
> **End for**
> **End while**
>   **End**

The algorithm describes an approach for optimal feature selection by integrating the firefly algorithm with random forest to improve the accuracy of disease diagnosis and minimize the time. The algorithm begins by randomly initializing the population of fireflies, which corresponds to the number of features. For each feature, fitness is measured, and the light intensity of the firefly is determined based on the fitness function. If the light intensity of one firefly is higher than that of another, it moves and is attracted to the other firefly. After the movement of fireflies, the light intensity of all fireflies is updated. Then, the fitness is re-evaluated based on the updated light intensities of the fireflies. To rank the features, a random forest decision tree is constructed. Initially, a set of weak learners is created based on the fitness of each firefly. The root node determines a firefly with a higher fitness is ranked first, followed by the others in ascending order. Finally, the results of the weak learners are combined using a preferential voting scheme to create a strong output. The majority votes of the weak learner results determine the final output. This process is repeated until the algorithm reaches the maximum number of iterations. Finally, the optimal set of features gets selected for accurate disease diagnosis.

EXPERIMENTS AND RESULTS

This research investigates the predictive effectiveness of Random Forest (RF), Firefly Optimization Algorithm (FOA), and their combination FOA-RF, across five datasets: Framingham, Heart Disease, Cardiovascular Disease Dataset, Cardio train, and Heart Attack, procured from Kaggle repository. Under the experiment's framework, each dataset undergoes particular preprocessing and feature extraction, followed by model training and evaluation using an 80-20 training-testing split. Performance metrics encompassing accuracy, specificity, and sensitivity are precisely recorded. The results indicated that FOA-RF consistently outperformed RF and FOA across all datasets, demonstrating superior feature selection capabilities and classification accuracy. Statistical analysis confirmed the significance of the performance difference between FOA-RF and the other algorithms. Overall, the integration of Firefly Optimization with Random Forest emerged as a promising approach for accurately diagnosing cardiovascular diseases, leveraging the complementary strengths of both algorithms.

Accuracy
In the prediction of heart disease, accuracy is a crucial performance metric that measures the proportion of correctly classified instances among all instances evaluated. It provides an overall assessment of how well a predictive model performs in correctly identifying individuals with or without heart disease. The formula for accuracy is:
Accuracy = (True Positives + True Negatives) / Total Instances

Sensitivity
Sensitivity, also known as recall, is a vital metric in feature selection for heart disease prediction. It measures the proportion of true positive cases correctly identified by the model. A high sensitivity indicates effective identification of individuals with the disease, minimizing false negatives. In our comparison of Random Forest (RF), Firefly Optimization Algorithm (FOA), and the integrated FOA-RF for feature selection, FOA-RF demonstrated superior sensitivity. Leveraging both FOA's efficient exploration of the search space and RF's robust classification, FOA-RF optimizes feature selection to maximize sensitivity, enhancing the accuracy of heart disease prediction models. The

Formula for Sensitivity

Sensitivity = True Positives / (True Positives + False Negatives)

Specificity

Specificity, along with sensitivity (recall), is a vital metric for evaluating the effectiveness of a model in disease prediction. It measures the proportion of true negative cases that the model correctly identifies. In heart disease prediction, specificity signifies the model's ability to accurately classify individuals who do not have heart disease.

The formula for Specificity:

Specificity = True Negatives / (True Negatives + False Positives)

CONCLUSION

This study investigated FOA-RF, a novel approach combining Random Forest and Firefly Optimization Algorithm, for selecting optimal features in heart disease prediction was conducted on five heart disease datasets from Kaggle: Framingham, Heart Disease, Cardiovascular Disease Dataset, Cardio train, and Heart Attack. FOA-RF outperformed RF and FOA individually in selecting optimal features for accurate diagnosis. Evaluation metrics such as Accuracy, Sensitivity, and Specificity showed FOA-RF's superior performance over individual algorithms. The hybrid method efficiently searched feature space, selecting relevant attributes for prediction tasks. SVM-based models with FOA-RF feature selection achieved better results than other selectors, streamlining diagnostics and enabling earlier intervention. The integration of Firefly Optimization and Random Forest addresses feature selection complexity in heart disease prediction, aiming to improve performance and model interpretability. Overall, experiments validate FOA-RF's effectiveness in feature selection for heart disease prediction, highlighting its importance in enhancing accuracy and healthcare outcomes.

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Table 1: Attribute Names

Dataset	Attribute Names	No. of Attributes	No. of Instance
Framingham (Kaggle)	Male, age, education, current Smoker, cigsPerDay, BPMeds, prevalentStroke, prevalentHyp, diabetes, totChol, sysBP, diaBP, BMI, heartRate, glucose, TenYearCHD	16	4240
Heart Disease (Kaggle)	Gender, age, education, currentSmoker, cigsPerDay, BPMeds , revalentStroke, prevalentHyp, diabetes, totChol, sysBP, diaBP, BMI, heartRate, glucose, Heart_ stroke	16	4238
Cardiovascular_Disease_Dataset (Kaggle)	patientid, age, gender, chestpain, restingBP, serumcholestrol, fasting blood sugar, resting relectro, max heart rate, exercise angia, old peak, slope, noofmajorvessels, target	14	1000
Cardio_train (Kaggle)	age, height, weight, gender, ap_hi, ap_lo, cholestrol, gluc, smoke, alco, active, cardio	12	70000
Heart attack (Kaggle)	Heart Diseaseor Attack, HighBP, HighChol, CholCheck, BMI, Smoker, Stroke, Diabetes. Phys Activity Fruits, Veggies, HvyAlcoholConsump, Any Healthcare, NoDocbcCost, GenHlth, MentHlth PhysHlth, DiffWalk, Sex, Age, Education, Income	22	253661

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Table 2: Comparison of Accuracy

Algorithms Dataset	All + SVM	Firefly Optimization (FO) + SVM	Random Forest (RF) + SVM	FO-RF + SVM
Framingham	78.4	83.4	84.2	86.0
Heart Disease (Kaggle)	78.2	79.7	85.9	89.0
Cardiovascular_Disease_Dataset	80.5	81.4	81.8	85.5
Cardio_train	79.1	85.9	87.1	89.1
Heart attack	83.3	85.0	86.4	91.3

Table 3: Comparison of Sensitivity

Algorithms Dataset	All + SVM	Firefly Optimization (FO) + SVM	Random Forest (RF) + SVM	FO-RF + SVM
Framingham	82.6	87.2	90.3	91.6
Heart Disease (Kaggle)	93.0	90.6	92.1	92.3
Cardiovascular_Disease_Dataset	76.3	75.4	77.5	76.4
Cardio_train	81.1	75.9	82.9	82.6
Hheart attack	90.1	91.3	96.1	97.3

Table 4: Comparison of Specificity

Algorithms Dataset	All + SVM	Firefly Optimization (FO) + SVM	Random Forest (RF) + SVM	FO-RF + SVM
Framingham	89.5	90.9	89.5	91.2
Heart Disease (Kaggle)	84.3	81.0	82.3	85.7
Cardiovascular_Disease_Dataset	76.1	77.3	76.8	79.5
Cardio_train	77.0	78.5	82.4	86.7
Heart attack	94.3	95.5	93.2	96.4
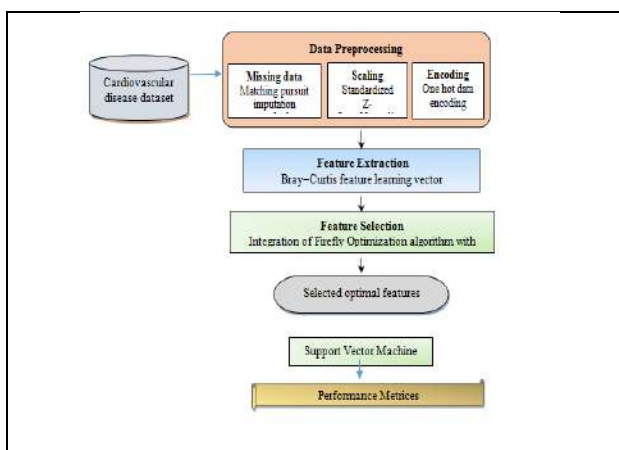
Figure 1: Architecture diagram of Proposed model	**Fig 2: Accuracy, Sensitivity and Specificity Comparison Chart**
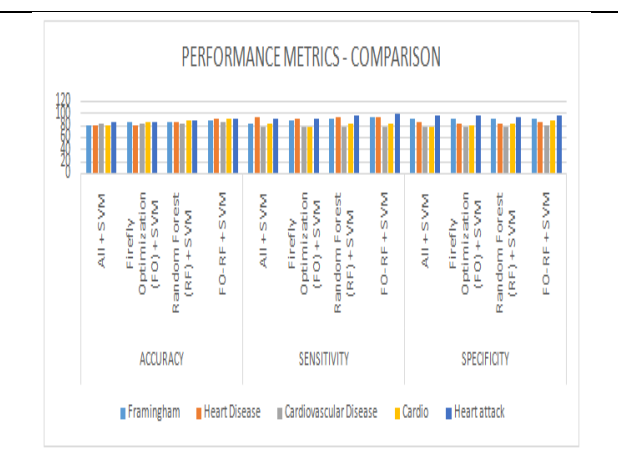
RESEARCH ARTICLE

Multi Objective - Emergency Transportation Problem (MOETP) using Neutrosophic Fuzzy

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ABSTRACT

Two MOTP procedures are utilized in this paper to resolve certifiable new issues. The essential objective of this new system is to offer the most ideal response, under any crisis situation, to a transportation issue with numerous goal capabilities. The target of this issue is to utilize a Neutrosophic fuzzy to decide the ideal transportation problem that will take the least amount of time, money, and most manpower to reach the people affected by flooding. Likewise a model with mathematical outcomes are given to think about the MOETP approaches.

Keywords: Entropy value, Heuristic Method (HM), Multi-objective transportation problem, Neutrosophic fuzzy set, Vogel's Approximation Method (VAM),

INTRODUCTION

A catastrophic event is an unforeseen series of terrible things that happen to society. Various catastrophic events hurt both the climate and the animals that possess it. Tidal wave, seismic tremor, flood, tornado, landslip, volcanic ejection, etc are a couple of them. Catastrophes give startling encounters to every individual who is impacted. Contingent upon the misfortunes, influenced people might encounter monetary strain because of property harm and loss of individual, business, or private property. Numerous businesses have made incredible progress with the utilization of the MOTP approach, including modern area, labor supply arranging, ventures, the travel industry, etc. This strategy's novel kind disposition and numerical properties are primary purposes behind its prosperity. The

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transportation issue, which manages the exchange of products between various beginnings and objections, is a direct programming issue of the dispersion type. Limiting costs and time while improving benefits is its essential objective.
. Hitchcock (1941) introduced and analyzed Transportation Problems (TP). He explained TP, which is the distribution of goods to different destinations from different supply points. These transportation-related problems belong to a single objective. However, transportation problems are typically multiple, complex, conflict and imprecise in real-life situations. There is a method called the Multi-Objective Transportation Problem (MOTP) for solving problems of this kind. Because of the conflict and imprecise nature, it is very difficult to solve.

In 1965, Zadeh[1] developed fuzzy. Fuzzy set is a collection of elements with each element having a degree of belongingness that ranges from 0 to 1. Since 1965, numerous researchers have examined and analyzed fuzzy transportation problems (FTP) and have also developed numerous novel ideas in this area. Zimmermann (1978) introduced the concept of Fuzzy Linear Programming (FLP) and demonstrated the method's consistent high efficacy. Even though FST is incredibly helpful, there are some cases of uncertainty where it is difficult to depict the membership degree. In 1986, Atanassov[2] proposed the Intuitionistic fuzzy set (IFS) as an extension of FST to address this limitation. To address the TP issue, multiple investigators took into consideration the IFS. An emergency event is surrounded by a lot of uncertainties and unreliable data. Inorder to address such incomplete and conflicting data, Smarandache[3] (1998) introduced additional uncertainties and put forth the idea of the Neutrosophic set (NS), considering the degree of Falsity (F), the degree of Indeterminacy (I), and the degree of Truth (T) as three factors.
After that, Wang et al.,[4] (2010) introduced the idea of Single Value Neutrosophic Set (SVNS) for solving real-world problems. For MOTP, Pitam Singh et al.[5] (2016) introduced the idea of fuzzy efficient interactive goal programming. R. Sophia Porchelvi et al.[6] (2018) created a new algorithm for the MOITP using the FPT. Using fuzzy programming, Yeola et al.[7] (2016) presented a parallel approach to solve the MOTP.

The concept of MOTP in a Neutrosophic environment was described by Rizk M. Rizk-Allah et al.[8] in 2018. In order to address the emergency transportation problem, Lin Lu et al.[9] (2020) also applied a single valued Neutrosophic set. Neutrosophic numbers were recently used by Aakanksha Singh et al.[10] (2021) to solve the bilevel transportation problem.

- This paper is organized as follows. Following the introduction, some basic concepts has been given in section 2.
- Section 3 discuss about the problem procedure and application of MOTP.
- Section 4 deals with comparison analysis of proposed method.
- Finally, conclusion of this paper is given in section 5.

Preliminaries
Neutrosophic fuzzy set
A Neutrosophic fuzzy set N^A of X can be defined as
$$N^A = \{(x, T_{N^A}(x), I_{N^A}(x), F_{N^A}(x))/x \in X\}$$
Where $T_{N^A}(x)$ is truth − membership, $I_{N^A}(x)$ is indeterminacy membership $F_{N^A}(x)$ is falsity- membership function such that $T_{N^A}(x), I_{N^A}(x), F_{N^A}(x)$: X→ [0,1] for all $x \in X$ and $0 \le T_{N^A}(x) + I_{N^A}(x) + F_{N^A}(x) \le 3$.

Basic values of Neutrosophic fuzzy set
a)   Normalize value $r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}$
b)   Entropy value, $e_j = -h \sum_{i=1}^{m} r_{ij} \, In \, r_{ij}, j = 1,,2,,\ldots,n \; h = \frac{1}{In(m)}$ where m is the number of constraints
c)   Weight vector $w_j = \frac{1-e_j}{\sum_{j=1}^{n}(1-e_j)}, j = 1,,2,,\ldots,n$

Vogel's Approximation Method (VAM)
The following describes the steps involved in Vogel's Approximation Method (VAM).
1. Identify the problem and organize the data into a matrix form.

2. Determine which two minimum values exist in each row and column. After that, subtract those two lowest values.
3. Decide which row and column has the biggest difference in value.
4. Choosing the cell in a row or column that has the smallest difference value. Allocate the cell after that.
5. Steps 2 through 4 should be repeated until the cell is allocated as much as possible.
6. From table 2, we get the initial feasible solution for VAM

Heuristic Method (HM)
➤ Verify whether the specified problem is balanced or not.
➤ Determine the penalty cost, the difference between the high and low costs, for every row and column.
➤ Allocate this variable as much as you can.
➤ Make necessary quantity and variable adjustments.
➤ To achieve the best outcome, repeat this process.
➤ Table 3 shows the initial feasible solution for HM

Finding The Minimum Transportation Cost, Time And Maximum Man Power For Community Welfare Team To Help Flood Affected Area
In this segment, We have addressed the requirement for individuals to get by in critical conditions, with government assistance local area groups filling in as our targets and limitations. We want to limit individuals' transportation costs and time while likewise giving the best measure of labor conceivable. Likewise, the Vogel's Estimate Technique (VAM) and Heuristic Strategy are applied to take care of the issue utilizing TORA and Zmath Programming. Ultimately, the results of both of these strategies are looked at. Mentioned in table 4

PROBLEM PROCEDURE FOR NEW APPROACH
There are computational processes for the creation of mathematical models that can be used to transform real-world situation problems into optimization models.The suggested approach is summed up in the following steps for solving MOTEP. table 5 and table 6

➤ Formulate the objective function of a real-life MOTEP using Neutrosophic fuzzy parameters.
➤ Construct the membership values (H_D), non-membership values(K_D), and indeterminacy values $(I_D)$of the problem.
➤ Compute the lower and upper bounds by taking $U_K = max\{H_K(x)\}_{K=1}^K$ and $L_K = min\{H_K(x)\}_{K=1}^K$
➤ Define the membership values under Neutrosophic environment.
➤ Selecting the lowest values for truth and indeterminacy membership, and selecting the highest values for falsity membership
➤ To find the best compromise solutions, solve the MOTEP using any fundamental TP method.

APPLICATION OF MULTI-OBJECTIVE EMERGENCY TRANSPORTATION PROBLEM (MOETP)
After a heavy **flood**, A community welfare teamhas shipped their units of
i)   Food and water items
ii) Health supplies like medicine and sanitation etc.,
iii) Man power

From their welfare centres WC1, WC2, WC3 to most affected rural areas RA1, RA2, RA3, RA4 respectively with the following characteristics; the transportation cost, time, and loss of deterioration are considered as Neutrosophic penalties. given in Table 7
Supplies: 8,19,17; Demand: 11,3,14,16
Penalties:
Category 1:

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$$C_1 = \begin{bmatrix} (0.5,0.3,0.6) & (0.3,0.1,0.2) & (0.6,0.7,0.3) & (0.5,0.4,0.6) \\ (0.5,0.4,0.6) & (0.4,0.4,0.5) & (0.5,0.3,0.7) & (0.5,0.5,0.4) \\ (0.6,0.5,0.3) & (0.6,0.7,0.4) & (0.4,0.4,0.5) & (0.6,0.4,0.3) \end{bmatrix}$$

Category 2:

$$C_2 = \begin{bmatrix} (0.4,0.4,0.5) & (0.4,0.3,0.7) & (0.5,0.6,0.3) & (0.6,0.5,0.2) \\ (0.6,0.5,0.2) & (0.7,0.6,0.4) & (0.3,0.7,0.3) & (0.5,0.3,0.7) \\ (0.4,0.3,0.6) & (0.6,0.5,0.7) & (0.5,0.2,0.6) & (0.6,0.4,0.3) \end{bmatrix}$$

Separating the membership function in matrix format as shown below

$$H_1 = \begin{bmatrix} 0.5 & 0.3 & 0.6 & 0.5 \\ 0.5 & 0.4 & 0.5 & 0.5 \\ 0.6 & 0.6 & 0.4 & 0.6 \end{bmatrix} \& H_2 = \begin{bmatrix} 0.4 & 0.4 & 0.5 & 0.6 \\ 0.6 & 0.7 & 0.3 & 0.5 \\ 0.4 & 0.6 & 0.5 & 0.6 \end{bmatrix}$$

$$I_1 = \begin{bmatrix} 0.3 & 0.1 & 0.7 & 0.4 \\ 0.4 & 0.4 & 0.3 & 0.5 \\ 0.5 & 0.7 & 0.4 & 0.4 \end{bmatrix} \& I_2 = \begin{bmatrix} 0.4 & 0.3 & 0.6 & 0.5 \\ 0.5 & 0.6 & 0.7 & 0.3 \\ 0.3 & 0.5 & 0.2 & 0.4 \end{bmatrix}$$

$$K_1 = \begin{bmatrix} 0.6 & 0.2 & 0.3 & 0.6 \\ 0.6 & 0.5 & 0.7 & 0.4 \\ 0.3 & 0.4 & 0.5 & 0.3 \end{bmatrix} \& K_2 = \begin{bmatrix} 0.5 & 0.7 & 0.3 & 0.2 \\ 0.2 & 0.4 & 0.3 & 0.7 \\ 0.6 & 0.7 & 0.6 & 0.3 \end{bmatrix}$$

Now, evaluating the membership values and we get

$$H_1 = \begin{bmatrix} 0.5 & 0.3 & 0.6 & 0.5 \\ 0.5 & 0.4 & 0.5 & 0.5 \\ 0.6 & 0.6 & 0.4 & 0.6 \end{bmatrix}; U_1^H = 0.6 , L_1^H = 0.3 \& H_2 = \begin{bmatrix} 0.4 & 0.4 & 0.5 & 0.6 \\ 0.6 & 0.7 & 0.3 & 0.5 \\ 0.4 & 0.6 & 0.5 & 0.6 \end{bmatrix}; U_2^H = .7, L_2^H = 0.3$$

We get the truth membership values as given below

$$H_1(U(u)) = \begin{bmatrix} 0.33 & 1 & 0 & 0.33 \\ 0.33 & 0.67 & 0.33 & 0.33 \\ 0 & 0 & 0.67 & 0 \end{bmatrix} \quad \& \quad H_2(V(v)) = \begin{bmatrix} 0.75 & 0.75 & 0.50 & 0.25 \\ 0.25 & 0 & 1 & 0.50 \\ 0.75 & 0.25 & 0.50 & 0.25 \end{bmatrix}$$

From above two matrices, we get a truth membership matrix as

Finding solution using Heuristic method

The minimum total transportation cost =0×8+0.25×10+0×3+0.33×6+0×1+0×16=4.48
Here, the allocated cell's number = 6 (is equal to m + n - 1 = 3 + 4 - 1 = 6)
∴ This is not a degenerate solution.

Finding solution using Heuristic method

The minimum total transportation cost =0×8+0.25×11+0×3+0.33×5+0.5×1+0×16=4.9
Here, the allocated cell's number = 6 (is equal to m + n - 1 = 3 + 4 - 1 = 6)
∴ This is not a degenerate solution.

Now taking the indeterminacy values, We get the indeterminacy membership values as given below

$$I_1(U(u)) = \begin{bmatrix} 0.67 & 1 & 0 & 0.5 \\ 0.5 & 0.5 & 0.67 & 0.3 \\ 0.3 & 0 & 0.5 & 0.5 \end{bmatrix} \& I_2(V(v)) = \begin{bmatrix} 0.6 & 0.8 & 0.2 & 0.4 \\ 0.4 & 0.2 & 0 & 0.8 \\ 0.8 & 0.4 & 1 & 0.6 \end{bmatrix}$$

From above two matrices, we get a indeterminacy membership matrix as

Similar techniques are applied, IFS for the problems are given in table.

The minimum total transportation cost =0×8+0×6+0.3×13+0.3×11+0×3+0.5×3=8.7 Here, the allocated cell's number = 6 (is equal to m + n - 1 = 3 + 4 - 1 = 6) ∴ This is not a degenerate solution.

The minimum total transportation cost =0.4×8+0.2×3+0×14+0.3×2+0.3×11+0.5×6=10.7 Here, the allocated cell's number = 6 (is equal to m + n - 1 = 3 + 4 - 1 = 6)
∴ This is not a degenerate solution.
Now taking the falsity values, We get the falsity membership values as given below

$$K_1(U(u)) = \begin{bmatrix} 0.8 & 0 & 0.20 & 0.8 \\ 0.8 & 0.6 & 1 & 0.4 \\ 0.2 & 0.4 & 0.6 & 0.2 \end{bmatrix} \& K_2(V(v)) = \begin{bmatrix} 0.6 & 1 & 0.2 & 0 \\ 0 & 0.4 & 0.2 & 1 \\ 0.8 & 1 & 0.8 & 0.2 \end{bmatrix}$$

From above two matrices, we get a falsity membership matrix as
Similar techniques are applied, IFS for the problems are given in table 8 and table 9

In VAM , the maximum profit(man power) =0.8×5+1×3+1×3+1×16+0.8×6+0.8×11=39.6
Here, the allocated cell's number = 6 (is equal to m + n - 1 = 3 + 4 - 1 = 6)
∴ This is not a degenerate solution.
In HM, the maximum profit(man power) =0.8×5+1×3+0.8×3+1×16+0.8×3+0.8×14=39
Here, the allocated cell's number = 6 (is equal to m + n - 1 = 3 + 4 - 1 = 6)
∴ This is not a degenerate solution.

COMPARISON OF TWO TRANSPORTATION PROBLEM METHODS

The results of VAM and Heuristic Method are compared by evaluating weight age of results using entropy method. The above results show that the minimum of cost and time (H and I) for transportation to supply food, water and health supplies like medicine and so on. And maximum man power (K) to help the flood affected area peoples. Computing entropy for table 11 and get the values as follows (table 12) and Weight age of constraints is evaluated and is shown in table 13. which was calculated in Table 10.

RESULT AND DISCUSSIONS

In the wake of deciding the weightage, it was apparent that VAM gives the best answer for this MOETP. Accordingly, the heuristic methodology won't exactly yield the most intelligent response when contrasted with VAM and furthermore it requires UI aptitude. Hence, we enthusiastically suggest VAM for this proposed approach. Figure 1 displays the Comparative Weight of Two Transportation Methods.

CONCLUSION

In this paper, we had the option to track down the best answer for the crisis transportation issue by utilizing VAM. This approach saves time and is easy to fathom. Likewise, VAM is more promptly applied than different strategies. Consequently, affected individuals who are dealing with this sort of crisis transportation issue, thinks that it is helpful.

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Table 1. Truth Membership Matrix

	RA1	RA2	RA3	RA4	Supply
WC1	0.33	0.75	0	0.25	8
WC2	0.25	0	0.33	0.33	19
WC3	0	0	0.5	0	17
Demand	11	3	14	16	

Table 2. Initial feasible solution(IFS)

	RA1	RA2	RA3	RA4	Supply	Row Penalty
WC1	0.33	0.75	0**(8)**	0.25	8	0.25 | -- | -- | -- | -- | -- |
WC2	0.25**(10)**	0**(3)**	0.33 **(6)**	0.33	19	0.25 | 0.25 | 0.25 | 0.08 | 0.08 | 0.25 |
WC3	0**(1)**	0	0.5	0 **(16)**	17	0 | 0 | 0 | 0.5 | -- | -- |
Demand	11	3	14	16		
Column Penalty	0.25 0.25 0.25 0.25 0.25 0.25	0 0 0 -- -- --	0.33 0.17 0.17 0.17 0.33 --	0.25 0.33 -- -- -- --		

Table 3. IFS of HM

HM	RA1	RA2	RA3	RA4	Supply	Row Penalty (P)	Total (T)	P×T
WC1	0.33	0.75	0**(8)**	0.25	8	0.25 | 0.33 | 0.33 | 0 | -- | -- |	1.33	0.33 | 0.44 | 0.44 | 0 | -- | -- |
WC2	0.25 **(11)**	0 **(3)**	0.33 **(5)**	0.33	19	0.25 | 0.25 | 0.08 | 0.33 | 0.33 | -- |	0.91	0.23 | 0.23 | 0.07 | 0.3 | 0.3 | -- |
WC3	0	0	0.5 **(1)**	0 **(16)**	17	0 | 0 | 0.5 | 0.5 | 0.5 | 0.5 |	0.5	0 | 0 | 0.25 | 0.25 | 0.25 | 0.25 |
Demand	11	3	14	16				
Column Penalty (P)	0.25 0.25 0.25 -- --	0 0 -- -- --	0.33 0.33 0.33 0.33 0.17	0.25 -- -- -- --				

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	--	--	0.5	--				
Total (T)	0.58	0.75	0.83	0.58				
P×T	0.15	0	0.27	0.15				
	0.15	0	0.27	--				
	0.15	--	0.27	--				
	--	--	0.27	--				
	--	--	0.14	--				
	--	--	0.42	--				

Table 4. indeterminacy membership matrix

	RA1	RA2	RA3	RA4	Supply
WC1	0.6	0.8	0	0.4	8
WC2	0.4	0.2	0	0.3	19
WC3	0.3	0	0.5	0.5	17
Demand	11	3	14	16	

Table 5. IFS of VAM

VAM	RA1	RA2	RA3	RA4	Supply
WC1	0.6	0.8	0**(8)**	0.4	8
WC2	0.4	0.2	0**(6)**	0.3**(13)**	19
WC3	0.3**(11)**	0**(3)**	0.5	0.5**(3)**	17
Demand	11	3	14	16	

Table 6.: IFS of Heuristic Method

HM	RA1	RA2	RA3	RA4	Supply
WC1	0.6	0.8	0	0.4**(8)**	8
WC2	0.4	0.2**(3)**	0**(14)**	0.3**(2)**	19
WC3	0.3**(11)**	0	0.5	0.5**(6)**	17
Demand	11	3	14	16	

Table 7. Falsity Membership Matrix

	RA1	RA2	RA3	RA4
WC1	0.8	1	0.2	0.8
WC2	0.8	0.6	1	1
WC3	0.8	1	0.8	0.2

Table 8. IFS of VAM

VAM	RA1	RA2	RA3	RA4
WC1	0.8 **(5)**	1 **(3)**	0.2	0.8
WC2	0.8	0.6	1 **(3)**	1(16)
WC3	0.8 **(6)**	1	0.8 **(11)**	0.2

Table 9: IFS of HM

HM	RA1	RA2	RA3	RA4
WC1	0.8**(5)**	1 **(3)**	0.2	0.8
WC2	0.8 **(3)**	0.6	1	1 **(16)**
WC3	0.8 **(3)**	1	0.8 **(14)**	0.2

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Table 10: Matrix of Obtained Optimal Solution

	VAM	Heuristic Method
H	4.48	4.9
I	8.7	10.7
K	39.6	39

Table 11: Normalized decision matrix

	VAM	Heuristic Method
H	0.0849	0.0897
I	0.1648	0.1959
K	0.7503	0.7143

Table 12 Entropy values

	VAM	Heuristic Method
e_j	0.6572	0.7062

Table 4. Weightage and rank of two Methods

	VAM	Heuristic Method
W_j	0.2602	0.2229
Rank	1	2
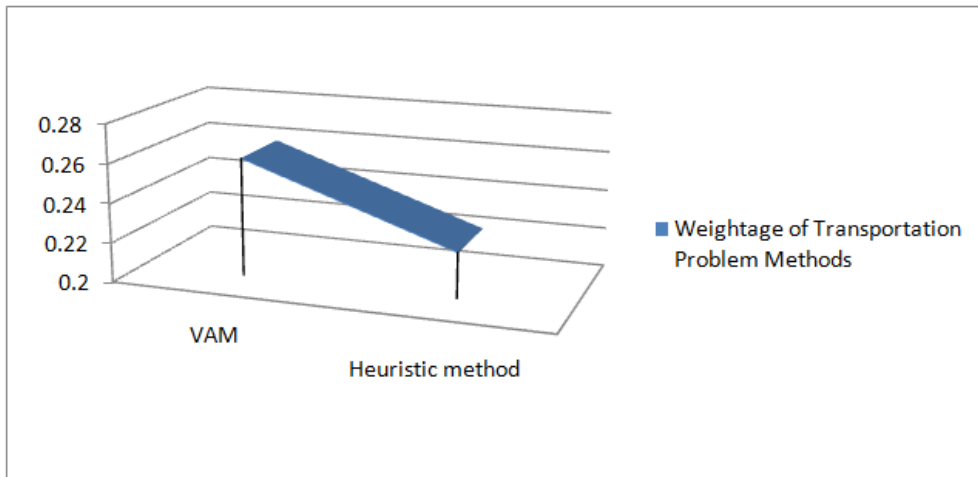
Figure 1 Weightage of two Transportation Techniques

RESEARCH ARTICLE

Dried Sewage Waste in Agriculture: Opportunities and Concerns from a Practical Viewpoint

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ABSTRACT

Problems with waste management and handling have arisen as a result of the exponential expansion of urban areas in India. A product of wastewater treatment facilities, dried sewage waste (DSW) can be utilised in agriculture due to its organic and inorganic constituents. Once treated, DSW is safe for use in agriculture and is the result of primary, secondary, and tertiary treatment procedures. The high nutrient content of DSW, which includes nitrogen, phosphorus, and potassium, makes it highly valued in agriculture. These nutrients contribute to plant development and soil fertility. Many farmers use direct soil integration to incorporate DSW into the soil. This method also recycles waste, conserves natural resources, reduces the use of chemical fertilizers, and lowers agricultural expenses. Nevertheless, in order to lessen the risks and unfavourable perceptions associated with their waste, adequate management and research are required. DSW should be tested for pollutants (e.g. pathogens, heavy metals) before use in soil amendment, agriculture, or other uses. Additionally, it requires frequent monitoring, sampling, and analysis based on production and quality. DSW management strategies should prioritise economic, technological, and societal constraints. The regulatory climate, cultural acceptability, and economic

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circumstances of individual regions determine the worldwide distribution of DSW. Concerns about health, environment, and society are just a few of the downsides to using DSW in agriculture.

Keywords: Dried sewage waste, Wastewater, Organic amendment, Soil health, Nutrient cycling, Food chain.

INTRODUCTION

The fast growth of cities, towns, and villages in India, driven by the country's expanding population, high demographic expansion, urbanisation, industry, and lifestyle changes will increase water demand and anthropogenic wastewater production of various compositions [9].The global population crossed the mark of 8 billion, and 1/6th of the population resides in India, which is the highest in any country. Consequently, waste generation is teeming and causing problems in management and handling. At the same time, mishandling and improper management lead to bad consequences from an ecological, economic, and societal perspectives [10]. Out of several wastes, dried sewage waste (DSW), also known as biosolids is the byproduct of wastewater or effluent treatment plants. In a general sense, it is the residue generated during different stages of the treatment of sewage sludge coming from different sources, including households, offices, industries, and others [11]. Primary treatment is to remove solid and inorganic materials; secondary treatment to degrade biological content through microbial activity; and sometimes tertiary treatment to further reduce pathogens and nutrients. The sludge from these processes is then further processed, stabilized through methods like anaerobic digestion, aerobic digestion, or composting, and then dewatered and dried to reduce volume and improve handling properties. The resulting DSW is nutrient rich and has a soil like texture, which can be used beneficially in agriculture, reclamation of mining sites, and landscaping [12]. The number of wastewater treatment plants and the scale of their operations are also dynamically increasing. However, many plants are either non-functional or not able to handle the huge burden of waste, resulting in a quandary. The practice of using waste products in agriculture dates back thousands of years, with ancient civilizations such as the Greeks and Chinese recognizing the value of human and animal waste as fertilizer. In the 20th century, the development of modern sewage treatment technologies led to the production of more sanitized and concentrated forms of sewage sludge, which has been utilized as DSW since. This transition marked a significant shift from merely disposing of waste to recognizing and harnessing its value in sustainable resource management [8].

Domestic wastewater treatment plants create nutrientrich DSW. After treatment and processing, these materials become fertilizers and soil additives, supporting sustainable agriculture. DSW are safe for agricultural application after primary, secondary, and tertiary wastewater treatments, stabilisation, and dewatering. The U.S. Environmental Protection Agency (EPA) tests DSW for heavy metals, pathogens, and organic chemicals to ensure safety. DSW are prized in agriculture for their high nutrient content, which includes nitrogen, phosphorus, and potassium, which promote plant development and soil fertility. Direct soil integration or surface application followed by ploughing often blend DSW into the soil (Figure 1). This recycles trash, conserves natural resources, reduces chemical fertilizer use, and lowers agricultural expenses, promoting an environmentally and economically sustainable agricultural model. DSW have many benefits, but they must be managed properly to meet public health, environmental safety, and public perceptions, which can hinder their adoption. Agriculture uses DSW to recycle nutrients and organic debris that might otherwise pollute water or landfills. This enriches the soil and minimises the carbon footprint of energy intensive chemical fertilizers. Sustainable techniques like DSW help close nutrient cycles, encouraging a circular economy where waste is reused to create wealth [13]. This strategy promotes resource efficiency and sustainability in agriculture, improving environmental and community health. The use of DSW in agriculture presents both benefits and challenges but using them is difficult and controversial. On one side, they supply critical minerals that promote soil health and agricultural yields while eliminating the need of environmentally harmful chemical fertilizers. While on the other side, include health risks from heavy metals and infections, environmental implications such leaching and runoff, and societal concerns about applying treated sewage sludge on food crops.

Regulatory, public image, and scientific research issues also affect DSW sustainability. Globally, the use of DSW in agriculture varies significantly depending on regulatory environments, cultural acceptance, and local economic conditions. In the United States, about 50% of all DSW produced are applied to land, according to EPA estimates [3]. European countries also actively use DSW under strict regulations ensuring safety and environmental protection. In contrast, in some developing countries, the use of untreated or inadequately treated sewage sludge is more common, raising significant health and environmental concerns. Recent trends show a growing interest in maximizing the sustainability aspect of wastewater treatment and DSW production, focusing on energy efficiency and the recovery of resources such as phosphorus and nitrogen, crucial for agriculture but limited in natural availability. This reflects a broader global shift towards a more circular economy, where waste materials are seen as resources to be cycled back into productive use.

Opportunities of using dried sewage in agriculture
Nutrient recycling
DSW are a nutrient rich product resulting from wastewater treatment and are especially high in essential nutrients such as nitrogen, phosphorus, and potassium. This makes them an excellent resource for recycling nutrients back into the soil, reducing the need for synthetic chemical fertilizers (Table 1). Unlike these chemical alternatives, DSW release nutrients slowly, which benefits plant growth over a longer period and minimizes nutrient runoff and leaching, thus supporting a more sustainable agricultural practice.

Soil health and productivity
Incorporating DSW into agricultural land improves soil structure, enhances water retention, and increases the microbial activity essential for healthy soil ecosystems. The organic matter in DSW boosts the soil's ability to retain both water and nutrients, leading to improved root growth and resistance to erosion. Numerous case studies have demonstrated that fields treated with DSW show marked improvements in crop yields and soil quality compared to those treated with traditional chemical fertilizer [1].

Environmental benefits
The environmental advantages of using DSW are significant. By diverting waste from landfills, where it would decompose and potentially release CH_4 a potent greenhouse gas [5]. DSW use helps reduce greenhouse gas emissions. Additionally, the recycling of these organic materials conserves natural resources by decreasing the demand for chemical fertilizers, which require intensive resource extraction and energy inputs to produce (Figure 2).

Economic advantages
The use of locally produced DSW can offer substantial cost benefits to farmers, who might otherwise rely on expensive imported fertilizers. Local processing and application of DSW can also stimulate local economies by creating new jobs in DSW processing and distribution, further supporting sustainable economic growth and development in agricultural communities. promoting sustainable agriculture, enhancing environmental health, and providing economic benefits (Table 2). However, the successful integration of DSW into agricultural practices requires careful management to ensure environmental safety and public acceptance, underscoring the need for rigorous standards and ongoing monitoring.

Concerns of using DSW in agriculture
Safety and health risks
The use of DSW in agriculture raises significant safety and health concerns primarily due to the potential presence of contaminants such as heavy metals, pathogens, and pharmaceutical residues. These contaminants can pose serious risks to food safety and public health if DSW are not properly treated and monitored. The presence of heavy metals can lead to their accumulation in the soil and eventual uptake by crops, which can enter the human food chain. Similarly, pathogens and pharmaceuticals can also persist in the environment, potentially leading to health risks for both consumers and farm worker [4].

Regulatory standards for DSW usage and their sufficiency

While there are regulatory standards in place intended to ensure the safe use of DSW, questions often arise regarding their adequacy and uniformity across different regions. These standards vary widely, with some critics arguing that they do not sufficiently account for the long-term impacts of DSW application on soil and human health, or the cumulative effects of multiple contaminants.

Public perception and acceptance

The use of processed sewage sludge in food production often faces significant public resistance. Negative perceptions and skepticism generally stem from concerns over contaminants and the overall safety of using waste products in agriculture. Overcoming these perceptions requires transparent, proactive communication strategies, public engagement, and educational initiatives that inform communities about the benefits and safety measures associated with DSW.

Environmental impact

Environmental concerns associated with DSW include the potential for nutrient runoff, which can lead to eutrophication of water bodies, and pollution from improperly processed or applied DSW. Additionally, there are worries about the long-term effects on soil health, such as the accumulation of heavy metals which can adversely affect soil biology and function, potentially making the land less productive or unsuitable for agricultural use over time [7].

Economic and operational challenges

The costs associated with the processing, testing, and safe transportation of DSW can be substantial. Furthermore, substantial infrastructure is required to support the effective and widespread use of DSW, including facilities for processing, storage, and application, as well as systems for monitoring and managing environmental and health impacts. These requirements represent significant investments and operational challenges for municipalities and agricultural operators, which can deter the use of DSW despite their potential benefits. Each of these challenges underscores the need for stringent regulatory oversight, continued scientific research, and robust infrastructure development. Additionally, finding cost-effective, low-tech, user-friendly approaches that safeguard precious natural resources and livelihoods from wastewater deterioration is a challenge [6]. Addressing these concerns comprehensively is essential to fully realizing the benefits of using DSW in sustainable agriculture (Table 3).

Future Directions and Research Needs

Identifying gaps in current research on DSW in agriculture

There are several areas where further research is needed to enhance our understanding of the impacts and benefits of DSW in agriculture. Key gaps include long-term studies on the effects of DSW on soil health, including changes in microbial communities and potential accumulation of contaminants over time. Research is also needed to assess the fate of emerging contaminants such as pharmaceuticals and personal care products within treated soils. Additionally, more data are required on the economic impacts of DSW use in different agricultural contexts, to better understand its cost-effectiveness and scalability.

Potential technological innovations to improve safety and efficiency

Advancements in technology could significantly enhance the safety and efficiency of DSW use. Innovations might include development of more sophisticated treatment processes that can remove a broader spectrum of contaminants more effectively. There is also potential for the development of precision application technologies that could ensure DSW are applied in a manner that maximizes benefits and minimizes risks. Furthermore, realtime monitoring technologies could be developed to track the environmental and health impacts of DSW application, providing immediate data to manage risks proactively. Additionally, DSW based biochar and co-composting of biochar can also look upon for efficient handling [2].

Policy recommendations for encouraging safe and beneficial use of DSW

To promote the safe and beneficial use of DSW, policy recommendations should focus on strengthening regulatory frameworks to ensure comprehensive and uniform safety standards. Policies could encourage research and development in advanced treatment and monitoring technologies by providing funding or incentives. Additionally, there is a need for policies that support educational and outreach programs to improve public perception and acceptance of DSW. These programs should aim to transparently communicate the benefits and safety measures associated with DSW use, addressing public concerns directly and fostering a more informed discourse around the subject.

CONCLUSION

The study in question examined the complicated potential and constraints of using dried sewage in agriculture. DSW offer nutrient recycling, improved soil health and production, environmental benefits through waste reduction and resource conservation, and economic benefits from cost savings and local employment generation. DSW can assist sustainable agriculture and a circular economy because to these benefits. The usage of DSW is not without problems. Concerns include heavy metals, pathogens, and medicines, as well as public scepticism about applying treated waste products to farmlands. Nutrient runoff, pollution, and long-term soil health concerns impede DSW adoption. Moreover, the economic and operational challenges of DSW processing, transport, and infrastructure make scaling this technique difficult. Given these factors, action is required. More study on long-term environmental consequences and new pollutants is needed to bridge knowledge gaps. Technological innovation should improve DSW treatment and application safety and efficiency. Better restrictions are needed to protect safety and build public faith in DSW as a sustainable agricultural resource. Stakeholders, farmers, legislators, scientists, and the public must communicate to handle issues honestly and collaboratively. By improving awareness and collaboration, DSW practices and policies may be refined to maximise benefits and minimise hazards, promoting its wider use in sustainable agriculture. Such activities are essential for global food system sustainability and resilience.

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Table 1: Nutritional benefits of using DSW

Nutrient	Contribution of DSW
Nitrogen (N)	DSW are a rich source of nitrogen, which is released slowly, providing a steady supply to crops over time
Phosphorus (P)	High phosphorus content in DSW helps stimulate root development and increases flowering and seed production.
Potassium (K)	Though less than N and P, DSW contain potassium which is vital for overall plant health and resistance to disease
Organic matter	DSW add significant organic matter that enhances soil fertility and structure, promoting better water retention and aeration.
Trace elements	DSW often contain these micronutrients which are essential for various plant metabolic functions and stress resistance
pH adjustment	DSW can help in moderating soil pH levels, improving nutrient availability and preventing toxicities or deficiencies

Table 2: Other opportunities of using DSW in agriculture Together, these opportunities demonstrate how DSW can play a crucial role in

Aspect	Benefits of DSW	Considerations
Soil structure	Improves soil texture and porosity	Heavy application can lead to soil compaction
	Enhances water retention and aeration	Consistency in application is crucial for expected results
Organic matter	Adds organic matter to the soil, improving soil fertility	May contain pathogens if not properly treated
	Promotes microbial activity, aiding in nutrient cycling	Quality and treatment levels can vary
Erosion control	Helps reduce soil erosion by improving soil structure	Application rates must be controlled to prevent runoff
Economic efficiency	Often more cost-effective than commercial fertilizers	Costs associated with transportation and application

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	Local availability can reduce logistics costs	Requires regular monitoring and compliance with regulations
Environmental impact	Reduces landfill waste by recycling nutrients back into soil.	Potential contamination from heavy metals and other toxins
	Can be part of sustainship waste management practices	Public perception and acceptance vary

Table 3: Concern of using DSW in agriculture with their solutions

Concern	Description	Solutions
Environmental impact	Uncontrolled application can lead to runoff and pollution of water bodies with nutrients and pathogens.	Implementing proper application methods like controlledrelease techniques and buffer zones near water bodies.
Heavy metals	DSW may contain heavy metals such as cadmium, lead, and mercury, which can accumulate in the soil and enter the food chain.	Regular testing of DSW for heavy metal content and adjusting application rates accordingly. Using phytoremediation techniques to reduce metal uptake by crops.
Pathogens	If not properly treated, DSW can harbour harmful bacteria, viruses, and parasites that pose health risks.	Ensuring proper treatment methods such as composting, heat treatment, or anaerobic digestion to eliminate pathogens. Following strict guidelines for application and handling.
Chemical contaminants	Presence of industrial chemicals, pharmaceuticals, and personal care products that are not completely removed during treatment	Upgrading treatment processes to enhance removal efficiency. Regular monitoring and testing for chemical contaminants. Proper disposal of contaminated DSW
Odour and aesthetics	Improperly processed or stored DSW can emit strong odours and affect the aesthetics of the application area.	Implementing odour control measures such as covering storage piles, using additives, or applying DSW during favourable weather conditions
Public perception and acceptance	Skepticism and negative perceptions about using wastederived products in food production can influence acceptance	Conducting public outreach and education programs to raise awareness about the benefits and safety of DSW use. Transparent communication about treatment processes and testing results
Regulatory compliance	Meeting stringent regulatory standards to ensure safety in the application of DSW can be challenging and costly.	Adhering to regulatory guidelines and investing in technologies that ensure compliance. Engaging with regulatory agencies to streamline processes and standards
Logistical challenges	Transporting storing and applying DSW at the right time and in the right amount requires careful logistics	Developing efficient transportation and storage infrastructure Utilizing precision application techniques and integrating DSW application into overall farm management practices.
Soil health and productivity	Potential for long-term degradation of soil quality due to imbalance in soil microbiome or physical properties.	Implementing soil health monitoring programs and using complementary soil amendments to mitigate negative impacts. Practicing crop rotation and diversification to maintain soil fertility.
Economic considerations	Costs associated with treatment, testing, and application of DSW versus benefits gained from their use	Conducting cost-benefit analyses to assess the economic feasibility of DSW use Exploring collaborative partnerships and subsidy programs to offset costs.
Monitoring and management	Continuous monitoring is needed to manage risks and ensure that	Investing in robust monitoring systems for both DSW quality and environmental impacts

	application guidelines are followed to avoid environmental degradation.	Establishing clear management protocols and training programs for personnel involved in DSW handling.

Figure 1: Overview of DSW collection and utilisation in agriculture

Figure 2: Environmental aspect of using DSW in agriculture (Adopted from [5])

RESEARCH ARTICLE
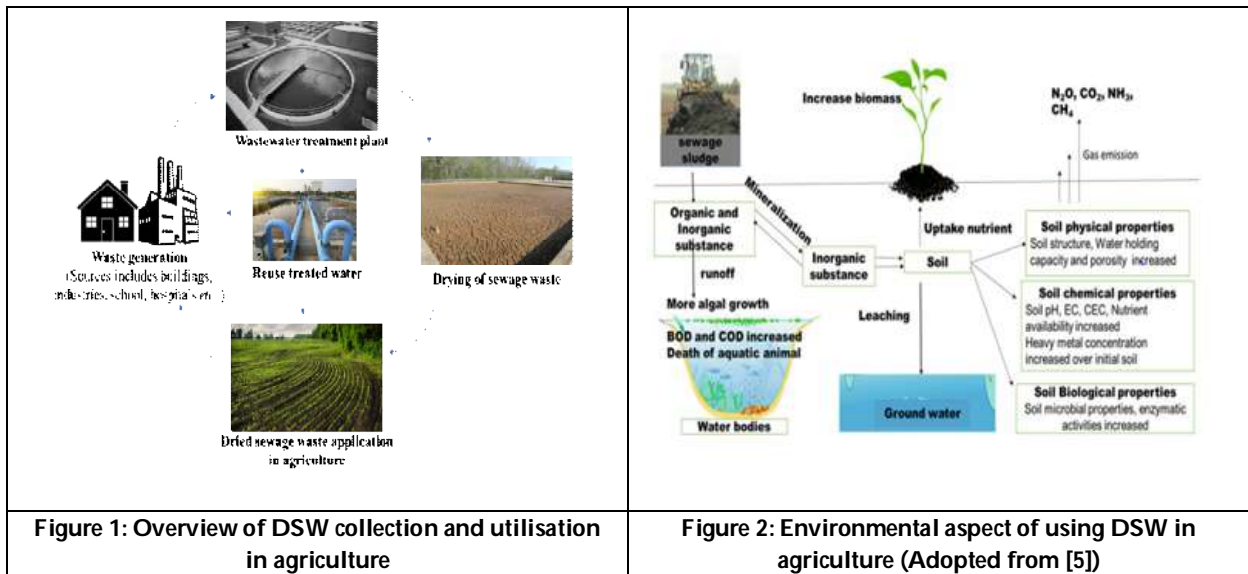
Intervention of Benzodiazepine - GABAergic, Serotonergic and Adrenergic Systems to Show Anxiolytic and Anti-Depressant Activity of Fraction of Medicinal Herbs in Alcohol Withdrawal Mice

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ABSTRACT

To Elucidate therapeutic potential anxiolytic and depression activity of fraction of medicinal plants Future aspects of these medicinal plants compared with marketed formulation to minimize the side effects 30 mice were divided into six groups, each consisting of five animals. These groups included a Saline group receiving saline solution, a Alcohol withdrawal group receiving alcohol, a Standard group receiving Diazepam, and three Test groups receiving extracts from *Psidium guajava, Piper betle, and Morinda citrifolia.* All groups, except the Control and Test groups, were subjected to alcohol administrationThroughout the course of three days, following which theStandard medicine, Diazepam, was administered to Standard groups, and the animals were evaluated for anti-depressant and anti-anxiety activity after one hour. Anti-depressant activity was assessed through the Sucrose Preference Test (SPT), while anti-anxiety activity was evaluated using the Elevated Plus Maze (EPM), Open Field Test (OFT), and Marble Burying Test (MBT). Animals were weighed, and the appropriate dose of each drugwas administered orallytothe respective groups. They undergo GABAergic and Serotonergic Mechanism In behavioral tests, Piper betle extract (MPB) administered at 50mg/kg orally demonstrated superior efficacy in reducing anxiety in mice undergoing alcohol withdrawal compared to *Psidium guajava* (MPG) and *Morinda citrifolia* (MMC) extracts in the same amount. Specifically, MPB showed stronger anxiolytic effects than MPG and MMC in the Open Field Test and Elevated Plus Maze, indicating its potential as a therapeutic agent for alcohol withdrawal-induced anxiety. Additionally, in the Marble Burying Test, MPB exhibited notable anxiolytic effects in the alcohol withdrawal group, suggesting its effectiveness in reducing anxiety-related behaviours.

Keywords: Open field test , Elevated plus maze, Marble burying test , Sucrose preference test Methanolic extract from Piper betle (MPB) , Methanolic extract of Morinda citrifolia (MMC) , Methanolic extract of Psidium guajava (MPG) ,Diazepam.

INTRODUCTION

Anxiety is a typical human emotion that functions as a moderate stimulus for anticipatory and adaptive responses to challenging or stressful situations. However, when anxiety becomes excessive, it can destabilize individuals and lead to dysfunctional states. Anxiety that is pathological is identified when it arises without any actual challenge or stress, or when its intensity or duration is disproportionate, causing significant distress and impairing psychological, social, occupational, biological, and other aspects of functioning.[1]While the full scope of the pandemic's impact on mental health is not yet fully understood, its profound effect on individuals globally is apparent. The COVID-19 Mental Disorders Collaborators analyzed international survey data from both before and after the pandemic to gauge the prevalence of utilizing the Global Burden of Disease Study model for depression and anxiety. They predicted a 27.6% increase in global cases of major depressive disorder, resulting in 53.2 million new cases. Similarly, they found a 25.6% rise in anxiety disorders, adding 76.2 million new cases. These troubling trends are seen across all genders and various age groups, which is particularly worrisome given that anxiety and depression are already significant causes of disability worldwide..[2] Lockdowns, closings of schools, unemployment, and a rise in deaths—not only in nursing homes—became the new normal. The new corona virus, its quick spread, and the lack of scientific knowledge about it resulted in long-term living circumstances characterized by high levels of stress and unpredictable events that were beyond of people's control. According to the World Health Organization (WHO), the incidence of anxiety and depression has increased globally by 25% since the beginning of the COVID-19 pandemic.

Suicidal conduct was found to be predicted with unemployment, especially in Slovakia during the first wave. This was evidenced by survey data that revealed 54.1% of participants had previously sought treatment for affective disorders or anxiety, and 86.6% of respondents believed the pandemic had a detrimental influence on mental health**. [3]** By the first week of August 2020, the novel corona virus (COVID-19) had reached over 275 countries, regions, and territories, resulting in more than 19 million confirmed cases and over 700,000 deaths worldwide.**[4]** Outbreaks of infectious diseases such as COVID-19 are commonly associated with widespread anxiety and significant mental distress.**[5]**India saw a spike in the number of reports of persons having symptoms of alcohol withdrawal during the early stages of the COVID-19 pandemic. It was not possible to purchase alcohol because of the sudden and severe mobility restrictions as well as the lockdown-related closure of stores and pubs that sold it. Those with addictions to alcohol experienced severe despair when alcohol was unavailable, and a small percentage of them considered suicide as a result. National media reports claim that alcohol withdrawal symptoms have caused an apparent (and unprecedented) rise in the number of attempted suicides and deaths in India.**[6]**To investigate the link between alcohol withdrawal and suicide during the COVID-19 lockdown in India, we analyzed suicide reports from current news stories. Using search terms such as "alcohol accessibility," "COVID-19 pandemic," "COVID-19 self-harm," and "alcohol withdrawal symptoms," we utilized the Google News search engine to collect reports of suicide incidents from English-language online news sources in India between March 25 and May 17, 2020. We gathered detailed information on 27 cases of alleged suicide or attempted suicide. Duplicate reports of the same incidents across different sources were excluded, as well as cases of suicide not related to COVID-19, alcohol unavailability, or alcohol withdrawal symptoms. A summary of these 27 cases is presented..**[7]**About 45 alleged suicides connected to alcohol withdrawal symptoms were recorded as everything was under lockdown, says a 2020 storyInside The Economic Times. However, for just 27 of these cases was comprehensive information available. All 27 recorded victims of alleged suicides or There were male suicide attempts., aged between 25 and 70 years (with some ages not specified). These cases were reported from the states of Kerala (n = 11), Karnataka (n = 2), Telangana (n = 8), Tamil Nadu (n = 4), and Assam (n = 2). Except for one case of an alleged suicide attempt in Kottayam, Kerala, the remaining 26 cases were completed suicides. The most common method among these suicides was the consumption of hazardous liquids (n = 8). Other methods included hanging (n = 6), electrocution (n = 2), wrist-slitting (n = 1), drowning (n = 2), and jumping from a building (n = 1). The high incidence of deaths from consuming hazardous liquids raises questions about whether individuals mistakenly believed the liquids included alcohol or a replacement for alcohol. (accidental deaths) or if the suicides were intentional..**[8]**Furthermore, a study examined the potential role of alcohol consumption and withdrawal symptoms in reported suicides and suicide attempts during the lockdown. Previous

research has proposed several reasons for suicides connected to COVID-19, including apprehension about catching the infection, aversion to propagating it to others (like family members, friends, or hospital patients), mental distress brought on by financial hardships (such as job loss or financial instability during the lockdown), depression stemming from social isolation and quarantine measures, challenges in accessing food, xenophobia, and the inability to obtain alcohol[9]Moreover, it has been observed that stressors such asjoblessness and depressive symptoms, hopelessness, vulnerability, and a sense of inadequacy in supporting one's family can exacerbate suicidal ideation, suicide attempts, and the risk of actual suicide.[10] The travel restrictions imposed during India's statewide lockdown have had severe consequences for individuals battling addiction. Alcohol's scarcity, recreational drugs, and other addictive substances has led to significant psychological distress for some, often resulting in self-harm. Additionally, there have been documented instances of self-harm and suicide linked to attachment to playing games online.[11]Several neurotransmitters, such as adenosine, glutamate, gamma-aminobutyric acid (GABA), cholecystokinin, and serotonin, play a role in anxiety. While some exert excitatory effects, others have inhibitory functions. These neurotransmitters are implicated in the modulation of anxiety-related states, either by up regulating or down regulating them. [12]Moreover, they are ineffective in treating depression. Effective treatment for depression often involves the use of traditional antidepressants, such as tricyclic antidepressants (TCAs), selective serotonin reuptake inhibitors (SSRIs), selective noradrenaline reuptake inhibitors (SNRIs), and monoamine oxidase inhibitors (MAOIs). Among them, SNRIs and SSRIs have been shown to be generally effective in treating depression and anxiety. But when taking these drugs, those who have co-occurring depression and anxiety may first feel more anxious. [13]

MATERIALS AND METHODS

Chemicals uses
The following chemicals were used for this study : Methanol, chloroform, distilled water, Sodium hydroxide, Ethyl acetate, ferric chloride, Copper sulphate, Ethanol (Changshu Hongsheng Fine Chemical Co., Ltd), Lead acetate Potassium hydroxide, concentrated hydrochloric acid, Diazepam Injection I.P(Neon Laboratories Limited) ,Acetic acid, Hager Reagent, Wagers Reagent, Glacial Acetic acid, Sodium Hydroxide Pellets,

Instrument used
Magnetic stirrer(REMI Magnetic Stirrer, Elevated Plus), and glassware (Borosil).Heating mantel, Rotary Evaporator. Open field Apparatus, Elevated Plus Maze,, Electronic Weighing Balance (LABINDIA), Marble Burying Test, Soxhlet extractor.

Experimental Animals
Male Swiss albino mice, weighing between 25 and 30 grams, were used in the study. They were housed in typical housing settings, had unlimited access to water, and feed a conventional pellet diet. Under the ethical number 02/IAEC/CLPT/2023-24, the study was approved by the Institutional Animal Ethics Committee (IAEC) on March 24, 2024, and was carried out in the Department of Pharmacology, Chalapathi Institute of Pharmaceutical Sciences.

Collection And Authentication Of Plant Material
Psidium guajava leaves were collected from Cumbum, Andhra Pradesh, and verified by Dr. Satyanarayana Raju, a plant taxonomist and botanist affiliated with the Department of Botany and Microbiology at Acharya Nagarjuna University in Guntur. The Morinda citrifolia fruit and Piper betle leaves were sourced from Lam, located in Andhra Pradesh's Guntur District, and were authenticated by the same authority, Dr. Satyanarayana Raju.

Preparation of Guava Leaf Extract
The methanolic extract of Psidium guajava Linn was prepared by macerating 50 grams of guava leaf powder with 250 milliliters of 75% v/v methanol in a 500-milliliter beaker, which was covered with aluminum foil. The beaker was then placed on a magnetic stirrer for approximately three days. After maceration, the mixture underwent filtration

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using Whatman No. 1 membrane filter paper and was subsequently vacuum-dried in a rotary evaporator operating at 45°C and 180 revolutions per minute (rpm). Next, the substance's output as an amount was determined.

Preparation of Piper Betle Extract

Young Piper betle Linn petals were harvested, shade-dried, and subsequently ground into coarse powder using a mechanical grinder. The dried powder was then subjected to extraction in a Soxhlet extractor, utilizing 250 milliliters of methanol as the solvent. The extraction process was completed at temperatures ranging from 70°C to 80°C for a duration of 23 hours. Following extraction, Concentrating the extract was done with a rotary evaporator running at 180 rpm and 45°C. The % yield of the extract was then determined.

Preparation of Morinda Citrifolia Fruit Extract

After gathering fresh Morinda citrifolia fruits, they were shade-dried and then mechanically ground into coarse powder. Five grams of this powder were weighed and placed into a 250 ml separating funnel. Next, 100 milliliters of water was added, followed by 5 grams of methanolic extract from Morinda citrifolia. Additionally, 100 ml of ethyl acetate was introduced into the separating funnel. The contents were vigorously shaken for two hours to facilitate the separation into organic and aqueous layers. Following this, the two layers were transferred into separate beakers. The layer of water underwent another round of extraction via the addition of 100 ml of ethyl acetate and shaking for an additional two hours before separating the organic phase. The layer of organic matter was then subjected to a rotary evaporator under a pressure of 100 pascals, maintaining a temperature of 50°C for three hours, and rotating at 200 rpm. The resulting semi-solid content was collected. Meanwhile, the aqueous layer was also processed in a rotary evaporator under a pressure of 100 pascals, at a temperature of 70°C, and rotating at 200 rpm for two hours. After Morinda citrifolia's ethyl acetate and methanolic extracts were extracted, the organic semi-solid drug content was manually dried, and the % yield was determined.

Experimental Design

30 mice in total (n = 30) were utilized for the research. The Animals were separated into six groups, each consisting of five animals:

Group	Treatment
Group I	Saline (0.5% saline solution)
Group II	Negative Control (Alcohol)
Group III	Standard (Diazepam 1mg/kg, i.p.)
Group IV	Test-1 (Psidium guajava 50 mg/kg ,p.o)
Group V	Test-2 (Piper betle 50 mg/kg ,p.o)
Group VI	Test-3 (Morinda citrifolia 50 mg/kg ,p.o.)

With the exception of the Saline group and the test groups (Test-1, Test-2, Test-3), all groups were exposed to alcohol treatment for three consecutive days. On the fourth day, the A popular medication (Diazepam) was given to the respective groups one hour after drug administration. Subsequently, the animals were assessed for antidepressant and anti-anxiety activities. The antidepressant activity of the test drugs was assessed through the Sucrose Preference Test (SPT). Meanwhile, the anti-anxiety activity of the test drugs was evaluated using the Elevated Plus Maze (EPM), Open Field Test (OFT), and Marble Burying Test (MBT). Before drug administration, Animals was measured, and the appropriate The drug's dosage was given orally to each of the groups.

Anti-Anxiety Models
Elevated Plus Maze

To explore the anxiolytic-like effects of novel chemical entities (NCEs) in mice, the Elevated Plus Maze (EPM) serves as a well-established animal model. The EPM equipment is made of grey-painted plexiglass and consists of two open arms measuring 35 × 5 cm and two enclosed arms measuring 35 × 5 × 15 cm. The arms extend from a central platform measuring 5 × 5 cm, which is raised 40 cm above the floor. Every mouse was positioned separately in the middle of the device, facing one of the open arms, and its movements were recorded for five minutes using a video camera, noting how long it stayed in each arm and how many entries it made. Following each trial, the maze was meticulously cleaned with 10% v/v ethanol and dried to prevent scent cues from influencing subsequent trials. Successful passage of all four foot beyond the arm's boundary into the central region was deemed an effective entry. A rise in the quantity of duration spending in the open arms and/or the duration of entry into them suggested that the NCEs were having anxiolytic effects. Additionally, the overall number of entries and the amount of entry into the closed arm were assessed to gauge the impact of NCEs on the motor aspects of the animals' exploratory behaviour. [14]

Open field test

The Open Field Test equipment is made up of a central compartment and a peripheral compartment. The peripheral compartment is separated into 16 squares of equal proportions, while the central compartment contains 9 squares, each measuring 10 x 10 cm. The total dimensions of the OFT box are 50 × 50 × 15 cm. When the experiment began for the first time, The animal was positioning itself in a corner of the outer square of the OFT box and allowed five minutes to explore. A Logitech HD webcam positioned above the apparatus, linked to the computer, was used to track The quantity of square crossings and the duration of time in both the center and peripheral compartments. The number of square crossings and the amount of time spent within the Central compartment were then calculated.. [15]

Marble Buryi

Every mice was housed in an individual plastic cage measuring 38 × 21 × 14 cm, with husk bedding positioned 5 cm below the bottom surface. The bedding contained twenty-seven small glass marbles, each with a diameter ranging between 10 and 12 micrometers, arranged in three rows and nine columns. After being exposed for five minutes, the number of marbles that remained buried was counted.Marble was considered to be "buried" if it occupied a minimum of 2/3 of the region at Husk.[16]Anxiolytic drugs have been shown to reduce the total number of marbles concealed, and the animals' marble-burying behaviour is suggestive of anxiety.

Anti-Depression Models
Sucrose preference test

Two bottles were given to each mice cage; one had regular consuming water and the other a solution containing one percent sucrose (1 gramme of sugar in 100 milliliters of distilled water .Following this acclimationT he mice were provided a whole day's fast without food or liquids, and the amounts of regular and sugar-sweetened water they consumed were measured and recorded. The indication of anhedonia was the sucrose-preference test. Applying the equation. The quantity of sugar and water ingested (measured in milliliters) was recorded after an entire day, and the sucrose preference was computed as follows: sucrose preference %)=sucrose consumption/(sucrose consumption water consumption)×100. [17]

RESULTS

Results of testing for the phytochemicals in secoundary metabolites presence and absence of selected herbs. **+ PRESENCE - ABSENCE**

ANTI-ANXIETY ACTIVITY

A)   Open Field Test

The outcomes of the Two-Way ANOVA with Tukey's Multiple Comparison Test are shown in Figure 2. A) The quantity of line segments in the middle section B) The quantity of line intersections inside the periphery compartment C) Duration of stay in central section D) Significant differences were found between the treatment groups based on the amount of time spent in the peripheral compartment [$F_{(5,15)}=37.50$; $P<0.0001$], [$F_{(5,15)}=20.92$; $P<0.0001$], [$F_{(5,15)}=15.88$; $P<0.0001$], and [$F_{(5,15)}=22.64$; $P<0.0001$], respectively. Compared to saline withdrawal mice, alcohol-deprived mice spent less time, made fewer entries, and crossed fewer lines in the middle compartment of the open field test. In contrast, compared to alcohol withdrawal mice, the Diazepam-treated group spent longer time, produced more entries, and crossed more lines in the OFT's center compartment. MPG, MBP, and MMC (50 mg/kg, p.o.) exhibited a more pronounced Diazepam-like effect onmice going through an alcohol detox.

B)   Elevated Plus Maze

The elevated plus maze test showed significant differences in both A) amount of the duration spending time in the open arm and B) the amount of entry in the open arm between the different treatment groups, as shown by the two-way ANOVA with Tukey's multiple comparison test in Figure 3 [$F_{(5,15)}=7.243$, $P<0.0012$] and [$F_{(5,15)}=21.67$, $P<0.0001$], accordingly Interestingly, animals going through saline withdrawal showed no anxiogenic activity at all, but those going through alcohol withdrawal did. Animals administered 50 mg/kg orally with MPG and MMC spent a shorter period in and made smaller entry into the open arm than mice suffering alcohol withdrawal. In contrast, animals treated with MBP spending longer in and made greater entries into the open arm.However, this study highlights MPB's calming effects in mice going through alcoholic addiction**.**

C)   Marble Burying Test (MBT)

Figure :3ANOVA in Two Ways will The results of Turkey's multiple comparison test indicated a significant difference [$F_{(5,17)}=17.60$;$P<0.0001$] between the various treatment groups. correspondingly In the marble burying experiment, mice on alcohol withdrawal buried more marbles than mice on saline withdrawal, suggesting that the mice were nervous. Additionally, animals given the drug diazepam buried less marbles than the alcohol withdrawal mice, suggesting that the drug had an anxiolytic effect on the alcohol withdrawal mice. Furthermore, the test drugs MPG and MMC were less successful than test drug MPB at 50 mg/kg p.o. in decreasing the quantity of marbles buried in mice as compared to the group treated with diazepam, indicating The calming effects of MPB

ANTI-DEPRESSION ACTIVITY

A) Sucrose Preference Test

The impact of 50 mg/kg orally administered MPG, MPB, and MMC on alcoholic withdrawal-induced SPT in mice was investigated. There was a 13.58% decrease in sucrose intake in contrast to saline consumption during alcoholic beverage withdrawal. However, there was a 13.10% increase in sucrose intake with diazepamin comparison to quitting alcohol Additionally, there was a 17.56% increase in sucrose intake with MPG (50mg/kg) compared to alcohol withdrawal, and a 18.25% increase in sucrose intake with MPB (50mg/kg) compared to alcohol withdrawal. Moreover, there was a 16.60% increase in sucrose intake at a dosage of MMC (50mg/kg) compared to alcohol withdrawal.

DISCUSSION

According to the present research, withdrawal symptoms may be exacerbated by malfunction inreceptors that are responsible for neurotransmitter, including adrenergic, serotonin, and GABA. Abuse of alcohol lowers GABA levels, which upsets the brain's delicate balance between both restrained and stimulated messages. By limiting ethanol metabolism by inhibiting the activity of the alcohol dehydrogenase enzyme, a 0.1% volume/volume ethanol solution

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might increase ethanol bioavailability and perhaps reduce withdrawal symptoms. Furthermore, increased 5-HT2A serotonin receptor activation may exacerbate withdrawal symptoms.Research on mice using selective agonists and antagonists has shown evidence that 5-HT2C receptors may have a role inthe signs of drinking too much alcohol. Chronic ethanol withdrawal hypo activates GABAergic-benzodiazepine inhibitory circuits, which is linked to anxiogenic effects and anhedonia. This work provides important new information about the ability of methanolic extracts from the leaves of Psidium guajava, Piper betle, and Morinda citrifolia to relieve the symptoms of alcohol withdrawal in mice. These extracts' anxiolytic and depressive properties have been shown in earlier studies on normal mice, maybe as a result of their high bioactive alkaloids and flavonoid content.

1. **Open Field Test:** When it comes to OFT, MPB (50 mg/kg, po) had a greater effect on the mice's anxiety caused by alcohol detoxification than MPG and MMC (50 mg/kg, po).
2. **Elevated Plus Maze:** in the case of EPM, MPB hadCalming effects in alcohol withdrawal mice ,with MPB (50mg/kg,p.o.)having a stronger impact than MPG,MMC (50mg/kg,p.o.)in the comparision group.
3. **Marble Burying Test:** When it comes to of MBT , a strong anxiolytic effect was seen in the Alcohol detoxification group by MPB (50mg/kg,p.o.).
4. **Sucrose Preference Test:** In this particular instance of SPT, the beverages discontinuation group consumed more sucrose because Psidium guajava and Morinda citrifolia extracts were more efficient than Piper Betle at (50 mg/kg, p.o)

Statistical Analysis

The mean standard error (SEM) represented all mentioned results. Analysis was conducted via Two-Way ANOVA, and Tukey's The Several Comparison Procedure was used to determine statistical significance, with the threshold set at $P < 0.0001$.

CONCLUSION

Phytochemical analysis reveals that the methanol-based extraction of Psidium guajava, Piper betle, and Morinda citrifolia contains phytocompounds including alkaloids, flavonoids, steroids, tannins, and volatile oils. Confirmation of these phytocompounds was achieved through TLC analysis, employing standards like Quercetin, Rutin, and Scopoletin.In animal behavioral studies, it was observed thatThe methanol-based Psidium guajava extractionand Morinda citrifolia,delivered at a 50-mg/kg (p.o.), dosage of exhibited a less significant antianxiety and antidepressant effect Mice without alcohol.In contrast toPiper Betle.

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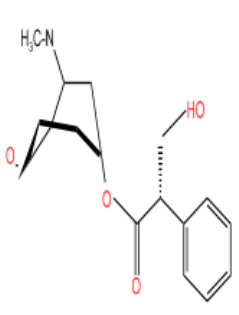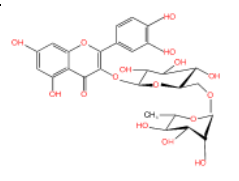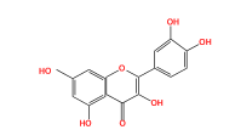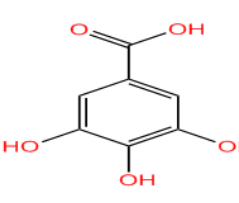
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Table 1 : Plant profile

S. NO	PLANT NAME	BASIC STRUCTURE	CHEMICAL CONSTITUENTS	PHARMACOLOGICAL ACTIVITY
1.	*MORINDA CITRIFOLIA*	**SCOPOLETIN**	• Scopolatin • Flavanoids • Beta-sitosterol • Catechin • **Damnacanthal** • **Fatty acids** • **Alkoloids**	➢ Anti-diabetic activity ➢ Anti-inflammatory activity ➢ Anti-fungal activity ➢ Anti-oxidant activity ➢ Anaphylactic activity ➢ Immune stimulant activity ➢ Anti-ulcer activity ➢ Anti-hypertenssive activity ➢ Anti-bacterial activity

2.	*PSIDIUM GUAJAVA*	**RUTIN**
		  QUERCETIN
		  GALLIC ACID
			• Quercetin
			 • Rutin
			 • Proteins
			 • Vitamins
			 • Minerals
			 • Enzymes
			 • Triterpinoids Gallic acid
				➢ Anti-oxidant activity
				 ➢ Anti-Diabetic activity
				 ➢ Anti-diarrheal activity
				 ➢ Anti-microbial activity
				 ➢ Anti-obesity activity
				 ➢ Anti-inflammatory activity
				 ➢ Anti-fungal activity
				 ➢ Anti-cancer activity
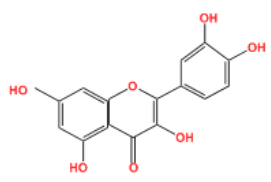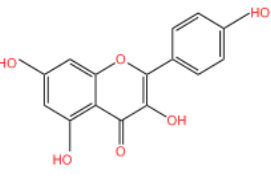
3.	*PIPER BETLE*	QUERCETIN KAEMPFEROL	• Quercetin • Kaempferol • Eugenol • **Hydroxychavicol** • **Tannins**	➢ Anti-bacterial activity ➢ Anti-fungal activity ➢ Anti-oxidant activity ➢ Anti-diabetic activity ➢ Anti-cancer activity ➢ Gastro protective activity ➢ Anti-depressant activity

Table : 2 Phyto Chemical Screening

S.NO	Secondary Metabolites	Psidium Guajava	Piper betle leaf	Morinda citrifolia fruit
1	**Alkaloids**	+	+	+
2	**Flavonoids**	+	+	+
3	**Glycosides**	-	+	+
4	**Steroids or Lipids**	+	+	+
5	**Carbohydrates**	+	+	+
6	**Tannins**	+	+	+
7	**Volatile oils**	+	+	+
8	**Proteins**	+	+	-
9	**Phenols**	+	+	+
10	**Terpenoids**	+	+	+
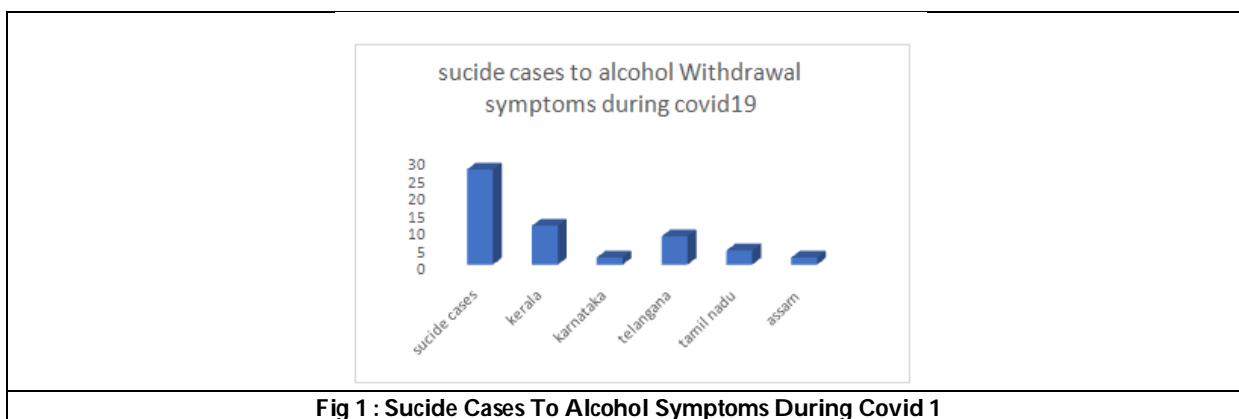
Fig 1 : Sucide Cases To Alcohol Symptoms During Covid 1

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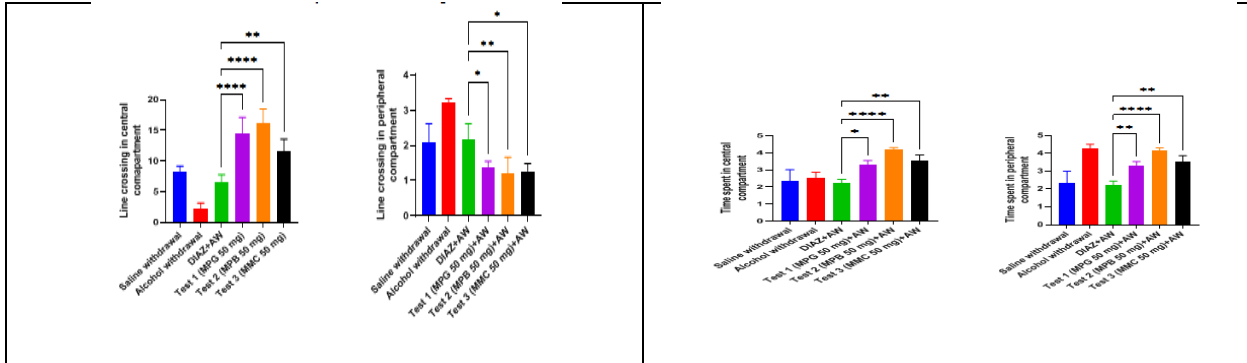
Fig 2: Impact of 50 mg/kg.p.o. MPG, MBP, and MMC on A) Line Crossing Percentage in Central Compartment B) % of the peripheral compartment's line crossings C) Duration of Stay in Central Section D) Spending Time in the OFT Mice Model Peripheral Segment
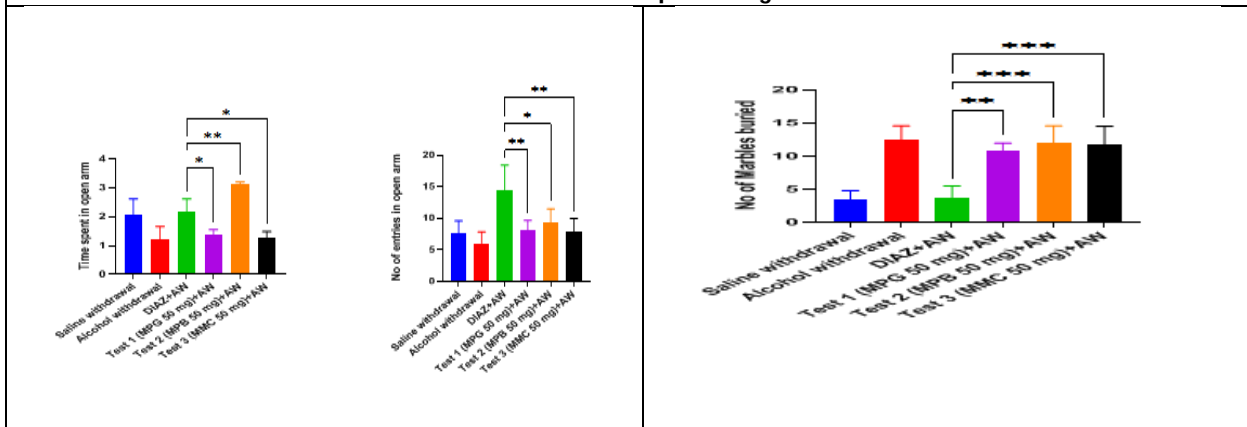
Fig 3:Impact of MPG, MPB, MMC (50mg/kg.p.o.) on Alcohol withdrawal induced EPM
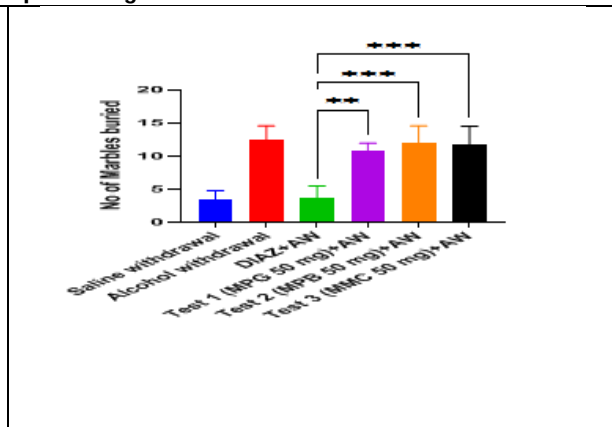
Fig 4 : Effect of MPG, MPB, MMC (50mg/kg.p.o.) on Alcohol withdrawal induced marble burying in mice.

RESEARCH ARTICLE

A Robust SVM-SIFT Machine Learning based Architecture for Detecting Diseases in Solanaceae Plants

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ABSTRACT

A local plant disease detection system is crucial for ensuring food security and safeguarding the livelihoods of farmers. By enabling early identification and intervention against crop diseases, such a system can prevent yield losses and preserve agricultural productivity, thereby directly impacting the lives and incomes of people dependent on agriculture. Additionally, localized disease detection systems empower communities to address specific agricultural challenges unique to their region, fostering resilience and sustainability in local food production systems. This study presents an approach to plant disease detection using Support Vector Machine (SVM) classification and Scale-Invariant Feature Transform (SIFT) for feature extraction.The methodology harnesses a dataset comprising 11,336 manually collected images of three prevalent solanaceae plant species: potato, tomato, and eggplant. These images were captured in the agricultural fields of the Anand region, Gujarat, India, employing a smartphone camera. The developed SVM model achieved an accuracy of 71.54% in classifying plant diseases. This research contributes to the advancement of automated disease detection in agriculture, particularly in the context of solanaceae crops prevalent in the Anand region. The findings demonstrate the potential of SVM-based approaches for accurate and efficient disease diagnosis, offering valuable insights for crop management and agricultural sustainability in the region.

Keywords: Plant diseases, solanaceae plants, machine learning, Support Vector Machine, Scale-Invariant Feature Transform.

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INTRODUCTION

Plant ailments pose considerable challenges to international nutrition security and environmental farming practices [1]. Identifying these diseases early and precisely is crucial for efficient adminstration and alleviation tactics. Standardpractices of plant health monitoring, reliant on direct observation by trained persons requires much effort and prone to errors [2], [3]. However, advancements in technology, particularly in machine learning, have transformed the landscape of plant disease detection [4], [5], [6], [7]. Machine learning techniques, such as SVM (Support Vector Machines), ANN (Artificial Neural Networks), RF(Random Forest), KNN (k-nearest Neighbours), DT (Decision Trees), and convolutional neural networks (CNNs), have revolutionized the automation of disease diagnosis in plants[8], [9], [10], [11]. These techniques leverage extensive datasets of images depicting healthy and diseased plants to train models capable of accurately classifying and diagnosing plant diseases based on visual symptoms. By analyzing leaf images or other plant parts, machine learning algorithms can identify subtle patterns and indicators of disease that may evade human observation[12][13].

Machine learning methods' effects on plant disease detection have been investigated, revealing significant improvements in accuracy and automation.Patil & Lad, 2021 have introduced chilli plant leaf disease diagonosis system which is fully automated and it is employing SVM and KNN algorithms. By utilizing image classification and GLCM feature extraction techniques, accuracy of the model is enhanced[14]. This study introduces an automated model for detecting and classifying stem diseases, integrating digital image processing with four different ML methods including RF, KNN,IL(Impact Learning) and SVM. Using the collection of approximately 3000-4000 images belonging to different classes of diseased and healthy stems, SVM exhibited the highest performance with87.00% accurate result[15]. A study introduces a novel method for detecting papaya fruit and leaf diseases, integrating GLCM feature extraction with classifier hyperparameter tuning. Considering eight classes of healthy and diseased papaya, 16 features were extracted using GLCM. Hyperparameter tuning with SVM and RF resulted in accuracies of 91.47% and 90.22% respectively, surpassing existing methods [16]. This research introduces a method for detecting and classifying diseases in rice plants, utilizing Residual Neural Network (ResNet). ResNet proved to be a rapid and highly efficient techniquepreventing saturation in larger datasets or deeper networks [17]. The proposed method enhances leaf disease identification in tomato plants by combining multiple features to improve classification accuracy. Utilizing random forest and decision tree classifiers, results show the random forest classifier achieves higher accuracy (94%) compared to the decision tree classifier (90%) [18].Machine learning models are scalable and can be deployed on various platforms, including smartphones and drones, enabling rapid and widespread monitoring of agricultural fields[19], [20]. This scalability enhances the coverage and effectiveness of disease surveillance efforts. Despite initial investments in technology and infrastructure, the long-term cost savings associated with early disease detection and targeted treatment outweigh expenses, thus promoting cost-effectiveness. Furthermore, machine learning-driven disease detection fosters information basedselection in the field of agriculture[21]. Farmers and policymakers can leverage insights from large datasets to implement proactive measures for disease prevention and management. This strategy enhances eco-friendly farming by maximizing the use of resources and decreasing the application of chemicals, consequently lessening ecological footprint Moreover, it has indirect benefits for public health, as early detection and management of plant diseases contribute to food safety and security[22], [23], [24]. Machine learning techniques have revolutionized plant disease detection, offering unprecedented opportunities for precision agriculture, sustainable food production, and economic development. By harnessing the power of data and technology, stakeholders can effectively combat plant diseases and ensure the resilience and vitality of agricultural systems[25].

METHODOLOGY OF PROPOSED WORK

Workflow
The workflow for plant image processing begins with the manual collection of images from the local fields of AAU, Anand. Once gathered, these images undergo preprocessing, where initial adjustments such as resizing, cropping,

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and noise reduction are applied to enhance image quality and remove any irrelevant information. This preprocessing stage lays the foundation for subsequent analysis by ensuring that the input images are of high quality and contain relevant features for disease detection. Advantages of image processing on model accuracy are manifold. By enhancing the quality and clarity of input images, preprocessing techniques like noise reduction and contrast adjustment help to reduce noise and irrelevant features, thereby improving the accuracy of the model[26], [27]. This refinement in image quality enables more accurate disease detection and classification by the model, ultimately leading to better outcomes in agricultural disease management. Dataset balancing is a crucial step in addressing class imbalance issues that may arise during model training[28], [29]. In scenarios where certain disease classes are underrepresented in the dataset, we can make use of Synthetic Minority Over-sampling Technique to generate synthetic samples for minority classes, ensuring equal representation of all disease classes[30], [31].This balancing act prevents the model from being biased towards the majority class and enhances its ability to generalize effectively across all classes.

Feature extraction using SIFT (Scale-Invariant Feature Transform) works by capturing characteristic traitsof images belonging to plants.[32], [33]. SIFT's ability to detect invariant features across different scales and orientations makes it particularly suitable for anomaly detection of plants, as it enables the model to identify fundamental structures and characteristics of plant anomalies. By extracting relevant features from the images, SIFT empowers the model to make accurate disease classifications, even in the presence of variations in image conditions and disease manifestations. Finally, classification of plant images into various categories of their anomaly can be leveraged using SVM (Support Vector Machine). SVM's ability to handle high-dimensional feature spaces and find optimal decision boundaries makes it well-suited for leaf disease detection. The SVM's capacity to manage attribute domains with numerous dimensions and identify ideal choice limits renders it highly suitable for detecting diseases in leaves.[34], [35]. Its robust generalization capabilities and effectiveness in handling nonlinear relationships between features contribute to improved model performance, making SVM a popular choice for disease classification in plant pathology.

Dataset Description
In this study, we delve into the dataset composed of plant images sourced from the agricultural fields of Anand Agriculture University, Anand. This dataset is meticulously collected, encompassing images obtained from both the Fields at Main Vegetable Centre, Anand Agriculture University (AAU), and the local agricultural fields of the Anand region. It comprises a substantial total of 11,363 images, representing three distinct Solanaceae plant species: potato, tomato, and brinjal. These images were captured during daylight hours under natural lighting conditions, utilizing a smartphone camera for acquisition. A detailed examination of the dataset reveals comprehensive specifications regarding the image-capturing device employed during data collection. The device utilized for capturing plant images in the fields was a routine use camera, specifically the Samsung Galaxy A70 model. The camera specifications include a triple setup, 32 MP wide-angle lens (f/1.7 aperture, 26mm focal length) and an 8 MP ultrawide lens (f/2.2 aperture, 12mm focal length). The resulting images have dimensions of 2268 x 4032 pixels, with a horizontal and vertical resolution of 72 dpi.

These meticulously collected images are meticulously categorized into 8 distinct classes, each representing various health conditions and diseases affecting the plants. The classes include Tomato (with subcategories: Healthy, leaf curl disease, late blight, and complex leaf curl and blight), Brinjal (comprising Healthy and little leaf disease categories), and Potato (encompassing Healthy, late blight, leaf curl, and Little leaf conditions). This comprehensive classification scheme provides a structured framework for analyzing and understanding the diverse health conditions observed across the dataset.

Image Pre-processing
The preliminary processing phase assumes an indispensable role in refining the unprocessed data drawn from comprehensive plant visuals, with the objective of optimizing the input for the neural network and augmenting the

durability and precision of the ultimate model. This stage is tailored to eliminate innate disturbance and deviations evident in plant visuals, thereby expediting more precise scrutiny and categorization. The delineated preliminary processing methodologies encompass a sequence of actions, encompassing the conversion to LAB color space, division of the LAB depiction into distinct segments, administration of Gaussian blur to the L channel, implementation of histogram equalization to enhance contrast, fusion of the equalized L channel with the authentic A and B channels, and ultimately, reconversion of the equalized LAB depiction to BGR color space, culminating in an evened-out depiction output.

In real-world settings and concrete datasets, the pervasiveness of disproportionate data presents a substantial impediment, wherein the subordinate category, often pivotal, is markedly underrepresented relative to the dominant category. This disproportion poses a noteworthy obstruction for categorization algorithms, particularly when the cost of incorrectly categorizing the subordinate category is heightened, thereby affecting performance indices for the constructed model. To address this predicament, we can make use of Synthetic Minority Oversampling Technique in uneven categorization exploration. SMOTE addresses imbalanced datasets by excessively expanding them, creating artificial occurrences within the attribute domain based on the occurrence and its nearest neighbors.This tactic alleviates concerns pertaining to overfitting and aids the classifier in defining distinct demarcation lines between categories, thereby augmenting comprehensive categorization accuracy.

Model using SVM with SIFT

SVM offers a systematic solution to machine learning obstacles owing to its statistical learning theory foundation. It is extensively utilized in various tasks including classification, regression, novelty detection, and feature reduction [36]. Feature extraction constitutes a pivotal aspect of computer vision applications aimed at object recognition within images. In this context, we used SIFT for finding attributes from images of plants, followed by performing classification using SVM to develop a plant disease detection model. SIFT identifies local image features immune to operations such as scaling and rotation, converting an image into a comprehensive set of attributes orientations[37]. These identified characteristics demonstrate size and alignment constancy, hence possessing substantial discriminative capability within the picture.[38]. The process encompasses four stages: first, the detection of depths and peaks through a set of Difference of Gaussian filters. Next the filters are used across various proportions throughout the image to ascertain potential points of interest, with each pixel (key point) encompassing a total of 26 neighbors. Subsequently, refining the positions involves eliminating weak features. Afterward, every significant spot is allocated a direction determined by regional image characteristics. Ultimately, a descriptive attribute unique to the locality is calculated for each significant spot. Support Vector Machine classifiers represent a collection of supervised approaches of learning, employed for both categorization and regression assignments, belonging to the wider category of generalized linear classification techniques[39]. SVM operates as a binary classification method, leveraging the principle of structural risk minimization to ascertain the optimal linear decision boundary[40]. This decision boundary is a weighted amalgamation of the features within the training dataset.

Implementation

The setup was carried out using personal computer having 11th Generation Intel(R) Core i9-1900K central processing unit operating at 3.50GHz and 32 gigabytes of random-access memory. The OS (Operating System) utilized was a 64-bit OS. The graphics processing unit utilized to execute the code is the NVIDIA RTX A2000 with a capacity of 12 gigabytes. Furthermore, the applications employed in this investigation included Python 3.11.0 (within the Anaconda Environment), Jupyter Notebook, the Tensorflow framework, Keras, and the CudaTool kit. For image manipulation, the openCV library was utilized.

In implementing the SVM classification method for detecting plant diseases, initiallywe manually collect plant images from agricultural fields of Anand Agriculture University, Anand District, Gujarat, India. Next,Image preprocessing is carried out to enhance their quality and extract relevant features using the Scale-Invariant Feature Transform algorithm. This algorithm plays a crucial role in identifying majorstructures and characteristics of plant anomalies. Afterward, the treated images and derived characteristics are inputted into the SVM, which is trained to

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categorize the images into various illness classes according to the derived traits.Through this process, the SVM classification method, in conjunction with SIFT feature extraction, provides a effective mechanism for automated identification of diseased plants. After constructing the model, its effectiveness is assessed employing diverse performance metrics like correctness, exactness, retrieval, F1-measure, and Area Beneath the Curve (AUC). These measures aid in gauging the model's capacity to precisely categorize plant ailments and its comprehensive efficacy. Additionally, visualization techniques are employed to interpret the results. For instance, confusion matrices can visually represent the model's classification results. ROC (Receiver Operating Characteristic) curves can also be plotted to illustrate the model's performance across different threshold values, providing insights into its sensitivity and specificity.

RESULTS AND DİSCUSSİON

After implementing the model using Support Vector Machine (SVM) for classification with Scale-Invariant Feature Transform, the following metrics values were obtained: Training Accuracy of 76.80%, Validation Accuracy of 71.82%, Test Accuracy of 71.54% and AUC/ROC curve value of 94.91%. The values obtained for Precision, Recall, and F1-score were 67.85%, 66.91%, and 66.63% respectively. The obtained results indicate that the implemented model demonstrates moderate to good performance in classifying plant diseases based on the extracted features. The Training Accuracy of 76.80% suggests that the model is able to learn effectively from the training data, while the Validation Accuracy of 71.82% indicates that the model generalizes reasonably well to unseen data. The Test Accuracy of 71.54% reflects the model's performance on an independent test set, further validating its effectiveness in realistic applications. For this model, AUC value of 94.91% indicates that the model exhibits excellent discriminatory power between healthy plants and plants having anomalies. Precision, Recall, and F1-score values of 67.85%, 66.91%, and 66.63% respectively, demonstrate the capacity of the model to accurately recognize afflicted plants, while minimizing false positives.

Overall, while the model shows promising results, there is still room for improvement, particularly in increasing precision and recall values to enhance the model's performance further. Additionally, research could focus on fine-tuning model parameters, optimizing feature extraction techniques, and augmenting the datasetto include extensive variety of plant diseases and environmental conditions. Additionally, exploring ensemble methods or deep learning approaches could potentially yield even better results in plant disease classification.

CONCLUSİON

In this study, we developed a model utilizing the SIFT algorithm to identify key features of infected leaves, coupled with an SVM classifier for plant image classification. Trained on a dataset of 11,363 solanacea plant images, including tomato, potato, and eggplant varieties sourced from Anand Agriculture University, the model achieved notable performance metrics, with Training, Validation, and Test Accuracies of 76.80%, 71.82%, and 71.54% respectively, and a high AUC value of 94.91%. Precision, Recall, and F1-score values of 67.85%, 66.91%, and 66.63% respectively demonstrate its effectiveness in accurately identifying diseased plants while minimizing false positives. Further refinement is necessary to enhance precision and recall, with future research focusing on parameter optimization, feature extraction, dataset expansion, and advanced machine learning techniques. Despite this, our SVM with SIFT model represents a significant advancement in automated plant illness detection, offering potential benefits for sustainable agriculture and crop health monitoring.

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Table 1. Results of the SVM model performance on AAU field dataset.

	Training Accuracy	Validation Accuracy	Test Accuracy	Precision	Recall	F1-score	AUC/ROC
CNN Model using SVM with SIFT	76.80%	71.82%	71.54%	67.85%	66.91%	66.63%	94.91%

The confusion matrix and classification report is presented in fig-3 and fig-4 respectively.

Fig. 1.The workflow of the development of plant disease detection system	**Fig. 2.Dataset of manually collected images from local fields of AAU, Anand.**

```
Confusion Matrix:
 [[461   7  46   7   1   0  24   5   0   2]
 [ 35  70  15  38   0   0   3  16  12   5]
 [ 49  15 623  28   0   3  39  23  16   3]
 [  6  29  53 458   0   0  26  28  42  15]
 [  0   0   1   0  13   0   2   0   0   0]
 [  2   1   3   0   3  25   2   0   0   0]
 [ 37   4  63  27   1   1 447  29   6  10]
 [ 11  15  43  23   5   0  42 272   1   5]
 [  0   4  13  65   0   0   9   2 540  15]
 [  2   8  13  27   0   0  21  17  44  65]]
```

```
Classification Report:
                                  precision  recall  f1-score  support

         Brinjal healthy leaves      0.76     0.83     0.80      553
    Brinjal_little leaf disease      0.46     0.36     0.40      194
                 Potato Healthy      0.71     0.78     0.75      799
             Potato Late blight      0.68     0.70     0.69      657
        Potato_leaf curl disease      0.57     0.81     0.67       16
    Potato_little leaf disease      0.86     0.69     0.77       36
                 Tomato Healthy      0.73     0.72     0.72      625
             Tomato late blight      0.69     0.65     0.67      417
        Tomato leaf curl disease      0.82     0.83     0.83      648
Tomato-complex-curl_blight and tunnel  0.54   0.33     0.41      197

                       accuracy                        0.72     4142
                      macro avg      0.68     0.67     0.67     4142
                   weighted avg      0.71     0.72     0.71     4142
```

Fig. 3. Confusion Matrix (Proposed SVM Model)	**Fig. 4. Classification Report (Proposed SVM Model)**

RESEARCH ARTICLE

Spectral Characterization of Fumaric Acid Single Crystal

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ABSTRACT

Single crystal of fumaric acid was grown by slow evaporation method. The single crystal was screened by UV Vis NIR spectral analysis for its suitability in optoelectronic applications. The crystal of fumaric acid shows very good transmittance in the range of 190 nm to 1100 nm with the transparency of 99%. The cut-off wavelength is observed at 300 nm. The optical band gap energy of fumaric acid was found from the Tauc's plot as 4.1 eV. The urbach energy (E_u) is calculated as 0.454 eV, suggests a lesser amount of crystalline defects of the grown single crystal. The steepness parameter of the single crystal was clculated. The various optical constants such a s absorption co-efficient, extinction coefficient, reflectance, refractive index, optical conductivity, electrical conductivity and susceptibility has been determined from the UV-Vis transmission plot. The recorded fluorescence spectrum shows the first emission peak at 362 nm, sharp peak at 611 nm and a weak peak observed at 714 nm. The wide transparency window and emission peaks indicate the suitability of the crystal for optoelectronic device fabrication.

Keywords: transmittance, band gap energy, optical constant, emission.

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INTRODUCTION

Researchers are now focusing on nonlinear photonic crystals because of its relevance in band gap materials for guiding and controlling the passage of light. The rapid technological advances in connected domains, such as ultra fast phenomena, optical communication and storage devices, have had a significant impact on nonlinear optics research [1]. Many organic crystals have been developed and examined for their utility as optical applications. Fumaric acid is gaining popularity due to its many physic-chemical characteristics [2]. It is used in the field of medicine. The introduction of fumaric acid in the crystalline structure transforms it from centrosymmetric to non-centrosymmetric, hence increasing high NLO efficiency via metal ligand interactions. Recently conducted characterization experiments demonstrated that fumaric acid-based compounds are effective NLO crystals [3,4]. Certain characterization investigations of Dipotassium Fumarate Dihydrate [5] and L-histidinium fumarate fumaric acid [6] were recently reported, and they proved to be appropriate SHG materials. Aroused by the curiosity of the optical properties of fumaric acid, we have grown the crystals of fumaric acid and the crystal has been characterized by UV-Vis NIR and fluorescence for its suitability as optical material for optoelectronic applications. The various optical values such as band gap, refractive index, reflectance, absorption coefficient, extinction coefficient, optical conductivity and electrical conductivity of the crystal has been determined.

EXPERIMENTAL
The fumaric acid single crystal was grown by slow evaporation solution growth technique at ambient room temperature using double-distilled water as a solvent. The prepared solution was filtered. The filtered solution was kept undisturbed in an environment conducive for single crystal growth. Colourless crystals were harvested after fifteen days. Figure 1 shows the chemical diagram of fumaric acid.

RESULT AND DISCUSSION

UV-VISIBLE SPECTRAL ANALYSIS
UV-visible spectrum gives limited information on the structure of the molecule since UV and visible light absorption entails the promotion of the electron from the ground state to higher energy levels [7]. The UV–visible absorption and transmission spectrum of the grown fumaric acid crystal was recorded using a Perkin Elmer Lambda-35 UV–visible–NIR spectrometer in the wavelength range of 190 nm–1100 nm and are shown in figure 2 and 3. The transmittance graph shows the transmittance percentage of the grown crystal and it has about 99%. The absorption spectrum indicates that the grown fumaric acid crystal having the lower cut-off wavelength at about 300 nm. The transmission percentage, lower cut-off wavelength and absorption band of a crystal are important property for optoelectronics applications [8].

Determination of Band gap Energy
The analysis of the band structure and kind of electron transition is helped by the variation of the optical absorption coefficient on photon energy [9]. The optical absorption coefficient (α) and thereby the energy band gap are evaluated using the formula,

$$\propto = \frac{2.3036 \log(\frac{1}{T})}{d}$$

Where T is the transmittance and d is the thickness of the crystal. Owing to the band gap, the crystal under study has an absorption coefficient obeying the following relation for high photon energies,

$$(\alpha h\upsilon)^2 = A\,(h\upsilon - E_g)$$

Where α is the absorption coefficient, hυ is the photon energy, Eg stands for the optical band gap of the crystal and A is the constant. The band gap energy of fumaric acid single crystal was evaluated to be 4.1eV by considering the linear part of the tauc's plot from $(\alpha h\upsilon)^2$ versus photon energy (hυ) as shown in figure 4. The wide band gap of the fumaric acid single crystals provides information on large transmittance in the visible region as well as defect less concentration in the grown crystal [10] makes it a suitable candidate for UV tunable laser and non linear optical

device applications. A reported cut-off wavelength and band gap energy of fumaric acid complex crystals are compared in table 1.

Determination of Urbach Energy

The urbach relationship expresses the observed exponential dependency of the absorption coefficient on photon energy below the fundamental absorption edge in the class of crystalline materials, which is typically in the exponential-edge region [16],

$\alpha = \alpha_o \exp(h\upsilon/E_u)$

Where α_o is the constant, E_u indicates the urbach energy, h stands for Planck's constant and υ indicates the frequency of radiation. The high crystallinity nature of the crystal is clear in the linear section of the plot ln (α) with photon energy (hυ), which is used to determine the slope. Figure 5 displays the relation of ln (α) with photon energy (hυ). By taking the reciprocal of this slope, the value of urbach energy is evaluated and it is found to be 0.454. The estimated urbach energy possesses low value and it clearly show that the grown crystal has minimum structural defect [17].

Determination of Steepness parameter (σ_s)

The steepness parameter is a temperature-dependent parameter characterizing the broadening of the absorption edge due to electron-phonon or exciton-phonon interations . The steepness parameter σ in below equation has been found to follow the relation [18],

$\sigma = \dfrac{K_B T}{E_u}$

Where E_u is the Urbach energy (0.454 eV), K_B is the Boltzmann's constant 8.6173 x 10^{-5} eV and T is the absolute temperature. The estimated value of steepness parameter is found to be 0.0518.

Determination of Optical constant

The material's optical characteristics play a significant role to identify its usage in the domain of optoelectronic devices and its potentiality in this field is well examined by understanding the optical constants. The total energy out flow of the applied electromagnetic radiation when it is transmitted throughout the material is calculated by the extinction coefficient (K)[19]. Extinction coefficient of the crystal is calculated using the below equation and is directly related to the absorption coefficient [20, 21].

$K = \dfrac{\alpha\lambda}{4\pi}$

Where α is the optical absorption coefficient, λ is the wavelength of the photons incident on the material. The plot of extinction coefficient versus wavelength is shown in Figure 6. The calculated value of extinction coefficient 14.67. The amount of light that is reflected from a surface or optical element is described by its reflectance. In general, the direction of the light source affects reflectance. The following relation [22] can be used to calculate the reflectance (R) in terms of the absorption coefficient and the thickness (t) of the crystal.

$R = 1 \pm \dfrac{\sqrt{1 - \exp(-\alpha t) + \exp(\alpha t)}}{1 + \exp(-\alpha t)}$

The refractive index estimates how much light is bent, or refracted, when enters the material. The refractive index n can be derived as [23],

$n = \dfrac{-(R + 1) \pm \sqrt{-3R^2 + 10R - 3}}{2(R - 1)}$

Figure 7 exhibits the variation of refractive index with wavelength. The calculated refractive index (n) is 2.59 for the fumaric acid single crystal. From the graph it is clear that refractive index decreases with increase of wavelength. This lowering of refractive index emphasize that the fumaric acid single crystal exhibit the regular dispersion behavior. The refractive index can be determined from the reflectance (R) data using [24],

$R = \dfrac{(n - 1)^2}{(n + 1)^2}$

The calculated value of reflectance (R) is 0.1973. From figure 8 reflectance of the material decreases as the wavelength increases. It is an important character of the material which possesses optoelectronic properties.

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Optical Conductivity

One of the most effective methods for researching the electrical states of materials is optical conductivity. Refractive index (n) and the speed of light (c) are related to the photonic response of the materials optical conductivity (σ_o) when exposed to light [25],

$$\sigma_o = \frac{\alpha nc}{4\pi}$$

The variation of optical conductivity with wavelength is shown in Figure 9 (a). Figure 9(b) illustrates that the optical conductivity (σ_o) increases with photon energy (hυ), having high magnitude ($10^8 S^{-1}$) thus concludes the presence of high photo tunable nature of the material. Hence this material is prominent for device applications in computing ultrafast optical data [26]. The calculated value of optical conductivity 0.1827.

Electrical Conductivity

The optical conductivity of the fumaric acid single crystal, which is caused by electrons energized by photon energy, is connected to the electrical conductivity and is shown below [27],

$$\sigma_e = \frac{2\lambda\sigma_o}{\alpha}$$

The variation of electrical conductivity with wavelength is shown in Figure 10 (a). The electrical conductivity as a function of photon energy (hυ) is shown in Figure 10 (b). Electrical conductivity of fumaric acid crystal is 866.450.

Electric susceptibility

Electric susceptibility is the quantitative measure of extent to which electric field applied to dielectric material causes polarization. Electric susceptibility (χ_c) can be calculated from the following relation [28],

$\varepsilon_r = \varepsilon_0 + 4\pi\chi_c = \eta^2 - k^2$

$\chi_c = \eta^2 - k^2 - \varepsilon_0/4\pi$

ε_0 is the dielectric constant in the absence of any contribution from free carriers. The complex dielectric constant is given by ε_c. The real and imaginary part of dielectric constant from extinction coefficient is given as [29,30].

$\varepsilon_c = \varepsilon_r + \varepsilon_i$

$\varepsilon_r = n^2 - k^2$

$\varepsilon_i = 2nk$

Where ε_r and ε_i are real and imaginary part of dielectric constant. The electric susceptibility is calculated as $\chi_c = 5.303$. The real ε_r and imaginary ε_i values of dielectric constant are 6.7558 and 1.2389×10^{-6}.

FLUORESCENCE ANALYSIS

The fluorescence is the most important nondestructive method for evaluating flaws, surface contacts and transitions between energy levels. It thus finds extensive use in biological, photonics and chemical applications [31]. The excitation and emission spectrum of grown fumaric acid single crystal was recorded in the range of 260 nm to 900 nm by means of Perkin Elmer model LS-45 fluorescence spectrometer and it is emission spectrum shown in figure 11. The sample is excited at 320 nm as excitation wavelength. There are three categories of luminescent peaks in the spectra. The first emission peak at 362 nm shows the emission of visible violet and the sharp peak at 611 nm is due to the emission of orange light. The weak emission peak observed at the wavelength 714 nm is red. The result indicates that the grown crystals have emission in the visible region, suggests that they are excellent for non linear optical applications.

CONCLUSION

Good quality single crystal of fumaric acid has been grown by slow evaporation solution growth techniques from aqueous solution. Its optical transparency has been assessed by UV-Vis spectroscopy and the cut off wavelength was found to be around 300 nm. The band gap energy is calculated as 4.1 eV from the Tauc's plot. The urbach energy (E_u) is determined to be 0.454 eV. The estimated value of steepness parameter is found to be 0.0518. Several optical constants namely extinction coefficient, refractive index and reflectance clearly indicate the high transparency

character of fumaric acid. Optical conductivity, electrical conductivity and susceptibility were also calculated. The fluorescence spectra revealed visible violet, visible orange and red fluorescence emission. The optical characterization studies and the results shows that the fumaric acid is suitable for optical applications.

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Table 1. Comparative table for UV cut-off wavelength and Band gap energy of fumaric acid complex crystals

SNo	Crystal Sample	UV Cut-off wavelength (nm)	Band gap energy (eV)
1	L-tryptophan-Fumaric acid [11]	275	5.31
2	2-Aminopyridinium Fumarate Fumaric Acid [12]	343	6
3	Terbium Fumarate Heptahydrate [13]	266	4.65
4	Potassium Hydrogen Phthalate Fumaric Acid [14]	295	4.2

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5	L-histidinium Fumarate Fumaric Acid [15]	254	3.9
6	Fumaric Acid [Presented Report]	300	4.1

Table 2: Optical data of fumaric acid single crystal

Optical Parameters	Fumaric Acid
Cut-off wavelength	300 nm
Optical band gap energy	4.1 eV
Urbach energy	0.454
Steepness parameter	0.0518
Extinction coefficient	14.67
Refractive index	2.59
Reflectance	0.19
Optical conductivity	0.1827
Electrical conductivity	866.45
Electric susceptibility	5.303
Real dielectric constant	6.7558
Imaginary dielectric constant	1.2389×10^{-6}
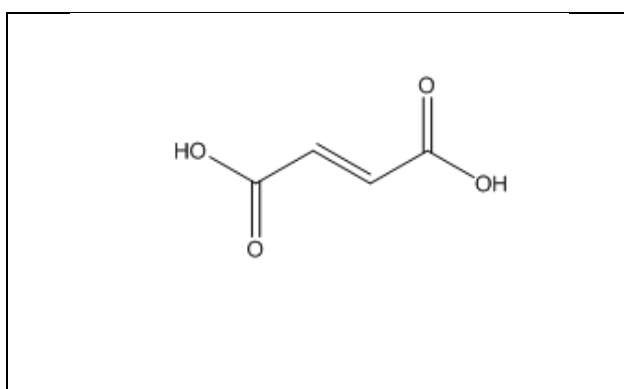
Figure 1. Chemical Diagram of Fumaric acid
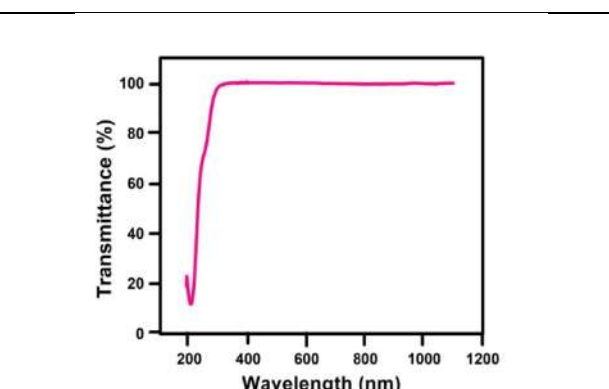
Figure 2. Transmission spectrum of fumaric acid
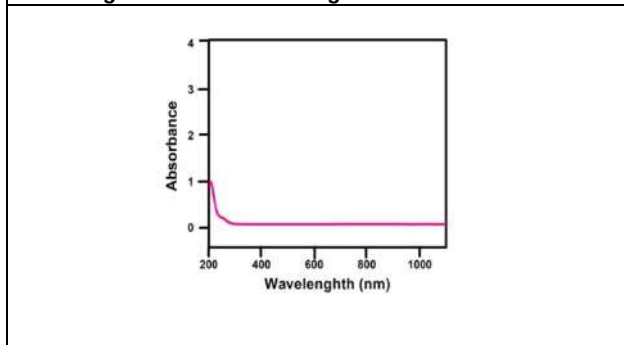
Figure 3. Absorption spectrum of fumaric acid
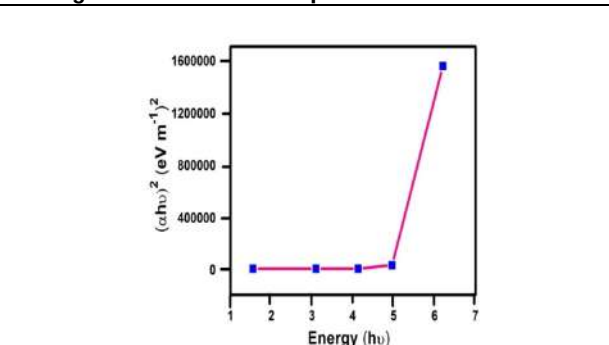
Figure 4. Plot of $h\upsilon$ versus $(\alpha h\upsilon)^2$

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Figure 5. Photon Energy versus absorbtion energy

Figure 6. Wavelength versus K

Figure 7. Wavelength versus n

Figure 8. Wavelength versus R

Figure 9(a). Plot of λ versus σ$_{op}$ of fumaric acid Figure

Figure 9(b). Plot of hυ versus σ$_{op}$ of fumaric acid
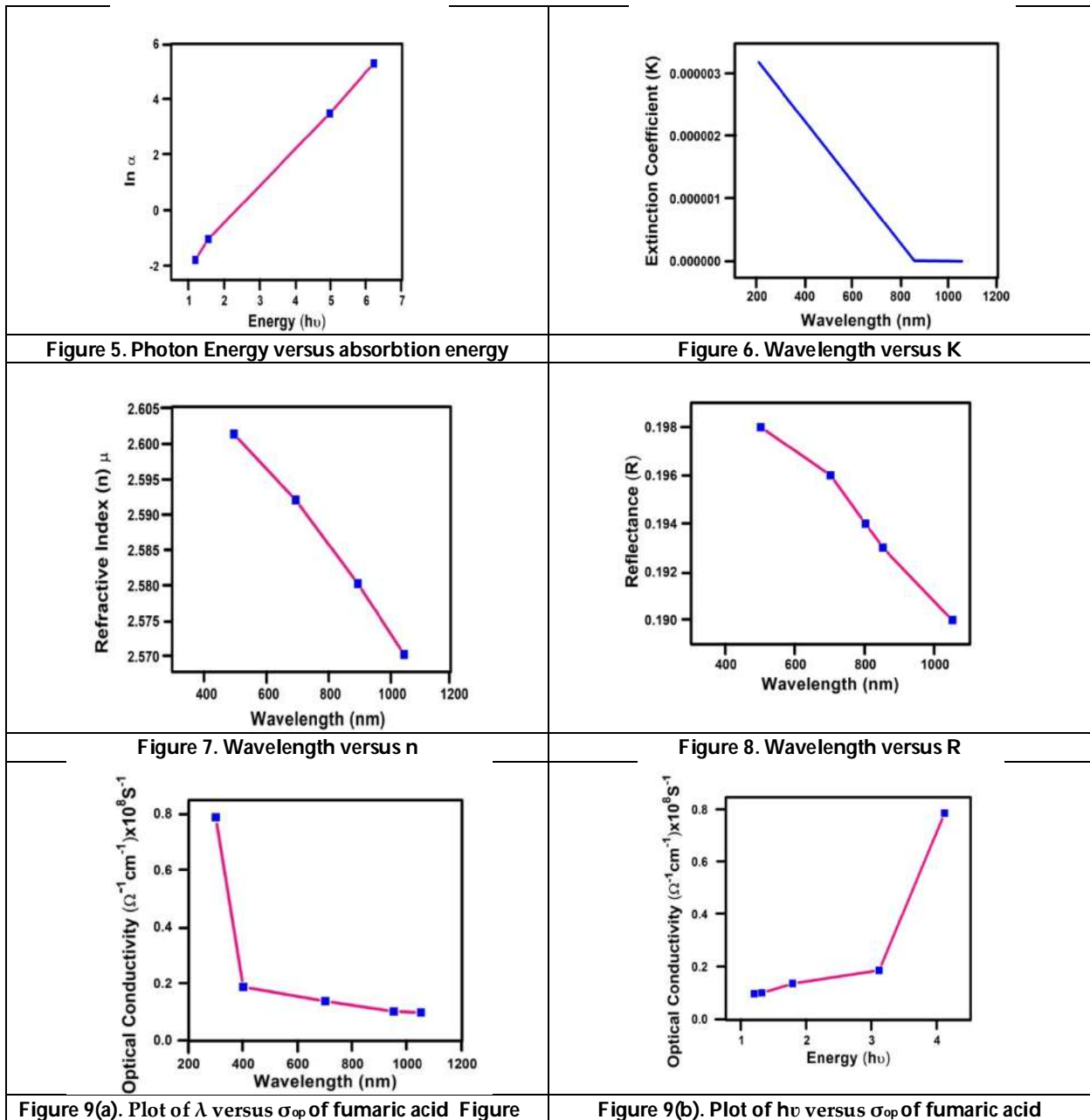
Anantha Meena Geetha and Samuel Robinson Jebas
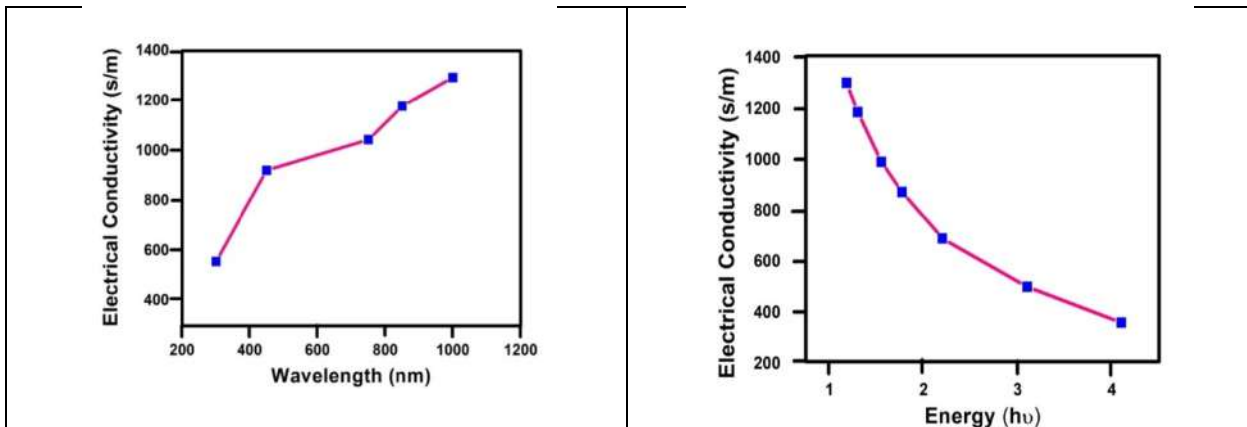
| **Figure 10(a). Plot of λ versus σₑof fumaric acid** | **Figure 10(b). Plot of hυ versus σₑof fumaric acid** |
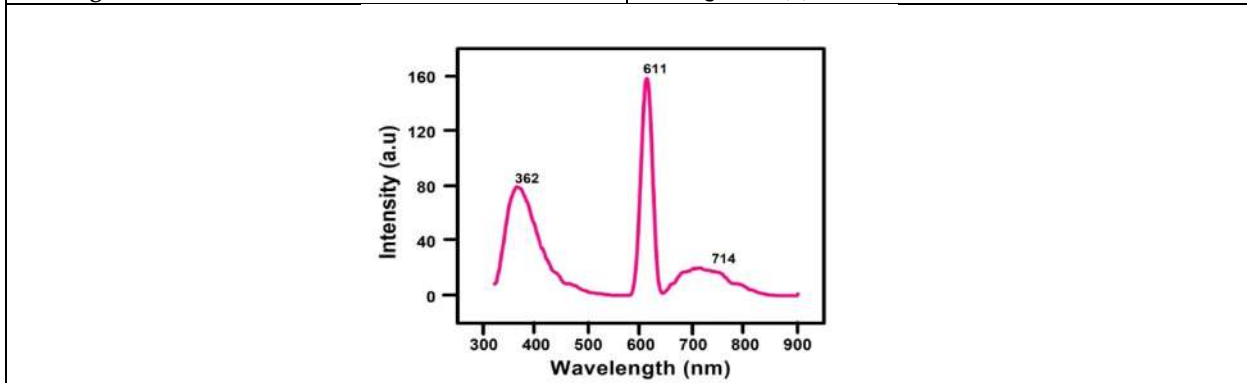
Figure 11. Emission spectrum of fumaric acid

RESEARCH ARTICLE

Nanoparticles: Their Types, Properties and Application in Cancer Diagnosis and Treatment

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ABSTRACT

Nanotechnology is the most exclusive field of science that is involved in the synthesis of nanoparticles (NPs). These particles can be formed in two different ways, i.e., the top-down approach and the bottom-up approach. Nanoparticles are engineered so that they are suitable for biological systems, non-toxic, anti-angiogenic, etc. Due to the versatile nature of nanoparticles, they are being modified from time to time for innovative administration of drugs and medication in target regions. In this review, a comprehensive overview of the different types of nanoparticles and targeting strategies for nanoparticles is discussed. Recently, nanoparticles made of various components, such as liposomes, solid lipid nanoparticles, dendrimers, micelles, polymeric micelles, polymersomes, hydrogels, and inorganic NPs such as metal nanoparticles, i.e., AuNPs, AgNPs, magnetic nanoparticles, etc., have been prominently used for therapeutic purposes in cancer and other diseases. Nanoparticles have shown relevant improvements in the treatment of cancer through direct drug delivery to tumor cells. NPs increase the intracellular concentration of pharmaceuticals through active or passive targeting, minimizing toxicity in healthy tissue. It also highlights the importance of "physio-chemical characteristics" of NPs, including their size, shape, molecular composition, and surface chemistry, which play a significant role in the localized drug delivery system.

Keywords: cancer, nanoparticles, top-down, bottom-up, liposomes, dendrimers, magnetic nanoparticles

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INTRODUCTION

Cancer is one of the deadliest diseases that can cause the death of more than 10 million people worldwide, in U.S., the number of newly diagnosed cancer reached over 1,958,310 and also there was prediction of about 609,820 deaths [1]. Cancer being a detrimental disease, it's full cure has not even developed until now. However, patients who have got diagnosed at an early stage of cancer they might survive. Although various therapeutic measures have been developed to treat the cancer, such as chemotherapy, radiation therapy, hormone therapy, hyperthermia, immunotherapy, surgery, stem cell transplantation, targeted therapy etc. since so long but none of them were fully effective. In recent few decades, scientists have shown their interest toward nanoparticle applications. Nanoparticles is being utilized as delivery medium for chemotherapeutic medicines direct to the cancerous cell [2]. The NPs are advantageous as biomarkers for purposes like cancer diagnosis, as these curative agents tagged with NPs are highly tend to accumulate in system by EPR effect [3]. The NPs have proved the advantage over chemotherapy because of their capability to passive accumulation in cancer cells and thus subsiding the side-effects of medicines [4]. In the current review, we will focus on various types of nanoparticles, like organic and inorganic, their subtypes, and their benefits over other therapeutic measures. This will also include the drug being delivered via nanoparticles and their overall effects in the treatment of cancer.

Features of an ideal NP
In recent era, NP use is increasingly growing in medicine due to their better result in cancer therapy but there should be some features of these NPs. It should increase the stability, easily absorbed in tumor cells, and increased therapeutic action in target region and persistent drug release. Hydrophilic NPs are preferable since they can circulate for a longer duration after being injected and less uptake by the liver and spleen, such as NPs made of polyvinyl, while the use of 50% PNVP and N- isopropyl acrylamide showed faster uptake. Thus, the particles with 100 nanometre or less diameter and having hydrophilic surface are preferable [5]. Moreover, nanotechnology also involves inorganic NPs for drug delivery. Most inorganic NPs are made-up of silver and gold. Gold nanoparticles (AuNPs) is suitable for passive as well as active agents due to their anti-angiogenic and antitumor properties [6] Also, the AuNPS can be used for various imaging and diagnostic purposes [7].

Classification of NPs
In recent days there are various types of nanoparticles are used based on components the NPs are made up of, they are classified into two major classes: organic and inorganic. Inorganic groups are further divided into subgroups. The NPs having organic matter as their building material is called organic nanoparticles, while the NPs with inorganic parts as their main constituent is called inorganic NPs (Fig. 1). These inorganic NPs should also be non-tumorigenic and non-reactive for the biological system.

Organic Nanoparticles
The nanoparticles have organic cores like lipids, and basically, the phospholipids are known as organic nanoparticles. These are spherical structures resulting from the interactions of phospholipids with their aqueous surroundings. They are capable of carrying the drug within themselves and can deliver them to targeted locations. So far, lots of evolution has been made in constructing the more advanced organic nanoparticles. There are various types of organic nanoparticles:

Liposomes
The discovery of liposomes dates back to 1961 by Alec D. Bangham. These are bilayer vesicles formed due to the hydrophilic and hydrophobic interactions of constituents of liposomes, i.e., phospholipid, with the head portion being on the outer side and the tail portion on the interior side. These phospholipids are similar to lipid bilayer as similar to the cell membrane.

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Liposome NPs are able to circulate in the system for longer durations when they are modified to avoid phagocytic attacks by mononuclear phagocytes [8]. These liposome NPs are basically non-toxic, biodegradable, and most importantly, non-angiogenic and having similar components like in biological systems i.e., phospholipid. Some other drugs that have been used using liposome NP, such as liposomal daunorubicin, which has a smaller (~45) and rigid surface with a longer duration of circulation in the system, have shown impressive performance in Kaposi's sarcoma [9]. It is also found that PEGylated liposomes show 5 times longer stability in biological system in addition with reduced uptake by liver or spleen cells [10].

Solid lipid NPs
Solid Lipid NPs (SLN) are phospholipid monolayer–emulsifier–water colloidal nanocarriers (1–100 nm) [11]. These are rapidly growing branches of nanobiotechnology contributes to the development of drug delivery, chemical purposes, research fields, etc. these are helpful in analytical studies (spectroscopy, SEM, etc.) [12]. The size of SLN is smaller than 1 micrometre and is insoluble in the biological system. They are also known as dimensionless nanoparticles. Triglycerides, fatty acids, waxes, steroids, and PEGylated lipids are some examples of the lipid component [13]. By employing SLNs, it is also possible to successfully minimize the difficulties with liposomes, including their poor retention stability, limited encapsulation capacity, and leakage of water-soluble medications when blood components are present. SLNs can also carry large amounts of drugs, for example, tetracaine and etomidate [14].

Polymer NPs
Polymers are the most prevalent NP drug delivery systems. The polymers that are employed in regulated medication release are biodegradable because of their compatibility with living organisms [15]. It needs to have a structurally sound design and a sufficient half-life. The average diameter of polymeric NPs produced using various techniques might range from 100 to 300 nm. It is also possible to produce particles with dimensions between 60 and 70 nm or even smaller than 50 nm [16].

Nanospheres (matrix system) and Nanocapsules (vesicular system) are two different types of polymeric nanoparticles. While Nanospheres (NS) are polymer-only matrix systems, Nanocapsules (NC) are nanoparticles with either an oily or aqueous interior encased in a polymeric exterior. Typically, lipophilic, and hydrophilic surfactants are combined with Nanocapsules (NC). The increased drug loading of NC versus NS is one of its key benefits [17].PEGylated-PLGA nanospheres were less harmful than unbound dexibuprofen, according to investigations on the survival of cells in the human retinoblastoma cell line [18].

Polymer Micelles
The self-assembling macromolecules known as polymer micelles are generated via non-covalent bonds between block copolymers. Micelles made of block copolymers have a core-shell framework. Critical micelle concentration (CMC), cumulative number, size, and final structural feature are a number of the specific traits of micelles [19]. The robust drug-loading potential of the micelles as well as the distinct disposition features in the body have recently generated interest in using the micelles as innovative carrier systems in the field of therapeutic targeting [20].

Dendrimers
Dendrimers were first introduced by Vogtle in 1978, are highly branched, well-defined molecular structural polymers that have made for the development of the most innovative and effective technological tools for drug administration [21]. Due to its high affinity for shape, size, charge, hydrophilicity, biocompatibility, branches etc., dendrimers have drawn a lot of attention in biological areas as a good vehicle for drug administration [22]. Polyamidoamine(PAMAM) dendrimers, out of all other the commonly found dendrimers, have drawn the most interest as probable non-viral gene carriers because of their cationic nature, which allows deoxyribonucleic acid (DNA) binding at the normal pH [23].   Dendrimers are so adaptable that they are being utilized for various other purposes such as in PDT (photodynamic therapy) where AlPcS4 capsulizing GA-G3-PHSNPs are used diminish the tumor cells [24], PAMAM

dendrimers complexed with Gd(III), a paramagnetic contrast agent for MRI, showed its application as imaging agent in examination of vascular and lymphatic system involved in tumor [25].

Polymersomes

In both fundamental and applied research, there is growing interest in the dependable production of polymersomes, the vesicles generated from the self-association of amphiphilic block-copolymers, for applications including the encapsulation and diffusion of pharmaceuticals or additional products like proteins, enzymes, and DNA. Petit et al. observe that the polymersomes made using PDMS-based microfluidic platform method are monodisperse in size and persistent for certainly three months in natural environment. Such characteristics are extremely important for fundamental research of, for instance, membrane mechanisms and fusion [26].

Hydrogels

Hydrogels are three-dimensionally arranged polymeric structures that may incorporate a lot of water or organic fluids. The hydrophilic groups included in the polymer chains, including ether, amine, hydroxyl, sulphate, and carboxyl, are what are responsible for their affinity for water. The formulation of hydrogels can be restricted to smaller dimensions or made into macroscopic networks [27]. Hydrogels have several features, such as being phagocytosis-resistant, prolonging drug delivery, having a smaller size to enter the thinnest capillary, etc., that make them more applicable as drug delivery agents. [28]. The hydrogel provides variety of efficiency to encapsulate the drug for example, Poly(lactide-co-glycolide) is used to encapsulate the anti-cancer drug Taxol with 100% efficiency [29].

Inorganic NPs:

Recently, extensive research has been done on the use of inorganic nanoparticles (NPs), such as those made of metals (such as gold, silver), semiconductors (such as quantum dots), oxides (such as iron oxide), magnetic elements, etc., for both therapeutic and diagnostic applications in oncology. Inorganic NPs provide a number of benefits over organic nanoparticles, as well as special qualities that make them superior for scanning and medication administration. However, there are still very few inorganic NPs that are applied in therapeutic settings.

Silica Nanoparticles

Amorphous silica, which is naturally harmless and nontoxic, has undergone potential medically pertinent approaches to be modified for specific diagnostics and/or therapies. It has been demonstrated that sustained exposure of A549 cell line, a permanent cell line prepared from human lung adenocarcinoma [30], is exposed with silica nanoparticles along with Buthionine-[S,R]-sulfoximine(BSO) (oxidants; increase oxidative stress, acting as GSH reducer) and N-acetyl cysteine(NAC) (anti-oxidants; decrease OS, acting as GSH precursor) for 48 hrs resulted to notion that pure silica nanoparticles are least toxic for normal lung epithelial cells then the metal impurities containing NPs. Additionally, reactive oxygen species (ROS) production and membrane lipid peroxidation (LPO) were reported to be induced by silica nanoparticles in a dose-specific way, indicating the development of oxidative stress [31]. The pure silica nanosphere has been found to emit the brightest image in ultrasound measurement among various other compositions of silica with other components [32]. Furthermore, because silica NPs are simple to tag with fluorescent agents, the creation of a quaternary multifunctional scanning system may be straightforward. This system would also readily enable confocal microscopy to reveal the relative location of the nanoparticle at a tissue level [33]. These nanosystems might be employed for medicinal applications in supplementary to medical imaging, including the administering of hyperthermia and the magnetically controlled administration of medications that could be carried via the silica core [34].

Gold Nanoparticle

AuNPs are becoming increasingly popular, for a variety of reasons such as tumor sensors, drug delivery agents, and in plasmonic photothermal therapy. To begin, AuNPs are thought to be relatively biologically non-reactive and thus suitable for in vivo applications when compared to the extremely toxic cadmium and silver NPs [35,36].

It has been demonstrated that the characteristics of AuNPs, such as their size, charge, and surface make-up, influence both the uptake of AuNPs into cells and their targeted location in subcellular components. Potent drug delivery system also considers the type of drug-AuNP interaction (covalent vs. non-covalent binding) as well as the mechanism of drug release after the drug-AuNP mixture have been introduced to the cells [37].

AuNPs are currently being investigated as possible medicinal agents for the administration of medications into tumor cells in the context of oncology therapy [38]. They were linked with suitable exterior molecules that aim the NPs only at tumor cells in order to make sure the targeted terminating of cancer cells at the same time shielding cells that were not cancerous. Two approaches to tumor targeting were described by Huang et al. (2008): the first involved coupling AuNPs to PEG, and the other involved coupling AuNPs with particular antibodies that adhere to distinct physiological indicators expressed on cancer cells [39]. PEG extended AuNP retention in blood and minimized AuNP clumping together. This made it easier for AuNPs to accumulate preferentially in tumor cells as opposed to healthy cells due to the improved permeability of blood vessels that have not fully developed surrounding tumor after vascular angiogenesis and the reduced elimination rate brought on by the absence of functional lymphatic vessels in tumors [40].

Silver NPs

AgNPs are silver nanoparticles with a size between 1 and 100 nm. AgNPs offer special qualities which make them useful for molecular therapeutics, diagnosis, and gadgets utilized in many medical applications [41]. AgNPs of all forms and sizes can now be produced using physical, chemical, and biological techniques. The physical technique includes evaporation-condensation and laser ablation. Atmospheric pressure was used in a cylindrical furnace to perform the evaporation-condensation process [42]. The lack of chemical reagents in solutions makes laser ablation superior to conventional processes for the creation of metal colloids. Thus, using chemical technique, clean and untainted metal colloids for various purposes can be created [43]. Plant extract-based synthesis of NPs has some benefits over similar biological procedures in that it does not require the complicated procedure of preserving cultivated cells and can be appropriately developed for the manufacturing of NPs on a major scale [44].

AgNPs have demonstrated positive antitumor outcomes. According to a number of scientists, AgNPs caused a cytotoxic impact against leukemic cells. PVP-coated AgNPs, according to Guo *et al.,* efficiently decrease the survival of acute myeloid leukaemia (AML) cells by producing reactive oxygen species (ROS) and releasing silver ions, which promote DNA breakage and programmed cell death [45]. Gurunathan et al. further noted that AgNPs could serve as a possible substitute agent for the treatment of human breast cancer. Through the stimulation of caspase-3 and the production of ROS, AgNPs demonstrated dosage-dependent toxicity towards MDA-MB-231 cells, inducing death and breakdown of DNA [46,47].

Magnetic NPs

Targeted drug distribution is made possible by the administration of medicinal magnetic nanoparticles. Medicines can be directed to a specific place in the body with the help of magnetic field gradients, essentially mounting endogenous biodistribution [3]. MNPs can very specifically upgrade the accumulation of drugs in tumor cells supplied via them. Methods where the MNPs are used for hyperthermia therapy are called Magnetic hyperthermia (MH). Chemotherapeutic agents can concurrently release medicines and transmit heat to tumour cells with the help of MNPs. Utilising MNPs to combine hyperthermia with radiation and chemotherapy predicts increased malignant tissue permeability, targeted tumour removal, reduced side effects, and enhanced therapeutic response [48].

There are several methods, both chemical and physical, that may be used to create magnetic nanoparticles, and then the results have different ultimate characteristics. Based on the state of matter of the raw materials, the following categorization method might be used. Goya et al. (2008), demonstrated methods for synthesis of these magnetic NPs; top-down approach and bottom-up method. The solid element used as an initial basis is shrunk to a nanometric scale in one (thin films), two (nanowires), or three (nanoparticles, or quantum dots) dimensions using the top-down approach. As said in the aforecited method, bulky constituents are disbanded to an extent at which they attain the

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expected shape or size to be credited as a NP. This approach frequently relies on mechanical processes such as reactive ion etching, laser chemical etching, mechanical alloying, and laser machining. On the other hand, the bottom-up strategy starts with atomic or molecular building blocks and grows bigger, nanometric structures from them. Chemical vapour deposition (CVD), reactive sputtering (RS), plasma enhanced CVD (PECVD), pulsed laser deposition (PLD), molecular beam epitaxy (MBE), and wet approaches like sol-gel and microemulsion techniques are examples of bottom-up procedures [49]. Unlike top-down approach, in this method, various minute components are constituted together to design an appropriate NP. These MNPS are extensively used in diagnosis of cancer by MRI detection method.

Iron oxide magnetic NPs

Nanomagnets with cores having magnetic properties are exclusively used in cancer therapy, due to their capacity for high accumulation in tumor cells. To be more particular, iron oxide MNPs are used in the majority, namely, superparamagnetic iron oxide nanoparticles (SPIONs). Because of their exceptional superparamagnetic characteristics, which enable them to be guided for accumulation in particular parts of the body under a magnetized environment, SPIONs have grown to be one of the much extensively researched targeting nanomaterials [50]. Additionally, when exposed to an alternating magnetic field (AMF), SPIONs display great magnetic resonance imaging (MRI), photothermal, and magnetic heating properties. They also have favourable biocompatibility when in contrast to manganese- and gadolinium-containing nanoparticles. All such characteristics result in their appealing potential for use as a contrast agent in MRI scans and in heat therapy as well as a means of administering drugs [51,52].

For multidisciplinary inquiry in tumour detection and treatment, bevacizumab has been labelled with a radioactive substance or a colouring agent. Technetium-99 m (^{99m}Tc)- SPIONs-bevacizumab nanoparticles were created by Zhao et al. (2014) and may enhance tumour access and retention [53]. The Food and Drug Administration (FDA) has authorized trastuzumab, the first humanized immunoglobulin-type G (IgG) 1 monoclonal antibody, for the treatment of breast cancer cells that overexpress HER-2 [54]. It may decrease the tyrosine kinase enzyme that acts on HER-2 receptors by transmitting signals. Trastuzumab has been combined with SPIONs to improve the effectiveness of anticancer drugs and MRI sensitivity for the detection of malignancy indicators [55]. Lee et al., (2007) explained the procedure where Trastuzumab was coupled to iron oxide nanoparticles to result in an ultrasensitive magnetic resonance probe agent for analysing of small grafted tumors in mouse [56]. Chen et al. (2009), also conducted the similar experiment, in which trastuzumab attached to the surface of SPIONs comprising dextran to create new MRI contrast agents. These agents may improve the internalization of nanoparticles by receptor-mediated selection in targeted malignant tumor, leading to enhanced MRI report [57].

Nickel-copper based magnetic nanoparticles

Bimetallic nickel/copper magnetic nanoparticles (NiCu MNPs), one of the other magnetic nanoparticles that are now being used in biomedicine, are particularly gaining popularity because of their special biomedical-appropriate features. These qualities include adjustable magnetic properties that may be altered by modifying synthesis settings, consistency in a variety of chemical conditions, and shown physiological compatibility with a variety of cells. NiCu MNPs appear to hold great promise for both the use of Magnetic Hyperthermia (MH) and regulated drug administration, according to recent results [58]. A new regulated drug delivery formulation made of $Ni_{67.5}Cu_{32.5}$ MNPs in a silica matrix created using the sol-gel method was developed by Stergar et al., (2018). In this study, the capacity of MNPs' to deliver the medication to diverse human cells using the fluorescent dye rhodamine 6G was tested. The progressive approach of $Ni_{67.5}Cu_{32.5}$ MNPs has proven to be a trustworthy and effective delivery method for various kinds of human cells [59].

The additive effects of Ni nanoparticles and daunorubicin on preventing the spread of malignant cells are seen. The reason for this may be that the modified Ni nanoparticles with positively charged tetraheptylammonium caps may easily penetrate the cancerous cells along with the daunorubicin molecules and consequently promote the internalization of daunorubicin in target cells that are cancerous. It might further boost the absorption of the

therapeutic agent daunorubicin into the K562 cancer cells, thereby improving daunorubicin's ability to block the growth of the target cancer cells [60].

Carbon-based NPs
Carbon-based nanomaterials (CBNs) are gaining popularity in the researched fields and technical sectors because of their variety of chemical and physical properties. Moreover, various branches of medical technology are diligently exploring these favourable CBN characteristics [61]. Due to the allotropic diversity of the carbon, it is being exploited for biosensory, drug delivery medium, gene therapy, etc. purposes by constructing a variety of nanomaterials, such as quantum dots.

Quantum dots
Nanotechnology has been proven to be the most magnificent discovery of the era, as it is assisting the human kind in various way. In the same trail of discoveries, Quantum Dots(QD) finding has achieved the Nobel prize in Chemistry 2023, is paving the way in treatment of Cancer. Nobel Prize is equally shared between 3 scientists, Alexei I. Ekimov, Louis E. Brus, and Moungi G. Bawendi for the discovery and engineering of quantum dots. QDs, a diverse group of manufactured nanoparticles with distinctive optic and chemical characteristics, have emerged as potentially among the most interesting developments in marking technology. QDs have a wide range of possible uses, from energy to therapy [62,63]. Presently, QDs are extensively employed in laboratory, including the identification of cancer indicators in molecular pathology, the outlining of cancer proliferation, the emphasis on the tumour environment, and the provision of a new approach for enhancing the knowledge, screening, categorization, and therapy of cancer diversity [64]. Mulder et al., (2006) used MRI and fluorescence scanning to efficiently treat tumour vascular proliferation using MR-fluorescent bimodal Qds [65,66]. To increase functionality, this strategy was expanded to QD-based bimodal devices housed in silica nanoparticles [67]. Biocompatible QDs are powerful primary sensors as well as scientific devices once these are created, and their mobility is significantly influenced by the cell types used and the chemical structure of the QD conjugates. In the future, major issues still require to be resolved, even if various innovative processes for producing QDs have been devised [68].

The majority of compounds that make up fluorescent QDs are found in groups II to VI and III to V, including Cd, Hg, Se, Ag, Ln, P, Pb, Te, and Zn. The frequency produced by quantum dots is increasingly limited as their diameter decreases. Because of their exact emit frequency, a range of fluorescence radiations are not visible in their spectra [69]. Advantageous features of QDs are still being studied and are under development; however, some harmful effects have also presented themselves during experiments. When compared to fluorophore dyes, CdSe quantum dots perform more efficiently and are twenty times more positive. Although they should have a solid polymer coating, CdSe based quantum dots are particularly hazardous [70]. CdTe QDs encased with mercaptopropionic acid (MPA) and cysteamine were reported to be harmful to rat pheochromocytoma cell (PC12) growth at doses of 10 µg/mL by Lovric et al. (2005). At 1 µg/mL, uncovered CdTe QDs proved deadly[71].

Diagnostic uses of NPs
Nanoparticle compounds are often utilised for a variety of reasons, including cancer detection and therapy [72]. Currently, a variety of nanoparticle forms, including liposomes, silica nanoparticles and quantum dots, stained with dye molecules, are utilised in molecular imaging to diagnose cancer. There is a growing need for fluorescent labelling labels that offer greater potential, stability, and reliability in order to accomplish accurate diagnosis [73,74]. Makarova et al. (2021) created FITC-doped ultrabright nanoparticles with success. The perspective for biological labelling of the developed nanoparticle as probe is very effective even at low concentration with reduced chemotoxicity and phototoxicity [75]. On the other hand, it has been documented that nanoliposomes can be used for imaging and cancer detection. Magnetic resonance imaging (MRI) is utilised to visualise tumour vascular development in vivo using antibody-conjugated paramagnetic liposomes (diameter 300-350 nm) [76]. Harisinghani et al. (2003) looked into the potential of SPION for non-intrusive MRI lymph node metastasis diagnosis in prostate cancer. All patients with metastatic nodal cancer were successfully diagnosed by MRI using these superparamagnetic nanoparticles, and the node-by-node analysis specificity was much higher than that of traditional MRI [76]. Magnetic

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resonance imaging (MRI)[51], multiplexed molecular cancer diagnostics, and in vivo diagnostics are among the prospective application. The anti-CEA monoclonal antibody rch 24 (rch 24 mAb) showed a highly potent and exclusive reactivity towards the PEGylated CdTe Q-dots, which proved to be a novel discovery. Using the resulting CdTe–(rch 24 mAb) conjugates, CEA formed on the outer cortex of cell line LS 180 was effectively detected. Subsequent tests revealed that compared to FITC, the fluorescent CdTe Q-dots had far greater photostability and stronger fluorescence imaging, which increased the effectiveness of detecting cancer markers [77].

Targeted gene therapy for retinopathy of prematurity (ROP) was developed by combining the magnetic NPs with the transcriptionally active PCR (TAP) products conjugated with biosensor sequences [78]. Sensitive biosensors devised by various nanocomponents is capable of being utilized to identify malignant tumors and additionally to provide certain beneficial data for cancer detection at an early stage by identifying mutations and genetic abnormalities [79]. Recently, a PEG-conjugated polyester dendrimer with folic acid at its distal extremity and gadolinium(Gd) chelate compounds were combined to create a tumor-targeting biodegradable contrast agent. It has been demonstrated that the dendrimer coupled contrast medium produces greater contrast than the widely accessible drug Magnevist®. Additionally, there was little accumulation of it in any of the organs, which decreased the toxicity caused by Gd. Thus, this dendrimer-based digestible carrier is a viable imaging agent due to these favourable results, namely improved MRI contrast and decreased Gd accumulation [80].

Given that ingrained silver MNPs with titanium can enhance anti-microbial ions to cure biological infections [81]. Iron oxide MNPs have visual and MRI capabilities and is capable of administering the hypothermic treatment to target cancer cell [82]. The diversity of multipurpose Mesoporous silica nanoparticles(MSNs) has enormous possibilities for the regulated encasing and transfer of medicinal molecules into numerous physiological uses when combined with the adherence of fluorescent compounds to their outer surfaces or within the pore walls, also can help in detection using of tumor using these capabilities [81].

Targeting with NPs

Targeting using NPs can be achieved by specificity toward the intended site in the body. This includes some methods such as, EPR effect, ability of NPs to avoid the RES in body, elevated specificity toward particular tumor using antibodies or Mab., by blocking angiogenesis, by transporting the gene likewise in gene therapy etc. targeting to particular location or tumor etc,. Numerous angiogenesis inhibitors have received FDA approval for the treatment of cancer. VEGF, its receptors, or various particular compounds that contribute to the formation of vessels were the focus of the majority of these personalised treatments. Among the authorized inhibiting agents of angiogenesis are: Axitinib (Inlyta®)[82] used in advanced renal carcinoma.Bevacizumab (Avastin®)[83] applied in variety of cancers such as cervical cancer, colorectal cancer, ovarian cancer, hepatocellular carcinoma, lung cancer and renal cell carcinoma.Cabozantinib (Cometriq®)[84] administered in differentiated and medullary thyroid cancer, renal cell and hepatocellular carcinoma.Everolimus (Afinitor®)[85] given in breast, pancreatic cancer, renal cell carcinoma subependymal giant cell astrocytoma etc., Lenalidomide (Revlimid®)[86] useful in follicular, marginal zone, mental cell lymphoma, multiple myeloma etc,.

CONCLUSION

The primary objective of this review is on diverse inorganic NPs that have been intensively created over the past 10 years for medical uses that include pharmacological and detecting purposes. These NPs have intriguing visual, magnetic, and biological capabilities. The physical characteristics, which include being absorbed, fluorescent imaging, scattering of light, Raman effect, and magnetic resonance, are mostly determined by the nanoscale size, making them effective agents for cancer imaging. Additionally, they can be employed as theragnostic agents due to their size- and geometry-dependent treatment modalities, which include the magnetothermal and photothermal ablation of cancer cells. In recent years, the application of NPs for treatments for cancer has grown tremendously, and as previously noted, important advancements can be achieved in this area of medicinal administration. It is

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envisaged that this field of study will soon result in the creation of unique, highly developed, diversified solutions that can achieve the intended results of early diagnosis, tumor regression with minimal collateral harm, and effective chemotherapeutic treatment management. Ultimately, each of this knowledge will aid in the logical development of nanoparticles conjugated with appropriate components to treat a variety of severe diseases for which there were no effective treatments, thereby enhancing the human medical treatment process for the next generation.

STATEMENTS AND DECLARATIONS

Ethics approval and consent to participate
Not Applicable

Availability of data and materials
Not Applicable

Competing interests
The authors declare that there is no competing interest.

Authors' Contributions
The manuscript was written and designed by Ms. Anshita Mishra. Dr. Jyoti Parmar reviewed and edited this manuscript with assistance.

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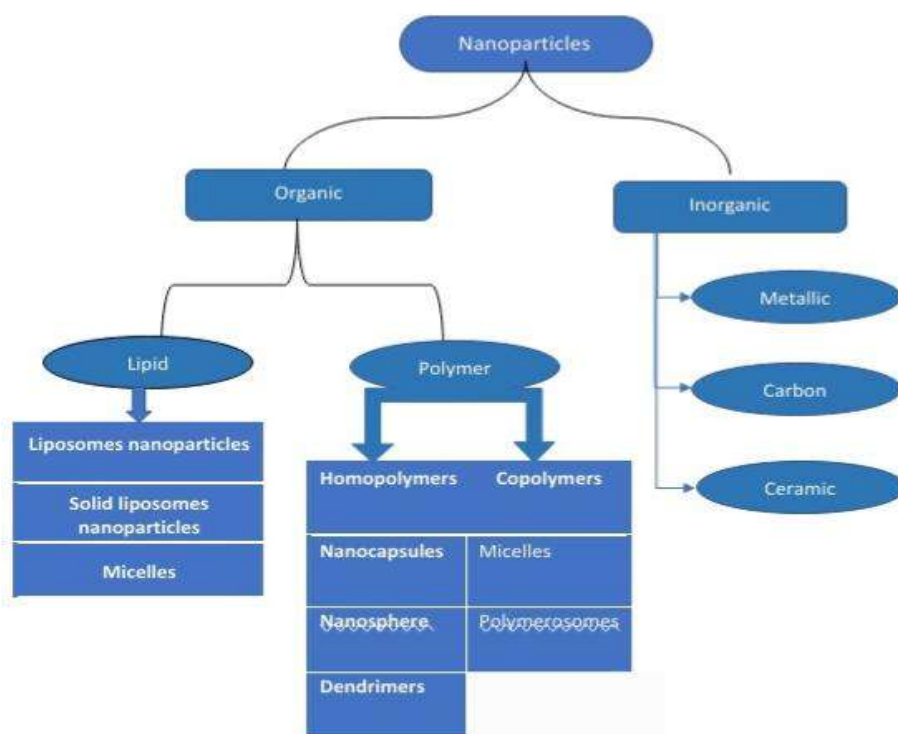
Fig. 1: Classification of Nanoparticles

RESEARCH ARTICLE

Formulation of Low-Cost Culture Medium using Agrowastes for the Cultivation of Industrially Important Fungi

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ABSTRACT

In the present study, various Agrowastes (Beetroot peel waste, Onion peel waste, Pineapple peel waste, Orange peel waste and Sugarcane bagasse) was collected and the prevalence of the Industrially Important Fungi in the Sacred Heart College Campus was studied by Open plate method during September 2023 to November 2024. The Beetroot peel agar showed that *Aspergillus niger* grew quickly whereas *Trichoderma viride* grew moderately. Orange peel agar's high acidity significantly aided *Aspergillus niger* growth, leading to the development of strong fungal colonies. However, *Trichoderma viride* had difficulties due to *Aspergillus niger* contamination and restricted development, highlighting the need of choosing appropriate substrates for certain bacteria. Compared to other substrates, *Aspergillus niger* grew less well on Onion peel agar, suggesting that the growing conditions were not ideal for this microbe. *Trichoderma viride* similarly showed only modest development on this medium, indicating that the conditions in which the onion peel agar was grown were not favorable for the growth of either microbe. Pineapple peel agar revealed ideal circumstances for the development of *Trichoderma viride* and *Aspergillus niger*. Both apparent coloring and the growth of extensive fungal colonies were supported by this substrate. The growth of *Trichoderma viride* was unaffected by the moderate acidity of Pineapple peel agar, which simultaneously encouraged the development of *Aspergillus niger*. The Sugarcane bagasse first

inhibited fungal development, but eventually it helped *Aspergillus niger* colonies proliferate. However, it prevented *Trichoderma viride* from growing, emphasizing how crucial substrate specificity is for different microbes.

Keywords: Beetroot peel waste,Onion peel waste,Orange peel waste, Pineapple peel waste, Sugarcane bagasse, *Aspergillus niger* and *Trichoderma viride.*

INTRODUCTION

India is a nation founded on agriculture, and since ancient times, the farming system has held a unique position in the cosmos. Vegetable gardening has taken centre stage among the many agricultural products produced in India because of its everyday need for cooking and the variety of nutrient components it contains. India is rapidly rising from its second-place ranking in vegetable output to the top due to increased demand brought about by the country's growing population. In addition to serving as a valuable source of nutrients for food, vegetable peel wastes are bad for the environment. Waste management has been a popular topic of discussion in a number of recent debates. Although the wastes produced by unspoiled vegetables do not pose a risk to public health or the troposphere, it is crucial to figure out how to make useful use of the vegetable peel wastes. In the current situation, getting rid of undesired agricultural wastes in a useful way is exceedingly difficult. There's little doubt that the planned study project will offer the best method for making useful use of the leftover vegetable peels [1]. The invisible creatures that are found all throughout the cosmos and in nature are known as microorganisms. Because of their both advantageous and detrimental properties, microbes have been described by several researchers as the "Double edged sword." The main groups of microorganisms in this universe include algae, protozoa, fungus, bacteria, and archaea. Among all the different kinds of microorganisms, fungi are essential to the manufacturing of many industrial goods that people use on a daily basis. Fungi are eukaryotes that are found in both air and soil. They can be divided into two main families based on their cellular makeup: molds and yeast. While yeast is a unicellular organism, molds are multicellular[2]. Spores from the mold are widely dispersed throughout the air and soil, and yeast is hardly ever present in these environments. Medicinally, the fungi belong to mold and yeast has an equal importance in causing acute and chronic infections in human beings. The molds are responsible for causing various diseases *viz.,* respiratory tract infection, skin infection, hair infection and nail infection. Commonly the fungal molds inhabit the respiratory tract then moves to lungs and results in various respiratory disorders. The Dermatophytes are well known for its infections in skin, hair and nail regions. The harmful effect of mold was extended to plant species also [3].

The fungi have the ability to synthesize the toxin Mycotoxin which causes serious health issues in human beings and agricultural crops. Every year the phytopathogens belong to the mold category is resulting in the cause of severe economic loss of various agricultural crops by causing diseases during various growth stages[4]. The harmful effect of yeast was reported against humans only and not against plant or animal species. The common harmful dimorphic fungal yeast namely, *Candida albicans* has showed severe effect against human beings particularly female community by causing Urinary tract infection, Nosocomial infection and Pulmonary candidiasis. The percentage of fungi that are beneficial is equal to the percentage of their negative effects. When it comes to fungi, the term "double edged sword" fits them better than other microbes [5]. According to Angenent *et al.* [6], the fungal Mold has discovered a unique purpose in the manufacturing of various Industrial products like enzymes, biopolymers, organic acids, biofuels, organic solvents, biopesticides, antibiotics, and biocontrol agents against phytopathogens[7]. Sir Alexander Fleming discovered Penicillin, the first antibiotic, from the fungus *Penicillium notatum*. Other fungi like *Beauveria bassiana* and *Metarhizium anisopliae* function as bioinsecticides. The fungi *Trichoderma viride* serves as a biocontrol agent. The pharmacological industries have long employed Mushrooms due to their existence of numerous bioactive chemicals and their role as a food source for humans. Numerous studies have looked at the function of fungal Mold in the bioremediation of different wastewaters and textile dyes [8]. Regrettably, because fungal Mold produces mycelial mats, its use in wastewater treatment has been limited. Instead, bacteria have taken its place because of their rapid

and very effective bioremediation. The fungal yeast *Saccharomyces cerevisiae* is commonly called as Backer's yeast and Brewer's yeast due to its active role in the production of bread, bioethanol, beer and wine. The role of *Saccharomyces cerevisiae* in alcoholic fermentation was reported in early days by the French scientist Louis Pasteur who was the Frontier of Microbiology research and named as Father of Modern Microbiology [9]. The yeast also fills its role in the category of food and feed. Some species of yeasts like *Saccharomyces cerevisiae*, Amoco toluol, *Candida tropicalis*, *Candida utilis*, *Candida novellas* and *Candida intermedius* can act as a Single cell protein (SCP) and used as a food for human beings and feed for cattle[10]. A culture medium is an environment that provides different chemical nutrients and growth ingredients to promote the growth of microorganisms. Culture media is divided into six categories based on the characteristics of the material: basal, enriched, differential, selective, and transport [11]. The typical culture medium for the cultivation of fungus is Sabouraud dextrose agar, or SDA as it was commonly abbreviated. In addition to SDA, two more frequently utilized culture media areRose Bengal agar (RBA) and Potato dextrose agar (PDA). For the benefit of microorganisms, all culture media are abundant in chemical nutrients such as carbon sources (often sugars derived from carbohydrates), nitrogen, phosphorus, and sulphur. The sugar made of carbohydrates One of the key components of fungus culture media is dextrose[12]. The increasing demand for research and the scarcity of raw materials are driving up the cost of commercial culture media. Researchers and industrialists face financial difficulties as a result of tax systems such as the Goods Service Tax (GST) in developing nations like India[13]. We must discover a different source for microbe cultivation in order to manage the economic problems. The right solution to replace synthetic culture medium is to use massive amounts of agrowastes for the cultivation of industrially significant fungi [14,15]. The prevalence of fungi in the environment was studied by various researchers on their research. They reported that the population of bacteria was comparatively less in atmosphere than the fungi. That was due to the moisture content which is naturally present in the air. The fungi are highly nuisance and irritable during to rainy season because the moisture content was very high during the rainy season and it results in the growth of fungi in various inanimate objects like books, cloths, house ceilings, beds, pillows and leather bags. The population of fungi varies from season to season. The prevalence of fungi was also noticed in the top surface of vegetables and peels of Onion and Garlic[16,17].

MATERIALS AND METHODS

Location selected in Sacred Heart College for Fungal Prevalence Study
a. UG Microbiology Laboratory
b. PG Microbiology Laboratory
c. Staff room
d. Library
e. Church
f. Abdul Kalam Research Centre
g. Staff Bike stand
h. Gate 2 cycle stand
i. Gate 3 cycle stand
j. College Ground
k. Gents Rest Room
l. Ladies Rest Room
m. Oasis Hall
n. Kamarajar Arangam
o. Carreno Hall.

Agrowastes Selected for Present study
a. Beetroot peel waste
b. Orange peel waste

c.   Onion peel waste
d.   Pineapple peel waste
e.   Sugarcane bagasse

Collection of Agrowastes

The Agrowastes (Beetroot peel waste,Onion peel waste, Orangepeel waste, Pineapple peel waste and Sugarcane bagasse) which are selected for the present research was collected from the Tirupattur market (Tirupattur district, Tamil Nadu, India). The collected Agrowastes were shade dried, powdered and then stored in Plastic bag at Room temperature[18].

Prevalence of Fungal population in Air in Sacred Heart College Campus

The prevalence of Fungal population in Air in Sacred Heart College Campus was studied by Open plate method. From September 2023 to November 2023, the study was carried out in 15 different locationsof Sacred Heart College (Autonomous), Tirupattur (UG Microbiology Laboratory, PG Microbiology Laboratory, Staff Room, Library, Church, Abdul Kalam Research Centre, Staff Bike Stand, Gate 2 Cycle Stand, Gate 3 Cycle Stand, College Ground, Gents Rest Room, Ladies Rest Room, Oasis Hall, Kamarajar Arangam, and Carenno Hall). The SDA plates were prepared and opened for 15 minutes per location. Then, the SDA plates were incubated for three days at Room temperature. The fully developed Fungal colonies were kept on SDA slants and kept in refrigerator for storage at 4 ºC[19,20].

Platting of Industrially Beneficial Fungi in Agro wastes
Inoculum Preparation

The fresh suspension of 72 hours old cultures of Industrially beneficial fungi (*Aspergillus niger* and *Trichoderma viride*) was used to study the growth analysis. The fungal cultures were inoculated into 50 ml of saline and incubated at Room temperature for 5 hours[21,22].

Growth Analysis of Industrially Beneficial Fungi in Agrowastes

From the Open plate technique, the two fungi are isolated (*Aspergillus niger* and *Trichoderma viride*) are injected into appropriate medium. Subsequently, about 6.0 grams of the selected Agrowasteswere mixed with 200 ml of Distilled water, brought to boil for 30 mins, let to cool for 2 hours in Room temperature, and filtered through Whatman No. 1 Filter paper. Then, 2.0 grams of Agar-Agar wasadded into the extracted water. The final mixture was Autoclaved at 121 ºC for 15 mins,allowed to solidify, and the Fungus was inoculated into the Agrowaste medium. On the 3rdday the fungal growth was visually assessed and noted[23].

RESULTS AND DISCUSSIONS

Prevenance of Fungal Growth in Sacred Heart College Campus

Three months of research were dedicated to examining the prevalence of specific Industrially advantageous fungus as well as other fungi before examining the fungi's capacity to develop in the Vegetable peel waste medium. The study on fungal prevalence was carried out in 15 sites of Sacred Heart College (Autonomous), Tirupattur, between September 2023 and November 2023. Fifteen locations in the college that was chosen for the current study. It includes, (1) UG Microbiology Laboratory, (2) PG Microbiology Laboratory, (3) Staff Room, (4) Library, (5) Church, (6) Abdul Kalam Research Centre (AKRC), (7) Staff Bike Stand, (8) Gate 2 Cycle Stand, (9) Gate 3 Cycle Stand, (10) College Ground, (11) Gents Rest Room, (12) Ladies Rest Room, (13) Oasis Hall, (14) Kamarajar Arangam and (15) Carreno Hall. The + sign was used to classify the fungal population. The sign (-) indicates no fungal growth, one plus (+) indicates very low fungal growth, two plus (++) indicates moderate fungal growth, three plus (+++) indicates strong fungal growth, and four plus (++++) indicates extremely high fungal growth that fills the whole Petri plate (Table – 1 to Table - 3). For the present research, the most used and important Industrially fungi (*Aspergillus niger* and *Trichoderma viride*) are involved. They are used for the fermentation of various Industrial microbial products which are very helpful for various purposes. *Aspergillus niger* has wide-ranging uses in many sectors of the economy,

especially in Biotechnology and Manufacturing operations. Enzymes that are vital to many industrial processes, such as α-amylase, lipase, cellulase, glycosylase, catalase, β-galactosidase, glucose oxidase, hemicellulose, protease, and more, are frequently produced using it. *Aspergillus niger* is a versatile filamentous fungus mold with the bio-economy transition potential. It is also used in Solid State Fermentation and Submerged Fermentation for the manufacture of organic acids, proteins, enzymes, and medicinal substances. *Aspergillus niger* is an important microbe for Industrial applications due to its metabolic plasticity and capacity to create large quantities of proteins, enzymes, and medicines. It also helps to manufacture numerous valuable substances and advances in Biotechnology. *Trichoderma viride* has a wide range of industrial uses, most notably in the solid-state bioprocessing of agro-industrial waste to produce enzymes such cellulase complexes. It has been demonstrated that an indigenous strain of *Trichoderma viride* can generate large titters of cellulase complex, which includes β-glucosidase, exoglycanases, and endoglucanase, all of which are necessary for a variety of industrial operations. Endoglucanase, the enzyme with the highest activity, has been effectively isolated and described, indicating its potential for application in industry. Bhavani and Saranraj [11]studied the prevalence of industrially beneficial fungal population in Sacred Heart College campus for Six months. The prevalence of both *Aspergillus niger* and *Penicillium chrysogenum* was high in the month of June 2017, August 2017 and November 2017, and low in July 2017, September 2017 and October 2017. It was observed that the growth and prevalence of *Aspergillus niger* was very high in Sacred Heart College campus when compared to *Penicillium chrysogenum*. Our present research was also carried out on the same location and in line with our findings. In our research also, the growth of *Aspergillus niger* and *Penicillium chrysogenum* was recorded good during November 2023 followed by September 2023 and October 2023. It was also assumed that the variation in the fungal growth was due to the seasonal and temperature change in the Tirupattur region.

Formulation of Low-cost Agrowaste based Culture medium for the cultivation of *Aspergillus niger* and *Trichoderma viride*

Growth of Industrially Important Fungi in Beetroot peel medium

Aspergillus niger is one of ubiquitous fungi that resides all around the world which can be grown in any type of media due to its fast-growing ability. Beetroot is most used edible vegetable with a well-served nutrient content. Butthe peels are through off to the ground, that have the sufficient vitamins and minerals for the *Aspergillus niger* to grow. On the Beetroot peel medium, *Aspergillus niger* formed a single colony on the third day. On the fourth day, two *Aspergillus niger* colonies start to develop on the Beetroot peel medium. *Aspergillus niger* colonies come in two distinct sizes: one is microscopic, and the other is enormous. On the fifth day, two *Aspergillus niger* colonies reach a mature stage of development. Another fungal colony was growing on the edge of the Beetroot peel waste medium. On the sixth day, the *Aspergillus niger* colonies are scattered over the plates containing the Beetroot peel waste medium. The first three days of *Trichoderma viride* development were modest; nevertheless, by the third day, the growth was evident. The species' nutrient intake had a positive effect on the plate. when the growth is entirely visible in the centre of the plate. The plate appeared to be somewhat filled with the fungus on the fourth and fifth (Table – 4).

Growth Industrially Important Fungi in Orange peel medium

The *Aspergillus niger* was greatly impacted by the orange peel, and on the second day, one or two colonies seemed to be growing. And in the days that followed, the growth was evident. *Aspergillus niger* flooded the Agar plate on the fourth and fifth day. The fungus species ability to replicate was significantly influenced by the acidity of the orange peel. The media presented a clear image of the black pigment. On the third day, a limited number of colonies are developed in the media due to the acidity of the Orange promoting good growth of *Trichoderma viride*. The species continued to develop well on the following days, the fourth and fifth, but *Aspergillus niger*, a common fungus, was also discovered to have contaminated the sidewalls of the agar plates. A moderate quantity of tainted fungus was cultivated; aside from that, the *Trichoderma viride* grew well and the pigmentation was clearly visible (Table – 5).

Growth of Industrially Important Fungi in the Onion peel medium

In Onion peel medium, *Aspergillus niger* was cultivated in tiny quantities. The incubation period was three days. There was not much development, after that little colonies might be spotted. *Aspergillus niger* did not respond well to

Onion peel agar. *Aspergillus niger* growth takes place on the fourth and fifth day. There was a modest growth observed for *Trichoderma viride*. The colonies that are visible may be seen on the third day, although they did not show much on the following day in the plate. The growth was visible, however the tiny number of *Trichoderma viride* was only visible. The fungal species development was comprehensively summarized in Table – 6.

Growth of Industrially Important Fungi in the Pineapple peel medium

The growth of the Industrially Important Fungi was analysed in the Pineapple peel medium. In the beginning of the Third day, little colonies were developed, similar to the *Aspergillus niger* fungus species. However, *Aspergillus niger* was grown aggressively over the medium plate after the prolonged incubation. The pigment was obviously visible, as the illustration illustrates. The fungus spread brilliantly over the Pineapple peel medium on days four and five. Due to the low acidity of the Pineapple peel medium, *Aspergillus niger* was able to fully proliferate on the medium. The growth can be evenly distributed throughout the *Trichoderma viride* plates where the species began to grow starting on the second day. According to the record, the entire plate was coloured and well-grown in the medium on the fourth and fifth days (Table – 7).

Growth of Industrially Important Fungi in Sugarcane bagasse

For the first three daysin Sugarcane bagasse, the fungus growth cannot be seen in the Agrowaste culture media because the sugar content in the Sugarcane bagasse predominates throughout. On the other hand, the fungus began to spread across the little colonies after three days, but not as much as orange or pineapple peel. The media resembles a little dot of the provided fungus (Table – 8). Abe [1]prepared the Culture media using the fruits peel Agrowastes such asMango peel, Jack fruitPine apple peel, BananaPine apple peel, Sweet LimePine apple peel,Pine apple peel, and PomegranatePine apple peel for studying the growth of *Aspergillus niger,Rhizopus stolonifer*and*Penicillium chrysogenum*. He observed the good and luxuriant growth of*Aspergillus niger* in the Culture medium comprising the Peels of Mango,Pine apple, Jack fruit, and Banana only. In the peels of Sweet lime and Pomegranate,*Aspergillus niger* did not showed any growth. Rhizopus *stolonifer* growth was observed in the medium which contains Pine apple, Mango, Sweet lime and Pomegranate. The *Rhizopus stolonifer*didn't exhibited any growth in the tested fruit peel wastes. However, the *Penicillium chrysogenum*shows some growth in the medium incorporated with the Peels of Pine apple, Mango, Sweet lime and Pomegranate only and no growth was recording in the medium containing Banana peel, Jack fruitpeel and Mangopeel. Saranraj and Jayaprakash [18]formulated the Novel culture medium using the Vegetable peel wastes (Onion peel waste and Garlic peel waste)for the cultivation of Two different Industrially Beneficial Fungi (*Aspergillus niger* and *Penicillium chrysogenum*). They concluded that the Onion peel waste was the good low costCulture medium than the Garlic peel waste for the cultivation of *Penicillium chrysogenum* and *Aspergillus niger*. They also found that the Garlic peel waste has showed an average growth for *Penicillium chrysogenum* and the fungi *Aspergillus niger* did not showed any growth on Garlic peel medium. In comparison, the Garlic peel waste medium was the good source for *Penicillium chrysogenum* cultivation but not for *Aspergillus niger*. In conclusion, the Onion peel waste act as a good source for the cultivation of *Aspergillus niger* and *Penicillium chrysogenum*when compared to the Garlic peel waste.

CONCLUSION

The present study has examined the development of Industrially significant fungi on a variety of Agricultural waste substrates, including *Aspergillus niger* and *Trichoderma viride*. Our findings showed the possibility of utilizing Agrowastes products (Sugarcane bagasse, Onion, Beetroot, Pineapple, and Orangepeels) as a growth substrate for the Industrially important fungi. In conclusion, agricultural waste substrates including Sugarcane bagasse, Pineapple peel, and Beetroot peel show potential as sustainable and affordable media for growing microorganisms of Industrial importance. In order to improve the microbial productivity and support environmentally friendly Biotechnological applications, growth conditions and substrate compositions can be further optimized.

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Table–1: Fungal growth in Sacred Heat College Campus (September -2023)

S. No	Location in Sacred Heart College	*Aspergillus niger*	*Trichoderma viride*	Other fungal isolates
1	UG Microbiology Laboratory	NG	NG	++++
2	PG Microbiology Laboratory	+	NG	++
3	Staff Room	NG	NG	++++
4	Library	+	+	+++
5	Church	+	NG	+++
6	APRC	++	NG	++++
7	Staff Bike Stand	+	NG	++
8	Gate – 2Cycle stand	+	+	+++
9	Gate – 3Cycle stand	+	NG	++++
10	College Ground	++	NG	+++
11	Gents Rest Room	NG	NG	++++
12	Ladies Rest Room	NG	NG	++++
13	Oasis Hall	++	+	+++
14	Don Bosco Indoor Stadium	NG	NG	++++
15	Carenno Hall	+	NG	+++

+ - Very Low Growth; ++ - Moderate Growth; +++ - High Growth; ++++ - Very High Growth covering full plate; NG No Growth

Table– 2: Fungal growth in Sacred Heat College Campus (October-2023)

S.No	Location in Sacred Heart College	*Aspergillus niger*	*Trichoderma viride*	Other fungal isolates
1	UG Microbiology Laboratory	+	+	++++
2	PG Microbiology Laboratory	+	NG	++++
3	Staff Room	+	+	++++
4	Library	++	+	++++
5	Church	NG	+	++++
6	APRC	++	+	++++
7	Staff Bike Stand	+	+	++++
8	Gate– 2 Cycle stand	+	+	++++
9	Gate– 3 Cycle stand	+	+	++++
10	College Ground	+	+	++++
11	Gents Rest Room	++	++	++++

12	Ladies Rest Room	++	+	++++
13	Oasis Hall	+	+	++++
14	Don Bosco Indoor Stadium	+	++	++++
15	Carenno Hall	+	+	++++

+ - Very Low Growth; ++ - Moderate Growth; +++ - High Growth; ++++ - Very High Growth covering full plate; NG - No Growth

Table– 3:Fungal growth in Sacred Heat College Campus (November– 2023)

S.No	Location in Sacred Heart College	*Aspergillus niger*	*Trichoderma viride*	Other fungal isolates
1	UG Microbiology Laboratory	NG	NG	++++
2	PG Microbiology Laboratory	NG	NG	++++
3	Staff Room	++	NG	++++
4	Library	NG	NG	++++
5	Church	NG	NG	++++
6	APRC	+++	NG	++++
7	Staff Bike Stand	++	+	++++
8	Gate – 2Cycle stand	NG	NG	++++
9	Gate – 3Cycle stand	NG	NG	++++
10	College Ground	++++	NG	+
11	Gents Rest Room	+++	NG	++
12	Ladies Rest Room	NG	NG	++++
13	Oasis Hall	+	+++	++
14	Don Bosco Indoor Stadium	+	+	++++
15	Carenno Hall	NG	NG	++++

+ - Very Low Growth; ++ - Moderate Growth; +++ - High Growth; ++++ - Very High Growth covering full plate; NG - No Growth

Table–4:Growth of Industrially Important Fungi in Beetroot peel medium

Industrially significant Fungal strains	Growth in Beetroot peel waste agar medium			
	Day– 2	**Day-3**	**Day– 4**	**Day–5**
Trichoderma viride	Initially a small colonies of *Trichoderma viride* were observed.	The colonies of *Trichoderma viride* were observed without contamination.	Small colonies of *Trichoderma viride* were observed in centre of the plate without any contamination.	The colonies of *Trichoderma viride* occupied the full plate without the contamination of *Aspergillus niger.*
Aspergillus niger	Only one colony of *Aspergillus niger* is observed.	Small number of colonies were start to grow.	Small number of *Aspergillus niger* colonies were occupied the full plate.	Throughout the medium. The matured *Aspergillus niger* separated colonies were observed.

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Table–5:Growth Industrially Important Fungi in Orange peel medium

Industrially significant Fungal strains	Growth in Orange peel waste agar medium			
	Day– 2	**Day-3**	**Day– 4**	**Day–5**
Trichoderma viride	Initiallya small colonies of *Trichoderma viride* were observed.	The colonies of *Trichoderma viride* were observed without contamination.	Small colonies of contamination were observed with the growth of *Trichoderma viride.*	The colonies of *Trichoderma viride* occupied the full plate with the contamination of *Aspergillus niger.*
Aspergillus niger	Only one colony of *Aspergillus niger* is observed.	Two colonies of *Aspergillus niger* were observed. One is smaller than another colony.	Matured colonies of *Aspergillus niger* were occupied the fullplate.	Throughout the medium, the matured *Aspergillus niger* colonies were observed.

Table–6:Growth of Industrially Important Fungi in the Onion peel medium

Industrially significant Fungal strains	Growth in Onion peel waste agar medium			
	Day-2	**Day-3**	**Day– 4**	**Day–5**
Trichoderma viride	Initiallya small colonies of *Trichoderma viride* were observed.	The colonies of *Trichoderma viride* were observed without any contamination.	The growth of *Trichoderma viride* were observed mostly in the centre of the plate.	The colonies of *Trichoderma viride* occupied the full plate without the contamination of *Aspergillus niger.*
Aspergillus niger	Only one colony of *Aspergillus niger* is observed.	Two colonies of *Aspergillus niger* were observed. One is smaller than another colony.	colonies of *Aspergillus niger* were occupied separated form.	Throughout the medium, the *Aspergillus niger* colonies were observed.

Table–7: Growth of Industrially Important Fungi in the Pineapple peel medium

Industrially significant Fungal strains	Growth in Pineapple peel waste agar medium			
	Day-2	**Day– 3**	**Day– 4**	**Day–5**
Trichoderma viride	Initiallya small colonies of *Trichoderma viride* were observed.	The colonies of *Trichoderma viride* were observed without contamination.	Small colonies of *Aspergillus niger* contamination were observed with the growth of *Trichoderma viride.*	The colonies of *Trichoderma viride* were occupied the full plate with two big colonies of *Aspergillus niger.*
Aspergillus niger	Only one colony of *Aspergillus*	Two colonies of *Aspergillus niger*	Small to big colonies of *Aspergillus niger*	Throughout the medium, the

	niger is observed.	were observed. One is smaller than Another colony.	were occupied the full plate.	matured *Aspergillus niger* colonies were observed.

Table–8:Growth of Industrially Important Fungi in Sugarcane bagasse

Industrially significant Fungal strains	Growth in sugarcane bagasse Peel Waste agar Medium			
	Day-2	**Day-3**	**Day– 4**	**Day–5**
Trichoderma viride	No growth was observed	No growth was observed	No growth was observed	No growth was observed
Aspergillus niger	Only one colony of *Aspergillus niger* is observed.	Two colonies of *Aspergillus niger* were observed. On is smaller than Another colony.	Very tiny colonies were observed throughout the media	No changes observed.

REVIEW ARTICLE

An Overview of Deviation Management Approaches in the Pharmaceutical Industry

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ABSTRACT

In the pharma industry, all activities are done as per the regulatory guidelines and standard operating procedures. Deviations are seen as a significant aspect of achieving Six Sigma attributes. Deviations are defined as unexpected occurrences during the product life cycle. US 21 CFR parts 210, 211, and EU volume 4 give information on good manufacturing practices. Corrective actions and preventive action are steps taken to prevent errors in the products and root cause analysis for identification of the problems which helps in preventing the problems in the future. Deviation management helps in preventing problems and ensuring product quality and safety, and deviations can be managed by various tools, This review article outlines information on deviations, and handling of deviation investigations, and proposes the corrective and preventive actions tools used to manage deviation investigations like fishbone analysis, failure mode effect analysis, 5why analysis and quality management systems and case studies in pharmaceutical industries.

Keywords: Deviation, CAPA, quality management system, Six Sigma

INTRODUCTION

An unexpected occurrence that takes place either during or after the production, processing, packaging, storage, transportation, or testing of pharmaceutical dosage forms. A deviation may be unplanned but occurs from an incident or error that happens during or after the process, or it may be scheduled as part of a brief modification

(HPLC column, extended calibration time, etc.).Low or no variances for a firm are often signs of documentation problems. Deviations occur in the following areas (figure1).[1]

CONTROL OF DEVIATION
During the documentation process, the following questions such as what, who, when, where, how, and why the deviation occurred should be recorded. When deviations occur during manufacturing, they should be first documented in the batch record. If deviation took place during quality control testing it should be documented in a notebook or worksheet maintained in the laboratory. When a company's standards do not adhere to the important quality attributes as specified in the regulations, the regulatory authorities notice deviations and report during an inspection of the facility[2].

Various deviations (figure 2)
Planned deviations
They are anticipated and approved in advance, but due to temporary changes in process and procedure, these planned deviations are controlled and documented to ensure the quality and safety profile of the products[2].

Unplanned deviations
Unplanned deviations arise unexpectedly, without warning or prior notice. They can result from a variety of things, such as equipment malfunctioning, human errors, or unforeseen circumstances. These deviations must be quickly found, recorded, and analyzed to ascertain how they affect product quality and safety and to set the right corrective and preventive action[2]. Based on the impact of deviations planned and unplanned deviations are further classified into three categories (table 1):
- ❖ Minor deviations
- ❖ Major deviations
- ❖ Critical deviations[3].

METHODS AND MATERIALS

The literature search for this review article was performed through various journals like Science Direct, Web of Science, PubMed, and the search engine: Google Scholar, with the terms " Deviation management" "corrective and preventive action" and "quality management system".

INVESTIGATION OF DEVIATION
The best way to begin an inspection is to provide an overview of the company's process and products by delivering a presentation orally to the investigator. during this process, the inspection is started by reviewing the documents by standard operating procedure(SOP).Operations, receiving, warehousing, manufacturing, packaging, and shipping as well as engineering, maintenance, and technical services are all taken into consideration while evaluating SOP[2].

DETECTION
In a variety of auditing circumstances, including regulatory assessments, complaints from consumers, staff assessments, trending data risk evaluations, process efficacy monitoring, management reviews, etc., non-conformities call for CAPAs. List the specific evidence that is available to demonstrate that the issue exists at this early level of the process [5].

EVALUATION
After the identification process is complete, the non-conformance must be evaluated in terms of its possible impact, such as how it can affect quality, safety, dependability, costs, or customer satisfaction[5].

INVESTIGATION & ROOT CAUSE ANALYSIS

Once a nonconformance that affects a lab's product, procedures, or service is identified, a need for action assessment to remove the underlying cause(s) will be carried out.

Tools used for root cause analysis

- Five WHYS
- Fishbone
- Fault Tree Analysis (FTA)

BRAINSTORMING

This is one of the innovative approaches to problem-solving that enables individuals to generate suggestions or thoughts that may assist in either solving the issue or locating its underlying cause. To determine the underlying cause, a cross-functional team meeting might be scheduled[6].

FIVE WHYS

5 why is a tool used to analyze technique in root cause analysis? Five questions are included to help identify the root of the issue. It's sometimes important to obtain information by asking more than five questions. Ask "why" frequently to get the issue until we identify the proper core cause[7,8].

For Example

Why did the batch fail? Answer: because the product did not meet the specified quality standard,

1. why did the product meet the quality standard? Answer: The concentration of the active ingredient was lower than required.
2. Why was the concentration of active ingredients low? Answer: The mixing process wasn't properly controlled.
3. Why was the mixing process not properly controlled? Answer: because the equipment used was not calibrated correctly.
4. Why was the equipment not calibrated correctly? Answer: the calibration schedule was not followed consistently. Therefore, here we understand that the root cause is calibration was not performed in the equipment.

FAULT TREE ANALYSIS(FTA)

The FTA tool is a tactic that relies on a process or product's failure to operate. This tool can integrate several causes of failure in addition to evaluating system (or sub-system) failures one at a time by finding causal chains[2].

The results are illustrated using a fault mode tree. The combined use of failure modes is represented by logical operators at each level of the tree. FTA uses the experts' process expertise to identify the causal elements.

Use of FTA:

- FTA is frequently used to pinpoint the failure's root cause.
- FTA can be utilized to thoroughly understand the cause of complaints or deviations, as well as to make sure that planned modifications would properly address the problem without creating new ones.
- Fault Tree Analysis is a practical method for determining how various variables affect a certain issue.
- The report of an FTA offers a graphic examination of failure modes. It can help with risk assessment and in developing monitoring techniques[8].

FISHBONE ANALYSIS

- To identify the root causes of a problem, various sources of the issue are categorized using a diagram of cause and effect, also known as a fishbone diagram. Using a fishbone diagram can assist in keeping the conversation on point during the problem-solving and product-development phases. The facilitator assists the group in creating an ordered list by assisting the group in ranking the various causes by their level of importance after they have considered all potential causes for a problem. The diagram's design closely resembles the structure of a fish. In a

fishbone diagram, which is frequently shown from right to left, each big "bone" of the fish branches out to contain several smaller, more specialized bones (figure 3)[6,8].

CORRECTIVE ACTION AND PREVENTIVE ACTION

A system for implementing corrective and preventive measures should be in place in the pharmaceutical industry after taking into account consumer complaints (figure 4), product flaws, deviations, recalls of goods variations, investigations, inspections by regulators and results, trends in process efficiency, and quality assurance monitoring[4]. Good manufacturing practice is a requirement for the term "corrective and preventive action." The goal of CAPA in the pharmaceutical sector is to identify deviations, non-conformities, and failures. In the context of OOS outcomes, this analysis provides a broad overview of the CAPA program's implementation and root cause analysis. The CAPA system provides a way to gather critically crucial quality data that permits performance outside of specifications, CAPA carries out preventive actions before such aberrations occur [4]. The CAPA system serves as the foundation of a quality management system, the quality management and is especially important in the pharmaceutical industry. The CAPA system feeds the Quality System to enhance business operations in a systematic, documented, and actionable way[4].

IMPLEMENTATION OF CAPA (figure 5)
Quality management systems in pharmaceutical industries

A quality management system is a group of operational practices intended to continuously satisfy consumers and meet their expectations. It adheres to the organization's strategy and goals[9]. To meet customer expectations, a quality management system (QMS) is a set of procedures aimed at attaining quality policy and quality objectives. The method is employed by a variety of industries, including those that produce medical devices. Three organizational processes—quality planning, quality control, and quality improvement are under the direction of a QMS. quality of the product can be ensured by the use of the Six Sigma concept[10].

Six Sigma

Carl Frederick Gauss (1777–1855) was the person who initially put out the concept of the normal curve and laid the groundwork for Six Sigma as the measurement standard. In statistics, the term "sigma" is used to denote standard deviation, which serves as a measure of the degree of variation in a set of data, a process, or a product (figure 6).A statistical idea or quality management strategy called Six Sigma measures a process or a product in terms of faults at the Six Sigma level and provides a mechanism to concentrate on creating and delivering flawless goods and services. The benefits of the Six Sigma methodology can lead to improved product quality, reduced defects, and improved customer stratification[11]. DMAIC (define, measure, analyze, improve, control) is a roadmap offered by Six Sigma as a technique for process improvement and as an initial organizational structure with distinct responsibilities for project owners and project leaders. The DMAIC stages involve statistical process control and failure mode and effect analysis among other statistical quality tools and approaches. They serve as project milestones. The DMAIC roadmap's Define phase is where the problem that needs to be solved is defined.

- Appropriate measurements, or what Six Sigma practitioners refer to as key to quality indicators, are required to quantify the performance of the existing process.
- Making a data-based diagnosis of how well the current process is performing is the aim of the analysis phase.
- The project team decided on goals for interventions to cut waiting times and eliminate waste after the process was diagnosed[12].

ELEMENTS OF SIX SIGMA
- process development
- Process management
- process design, and process re-design[13]

CASE STUDY
Case study on parenteral drug [3].

CAPA approach

After filtering during the production of X drug injection (vial), samples of Test 15 and Test 18 were taken from a 150l storage vessel and the temperature of the bulk solution held for the hold length investigation was found to be 13.7 and 14C^0, respectively. 2-8$C^0$are acceptable standards.

consequences: The product might not perform as expected.

Impact

Risk to its clients: There was no direct risk because the batch was a validation batch made for regulatory filing requirements rather than for commercialization. The batch also happened during a hold time study bulk.

Immediate action

The engineering department was also contacted because the temperature was above 8°C and needed additional examination.

Root cause analysis

Batch manufacturing process

According to the batch manufacturing record, the batch manufacturing record was produced. The temperature was held constant at 2 to 8 ^{c} during the manufacturing process. The temperature was kept at 5.2 ^{c} during the API, and no effect on the product's quality was discovered.

Process for filling and filtering

The filtration was performed between 08:52 and 8:58. During the filtration, filling, and loading of lyophilized powder procedures, no difference was seen.

Hold time study

The temperature was between 2 and 8 ^{c} when samples of the unfiltered solution were taken at times T6 and T12. It was discovered that the temperature had increased to 13.7oC on the same day at 22.53 when sample T15 was collected. Investigation revealed that the brain cooling plant's temperature was above 8°C because the chiller had tripped. After all, the compressor had short-circuited as a result of overheating. The brainchiller has two compressors of 10 TR. Due to overheating one chamber got short-circuited and the second chamber was connected with another compressor and got sorted.

Root cause identification from the investigation

It was found that there was a problem with the equipment.

CONCLUSION

Additional attention was needed based on the quality control results because the quality results were satisfied and the hold time study did not reveal any effects.

Action plan: CAPA

At the factory operational panel, an audio alert was put in case the product's temperature increased.

Facility modification [2]

Type of deviation: planned deviation Due to the flooring modification completed in warehouse I, the secondary packing material kept there has been moved to warehouse II. The following won't be adhered to at the warehouse during this time: Area cleaning will not be done by SOP and won't be documented. There won't be any temperature monitoring in the storage space for packaging materials. Dispensing of packing material will not be done at the warehousing.

Justification of deviations

To set up the flooring in the warehouse. There will be warehouse area cleaning. According to SOP, temperature tracking will be carried out. The materials will be distributed at warehouse II by SOP. All materials will be moved in a closed container from Warehouse I to Warehouse II.

The QA department's final decision about the deviation

Due to flooring modifications in warehouse I, this planned deviation was made to store secondary packaging materials in warehouse II. According to this deviation: All the individuals engaged in carrying out the deviation received training. The area was cleaned before moving any item, and the temperature was checked and documented by SOP. The following in the warehouse was not completed during this time. There was no area cleanup or temperature monitoring. Impact evaluation: Before the transfer of the material from warehouse I, warehouse II was cleaned and the temperature was maintained. Conditions were kept appropriate. Materials were carefully moved and stowed. The items were moved back from Warehouse I to Warehouse II in a closed container after the flooring modification in Warehouse I was finished. The deliberate diversion is over.

CONCLUSION

To ensure prompt and comprehensive resolution, any identified deviations must be addressed through a well-defined process. This process involves conducting a thorough study, determining the root causes, and implementing Corrective and Preventive Actions (CAPAs). The CAPA system is crucial in preventing recurrence and driving continuous improvement within the pharmaceutical quality management system.By adopting a proactive approach to addressing deviations, pharmaceutical companies can enhance operational effectiveness, mitigate potential risks, and uphold their commitment to providing safe and effective pharmaceuticals while complying with regulatory standards. Maintaining an unwavering focus on deviation management and integrating CAPAs will remain vital for sustained success in this critical industry as it evolves.

CONFLICT OF INTEREST

The authors declared no conflict of interest

Authors Contributions

The corresponding author - supported in preparing the manuscript, Performed the proofreading, and gave the final approval. 1st Author - Conceived the idea for the topic, interpreted the data, and Collected and compiled the data

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Table 1: Differentiation of deviations[3].

Minor deviations	Major deviations	Critical deviations
Which does not affect any essential process parameters, equipment, or instruments required for the production or control, as well as the quality, purity, or potency of a pharmaceutical product.	Deviation is categorized as major when it requires prompt action, an investigation, and documentation by SOP and when a quality attribute, a process parameter, or equipment, is affected with little likelihood of hurting patients (or personnel) or the environment.	Critical deviations are those that affect the quality attribute, critical process parameter, or equipment or instruments that cause highly probable, including life-threatening situations, and require immediate actions, investigation, and documentation as per SOP.

Figure 1: Occurrence of deviations	Figure 2: types of deviation

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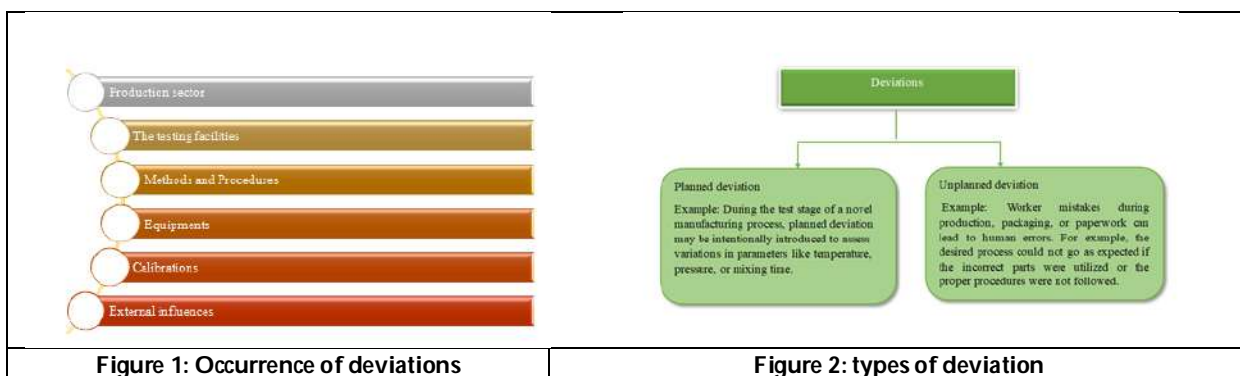
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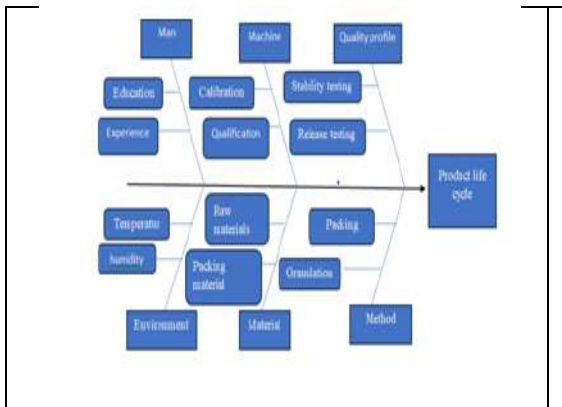
Figure 3: Example of fishbone diagram

Figure 4: Applications of CAPA in Pharmaceutical Product Development
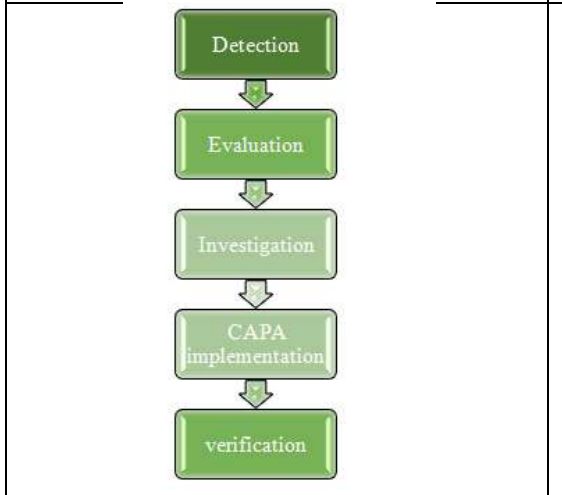
Figure 5: Implementation of CAPA

Figure 6: Elements of Six Sigma

RESEARCH ARTICLE

Effectiveness of Diaphragmatic Breathing Exercise Along with Core Strengthening Exercise on Pain, Range of Motion, Quality of Life in Subject With stage I Intevertebral Disc Prolapse

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ABSTRACT

From 30% of people in their 20s to 84% of people in their 80s, disk bulge prevalence. The prevalence of disk protrusion from 29% in people 20 years old to 43% in people 80 years old. From 19% of people in their 20s to 29% of people in their 80s, annular fissures were more common. To determine the effect of diaphragmatic breathing exercise along with core strengthening exercise in subject with stage I intervertebral disc prolapse. Experimental study was done. Atotalof50subjects were assigned inthisstudy. Pre test and post test were analyzed and documented by using Numerical pain rating scale, Range of motion,Quality of life questionnaire. The subjects wereseparated into a pair of groups based on the inclusion and exclusion criteria. Group DBE+CS and CS diaphragmatic breathing exercise and core strengthening exercise and only strengthening exercise were given respectively and documented in statistical analysis. Both the group intervention given for five days for four weeks. Each meeting time comprised two sets of ten repetitions with a ten-second hold in between for each group. According to the statistical analysis, there was an statistically significant enhancement (p<0.0001) in both groups' pre- and post-exercise values. Additionally, there's a significant difference (p<0.0001) in the post-exercise outcomes

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between the two groups, suggesting that diaphragmatic breathing plus core strengthening activities work better than core strengthening alone. Diaphragmatic breathing exercise along with core strengthening has been shown to be more effective than core strengthening exercise alone at relieving pain and increasing ROM, and improving quality of life.

Keywords: Intervertebral disc degeneration, lumbar vertebrae, breathing exercise, intervertebral disc displacement.

INTRODUCTION

About 80% of people will experience low back pain due to disc bulge at some point in their lives, and intervertebral disc structural alterations account for about 80% of the causes of this pain.[1] Disc herniation, often referred to as intervertebral disc prolapse (IVDP), is a common condition connected to the potential for degenerative discs on by bad posture or external damage to the spine, especially during back stretches and spinal flexion/rotation exercises. compression, bulging, a protrusion, sequestration, and herniation are the stages of IVDP.[2] The most prevalent recognized cause of lumbar discomfort is degenerative disc disease, which is prevalent around the world.[1]low back pain is the reason and impairment of symptomatic lumbar disc bulging. During imaging in the upright neutral, flexion, and extension positions, disc bulging beyond the intervertebral space was measured. Normal discs were categorized as grades 1 to 2, while degenerate discs were categorized as grades 3 to 5.[5] Degeneration of the disc is a cellularly mediated abnormal reaction to increasing structural failure. A disc that has structural breakdown together with rapid or advanced aging symptoms is said to be degenerative.In a structurally sound disc, early degenerative alterations should be interpreted as accelerated age-related changes..[6]The etiology of the condition of the subject has numerous investigations. Numerous factors have been linked to its genesis, including mechanical ones such as vibration, shear stress, and compressive pressures, as well as age-related, genetic, systematic, and toxic ones that can lead to the disc's degeneration through biochemical processes.[7] A nucleus pulposus, annular fibrosis, and end plates make up the healthy IVD's three separate parts. The NP, which is situated marginally eccentrically in the IVD, is a mucoid, white, bean-shaped structure that is primarily made of water.[7] The extracellular matrix supports the structural and mechanical activities of the disc; its structure and content determine how the disc responds mechanically. The two main macromolecular elements, matrix and collagens, have the primary mechanical role. [9]

Only the outermost portions of the annulus contains the sensory nerve fibers, which are supplied by the sympathetic cord and the recurrent sinovertebral nerve.[10] disc bulging over their entire spines, >90% of both men and women over the age of 50 had this condition. intervertebral spaces with disc bulging were most common. Obesity and advanced age were linked to all regions having disc bulging. The occurrence of disc bulge in the lower back was linked to low back discomfort.[11] The diaphragm supports the stability of the trunk biomechanically. It has been discovered that diaphragm contractions caused by phrenic nerve activation increased intra-abdominal pressure, which in turn increased spinal stiffness. The diaphragm performs two functions: it stabilizes the trunk and aids in breathing. Pelvic floor muscle, multifidus, and diaphragm transversus abdominis all help to balance the trunk. When there are repeated limb movements, the spine is stabilized by the transversus abdominis and diaphragm's tonic actions, which are adjusted to satisfy respiratory demands during inspiration and expiration.[12] The core is commonly described as the "powerhouse," the starting point or catalyst for all limb motion. It has been recommended that these core muscles be thoroughly strengthened or stimulated in order to prevent and treat a variety of lumbar vertebra and musculoskeletal problems as well as to improve athletic performance Though it is commonly used, not much research has been done on core strengthening. Providing an analytical framework for characterizing the existing literature was the aim of the current study .[12] The stability of the lumbar spine depends on both active rigidity, which is provided by muscles, and passive stiffness, which is supplied via osseous and ligamentous components. It is impossible for a naked spine to withstand significant compression without muscles. Spinal instability is the outcome of any interruption from one of these components..[13]

Special test

A Straight Legs raising (SLR) test for diagnosis is currently used as the primary method for diagnosing the lumbar region disc herniations and has been shown to have a strong correlation with results on operation. This is because the SLR test's sensitivity is limited to disc herniations causing root compression that may require surgery.[14]When a patient lays down on an examination table with the hip in normal rotation, the ankle hanging loose, and the knee completely extended, The patient's leg is passively raised by the therapist.When the hip flex angle reaches ninety degrees, the limb lift is terminated, and if no reactions are elicited, the test is considered inconclusive. To ascertain whether the reactions are muscular or neurological in origin, a structurally different movement unique to a particular site has been introduced to the assess the hip movements at which they have been elicited. The additional movement is givenin accordance with the site of the triggered reacts: At the exact same flexion angle as the elicited reactions, hip inner rotation is performed..[15]

MATERIALS AND METHODS

An experimental study was done with the subjects meeting the inclusion criteria and pre-evaluation of pain, range of motion, Quebec back pain disability scale of the group DBE+CS and CSgroup was recruited from physiotherapy OPD at primary hospital, Chennai, Tamil nadu. This study was approved by institutional scientific review board [ISRB][01/014/2023/ISRB/SR/SCPT]. Though convenient sampling technique 50 individuals were selected for the study. Fifty subjects diagnosed with stage I IVDP were screened for inclusion and exclusion criteria. This study involves both men and women, age group 35 years above with the confirmation of stage I IVDP, pain during SLR more than 30-70 degreeThis study excludes the subject with any abdominal surgery, hernia, neurological illness and non- cooperative person. It was requested of each participant to sign a consent form. Every research participant received the details of the experimental group before giving their informed consent. Two groups of patients (Group DBE+CS-25, and CS-25) were formed. The NPRS was used to measure the pre- and post-test values. lumbar range of motion, quality of life(Quebec back pain disability scale). Group DBE+CS diaphragmatic breathing exercise along with core strengthening exercise + Interferential therapy. (50Hz for 15mins) Group CS(Core strengthening exercise exercise + Interferential therapy).(50Hz for 15mins) Diaphragmatic breathing exercise The patient had to sit up erect in a chair, which extended the space between the sternum and navel. The patient is supposed to have a relaxed posture. You should keep your hands on both sides of your lower ribcage as the patient. They asked to inhale gently through their nose. As the patient inhales, their rib cage should rise and spread. During inhalation, There are three directions that the trunk can extend: front, sides, and back. It is instructed to the patient to exhale via their nose.

When they exhale, patients ought to sense their lower ribs shift inward. Exercise for strengthening the core The patients were given pelvic bridging exercise, piriform is stretching, active double leg SLR, active straight leg rise, single leg knee to chest, both the leg knees to chest exercises.[25] Pre and post test were analysed by pain , rom, qol and documented by using NPRS, inclinometer, Quebec back pain disability scale. numerical pain rating (NPRS) How to Measure Low Back Pain in the Lumbar Region Applying the Numerical Pain Rating Scale, or NPRS. Explain the NPRS as a rating system zero to ten, where 10 represents the greatest amount of pain. Reiterate that the person must choose the number that best represents their current level of pain. Enter the subject's pain score as the selected score on the NPRS scale.[17] To measure the rom range of motion with inclinometer .The inclinometer is zeroed and centred at the mark at T12. It is advised that the patient bend forward as much as they can without bending their knees. For total flexion, the inclinometer's ROM value is noted. To assess lateral flexion range of motion. The range of motion measurement measured by the inclinometer will be recorded as the patient is given instructions to lean as far to their right or right as they can while extending their fingertips along the side of their leg.The inclinometer is situated above the mark at T12 in order to measure extension.[15] Quebec back pain disability scale Describe how each activity has six answer categories that are scored on a 0–5 scale [0 = no effort at all, 5 = unable to do]. If the patient has a lot of pain on that particular day, they should rate the activity a five. If there are no issues, they should give it a zero. The twenty everyday activities that make up the the province of Quebec back pain disability scale are classified as follows: Bed rest 1–3,Sitting/standing 4–6,Ambulation 7–9,Movement 10–12, Bending/stooping 13–

16,Handling of large/heavy objects 17–20.Ask the participant to self-assess their current level of affecting the qol by choosing a number on the Quebec questionnaire Emphasize that their response should reflect their QOL at the present moment. [19]

RESULTS

Table -1 shows the baseline data of group DBE+CS mean(25.29) and CS mean(25.67). **Table-** 2,3,4,5,6 shows the pre test and post test values of pain , range of motion and quality of life of the group DBE+CS and CS group respectively. The significant differences between pre-test and post-test measures of same group were analyzed by Wilcoxon sign rank test and Mann-Whitney U test Diaphragmatic breathing exercise along with core strengthening exercise using NPRS and Quebec back pain disability scale The values for pain median pre-test (9.00) and post-test (2.00), Z value (-4.299) and T value (-300). The values for QOL median pre- test(78.00) post-test (10.00),Z value(-4.289) and T value(-300). As a result, the findings are considered statistically significant that the pvalue is <0.001 shows the Pre-test and Post-test values of pain in core strengthening exercise using NPRS and Quebec back pain disability scale. The values of pain median pre-test (9.75) and post-test(25.00) Z value (-4.242) and T value (-276). The value for QOL pre-test(77.25) post-tesr(58.75) , Z value(-4.202),T value(-276). As a result, the findings are considered statistically significant that the p-value is <0.001. shows the post test values of pain in diaphragmatic breathing exercise along with core strengthening exercise and only core strengthening exercise using NPRS , Quebec back pain disability scale. The values for pain median group DBE+CS(2.75) and group CS(5.00), U VALUE (86.00) and T value (386.00). the values for QOL median group DBE+CS(10.00) and CS(58.75), U VALUE (1.00) and T value (301.00). As a result, the findings are considered statistically significant that the p-value is <0.001. shows the Pre-test and Post-test values of ROM in diaphragmatic breathing exercise along with core strengthening exercise using inclinometer. The values for ROM mean pre-test (117.97) and post-test(134.4), SD value of pre test (2.71) and post test (2.46) and t value (30.33). The values for CS group mean(117.27) and post-test(134.4), SD value of pre test (2.88) post test (3.00), t value (23.60) As a result, the findings are considered statistically significant that the pvalue is <0.001.The significant differences between pre-test and post-test measures of same group were analyzed by unpaired t test. shows the post test values of ROM in diaphragmatic breathing exercise along with core strengthening exercise (group DBE+CS)and core strengthening exercise(group CS) . group (DBE+CS)mean value (134.4) and mean value (129.57) and SD value for group (DBE+CS)(2.46) and group (CS) SD value (3.00). CS group mean value(129.57), SD value(3.00), t test (6.81). As a result, the findings are considered statistically significant that the p-value is <0.001. The significant differences between post-test measures of same group were analyzed by unpaired t test.The results suggest that the findings in both within and between groups were considered to be statistically signif icant with p-value <0.001. thus, the diaphragmatic breathing exercise along with core strengthening exercise significant effectiveness for reducing pain, and improving range of motion, quality of life in subject with stage I intervertebral disc prolapse in mid age peoples.

DISCUSSIONS

The purpose of the study, which lasted four weeks, was to determine whether diaphragmatic breathing exercises and core strengthening exercises could help individuals with the first stage of intervertebral disc prolapse. The study's findings demonstrated that, in participants with the initial stage of intervertebral disc prolapse, core stability plus diaphragm breathing differed statistically significantly from core stability by the pain, range of motion, as well as quality of life. Diaphragmatic breathing exercise in groups DBE+CS, combined with the group CS core strengthening activities and only core strengthening exercises. The findings of the study shows that both groups' quality of life and range of motion had improved along with their pain levels. The p-value of 0.0001 demonstrated the high degree of significance of the outcome. When compared to group CS, the group DBE+CS showed a notable improvement. This decrease in pain is probably due to strengthened transversal abdominis muscle contraction, which strengthens stability, shields lowers stress on the discs between the vertebral bodies and lumbar vertebrae. Thus, the core's original role as "The biological Brace in humans" was restored. Additionally, it has been demonstrated that emotions

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such as anxiety affect how well muscles work[11] The diaphragm's costal fibers, which are regarded as aerobic, generate ATP, which powers muscle contractions. Therefore, regular exercise improves quality of life and has favorable psychological consequences for individuals with chronic low back pain. Increased transverse abdominis muscle strength from core strengthening gives the spine stability, which reduces pain because the spine can now more bear the strain placed on it[16] Diaphragmatic breathing involves stimulating the core structures and supporting through raising intra-abdominal pressure, the lumbar spine in along with maintaining a proper respiratory rhythm. Every joint must be positioned steadily to recruit every muscle chain and produce an economical breathing rhythm. The contours of the head, eyes, and spine should all line up, starting from the pelvis and hips and ending at the knee and feet. This can be achieved with adequate diaphragmatic breathing and muscle tone distribution.[16] Reduced chest expansion (CE) is recognized to be a result of pain difficulty, strain, and muscle spasms. It is well known that disc bulging, which causes lumbar discomfort, can result in respiratory issues; in patients with LBP, for instance, CE was significantly lower.[27] The trunk's biomechanical stability is supported by the diaphragm. It was found that phrenic nerve activation-induced diaphragm contractions raised intra-abdominal pressure, which in turn raised spinal stiffness. The diaphragm has two purposes: it helps with breathing and stabilizes the trunk. The diaphragm transversus abdominis, multifidus, and pelvic floor muscle all aid in trunk balancing. The transversus abdominis and diaphragm's tonic motions maintain the spine during repetitive limb movements. These actions are adjusted to meet respiratory needs during inspiration and expiration.[12] The core is commonly described as the "powerhouse," the starting point or catalyst for all limb motion. It has been recommended that these core muscles be thoroughly strengthened or stimulated in order to prevent and treat a variety of lumbar vertebra and musculoskeletal problems as well as to improve athletic performance. Despite its widespread use, there is little study on core strengthening. [12] According to O'Sullivan *et al.* were some of the first writers to contrast conventional aerobic activities with a specifically created stabilizing program. According to their study, patients who followed a specially designed program of stability exercises considerably outperformed individuals who did not receive stabilization exercises in terms of pain relief and functional ability. After 30 months, they conducted a control examination to establish the effects' persistence. The same authors performed a number of experiments on individuals with a condition known as spondylolisthesis, which are established causes of instability in the lumbar spine, with comparable results.[25] The diaphragm functions as the core's ceiling.

The lumbar spine is stabilized by higher pressure inside the abdomen and diaphragm contraction.. According to recent research, individuals suffering from sacroiliac discomfort exhibit compromised diaphragm recruitment. Similarly, difficulties with the body's ventilation system can worsen diaphragm dysfunction and increase compressive stresses on the lumbar spine. As a result, diaphragmatic breathing exercises could be a crucial component of a program for building core strength.[23] As to the research conducted by Priyanka P. Ostwal *et al.* (2014), abnormal breathing patterns are observed in 71% of individuals with disc bulging, irrespective of the stage, throughout several motor tasks.[24] According to study Rajasekar Sannasi, *et al.* (2023) The diaphragm is essential for both breathing and maintaining a stable posture. But in practice and studies, it has been disregarded in exercises to strengthen the core for low back pain. We have highlighted the diaphragm's critical function as a postural stabilizer in this narrative review, and we have suggested that the first step in any kind of stabilizing core exercise should be to facilitate regular breathing patterns and restore the diaphragm muscle's involvement in postural control. [23] According to Sokunbi *et al.* (2015) further documented a 17% rise in plasma levels of serotonin following a 30-minute session of training for core stability with chronic low back pain. Consequently, the process behind exercise-induced analgesia may potentially involve serotonin Exercises for core stability may also provide the patient more control over how they cope with their discomfort.[22] According to study Chul ki et, al (2016)The study demonstrate that vigorous breath exercise therapy can enhance trunk stability and help individuals with chronic low back pain function better in daily activities..[25] Hence the study compared the effect of diaphragmatic breathing exercise along with core strengthening exercise and only core strengthening exercise for pain, range of motion , quality of life in subject with stage I intervertebral disc prolapse. The study concluded that diaphragmatic breathing exercise along with core strengthening exercise was effective than only core strengthening exercise

Abbreviation

intervertebral disc prolapse*(IVDP),*annular fibrosis*(AF)*, nuclear pulposis*(NP)*, range of motion *(ROM)*,numerical pain rating scale*(NPRS),*quality of life*(QOL)*, straight leg rise *(SLR)*,Diaphragmatic breathing exercise *(DBE)*, core strengthening exercise *(CS)*, low back pain*(LBP)*, chest expansion *(CE)*

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Table 1: This table represents the age group mean of the participants
Demographic Data: Using descriptive and inferential statistics, the acquired data was tabulated and evaluated.

GROUP	AGE[mean]
GROUP DBE+CS	25.29
GROUP CS	25.67

this table represents the mean of age group among the DBE+CS and CS

Table 2: Pre-test and Post-test values of NPRS and Quebec back pain disability scale in diaphragmatic breathing exercise along with core strengthening exercise

OUTCOME MEASURE:	GROUP DBE+CS	MEDIAN	Z VALUE	T VALUE	P VALUE
PAIN	PRE-TEST	9.00	-4.299	-300	<0.001
PAIN	POST-TEST	2.00	-4.299	-300	<0.001
QOL	PRE – TEST	78.00	-4.289	-300	<0.001
QOL	POST –TEST	10.00	-4.289	-300	<0.001

This table compares median value and standard deviation of pain as measured by the NPRS and QOL measured by Quebec back pain disability scale of group DBE +CS and CS , Z value , T Value , and corresponding p –values are reported to assess the significance of changes between pre-test and post-test scores.

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Table 3: Pre-test and Post-test values of NPRS and Quebec back pain disability scale in core strengthening exercise

OUTCOME MEASURE:	GROUP CS	MEDIAN	Z VALUE	T VALUE	P VALUE
PAIN	PRE-TEST	9.75	-4.242	-276	<0.001
	POST-TEST	25.00			
QOL	PRE – TEST	77.25	-4.202	-276	<0.001
	POST –TEST	58.75			

This table compares median value and standard deviation of pain as measured by the NPRS and QOL measured by Quebec back pain disability scale of group CS, Z value , T Value , and corresponding p –values are reported to assess the significance of changes between pre-test and post-test scores.

Table :4 post test values of NPRS,QOL of diaphragmatic breathing exercise along with core strengthening exercise and core strengthening exercise only.

OUTCOME MEASURE: NPRS	GROUP DBE+CS & CS	MEDIAN	U VALUE	T VALUE	P VALUE
PAIN	POST-TEST	2.75	86.00	386.00	<0.001
	POST-TEST	5.00			
QOL	POST TEST	10.00	1.00	301.00	<0.001
	POST TEST	58.75			

This table compares median value and standard deviation of pain as measured by the NPRS and QOL measured by Quebec back pain disability scale of group CS,Z value , T Value , and corresponding p –values are reported to assess the significance of changes between post-test scores.

Table:5 pre and post-test values of ROM india phragmatic breathing exercise along with core strengthening exercise.

ROM		MEAN	SD	t value	P value
GROUP CS	PRE-TEST	117.27	2.88	23.60	0.0001
	POST- TEST	129.57	3.00		
GROUP DBE+CS	PRETEST	117.97	2.71	30.33	0.0001
	POSTTEST	134.4	2.46		

This table compares mean and standard deviation of ROM as measured by the inclinometer of group DBE+CS and CS, t Value, and corresponding p–values are reported to assess the significance of changes between pre test and post-test scores.

Table 6: Posttest values of ROM in diaphragmatic breathing exercise along with core strengthening exercise and only core strengthening exercise.

ROM		MEAN	SD	t test	P value
Group-DBE+CS	Posttest	134.4	2.46	6.81	<0.0001
Group-CS	Posttest	129.57	3.00		

This table compares mean and standard deviation of ROM as measured by the inclinometer of group DBE+CS and CS, t Value, and corresponding p–values are reported to assess the significance of changes between post-test scores

Fig.1 diaphragmatic breathing exercise The patient performing the diaphragmatic breathing exercise that is asked them to inhale through nose and exhale through mouth.	**Fig.2 Pelvic bridging** The patient performing bridging that is asked them to flex both knees and lifting the hip region and hold it for 10 seconds.

RESEARCH ARTICLE

Technology for Sustainable Future: A Study on the Evolution of Fintech in India and its Role in Environmental Sustainability

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ABSTRACT

Environmental technology refers to the invention of new technologies that help in reducing environmental degradation. Such technology is also referred to as green or clean technologies. Environmental sustainability and its protection have been some of the growing concerns of the global community. 'Digitalization', an invention of technology and a new buzz word has changed the functioning of businesses today. One of the objectives of India's economy is to move towards a cashless economy. Therefore, with the support of internet technology in the banking sector, Fintech or financial technology has emerged, which has improved the delivery of financial services in India. Financial technology encompasses within its scope current technology that seeks to automate the delivery and use of financial services. Fintech is used to help business owners, companies and consumers to manage their financial operations and processes in an enhanced manner. It comprises algorithms and specialized software that are used on smartphones and computers.

Keywords: Fintech, digital technologies, environmental sustainability, Fintech start-ups, digitization, cashless economy.

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INTRODUCTION

India ranks among the major markets across the globe where structural enablers have teamed up to incubate Fintech. The country is in a privileged space as it has nearly 87 percent Fintech adoption rate as compared to the global average of 64 percent. Smart devices endowed with internet and utility infrastructure that includes authentication based on Aadhar have provided impetus to the country's Fintech sector. The Indian Fintech market, which is seen as one of the highest growing technology segments globally and valued at INR 2,30 Trillion (India Today,2023). It is projected to reach approximately INR 8.35 Trillion by 2026 as per the same report if valued at a compounded annual growth rate of approximately 25 percent. According to Arner, Barberis and Ross, Fintech was introduced in 1966 in the United States of America, where the electronic mode of fund transfer was used for the first time. The first ATM was introduced in 1967. In 1970, as a result of NASDAQ being established, a technical communication mode was introduced to facilitate inter-institutional communication between financial institutions. Cross border payments in large volumes were facilitated. In 1990 the concept of digital banking was introduced. In 2008, the post-financial crisis brought new changes in the financial sector. Bitcoin came into existence in 2009, with the help of block chain technology. New innovations in mobile technology like smartphones became primarily indispensable, where people could access various financial services with the support of internet technology. Fintech helps in environmental sustainability as it uses big data, artificial intelligence, allows the adoption of green technologies which can reduce waste and work towards a low carbon footprint. Big data and block chain technology are a few examples where Fintech supports new digital payments and financial solutions that help businesses to move towards financial and environmental sustainability. In India, technological innovations in financial and banking sectors have been encouraged since 1991, when the new economic policy was introduced. Furthermore, in the present day, there are more than one hundred Fintech start-ups in existence. There has been a 40% growth in investments between 2014 and 2016.

REVIEW OF LITERATURE

Buckley, Ross &Arner, Douglas &Barberis, Janos. (2016), in their article on Fintech have described its growth in different phases from the 19th century till the present 21st century. The existence of Fintech is being felt in all developed, developing and emerging economies. The authors relate to the regulation aspect of the Fintech sector and how it increased due to the growth of digital technology. In the third phase as the authors have characterized as Fintech 3.0 relates the emerging era of start-ups and financial technology companies which delivers financial products and services to businesses, financial institutions and to the people. The article analyzes the evolution of Fintech and since 2008 there has been an increase in the number of Fintech across all economic sectors. Sofia Anyfantaki (2016) examines the factors that led to the emergence of the Fintech sector by considering the demand and supply side factors. According to him, the global financial crisis in 2008 was the main cause for Fintech. Due to changing consumer patterns, the traditional banking practices were transformed into digital banking practices due to the advancement in technology and industry 4.0 revolution. The role of banks and other financial institutions is emphasized in promoting the growth of Fintech. Muhammad Fakhrul Yusuf, Hasbullah Ashari & Mohd Rizal Razalli2 (2018) have analyzed how Malaysian firms have used environmental technological innovations in their businesses in view of changes in the global environment. They examined how environmental technology innovations can attain sustainable development which requires investment in research and development and the use of green technologies. Setiawan, Kukuh&Maulisa, Nadia (2020), the authors examine the regulatory approach for Fintech. They opined that Fintech has resulted in disruptive technology which has changed the activities in the financial sector. The article also discusses the evolutionary process of Fintech. To analyze the regulatory approach for Fintech the authors have conducted a historical legal research using qualitative analysis. They have combined the historical aspect with the regulatory approach towards digital financial innovation to measure the development of Fintech in the economic sector. VineetTyagi (2023), analyzes the challenges of environmental changes for the Government of India to maintain a sustainable future. The Government has set a target to obtain net-zero emissions by 2070 which

highlights the importance of environmental sustainability through sustainable financial systems. The author discusses the banking, financial services and insurance sector in India which has been a major driver to technological advancements. The author analyzes how an increase in digital banking and setting up of Fintech with new features in financial solutions will improve the efficiency, promote sustainable investments, and encourage sustainable business practices. With digital technologies such as the internet of things, artificial intelligence, block chain and big data can be used in Fintech to attain environmental sustainability. The author speaks about the role of green Fintech companies where funding is available for sustainable projects that results in reducing carbon footprints. He stressed on the role of banking, financial services and insurance in creating a green economy for environmental sustainability. Yun Qian Zhang (2023) analyzes how Fintech helps to reduce carbon emission in order to protect the environment. The author links green finance and digital finance for environmental sustainability. He analyzes the linkages between green finance and Fintech by using the data from India, Bangladesh and India between 2000 and 2018.

Theoretical Background

Industry 4.0 has resulted in a technology revolution with aggressive inventions and innovations which are adopted by all types of businesses. The very new financial technology known as Fintech has transformed traditional banking and financial services into technology-enabled functions which consist of various products, applications, processes and business models. The most familiar features of Fintech include online banking, online payments, online investments, online transfer of money etc. The theoretical application or framework related to Fintech can be explained in the chart. The Fintech sector includes not only financial players but also Governmental institutions that regulate Fintech related activities. Fintech instruments are shown in the chart which are the access to availability of finance, working capital and secure funding. The use of digital technologies depends on knowledge, skills and financial literacy. The present study finds its application in the Task-Technology Fit model stated by Goodhue and Thompson. The theory is based on the assumption of having a 'good fit' which refers to the expected task to execute with a new technology that is introduced. The theory explains the features of newly introduced technologies, description of the task to be executed where the 'good fit' assumption is applied such that task is executed with the use of technology which creates an impact on the outcome which can be applied to various online financial transactions and services. The chart also explains digital based financial products and solutions, online payments that are facilitated through technology enabled infrastructure. Another theoretical framework is explained to maintain environmental sustainability through the use and innovation of digital financial technologies.

Liu, D., Zhang, Y., and Hafeez, M. (2021) have stated that financial inclusion is necessary to attain sustainable development goals as per the United Nations. According to them, financial inclusion refers to where businesses look for affordable financing and get access to green technology investments by setting up financial technologies. The chart explains the reasons for the emergence of Fintech because of climate change and to meet sustainable development goals/environmental sustainability. The concept of financial inclusion is emphasized. Financial technology or Fintech is the product of the fourth industrial revolution where all financial transactions take place in the form of digital technologies using internet of things, block chain and artificial intelligence. The global economy is moving towards a cashless economy through the use of digital payment transactions which are facilitated by Fintech. Nicoletti et al. refers to financial technology as the utilization of software which includes computer programming and algorithms to improve financial management for consumers, businesses and financial institutions. The term sustainability was applied to the environment by Hans Carl Von Carlowitz. He examined how forests can be managed on a long term basis but over a period of time the environment started to deteriorate due to population growth, destruction of environmental resources and economic stagnation. It was during this time the term sustainable development was first used by the United Nations Conference held in Stockholm. New terms like eco innovation, green innovation and environmental technological innovation were introduced. Therefore, Fintech or financial technologies can be categorized under eco innovation and technology innovation where financial services, financial products, financial transactions take place in the digital technology form.

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Objectives of the Study

i.   To study the evolution of Fintech in India
ii. To examine the role of financial technologies in promoting environmental sustainability
iii. To identify the challenges in the growth of Fintech in India

The Evolution of Fintech in India

China and India have extensively adopted Fintech. It is 62 percent in China and 52 percent in India. Fintech has extensively evolved ever since the time when banks and banking services went online. The need for a cashless society opened doors for applications and platforms that helped create better management of finances. In fact, the Fintech sector in India has undergone a remarkable growth over the past years.Intense penetration of the internet as well as smartphones have played an important role in the evolution of the Fintech sector. It was the demonetization of the 500 and 1000-rupee currency notes in 2016 that charted the journey of Fintech in India. Though a countable few Fintech players did exist prior to 2016, the country was predominantly a cash dominant economy. The evolution of Fintech in India has been a remarkable journey, marked by rapid growth and innovation. Fintech, short for financial technology, refers to the use of technology to provide financial services. Here's an overview of how Fintech has evolved in India: Early Stages (2000s): The Fintech revolution in India began in the early 2000s with the advent of online banking and electronic trading platforms. Stock trading and online banking services were the first to embrace technology, making it easier for consumers to manage their finances.

Mobile Payments and Digital Wallets (2010s)

The introduction of smartphones and the expansion of internet connectivity in the 2010s paved the way for mobile payment solutions and digital wallets. Companies like Paytm, founded in 2010, gained immense popularity by offering digital wallets that allowed users to make mobile recharges, pay bills, and shop online.

UPI and BHIM (2016)

The Unified Payments Interface (UPI), launched by the National Payments Corporation of India (NPCI) in 2016, revolutionized digital payments in India. UPI made it easier for people to transfer money and make payments through their mobile phones. The Bharat Interface for Money (BHIM) app, based on UPI, further streamlined the digital payment process.

Lending and Credit Services (Late 2010s)

Fintech companies started offering lending and credit services, including peer-to-peer (P2P) lending platforms and digital lending apps. These platforms provided faster and more accessible loans to individuals and small businesses, often with lower transaction costs than traditional banks.

Robo-Advisors and Wealth Management (Late 2010s)

Robo-advisors emerged, offering automated investment and wealth management services. They use algorithms and data analysis to provide personalized investment advice, making it more affordable for retail investors to access professional financial advice.

Insurtech (Late 2010s)

The insurance sector witnessed the emergence of insurtech startups. These companies utilized technology to streamline the insurance buying process, claims management, and customer service.

Blockchain and Cryptocurrency (2017 Onwards)

The interest in blockchain technology and cryptocurrencies, such as Bitcoin and Ethereum, grew in India. Although there were regulatory challenges, many Fintech companies explored block chain applications, and cryptocurrency exchanges gained popularity.

Regulatory Changes (2020s)

The Reserve Bank of India (RBI) introduced regulatory changes to support the Fintech industry and promote digital financial services. These changes included guidelines for payment aggregators, digital lending platforms, and digital KYC processes.

Open Banking (Ongoing)

Open banking initiatives have started gaining momentum in India. This allows consumers to share their financial data securely with third-party providers, leading to the development of innovative financial products and services.

Rural and Tier 2/3 City Expansion (Ongoing)

Fintech companies are increasingly focusing on expanding their services to rural and smaller cities, reaching previously underserved populations and contributing to financial inclusion. The evolution of Fintech in India is ongoing, with innovations in areas like blockchain, artificial intelligence, and data analytics playing a significant role in reshaping the financial landscape. While challenges like data privacy and regulatory concerns persist, the future of Fintech in India appears promising, with continued growth and increased accessibility to financial services for all segments of the population.

Impact of Fintech on Banking and Financial Sector

The impact of Fintech on the banking and financial sector has been profound, reshaping the industry in numerous ways. Here are some of the key impacts:

Digital Transformation

Fintech has accelerated the digital transformation of the banking and financial sector. Traditional banks and financial institutions have had to adopt digital technologies and online services to remain competitive. This has led to the development of user-friendly mobile apps, online banking platforms, and digital customer service.

Increased Access

Fintech has expanded financial services to underserved and unbanked populations. Mobile banking and digital wallets have made it easier for people in remote and rural areas to access and use financial services.

Lower Costs

Fintech companies have introduced cost-effective and efficient solutions, reducing the fees associated with traditional banking services. This has made financial services more affordable for consumers.

Enhanced Customer Experience

Fintech companies prioritize user experience, resulting in more intuitive and convenient financial services. Customers can perform transactions, manage investments, and access financial information with greater ease and speed.

Alternative Lending

Fintech has revolutionized lending by introducing peer-to-peer lending platforms and digital lending apps. Borrowers can access loans quickly, and investors can diversify their portfolios, creating a win-win situation for both sides.

Risk Assessment and Fraud Prevention

Fintech leverages advanced data analytics and artificial intelligence for risk assessment and fraud prevention. Machine learning models help banks and Fintech companies identify unusual patterns and detect fraud in real time.

Personalized Services
Fintech leverages customer data to offer highly personalized financial services. This includes robo-advisors that provide tailored investment advice, custom credit offerings, and personalized budgeting and savings tools.

Block chain and Cryptocurrency
Fintech has played a significant role in the development and adoption of blockchain technology and cryptocurrencies. This has the potential to revolutionize cross-border transactions, reduce settlement times, and provide alternative investment opportunities.

Regulatory Changes
The rise of Fintech has necessitated changes in regulatory frameworks. Many governments have introduced new regulations to ensure consumer protection, data privacy, and cybersecurity. Regulatory sandboxes allow Fintech companies to test their innovations in a controlled environment.

Competition and Collaboration
Traditional banks face competition from Fintech startups, leading to innovation and improved services. Banks are also increasingly collaborating with Fintech companies to leverage their technology and reach new customer segments.

Global Reach
Fintech has made it easier for businesses and individuals to engage in cross-border transactions, investments, and payments, thus fostering international financial integration.

Financial Inclusion
Fintech has played a vital role in promoting financial inclusion by providing access to banking and payment services for those who were previously excluded from the formal financial sector.

Disruption of Traditional Banking Models
Fintech has disrupted traditional banking models by offering a variety of financial services without the need for brick-and-mortar branches. This has forced banks to rethink their strategies and adapt to a more digital-focused environment.

Data Security and Privacy Concerns
The collection and use of extensive customer data by Fintech companies have raised concerns about data security and privacy. This has led to a focus on data protection regulations and the need for strong cybersecurity measures. In summary, Fintech has had a transformative impact on the banking and financial sector. It has improved access, lowered costs, enhanced customer experiences, and driven innovation. However, it has also introduced new challenges related to regulation, data security, and privacy that both Fintech companies and traditional financial institutions must address to ensure the continued success and trust of the industry.

Role of Fintech in Promoting Environmental Sustainability
By operating a 'Green supply' chain
Fintech's intrinsic use of artificial intelligence, big data and real-time information renders the industry an exemplary role model when implementing environmentally friendly and sustainable logistical practices. Collaboration and transparency between the supply chain members is essential for the 'green' supply chain to function and this eventually reduces waste and improves the cost-effectiveness for all the participants.

Innovations in banking and payment solutions
The banking industry has transitioned well beyond recognition during the past few decades. Though the traditional high street banking services are available to date, development of new financial technologies has provided modern

alternatives for both individuals and businesses. The Fintech industry has developed very cost-effective, state of the art banking systems which are sustainable and which assist organizations in reducing their carbon footprints.

Acceleration of net-zero ambitions
The ways in which net-zero ambitions can be achieved are discussed below:

Optimization of process and digitization
This is possible by creating sustainable operations that consider the preference of stakeholders and promote business suppleness. By embracing advanced technologies like cloud native architecture for data driven optimization of processes, businesses are able to meet their emission reduction goals. Besides, they also set new industry standards. These measures facilitate the significant reduction of CO2 emissions.

Transparency with respect to carbon data
Making use of technology guided solutions that lead organizations with carbon accounting across the value chain IoT and block chain enabled technology.

Circular products and services
Providing services and building products that can be reused and are sustainable with negligible pollutants.

Data ecosystems and ventures
By adopting cross industry data-sharing ecosystems that enable adherence to sustainability regulations.
The data ecosystems provide valuable and real time insights into the societal as well as environmental impacts of any product or service; all this while permitting the organizations to meet their compliance goals and sustainability targets.

Responsible Artificial Intelligence for sustainable results
The role played by technology in promoting sustainable development like artificial intelligence has changed the way we think, work and live and relate to one another.

Business processes and operations can be enhanced with AI enabled systems
While on the one hand companies use AI to improve efficiency and output and reduce energy costs, training through artificial intelligence demands a lot of energy. So, in order to sustain any organization's efforts to lessen its environmental footprint, measures must be taken to decrease the carbon outputs of its AI models. AI models need to be significantly efficient to ensure that training through the AI model does not entail extensive use of energy or computing power to enhance accuracy and performance. Organizations need to conduct an accuracy versus efficiency test to find out if the resources used are justified from both the environmental and business perspective.

Challenges to Fintech in India
Fintech companies are generally known to use innovative, cutting edge technology in order to automate and improve financial services and face several challenges in the present economic climate. Let us discuss some of the frequent challenges posed.

Challenges to the Growth of Fintech
Uncertainty posed by the pandemic
One of the major challenges emanated from the uncertainty caused by Covid-19 pandemic. Furthermore, the sudden and acute economic downturn led to rapid decline in consumer expenditures and spending coupled with increased ambiguity and uncertainty for businesses rendering it difficult for Fintech companies to plan for their future ventures and future growth.

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Challenges posed by regulatory bodies

Increase in regulatory scrutiny poses another challenge to Fintech companies. As these companies become more conventional and mainstream, they disrupt traditional financial institutions. Hence regulators have started scrutinizing their operations to ensure that they adhere to their laws and regulations. These strict regulations and adherence requirements can enhance the costs and delays for Fintech companies thus rendering it challenging to contest and compete with well-established financial institutions.

Saturation of market

In addition, Fintech companies face immense rivalry from traditional financial institutions, which have adopted an identical path by adopting similar business models and technologies in order to stay competitive. Consequently, Fintech companies are finding it increasingly challenging to differentiate themselves in the crowded Fintech market to attract and retain customers.

Challenges posed by cyber security

Fintech companies face hurdles related to data privacy and cyber security. Since they gather and store sensitive financial data, they are perpetually at risk of data breaches and cyber-attacks. Such foes can result in damage to reputation, legal liabilities and losses, particularly financial losses, if they are unable to conserve the data of their customers. However, it is to their credit that despite such challenges many Fintech companies have adapted and are on the path to development and growth. Many Fintech companies have taken advantage of the increased demand for digital financial services which became very popular during the pandemic; some others have shifted their focus on digital payments and lending. The Fintech companies need to navigate the above mentioned challenges and find ways to remain competitive in order to succeed in the present economic climate.

Challenges to Fintech in Promoting Sustainability

Leaving aside the rosy side of green financing, it comes along with a set of challenges. The most challenging being winning over the consumer, which forms the initial phase of the journey. It becomes essential sometimes to convince the stakeholders to prioritise the planet over profit for the sake of larger gains. Alignment of environmental and financial objectives is another major challenge as environmental objectives are seen as contradictory to financial ones. Funding over the competing needs and addressing the inefficiencies in the green finance space are other challenges in this direction. India requires about 162.5 lakh crores till 2030 for NDCs (nationally determined contribution) and INR 716 lakh crores to obtain net-zero emissions by 2070. India suggested the issue of green bonds in 2015. RBI joined the Network for Greening the Financial System (NGFS) to support the green economy practices in 2021, thereby encouraging environmental progress and eliminating climate related risk. Looking closely at the landscape of green finance in India, it has evaluated the financial flow in energy, transportation, infrastructure and a footprint in several other sectors. GreenFintech plays a major role in the journey to a low-carbon future. Thus, a sustainable green Fintech company is no longer a fad. The Fintech industry adopts a green shade with new products, funds and investment strategies.

CONCLUSIONS

Industrialisation has resulted in environmental degradation, the environmentalists and according to the sustainable development goals, the environment can be saved and protected through new environmental technology and innovation. With rapid digitalization, every Fintech unit that uses digital technologies has made banking easy and with the use of AI, block chain technology has to an extent reduced the carbon footprint on the environment. Blockchain is one of the digital technologies which supports other technologies for financial payments and solutions. India being the hub of Fintech encourages disruptive solutions in the form of insurtech, analytics and investment digital platforms. In the Asia Pacific region India has the second largest number of Fintech startups with China in the lead. The policy makers should encourage green initiatives to develop new green Fintech business models which can

be cost-effective, use renewable energy, ensure transparency in financial transactions and contribute towards the attainment of environmental sustainability.

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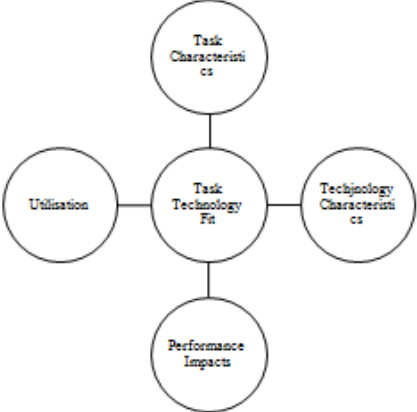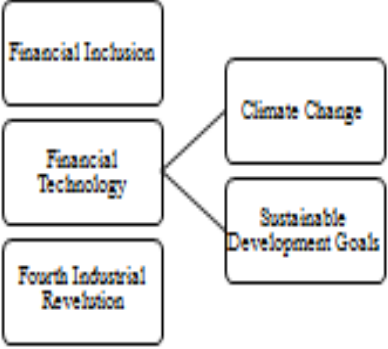
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Chart 1: Depicts Benefits and Features of Technology That Help Fintech.	Chart 2: Depicts How Fintech Contributes Towards Financial Inclusion and Environmental Sustainability Through the Products of the Fourth Industrial Revolution
Source: D. L. Goodhue and R. L. Thompson, "Task-technology fit and individual performance," *MIS Quarterly*, vol. 19, no. 2, pp. 213–236, 1995.	Source: David Mhlanga (2022),'The role of financial inclusion and Fintech in addressing climate-related challenges in the industry 4.0: Lessons for sustainable development goals',

RESEARCH ARTICLE

Mechanistic Insights into the Photoinduced Interaction of 1-Aminoanthraquinone with Fe_3O_4 and Fe_3O_4 / CdTe Nanoparticles

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ABSTRACT

The binding of the biologically important 1-aminoanthraquinone (1-AAQ) with magnetic nanoparticles such as Fe_3O_4, Fe_3O_4/CdTenanoparticles have been examined through various spectroscopic measurements. Absorption studies indicate the formation of ground state complex between 1-AAQ with Fe_3O_4 and Fe_3O_4/CdTenanoparticles. Fluorescence quenching of 1-AAQ is mainly due to static in nature which is confirmed through life time measurements. The binding constant values obtained from fluorescence measurements confirm the efficient binding of 1-AAQ with Fe_3O_4 and Fe_3O_4/Cd Tenanoparticles. Fe_3O_4 nanoparticles strongly bind with 1-AAQ when compared with Fe_3O_4/Cd Tenanoparticles. Thermodynamic parameters were calculated from the fluorescence quenching data and indicate the possibility of charge transfer from 1-AAQ to the nanoparticle. Therefore, combining 1-AAQ with magnetic nanoparticles as carriers is a promising avenue for improved delivery to cancerous areas in photodynamic therapy. These findings may also provide important information for optimizing 1-AAQ's application in this field.

Keywords: 1-aminoanthraquinone, Nanoparticle, fluorescence quenching

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INTRODUCTION

Numerous studies are being done on quantum dots (QDs) and super paramagnetic nanoparticles (MNPs), especially for their uses in biotechnology and medicine [1]. Innovative opportunities in biology, medicine, sensors, optics, solar cells, barcodes, lasers, etc. were made possible by the development of QD technology [2-6]. In light of their improved photostability and larger quantum yield, QDs have outperformed with organic fluorophores in labeling in recent years. QDs are employed in biotechnology and medicine in a variety of applications, including immunoassays, DNA hybridization, and optical detection of cancer cells [7-10]. Quantum confinement determines the size-dependent unique optical features of QDs [11]. For this reason, different QDs can be excited at a single wavelength by semiconductor QDs with size-tunable emission color and a broad absorption/narrow emission spectrum. The aforementioned is incredibly advantageous for optical detection of many objects or events. Superparamagnetic   Iron Oxides (SPIOs), typically react to an external magnetic field by potentially generating a signal or dragging or holding particles, are indispensable for the effective functioning of magnetic nanoparticles [12]. Thus, SPIOs are being employed in immunoassays, cell sorting, magnetic separation, and diagnostic imaging [13-17]. Specifically, academia and industry have done extensive research on the use of MNPs in cancer therapy, hyperthermia, drug/gene delivery, cell tracking, and magneto resistive biosensors. Porphyrin-iron oxide nanoparticle conjugates can be used as bimodal anticancer drugs for combined PDT and hyperthermia therapy [18]. HeLa cancer cells have a tendency to efficiently absorb these conjugates. The cells fostering the nanocomposites experienced apoptosis, triggering a major transformation in their shape when they were exposed to yellow light. These findings demonstrate that these nanoparticles endure the potential to be employed for cancer treatment. Hence, developing magnetic/fluorescent composites such as Fe_3O_4/CdTe nanoparticles for imaging, drug delivery are current area of research. These multi-functional nanocomposites exhibited favorable magnetic and fluorescent properties. It is anticipated that Fe_3O_4/CdTe nanoparticles could have prospective applications in magnetically guiding and optically tracking gene and medication delivery 1-Aminoanthraquinone (1-AAQ), a quinone photodynamic pigment having strong absorption in the visible region and possess high photostability. Scheme 1 shows the chemical structure of 1-AAQ. 1-AAQ proved to be a promising candidate for photodynamic treatment of some vascular diseases, such as port wine stains and age-related macular degeneration (AMD) [19]. Besides their excellent photodynamic activity they also show better activity towards tumors and viruses [20-27]. It was discovered that natural quinonoid molecule exhibits the antitumor and antiviral activities against several types of viruses, including the human immunodeficiency virus [28]. Since 1-AAQ is a good visible photosensitizer with high intersystem crossing quantum yield, its interaction with magnetic nanoparticles could reveal useful information in order to tune its application in photodynamic therapy.

Magnetic nanoparticles such as Fe_3O_4 and Fe_3O_4/CdTe nanoparticles are widely used as drug carriers in magnetic drug delivery system. 1-AAQ is potential drug for photodynamic therapy for some vascular diseases, including age-related macular degeneration and port wine stains. It is our prime intention to study the interaction of 1-AAQ with appropriate biological targets and in this perspective investigation on the interaction of 1-AAQ with FO and FCO nanoparticles is of utmost importance. Since 1-AAQ is a good visible photosensitizer its interaction with magnetic nanoparticles (acting as efficient carrier for its better delivery to cancerous part) could reveal useful information in order to tune its application in photodynamic therapy. By considering all these advantages we have investigated the interaction of 1-AAQ with magnetic nanoparticles such as Fe_3O_4 and CdTe/Fe_3O_4 through absorption and steady state fluorescence, measurements.

MATERIALS AND METHOD

Materials

1-AAQ purchased was from Merck., Te powder, $CdCl_2$. $5H_2O$, 3- Mercaptoprpopyl- trimethosysilane (MPS) purchased from Sigma Aldrich. Tetraethyl orthosilicate (TEOS), NH_4OH were purchased from Merck. Other chemicals and solvents were purchased from LOBA chemicals (India). Double Distilled Water was used for preparing solutions.

Methods

Due to the low solubility of 1-AAQ in water, the solution (1×10^{-3} M) was prepared by adding small amounts of ethanol to double distilled water [29]. A 3µl of 1-AAQ stock solution was taken and diluted to 3.0 ml by adding water resulting in the final concentration of 1×10^{-6} M which was titrated by successive addition of 30 µl stock solutions of Fe_3O_4 and Fe_3O_4/CdTe nanoparticles (1×10^{-3} M). Titrations were manually done by using micro pipette for the addition of Iron oxide. All spectral measurements were done in ambient temperature (25 °C).

Instrumentation

Steady-state measurements

Absorption spectra were recorded using Cary 300 UV- Visible spectrophotometer in the range of 200-800nm. Steady state fluorescence quenching measurements were carried out with JASCO FP-6500 spectrofluorometer. The excitation (460 nm) and emission (610 nm) slit, width (10, 20 nm) and scan rate (500 nm/min) of 1-AAQ were kept constant for all the experiments. Quartz cells (4x1x1cm) with high vacuum Teflon stopcocks were used for spectral measurements. Fluorescence lifetime measurements were performed using a picosecond time-correlated single photon counting (TCSPC) spectrometer. A tunable Ti-sapphire laser (TSUNAMI, Spectra Physics, USA) served as the excitation source. Data analysis was conducted with the DAS-6 software provided by IBH.

Preparation of Fe_3O_4 Nanoparticles

Under nitrogen atmosphere, $FeCl_3$ (anhydrous) and $FeSO_4.7H_2O$ were dissolved in water in a mole ratio of 2:3 of Fe^{3+}/Fe^{2+} and swirled with a magnetic stirrer for 30 minutes. Later that, 1.5 moles of NH_4OH were systematically added to the solution until the reaction mixture's pH reached 8. At this pH, the process was allowed to proceed for a maximum of two hours. Upon magnetic field separation, the resulting Fe_3O_4 nanoparticles were repeatedly precipitated, dried, and purified[30].

Preparation of Fe_3O_4/ CdTe Nanocomposite

Preparation of Iron - Oxide Magnetic Nanoparticle

The preparation of iron-oxide magnetic nanoparticles was accomplished by chemical co-precipitation [31]. The PEG 4000-modified Oxide solid precipitations were magnetically separated, rinsed with water numerous times until the pH value reached 7.0, and then dried at 40 °C for 48 hours following a 30-minute reaction at 40 °C under mechanical stirring and N_2 protection. Citric acid was added once again to the PEG 4000-modified iron oxide magnetic nanoparticles to improve their dispersibility, as previously described [32]. In 100 milliliters of 0.5 M citric acid, approximately 0.5g of PEG 4000-modified iron oxide nanoparticles were diluted. Large and aggregated particles were eliminated from the mixture by centrifuging it after it had been treated with ultrasonic therapy for 4.0 hours at room temperature while being stirred mechanically. The colloidal iron oxide nanoparticles were underwent washing four times with acetone. The resultant product is finally dried at 40°C for 1h.

Preparation of Fe_3O_4@SiO_2 – SH Nanocomposite

The Stober method was used to coat Fe_3O_4 nanoparticles with silica in order to create magnetic/fluorescent nanocomposites. Initially, we filled a 250 ml three-necked flask with 20 mg of citric acid-modified Fe_3O_4 powder, 20 ml of water, 2.5 ml of ammonia solution, and 50µl of ethanol. Following 30 minutes of mechanical stirring and sonication at room temperature, TEOS and 30 milliliters of ethanol were added to the flask dropwise. The amount of TEOS used was varied to adjust the thickness of the silica shell. Following an 8.0-hour reaction at 35°C with constant stirring, 10 milliliters of ethanol and various MPS were added to the flask dropwise. At 35 °C, the reaction continued for 12 hours. The resultant Fe_3O_4@SiO_2 – SH nanocomposites were stored to further use.

Preparation of TGA-CdTe QDs

The TGA-CdTe QDs was synthesized using the reaction between the Cd^{2+} and NaHTe solution by following a method [33], with TGA as a stabilizing agent. The $NaBH_4$ was reacted with Te powder (3:1 molar ratio) in water to produce NaHTe. The molar ratio of Cd/Te^{2-}/TGA of 1: 0.2: 2.4 was used. The fluorescence of the CdTe crystals could be tuned in color by changing the heating time at140 °C. Based on the literature procedure and TGA as a stabilizing

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agent, the TGA-CdTe QDs are formed by reacting Cd^{2+} with NaHTe solution. NaHTe was generated by a 3:1 molar ratio reaction between Te powder and $NaBH_4$. The $Cd/Te^{2-}/TGA$ molar ratio of 1:0.2: 2.4 was applied. A temperature change of 140 °C might be used to adjust the appearance of the CdTe crystals' fluorescence.

Synthesis of Fe_3O_4 / CdTe Nanocomposite

The thiol-functionalized Fe_3O_4 SiO_2 nanoparticles and the as-prepared TGA-functionalized CdTe QDs were conjugated via bonding between thiols on QDs and silica. To summarize, a 100ml flask with three necks was filled with 20ml of functionalized Fe_3O_4 SiO_2 aqueous solution and 5ml of produced TGA-stabilized CdTe QDs. The mixture was stirred while being protected by N_2 followed by dropwise addition of 3.0 M NaOH aqueous solution until the pH reached 11.0. A magnet was used to successfully collect and purify the magnetic/fluorescent nanocomposite after it had reacted for 6.0 hours at room temperature with mechanical stirring and N_2 protection [34]. It forms the magnetic/fluorescent nanocomposite.

RESULTS AND DISCUSSIONS

Spectral characterization of Fe_3O_4 (FO) and Fe_3O_4/CdTe (FCO) nanoparticles

The prepared Fe_3O_4 (FO) and Fe_3O_4/CdTe (FCO) nanoparticles were characterized by using absorption and fluorescence measurements. Figure 1 shows the absorption spectra of FO and FCO nanoparticles. FO nanoparticles show characteristic absorption band at 359 nm. A new absorption band appeared around 450-550 nm indicates the formation of FCO nanoparticles. The characteristic absorption spectrum of CdTe quantum dots becomes less pronounced after binding with FO to form FCO nanoparticles. Furthermore, the emission spectra of FCO nanoparticles appeared at 550 nm under excitation of 500 nm (Figure 1) supports the formation of FCO nanoparticles. The observed spectral values were well matched with the previously reported values [35].

Ground state interaction of 9-AAQ by Fe_3O_4 and Fe_3O_4/CdTe nanoparticles

The polar surface of nanoparticles assist adsorption of polar species in solution and such interactions can lead to absorption spectra changes of these molecules [36]. The absorption and emission spectrum of 1-AAQ is given in figure 2. The absorption of 1-AAQ appeared at 460 nm and emission at 610 nm. The interaction between 1-AAQ with FO and FCO nanoparticles in the ground state were investigated by UV–Visible absorption spectroscopy. Figure 3 and 4 shows the absorbance spectra of 1-AAQ in the absence and presence of FO and FCO nanoparticles respectively. In the presence of FO nanoparticles, the 1-AAQ absorption band at 460 nm increases along with red shift (up to 510 nm) which indicate a strong interaction between 1-AAQ and FO nanoparticles. Such charge-transfer type of interactions arising from the interaction of sensitizers with nanoparticles has been extensively investigated in earlier studies [37-40]. In the presence of FCO nanoparticles, the absorbance of 1-AAQ is increased without change in the location of peak. The inference is that the interaction of 1-AAQ with FO nanoparticles is stronger than FCO nanoparticles. This indicates that the presence of CdTe in FO nanoparticles reduces the binding efficiency of 1-AAQ with FO nanoparticles.

Fluorescence measurements

The excited state interaction of 1-AAQ with FO and FCO nanoparticles were studied by fluorescence spectroscopy. Fluorescence quenching may be due to static or dynamic mode. Static quenching refers to fluorophore-quencher complex formation whereas in dynamic quenching fluorophore and the quencher come into contact in the excited state. Figure 5 shows the emission spectra of 1-AAQ in the absence and presence of FO nanoparticles. Addition of FO nanoparticles leads to significant quenching of the fluorescence intensity of 1-AAQ. Similar type of quenching occurs by the addition of FCO (Figure 6). We have recorded the emission spectrum of FCO at the same excitation wavelength (460 nm) of 1-AAQ; the fluorescence of FCO is not observed at this excitation. Further FO is transparent at this excitation wavelength. From this observation we confirmed that the observed quenching is entirely due to interaction of 1-AAQ with nanoparticles and not due to inner filter effect or reabsorption.The Stern-Volmer relationship has been used for the analysis of fluorescence quenching,

$$I_0/I = 1 + K_{SV}[Q]$$

where 'I$_0$' and 'I' are the emission intensities of 1-AAQ in the absence and presence of quencher respectively. 'K$_{SV}$' is the Stern-Volmer constant and [Q] is the concentration of quencher. The bimolecular quenching rate constant 'k$_q$' is calculated by using,

$$k_q = K_{SV}/\tau$$

where 'τ' is the excited state fluorescence lifetime of 1-AAQ in the absence of quencher. The Stern-Volmer plots for the quenching of 1-AAQ by FO and FCO nanoparticles are shown in figure 7. The plots of I$_0$/I vs [Q] are linear for both FO and FCO nanoparticles. From this linear plot, the K$_{SV}$ and k$_q$ values were determined [Table 1]. Since the lifetime of 1-AAQ is in the order of 10^{-9} s, the calculated bimolecular quenching rate constant (k$_q$) was found to be higher than the maximum collisional quenching (k$_q$) of various kind of quenchers to biopolymers (2.0×10^{10} M^{-1}s^{-1}). Hence the fluorescence quenching results from complex formation of 1-AAQ with FO and FCO nanoparticles and not due to dynamic nature [41]. To get more insights, fluorescence quenching of 1,10-anthraquinone in presence of FO and FCO nanoparticles was measured. The bimolecular quenching rate constant (k$_q$) was found to be in the range of 3 $\times 10^{-8}$ M^{-1}s^{-1} and 5×10^{-8} M^{-1}s^{-1}. The obtained result indicates the vital role of –NH$_2$ group in the fluorescence quenching process. The presence of –NH$_2$ group enhance the electron density of the molecule and enable the 1-AAQ to bind efficiently with the nanoparticles. Fluorescence quenching experiments accomplished at three different temperatures in order to identify the sort of quenching mechanism. As the temperature increases, the quenching rate constant decreases (shown in table 1). It indicates the process of static quenching. Measuring the fluorescence lifetime is useful in figuring out the interaction between the acceptor and donor systems. Since a linear Stern-Volmer plot can also result from static quenching, as observed during steady-state measurement. The most reliable technique for differentiating between static and dynamic quenching processes is typically time-resolved measurement [42].1-AAQ shows single exponential decay in the presence of FO and FCO nanoparticles as well as in diluted solutions. The fluorescence lifetime of 1-AAQ remains unchanged as the concentration of FO and FCO nanoparticles increases. This suggests that a static mechanism causes quenching. The decay traces of 1-AAQ in the presence and absence of FO nanoparticles are presented in Figure 8, however the lifetime of 1-AAQ is unaltered in both circumstances. As a result of the kinetic traces, the plot appears as a single decay curve. This outcome demonstrates that FO and FCO nanoparticles quench 1-AAQ in a static manner. The fluorophore and quencher combine to produce a complex, which causes static quenching. Accordingly, the following procedure was used to calculate the association constant (K) using fluorescence quenching data. Hence from the fluorescence measurements the binding affinities of 1-AAQ to nanoparticles were calculated from the following equation.

$$\frac{1}{(F^0 - F)} = \frac{1}{(F^0 - F')} + \frac{1}{K(F^0 - F')[Q]}$$

where F^0 is the fluorescence intensity of free 1-AAQ, F' is the fluorescence intensity of 1-AAQ in the presence of nanoparticles and F is the observed fluorescence intensity at its maximum. A plot of 1/(F$_0$–F) Versus 1/[Q] gives a straight line and from the slope the association constant (K) was calculated (Figure 9). The K of both 1-AAQ-FO and 1-AAQ- FCO are listed in table 1. From the value it is clear that FO have stronger interaction with 1-AAQ than FCO. The decrease in fluorescence intensity of the 1-AAQ is mainly attributed to electron transfer to the conduction band of semiconductor nanoparticles [43]. The Vander Waals force, hydrogen bond formation, electrostatic interaction, and hydrophobic interaction were the forces responsible for the interaction between the nanoparticle and the 1-AAQ molecules. Thermodynamic parameters such as enthalpy change (ΔH) and entropy change (ΔS) can be used to confirm the fashion of interaction. Hydrophobic contact is indicated by $\Delta H > 0$ and $\Delta S > 0$; Vander Waals forces or hydrogen bond formations are implied by $\Delta H < 0$ and $\Delta S < 0$; the presence of electrostatic force is indicated by $\Delta H \approx 0$ and $\Delta S > 0$ [44,45]. According to thermodynamic equations

$$\ln K = -\frac{\Delta H}{RT} + \frac{\Delta S}{R}$$
$$\Delta G = \Delta H - T\Delta S = -RT \ln K$$

The preceding equation, where R is the gas constant, T is the temperature, and K is the association constant at the corresponding temperature, can be used to determine the free energy change (ΔG) based on association constants acquired at different temperatures. The plotting of lnK versus the reciprocal of absolute temperature (1/T) generates a straight line and renders the values for ΔH and ΔS. The table 2 reveals the results of the calculation of the thermodynamic parameters. When ΔG is negative, it signifies that the interaction is occurring spontaneously. The Vander Waals interaction and hydrogen bond formation are shown by negative enthalpy and entropy values. Thus, hydrogen bond formation and the Vander Waals interaction are the main mechanism that causes the nanoparticles bind with 1-AAQ. HongweiGu et. al., studied the interaction of FO nanoparticles with porphyrin through –OH group [18]. In a similar way the –OH groups present in 4th and –NH$_2$ group present in 9th position of 1-AAQ will be responsible for the efficient interaction with magnetic nanoparticles (Scheme 2). But in the case of FCO, CdTe quantum dots are in the surface of FO nanoparticles which reduces its efficient binding with 1-AAQ. Hence it possesses lower K value. Strong interaction with drug molecule is vital criteria for efficient drug carriers. From the results it is clear FO will be a better drug carrier candidate than FCO. Upon examining the table 2, it is evident that the magnitudes of ΔH and ΔS suggest the potential for both hydrogen bonding contact and charge transfer between 1-AAQ and nanoparticles. Charge transfer transpires between the molecules despite the oxidation potential and hydrogen bonding capabilities of 1-AAQ. The ability of the excited state of 1-AAQ to inject the charge transfer into the conduction band of FO is determined by energy difference between the conduction band potential of nanoparticles and the oxidation potential of the excited state 1-AAQ. According to the equation,

$$E_{s*/s+} = E_{s/s+} - E_s,$$

where $E_{s/s+}$ is the ground state oxidation potential (2.01 V), E_s is the excited state energy (2.69 eV). The calculated excited oxidation potential ($E_{s*/s+}$) of 1-AAQ is -0.68 V. The conduction band energy level favors the electron transfer from excited state 1-AAQ to the conduction band of FO and FCO and it is thermodynamically favorable. This might be the possible reason for the non-radiative process.

CONCLUSION

The potential drug 1-AAQ bind with magnetic nanoparticles such as Fe$_3$O$_4$(FO), Fe$_3$O$_4$/CdTe (FCO) was investigated by steady state and time resolved fluorescence measurements. The formation of ground state complex was observed from steady state measurements. Life time measurement support static quenching mechanism. The bimolecular quenching rate constant (k_q) and binding constant (K) values are calculated at three different temperatures using fluorescence quenching data. 1-AAQ binds strongly with FO than FCO nanoparticle. Thermodynamic parameters indicate the hydrogen bond formation and charge transfer process between the1-AAQ and nanoparticles. Electrons excited in the 1-AAQ are injected into the conduction band of FO and FCO nanoparticles. Charge transfer process occurs between the molecules and this might be the plausible mechanism of fluorescence quenching process. Hence the combination of magnetic nanoparticles (acting as efficient carrier of 1-AAQ for its better delivery to cancerous part) with 1-AAQ will be a promising pathway in the field of photodynamic therapy and these results could reveal useful information in order to tune its application in photodynamic therapy.

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Conflicts of interest
The authors report no conflict of interest.

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Table 1: Bimolecular quenching rate constants (k_q) and association constants (K) of 1-AAQ with FO and FCO nanoparticles calculated from the fluorescence data at different temperatures.

S. No.	Nano particles	$k_q(10^{13} M^{-1} s^{-1})$			$K(10^5 M^{-1})$		
		15°C	25°C	35°C	15°C	25°C	35°C
1	FO	9.8	7.7	5.4	3.26	1.375	0.92
2	FCO	4.2	2.9	1.2	0.093	0.0641	0.045

Table 2: Thermodynamic parameters of 1-AAQ with FO and FCO nanoparticles

S. No.	Nano particles	ΔG (kJ/mol)			ΔH (kJ mol^{-1})	ΔS (J/mol.K)
		15°C	25°C	35°C		
1	FO	-37.29	-31.83	-25.39	-12.34	-36.37
2	FCO	-19.92	-15.57	-12.87	-6.22	-14.86

Scheme 1: Structure of 1-Aminoanthraquinone	Scheme 2: Possible mode of interaction

Figure 1: Absorption spectrum of Fe₃O₄ (FO), Fe₃O₄/CdTe(FCO) nanoparticles and Emission spectrum of FCO	Figure 2: Absorption spectrum (A) and Emission spectrum (B) of 1-AAQ
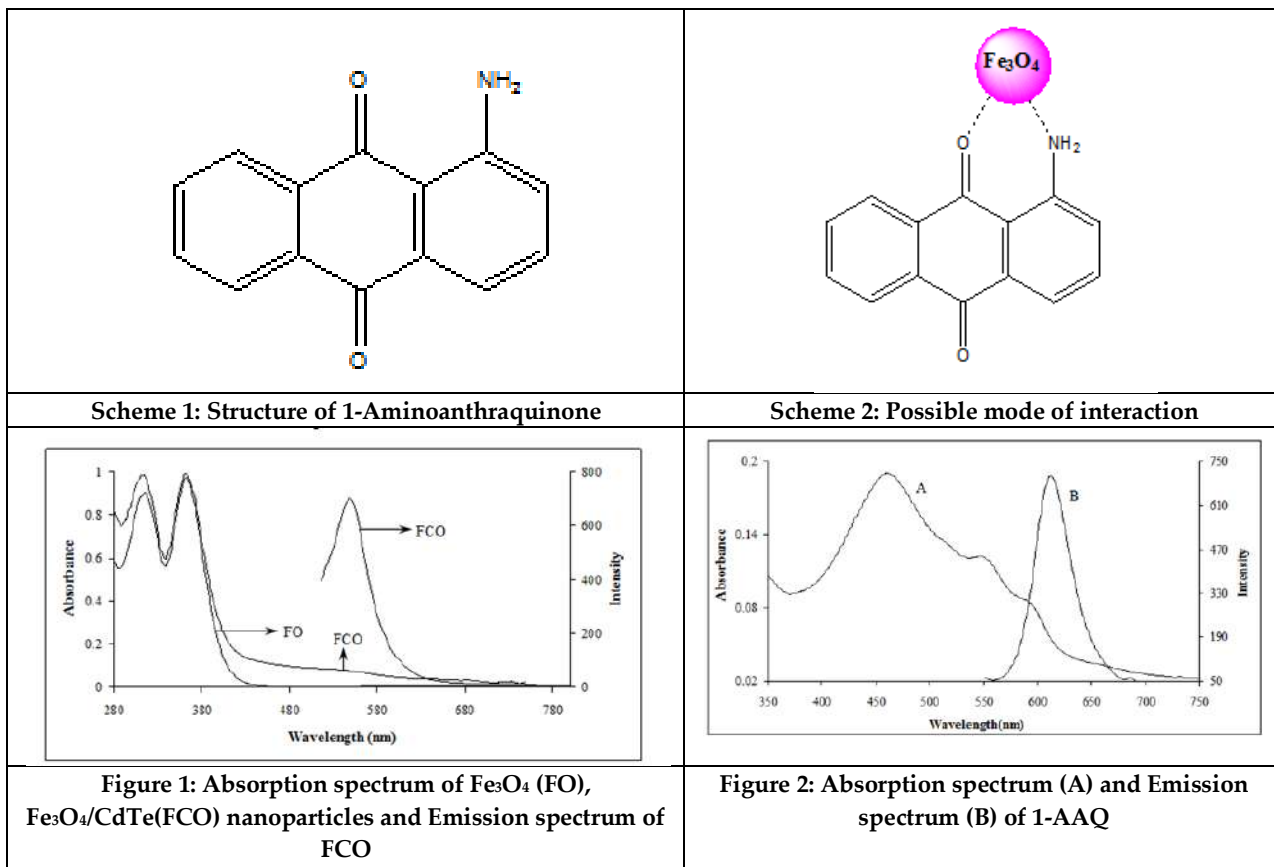
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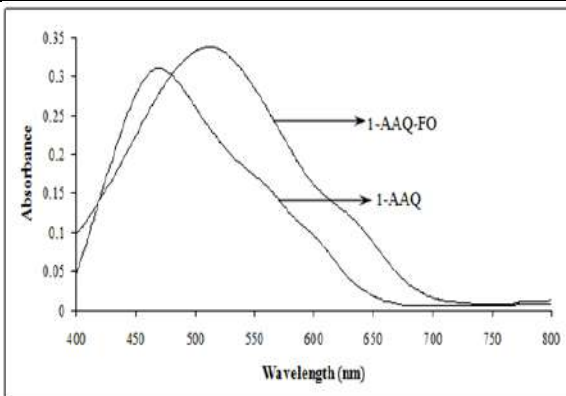
Figure 3: Absorption Spectrum of (1-AAQ, 1 x 10⁻⁶ M), 1-AAQ in the presence of FO (1-AAQ-FO, 5 x 10⁻⁵ M).
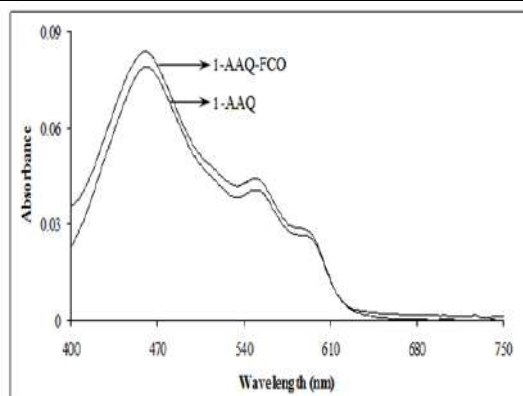
Figure 4: Absorption Spectrum of 1-AAQ (1 x 10⁻⁶ M) in the presence of FCO nanoparticles (5 x 10⁻⁵ M).
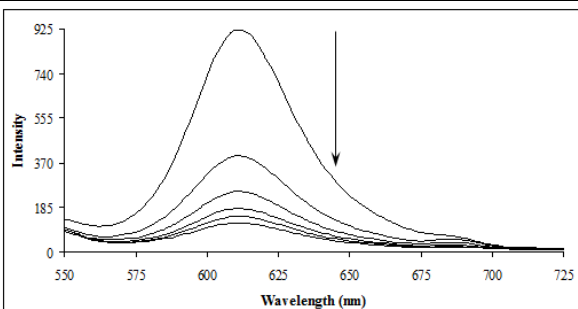
Figure 5: Fluorescence quenching of 1-AAQ (1 x 10⁻⁶ M)in the presence of FO nanoparticles (0 – 5 x 10⁻⁵ M) in water
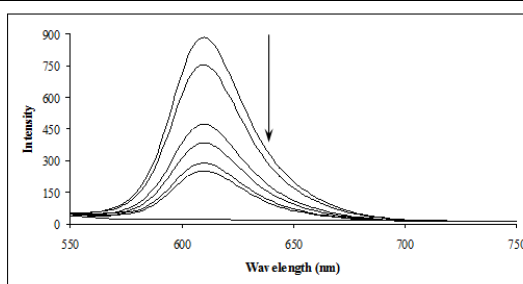
Figure 6: Fluorescence quenching of 1-AAQ (1 x 10⁻⁶ M) in the presence of FCO nanoparticles (0 – 5 x 10⁻⁵ M) in water.
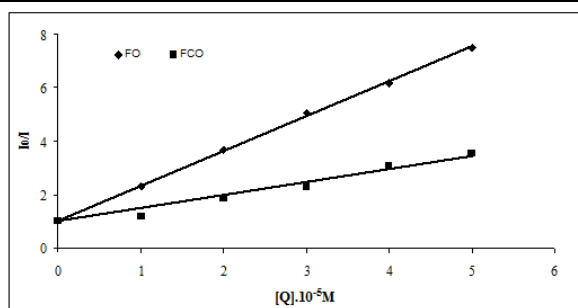
Figure 7: Stern-Volmer plot for fluorescence quenching of 1-AAQ by Fe₃O₄ (FO), Fe₃O₄/CdTe (FCO)nanoparticles
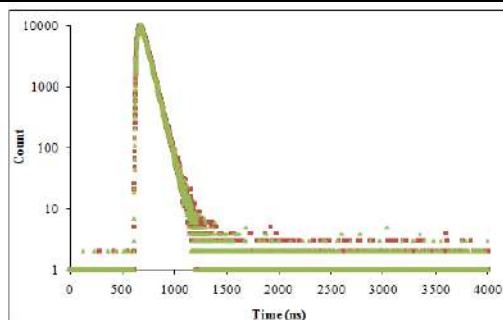
Figure 8: Lifetime measurement of 1-AAQ in presence and absence of Fe₃O₄ (FO) nanoparticles.

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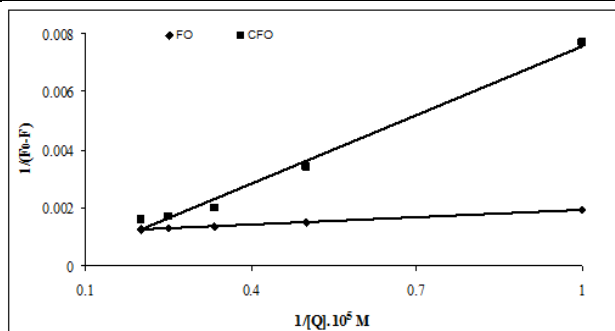
Figure 9: Binding constant plot for fluorescence quenching of 1-AAQ by Fe₃O₄ (FO),
Fe₃O₄/CdTe(FCO)nanoparticles

RESEARCH ARTICLE

MOODLE in the Academic Sphere: A Tertiary Level Perception Analysis

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ABSTRACT

Globally, the way that teaching and learning take place in universities has been revolutionized by digital education. In today's educational technology, a Learning Management System (LMS) such as MOODLE is indispensable. An LMS is used by almost all Higher Education Institutions (HEI) to improve learning, encourage creative activities that can be completed from anywhere, and actively involve students prior to, during, and following in-person sessions. This quantitative study intends to analyze MOODLE users' perceptions about the educational impact of MOODLE-based learning management systems. A self-constructed questionnaire was used to conduct this study.A representative sample of MOODLE users are students from social-sci and science contributed in this study is selected by purposive sampling. The findings showed that when compared to traditional classrooms, males perceive MOODLE as having a greater positive impact on learning outcomes, such as learning efficacy, control over learning, and more persistent learning. MOODLE specifically improves the learning environment by enabling instantaneous information access, assigning tasks, conducting online tests and discussion boards. Basically, while face-to-face interaction is essential for improving learning, adding MOODLE-based LMS activities can advance skill development.

Keywords: Perception**,** MOODLE, Learning Management System, Education technology

INTRODUCTION

Higher education institutions (HEIs) have the issue of improving opportunities for students to learn while demonstrating the efficacy of their programmes. Increasing student engagement and active learning is a vitalmission for higher education institutions [1].Regarding the long-term development of students' ability to apply knowledge in

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real-world contexts, the utilisation of traditional classrooms has changed [2].As a result, policymakers, scholars, and advocacy groups work to progress quality of higher education quality by implementing active methods of learning so that students acquire life-long learning skills which cater need of labour market [3]. Learning Management Systems (LMS) have turn out to be an essential component of educational technology and used by almost all higher education institutions (HEIs) to support teaching and learning activities. The free and open-source e-learning platform MOODLE, which stands for Modular Object-Oriented Dynamic Learning Environment, can be used with a variety of operating systems [4]. E-Learning systems are designed to assist educators and content experts in creating online courseware with rich interaction opportunities. Additionally, a lot of people and organizations all over the world have embraced the open-source teaching management system LMS MOODLE because it offers a tightly integrated set of tools that are said to be created from a socially constructive standpoint [5]. Internationally, higher education institutions (HEIs) have accepted the potential value of incorporating IT into curricula and pedagogical strategies, usually to support student-centered learning. MOODLE is an open-source application in the form of a website that developers can use without paying a license fee. This application allows teachers and students to interact during the digital learning process. The value of e-learning and e-learning means for enhancing educative culture in higher education has been highlighted by studies [6]. Existing e-learning tools like MOODLE, Blackboard, and WebCT are more user-friendly and provide a variety of services. Among them the most popular e-learning tools is MOODLE.

REVIEW OF LITERATURE

There are many studies from developed nations that evaluate MOODLE's efficiency as an e-learning resource in higher education. Face-to-face communication is still essential for enhancing speaking abilities; however, it should be complemented with MOODLE-based LMS techniques [7].More than 40% of teachers agree that the MOODLE facilities are excellent, and more than 60% of teachers agree that using MOODLE has a positive impact on learning. This study also revealed whether teachers believe that resources are not ready for use. More than 30% of teachers who use MOODLE disagree that they are prepared to use it[8]. The most recent technologies, like LMS plugins based on machine learning, could elevate the teaching and learning processes. Students' progress could be tracked with supervised machine learning integrated into an LMS like MOODLE, and positive steps could be used for improving the learning environment in addition to expediting time-consuming tasks [9]. MOODLE helps students learn more effectively and earn higher grades[10]. Students now find learning to be more interesting and accessible because to the integration of MOODLE into their curriculum and the creation of engaging activities [11].With its facilitation of a flexible and welcoming learning environment, MOODLE streamlines the educational process. However, the lack of knowledge, skills, and competences among learners may undermine MOODLE's usefulness and negate its expected advantages[12].

RATIONALE OF THE STUDY

Up until the finish of the academic year 2019–2020, the entire educational process has been conducted online. A learning management system called MOODLE is being used by one of the many educational institutes that are developing this online learning. MOODLE is one of the open-source software programmes in the category. The developer can utilize this application on a website without having to purchase a license. This application makes it possible for teachers and students to collaborate during the digital learning process[13].Using MOODLE is free, and it can be customized to meet user needs. Students who use MOODLE-based electronic learning will be able to access materials, tests, and exams through the website,inspite of not receiving textbooks from the institutions they attend, students can still access learning materials that are updated and delivered based on their needs. Additionally, this education can help students develop their independence in terms of academic tasks[14].Certain the expanding use of LMS in HEIs, a thorough and in-depth understanding of the advantages and disadvantages the pedagogical technology may present for education and its effects on students' lifelong learning is required. Measuring student learning satisfaction is crucial for assessing how well MOODLE support student-centered learning. The keypurpose

of this study is to determine whether MOODLE might be successfully implemented using current higher education practices for technology implementation [15]**.**

OBJECTIVES OF THE STUDY

1. To study the difference in perceptions of students about the role of MOODLE in improving learning outcomes with respect to
   a. Gender
   b. Stream

2. To study the difference in perceptions of students on the usage of MOODLE in terms of its accessibility and easiness with respect to
   a. Gender
   b. Stream

3. To study the difference in perceptions of students about the role of MOODLE based facilities in enhancing learning experiences with respect to
   a. Gender
   b. Stream

HYPOTHESES OF THE STUDY

1**.** There will be no significant difference in perceptions of students about the role of MOODLE in improving learning outcomes with respect to
   a) Gender
   b) Stream

2. There will be no significant difference in perceptions of students on the usage of MOODLE in terms of its accessibility and easiness with respect to
   a) Gender
   b) Stream

3. There will be no significant difference in perceptions of students about the role of MOODLE based facilities in enhancing learning experiences with respect to
   a) Gender
   b) Stream

RESEARCH METHODOLOGY

The present study aims to describe the difference in perception of students towards MOODLE as LMS at tertiary level. The survey method was selected which was most appropriate to the problem under investigation. The students studying in tertiary level using MOODLE constitute the population of   the study. The data is collected from 80 students from social sciences and sciences studying at tertiary level in central university of Jammu comprising the sample of the study.Purposive sampling technique is applied for determining the perceptions of students towards MOODLE as LMS.

TOOL USED IN THE STUDY

A self-constructed Perception scale as a tool developed by investigator with help of Google forms through extensive review of literature related to Perception of students towards MOODLE. The Perception scale consists of three domains and 20 items based on Likert scale consisting of Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. The dimensions of Perception scale are given as:

INTERPERTATION

In order to accomplish the objectives and hypothesis of the study, the investigator used T- test
Computations of t-ratios for different domain as under;

Testing hypothesis 1

1. To test the difference in perceptions of students about the role of MOODLE in improving learning outcomes with respect to Gender

2. Table 1 shows that the calculated value of t=4.72 is greater than 2.58 i.e at 0.01 level of Significance so it is significant at 0.01 level of significance. Thus, it is concluded that there is gender difference in perceptions of students about the role of MOODLE in improving learning outcomes. As mean of male is 18.85 greater than mean of female is11.28, reflects that male have better perception about the role of MOODLE in improving learning outcomes in terms of learn efficiently, academic performance, learning becomes effective, control over learning and gain more persistent learning than traditional classroom. Therefore, the hypothesis 1(a) that there will be no significant difference in perceptions of students about the role of MOODLE in improving learning outcomes with respect to gender is rejected.

3. To study the difference in perceptions of students about the role of MOODLE in improving learning outcomes with respect to Stream Table 2 shows that the calculated value of t=1.33 is less than 1.96 i.e. at 0.05 level of Significance so it is not significant at 0.05 level of significance. Thus, it is concluded that there is no difference in perceptions of students about the role of MOODLE in improving learning outcomes with respect to Stream i.e. Science and Social Science. Therefore, the hypothesis 1(b) that there will be no significant gender difference in perceptions of students about the role of MOODLE in improving learning outcomes with respect to Stream is accepted.

Testing hypothesis 2

1. To test the difference in perceptions of students on the usage of MOODLE in terms of its accessibility and easiness with respect to Gender Table 2,1 shows that the calculated value of t=0.813 is less than 1.96 i.e. at 0.05 level of Significance so it is not significant at 0.05 level of significance. Thus, it is concluded that there isno gender difference in perceptions of students about the usage of MOODLE in terms of its accessibility and easiness i.e. male and female have equal access and easiness in using MOODLE as LMS. Therefore, the hypothesis 2(a) that there will be no significant gender difference in perceptions of students about the usage of MOODLE in terms of its accessibility and easiness isaccepted.

2. To test the difference in perceptions of students on the usage of MOODLE in terms of perceive its accessibility and easiness with respect to Stream Table 3 shows that the calculated value of t=1.85 is less than 1.96 i.e. at 0.05 level of Significance so it is not significant at 0.05 level of significance. Thus, it is concluded that there is no significant difference in perceptions of students about the usage of MOODLE in terms of perceive its accessibility and easiness with respect to Stream i.e. Science and Social Science. Therefore, the hypothesis 2(b) that there will be no significant difference in perceptions of students about the role of MOODLE in improving learning outcomes with respect to Stream is accepted.

Testing hypothesis 3

1. To Test the difference in perceptions of students about the role of MOODLE based facilities in enhancing learning experiences with respect to Gender Table 3.1 shows that the calculated value of t=0.65 is less than 1.96 i.e. at 0.05 level of Significance so it is not significant at 0.05 level of significance. Thus, it is concluded that there is no gender difference in perceptions of students about the role of MOODLE based facilities in enhancing learning experiences i.e. male and female have equally participated in chats, forums, quizzes, assignments regularly, enhance collaborative learning, communicate with faculty and enjoy course on MOODLE. Therefore, the hypothesis 3(a) is accepted.

2. To Test the difference in perceptions of students about the role of MOODLE based facilities in enhancing learning differently with respect to Stream Table 3.2 shows that the calculated value of t=1.56 is less than 1.96 i.e. at 0.05 level of Significance so it is not significant at 0.05 level of significance. Thus, it is concluded that there is no significant difference in perceptions of students about the role of MOODLE based facilities in enhancing learning experiences with respect to Stream i.e. Science and Social Science. It reflects that learning experiences of students of science and Social Science enhanced equally with the help of MOODLE based facilities. Therefore, the hypothesis 3(b) is accepted.

FINDINGS AND DISCUSSIONS

Males have a more favorable perception about the role that MOODLE plays in enhancing learning outcomes, including learning effectiveness, control over learning, and more persistent learning compared to traditional classrooms than female. It is important to note that some people believe the Internet is primarily used by men and that women are unable to use it because they must balance work and family obligations. This has led to worries about educational equity, especially for women [16].The scholarly community agrees that more research is necessary to fully understand the gender discourse, with a particular emphasis on the differences and similarities in teaching methods and student results. Considering the widely held belief that people do not naturally fit into binary classifications, this is relevant [17;18;19].Numerous studies have found that male and female students engage with online environments in different ways, including in terms of their performance, motivation, perception, study habits, attitudes, and communication behavior.The findings are supported by learners' responses that the MOODLE platform was beneficial, time-saving, and most importantly, that it hadanoptimistic influence ontheir learning. Upon closer inspection of MOODLE, the researcher observed that all study participants engaged accordingly.

CONCLUSIONS AND RECOMMENDATIONS

It is possible to organize information, share ideas, exchange information, and improve communication both synchronously and asynchronously with the help of various courseware tools that are available to educational and training providers as well as users. To achieve the objectives and goals, it is crucial to keep in mind that these tools are merely a platform that must be integrated into the classroom. Users' perceptions of the value and usability of training and education will have an impact on the results. The responsibility is on those who develop and deliver education and training to get users ready to apply newly acquired intellectual capital to become more productive and competitive in the current global environment. Finally, and most importantly, it is the course instructor's duty to develop interactive content that is appropriate for the open learning environment and at the right level to fully utilize all of its functionalities. Overall, it appears that the students value the role that a MOODLE plays in their education and see it as an enhancement rather than a replacement for traditional classroom activities. However, since students appear to have trouble connecting to these concepts, the advantages gained from using communication and collaboration tools to support group work could be improved. Understanding MOODLE as a learning tool may improve class management, idea generation, interactive activities to foster more advanced communicative discussions, and the ability to improve learning outcomes. Therefore, it may be largely up to the faculty to improve the use of MOODLE in higher education, and their perspectives and difficulties should be the subject of specific research. We could achieve an improved considerate of the degree of satisfaction that users in various roles have with MOODLE by comparing their perceptions with those of faculty and students.

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Table 1

S.No.	Domain	Item Number	Total
1	The role of MOODLE in improving learning outcomes	Q1,Q2,Q3,Q4,Q5,Q19	6
2	Usage of MOODLE in terms of perceive its accessibility and easiness	Q6,Q7,Q8,Q14,Q15,Q16,Q17	7
3	Role of MOODLE based facilities in enhancing learning differently	Q9,Q10,Q11,Q12,Q13,Q18,Q20	7
	Total	20	

Table 2

Variable	N	Mean	SD	T	significance	Result
Female	47	11.28	4.46	4.72	Significant t at 0.01level	Hypothesis 1(a) is rejected
Male	33	18.85	8.38			

Table 3

Variable	N	Mean	SD	T	significance	Result
Science	42	18.43	5.65	1.33	Not significant even at 0.05level	Hypothesis 1(b)is accepted
Social Science	38	19.97	4.73			

Table 4

Variable	N	Mean	SD	T	significance	Result
Female	47	23.44	4.01	0.8136	Not significant even at 0.05level	Hypothesis 2(a)is accepted
Male	33	22.03	5.88			

Table 5

Variable	N	Mean	SD	T	Significance	Result
Science	42	22.05	5.22	1.85	Not significant even at 0.05level	Hypothesis 2(b)is Accepted
Social Science	38	24	4.31			

Table 6

Variable	N	Mean	SD	T	Significance	Result
Female	47	22.48936	5.973318	0.6522	Not significant even at 0.05level	Hypothesis 3(a)is Accepted
Male	33	23.30303	5.143309			

Table 7

Variable	N	Mean	SD	SE m	T	significance	Result
Science	42	21.28	7.27	1.122	1.56	Not significant even at 0.05level	Hypothesis 3(b)is Accepted
Social Science	38	23.61	6.05	0.98			

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Fig. 1- Distribution of students using MOODLE by gender

Fig.2- Distribution of students using MOODLE between Social Science and Science

RESEARCH ARTICLE
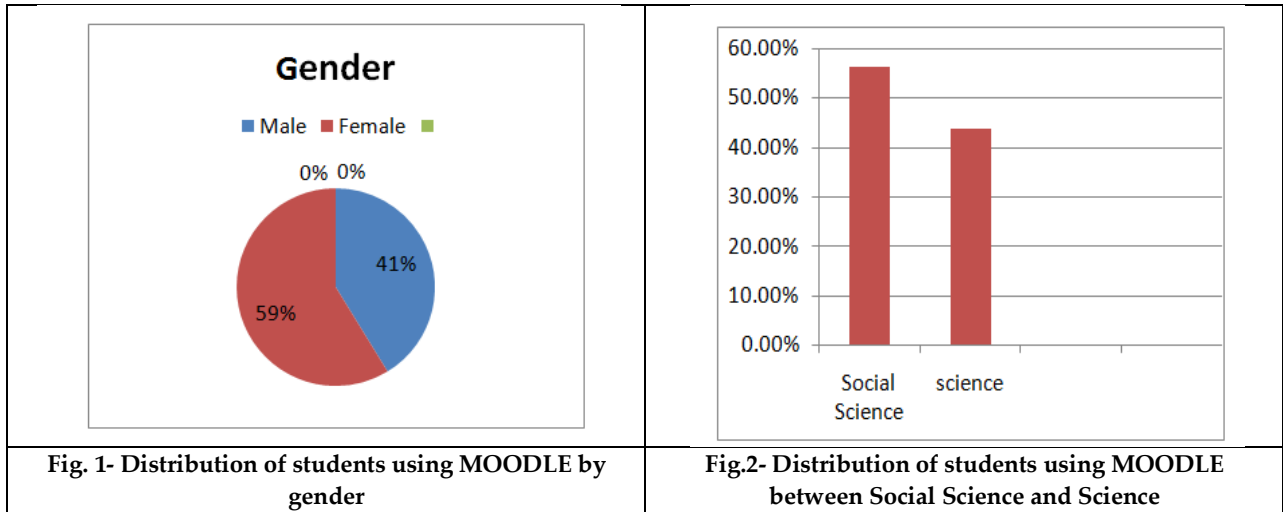
Joint Forest Management (JFM) in Karbi Anglong, Assam, India: Issues and Challenges

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ABSTRACT

After India's independence, several polices have been made in social forestry or community management of forest. There was a significant shift toward decentralized and people-oriented forestry. Joint Forest Management (JFM) has developed as a significant intervention in forest resource management since the National Forest Policy was adopted in 1988. The JFM program aims to foster collaboration between local community organizations and state forest agencies in order to manage public forest areas in a sustainable manner and share benefits. The fundamental goal of JFM is to guarantee that forests are used sustainably to meet local needs in an equitable manner while also ensuring environmental sustainability. In this backdrop, this study aims to investigate the status of JFM implementation in erstwhile district of Karbi Anglong in Assam. This study focused on the impact of the JFM scheme and how it was implemented with the help of local authorities, as well as the responses of those who played crucial roles in its implementation. This study also looked at the causes of the failure of the scheme and proposed actions that would have played a vital role if the government had embraced them. This study used qualitative research approaches to collect data and applied critical analysis to evaluate the JFM schemes in the study area. This study concluded that after the extinction of JFM at the national level in India as a result of the Forest Rights Act (FRA) of 2006, attempts to implement social forestry or community forestry at the village level in Karbi Anglong have also been unsuccessful due to the framing of alternative schemes within similar lines as the JFM initiatives in sixth schedule areas of Assam. Such developments have had a significant impact on social forestry or community forestry in the study area.

Keywords: Forest Rights Act (FRA) of 2006, Indigenous Knowledge, Mikir Hills, National Forest Policy of 1988, Social Forestry.

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INTRODUCTION

Forests have been used and protected locally in India for a long time. The earliest examples may be sacred groves, which are an indigenous community method to maintain conservation of the forest (Hughes and Chandran 1998, Tripathi 2005, Saikia 2006, Teron 2008, Medhi and Borthakur 2003, Shilpa et al. 2020, Dhanaraju and Bijeta 2022). Various communities have long safeguarded their forests. Revenue systems designated uncultivated areas as common lands, which included grazing and forest lands. Even after the colonial forest policies recognized the necessity for local ownership and management of forests, they included a provision for Village Forests. Although forest area in India has been largely steady and shows some signs of growth, forest degradation remains a major issue. Forest degradation disproportionately impacts poor rural populations that rely on forest resources for a living. Until recently, the management of government forests was focused on producing goods and services such as wood and other forest products, as well as maintaining the soil and water cycle. Communities' access to these resources was limited to rights and concessions provided for routes, dry wood for fuel wood, and grass and fodder as governed by the government. The management of forest resources in India has been one of the most difficult environmental challenges. Since 1951, degraded lands in India have doubled in area, reaching 174 million hectares by 1990 (Khawas 2003 The Indian government's significant attempts for reforestation and watershed control have predominantly been unsuccessful. The evolution of India's legislative and regulatory framework demonstrates a strong initial concentration on industrial forestry, a gradual transition to social forestry, and a significant shift toward conservation and the adoption of Joint Forest Management (JFM). The National Forest Policy of 1988 incorporates the majority of sustainable forest management principles. It focuses on conservation and expanding the role of communities in forestry stewardship, marking a significant shift in forest management aims. In June 1990, the Ministry of Environment and Forests released a policy circular encouraging state forest departments to incorporate local populations directly in forest management. The 1988 policy has been criticized in some circles for promoting forest conservation at the expense of commercial forest use, for failing to provide practical policy implementation options, and for maintaining forest departments' all-encompassing role, including the contradictory functions of being the forest authority and operating as a public enterprise in commercial forest production. Many of the key provisions governing community-based forestry in national policy have not been strengthened by a new national legal framework. Furthermore, over the last two decades, the Ministry of Environment and Forests has issued various legal amendments, policy circulars, and guidelines that, while supporting the evolution of JFM at the state level, have added excess complexity and overlaps to the legal framework when interpreted by states. Although many of these small legal adjustments were prompted by pressure to adopt creative state practices, there remains a large gap between national policy intent and field implementation at the state level.

MATERIALS AND METHODS

The forest area in Assam's hill areas accounts for around 34% of the region's total geographical area, compared to the regulated forest coverage of 60% specified by the National Forestry Policy of 1952. According to the State of Forests Reports (SFR), 2001, issued by the Forest Survey of India, the total area under forests in Karbi Anglong district was 7,97,200 hectares, accounting for 76.4% of its geographical area. Geographically, the Karbi Anglong region of Assam is separated into two parts: hills and plains. The Karbi Anglong Autonomous Council (KAAC) governs two districts in Karbi Anglong (East and West) under the sixth schedule of the Indian Constitution. However, these two were included the former district of Karbi Anglong in Assam. This region covers 10,434 square kilometres, or about 13.53% of the state's total geographical area of 78,438 square kilometers. Karbi Anglong is a significant hilly region in Assam. This study focused on three territorial forest divisions of the Karbi Anglong Autonomous Council (East Division, West Division, and Hamren Division). The primary data in this study was collected using qualitative research methods. These sources were compiled from relevant government publications, such as the KAAC and Assam State Forest Reports. However, mostly, this study employed secondary sources to comprehend the concept of JFM and its

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contemporary reality in India. This study employed critical analysis and interpretative techniques in order to understand the nature of implementation of JFM in Kabi Anglong district of Assam.

RESULTS AND DISCUSSIONS

History of Forest Management in India
Dietrich Brandis was a German forestry expert who became India's first Inspector General of Forests. The concept began in the late nineteenth century, when Deitrich Brandis, creator of the Indian Forest Service, predicted that a forestry system based only on state control would result in widespread dissatisfaction in the countryside (Johnson 1995, Patra 2015). Dietrich proposed four concepts for forest management in India: Brandis acknowledged the need for an appropriate system, which would necessitate parliamentary approval. It was important to develop rules for the exploitation of forest resources. Tree felling and grazing must be regulated in order to preserve forests and provide timber. Anyone who cuts down trees without following the guidelines will face consequences. Brandis established the Indian Forest Service in 1864 and helped enact the Indian Forest Act in 1865. The Imperial Forest Institute was established in Dehradun in 1906 to teach the "Scientific Forestry" system. Brandis had also proposed a forest management system based on a cooperative partnership between the state and local populations at the time (Patra 2015). As a result, his views were incorporated into both colonial and post-colonial forest policy frameworks. The British colonial intervention was a watershed moment in Indian ecological history (Gadgil and Guha 1992). The British were the first to legally recognize the forest recourse, and they were the ones who began the process of developing a forest policy in the second part of the nineteenth century. Historically, the first demonstration of concern in forest conservation, the reservation of teak forest in Malabar in 1806, was driven by strategic imperial needs (Ray 1998, Khawas 2003). This was due to the decline of oak forests in England and other western countries, as well as an increase in demand for wood from the shipbuilding industry.

Furthermore, the rapid expansion of the railway network in the late nineteenth century demonstrated that India's previously dense woods were not inexhaustible. However, the history of forest legislation in India began with a memorandum issued by the British in 1855, which was eventually replaced by the Forest Act of 1865 (Dhanaraju 2012). The 1865 Indian Forest Act was India's first effort at a comprehensive forest law, with the primary goal of asserting the British monopoly over Indian forest land and giving the government undeniable ability to administer the forest and pastures. However, the 1865 Act had many gaps; as a result, the Indian Forest Act 1878 was revised, amended, and introduced new regulations for the smooth operation and scientific management of the Indian forest Gadgil and Guha 1992, Poddar 2011, Dhanaraju 2012). According to Sangwan (1999), the British Government formulated the Forest Act of 1878 following extensive debate among the colonial bureaucracy. For him, the colonial officials' argument over forest legislation was not monolithic; rather, multiple perspectives were expressed by the colonial bureaucracy on the sort of forest legislation that should be enacted for forest management in India. He contends that it was this discourse that influenced the Indian Forest Act of 1878 (Rangarajan 1994).

The Indian government's policy guidelines outlined forest classification, giving the Act legal structure. It was made applicable to Reserve Forests, Protected Forests, and Village Forests. These forests were established legally for the first time. It gave the Revenue and Forest Department complete jurisdiction over the forest and grazing lands. It gave the state the authority to effectively control the wasteland. Finally, the 1878 Act was supplanted with all law-related features and changed in 1927, becoming known as XVI of the Indian Forest Act 1927, which is still in effect (Dhanaraju 2012). Sampriti Panda (2024) argued that during the colonial period, legal and policy mechanisms moved forest rights from communities to the government. The common property had become state property, and the process of alienating village communities from the forest had begun. Forest was shifted from the union to the state list under the Government of India Act of 1935. Even after independence, the state maintained its power over forest products. During the colonial period, perceptions of the state's hegemony over forest resources shifted, with the forest becoming increasingly perceived as a 'property of the state' with enormous commercial potential. (Dhanaraju 2023). Even after 1947, the colonial system of forest administration remained largely unchanged, stressing income

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creation and commercial exploitation while excluding tribes with the most longstanding claim to forest resources. The National forests Policy of 1952 proposed that the country aspire to cover one-third of its total land area with forests. Though the 1952 Forest Policy was based on the 1894 policy, the current research (Dhebar 1961) argues that it went beyond the latter in encroaching on tribal rights. It was declared that forest policy should be based on critical national needs. In some ways, this was an extension of colonial British policy, with the expectation that the rights of populations living near woods would not take precedence over national interests. This forest policy separated woods into four categories: protected forests, national forests, village forests, and tree lands. Another significant commission was the National Commission on Agriculture in 1976, which advocated for the commercialization of forests at any cost and without consideration for the sustenance of forest peoples. In 1980, a draft forest bill was circulated in response to the National Commission on Agriculture's suggestions. The bill included provisions that reduced people's rights to forest lands and crops. As a result, the National Policy of India 1988 envisions people's involvement in forest protection and development to meet the growing demand for fuel wood, timber, and fodder in light of the challenges faced in forest protection and conservation, as well as meeting the community needs of tribal and other villagers in the forest neighbourhood. The National Policy of India has recommended a new structure for forest management. The ensuing policy resolutions by several state governments to encourage JFM are regarded as a bold move toward participatory development of Common Property Resources in India (Pattnaik and Dutta 1997, Khawas, 2003). As a result of the June 1990 circular, the JFM program was implemented in 22 states by 2000.

They are: Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Gujarat, Himachal Pradesh, Haryana, Jammu & Kashmir, Kerala, Karnataka, Madhya Pradesh, Mizoram, Maharashtra, Nagaland, Orissa, Rajasthan, Punjab, Sikkim, Tripura, Tamil Nadu, Uttar Pradesh, and West Bengal. Goa, Manipur, and Meghalaya have yet to adopt the JFM plan. So far, no Union Territory has opted for JFM. The program is overseen by a Joint Forest Management Cell in the Ministry's Forest Protection Division, and according to data provided by the JFM Cell as of 1-1-2000, 10.24 million hectares of forest are managed through 36130 JFM committees in 22 states. JFM is a method of empowering people to manage the use of forest resources, gain access to and control over non-timber forest products, share income from timber sales, and benefit from forest eco system services such as provisioning services (food, fuel, fibre, medicinal plants, etc.), regulatory services (water recharge, flood and storm protection), supporting services, and eco-tourism. The key feature of JFM is that communities have the authority to govern the use of forests by members while also excluding non-members. They profit from direct access and control over the use and sale of the majority of NTFPs, as well as a share of timber income and other intangible advantages from local ecosystem services such as water recharge, pollination, wildlife habitat, and so on. Thus, community involvement in forest and animal protection is extremely important. Recognizing the importance of communities in forest protection and management, the National Forest Policy of 1988 resulted in the JFM Circular of June 1st, 1990, and the subsequent 2000 and 2002 Guidelines, which established the framework for state-level ordinances, resolutions, and JFM guidelines.

Panchayat Extension to Scheduled Areas Act (PESA),1996 and the Forest Rights Act of 2006 (FRA) enhanced local communities' rights and obligations in relation to forests. Forest Committees are formed to coordinate efforts with villages. However, the FRA does not apply to the sixth schedule areas in northeast India, which include the Karbi Anglong Autonomous Council. The Forest Department and Forest Committees draft a micro plan for the development of forests and villages. Along with forest protection and development, the primary goal of this strategy is to provide the local population's forest-based needs, such as small timber, minor forest produce, fuel wood, leaves, grass, fodder, and so on, through the regulated use of forests. Furthermore, initiatives to improve agricultural and forest production and processing generate job opportunities in villages, discouraging residents from engaging in illegal felling and forest encroachment. Attempts are being made to meet the villagers' other basic needs in order to reduce dependence on forest resources.

Nature of Forest Management in Karbi Anglong
The colonial government, Assam state after independence, and the Karbi Anglong Autonomous District Council (KAAC) from its formation in 1952 developed and authorized the implementation of different forest and land policies. The Council passed several important acts and regulations, including the Assam Land and Revenue

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Regulation, 1886, the Assam Forest Regulations, 1891 (Regulation No. VII of 1891), the Mikir Hills (Land and Revenue) Act, 1953, the Mikir Hills District (*Jhumming*) Regulation Act, 1954, and the Mikir Hills District (Forest) Acts, 1957, among others (Dhanaraju, 2023). All of these policies were designed to restrict people's access to forest resources and jhum farming in the Karbi Anglong district. However, many modifications to this legislation have been made, but none of them have succeeded in protecting people's customary rights to natural resources. The Karbi Anglong district is divided into three forest territorial divisions namely Karbi Anglong East division, Karbi Anglong West division, Hamren division. The headquarters of the two territorial divisions are at Diphu and the Hamren Territorial is at Hamren. There was no proper management of administrative and forest reports in three divisions in particular prior to the formation of the district in 1951 except some old Reserved Forest files (WPKAED 2008). The main reason for this is that some of the old reserved forests presently managed by these three divisions were under the management of old Sibsagar Division, Dhansiri valley Division and Nagaon Division. The past system of management of these Reserve Forest could be traced back to the old reports of the respective division. It is known fact that this task becomes more difficult due to the fact that no files have been maintained for these three divisions till creation of separate Karbi Anglong district in 1976. The old records and forest dept files were difficult to trace out. Since 31st December, 1996 the administrative control of forest department has been transferred to Karbi Anglong Autonomous Council from the Government of Assam.

The role of the State Government has become advisory in nature. As said, the forest areas are controlled by three territorial divisions namely Karbi Anglong East Division, Karbi Anglong West Division and Hamren Division. Besides, there are three functional divisions namely: Northern Afforestation Division, Working Plan Division (Hills) and Silvicultural Division (Hills). Each Division is headed by a Divisional Forest Officer. All these divisions are under the supervisory control of Conservator of Forests, Karbi Anglong Circle, Diphu. At present Karbi Anglong is administered under an Autonomous Council and it is one of the oldest Autonomous Councils created under Article 244(A) under Sixth Schedule to the Constitution of India. For our purpose the land in the whole district it may is divided into the four categories, namely, the State Reserve Forests, the District Council Reserved Forests, the Unclassified Forests and Lands suitable for wet- paddy cultivation. The Unclassified Forests may be divided into two categories namely hills and low-lying forest lands. While in the hills the tribal people practice shifting cultivation, in the low-lying forest lands other types of cultivation are carried on by making the land suitable after proper reclamation as the hills are concerned the tribal people think themselves to common owners and the District Council Authority does not enter with this common ownership. In the low-lying forest lands, which people undertake cultivation, they may apply for ownership right to District Council Authority. If the Authority grants this right ownership, it is well and good and in case of refusal conflicts develops. The people rather consider it to be an infringement on their rights in forest. There are instances of conflict when the District Council Authority wants to use low lying forest lands in the vicinity of a village for some particular purpose. The people have actual ownership rights only on the wet- paddy lands which cannot be acquired for any public purpose without paying due compensation provided the owners have already been issued *pattas* (Bordoloi 1991).

Implementations of JFM in Karbi Anglong
The Karbi Anglong Autonomous Council adopted the Joint Forest Management (JFM) Rule, 2000, passed by the Assam government. JFM covered the majority of the USF areas, as well as additional District Council Reserved Forest (DCRF) and State Reserved Forest (SRF) sites in this district. The general goals of management are:
1. Encouraging community involvement in forest management through new policy.
2. To restore the deteriorated region with new plantations.
3. Encouraging nearby people to protect existing forest areas and support annual departmental plantation efforts.

The areas designated to this district's East Division (Forest) are given in a table no.2. The majority of the places are in close proximity to human settlements, as well as degraded landscapes. The overall area of scrub/degraded and poor forests in the RFs is 19262.44 ha in the East Division and 1428.53 ha in the Hamren Division. The JFMC could take these areas on an annual basis as part of the Forest Development Agency (FDA), which is required by the JFM Act. One of the most significant parts of JFM management is developing micro-level plans at the village level with the

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assistance of Village Forest Protection Committees. The forest records show that the forest department is unable to prescribe area-specific prescriptions for all Village Forest Protection Committees that will be constituted in certain places. Because a detailed PRA exercise is required to reflect the local communities' consumption and livelihood demands, as well as measures for satisfying these needs in a sustainable manner. However, the following suggestions are presented as broad principles while constructing the micro plans:

1. Forest management should include its environmental function, carrying capacity, conservation value, and biodiversity.
2. Provide appropriate recommendations for planting on community and government lands outside of declared forest zones.
3. Utilize locally accessible information and improve local institutions.
4. The Forest Officer and Village Protection Committee shall create the micro plan. The term may be determined by the Conservator of Forests in collaboration with the local committee. This study observed that people in this area rea were widely opposed to sustainable management. They view the forest area, regardless of whether it is USF or RF land, to be their own, and because of the ready availability of firewood, small timber, and other forest produce, they see it as a right rather than a benefit, yet they would like to make money from these forests.

The Usage of Indigenous Knowledge System

A vital aspect of implementing JFM is the utilization of indigenous knowledge system in JFM. Due to the mountainous terrain and presence of tribal communities in the forested areas, it is necessary to utilize indigenous knowledge in order to effectively implementing the forest management in Karbi Anglong district. The forest and indigenous communities have coexisted since centuries ago. The forests flourish in the areas where indigenous communities reside. This correlation exists only due to indigenous knowledge. Therefore, when implementing any forest management in this hilly region, it is crucial to focus on enhancing the local tribal villages' native expertise for effective implementation of forest management. The following recommendations were proposed for incorporating indigenous knowledge into the implementation of forest management in Karbi Anglong.

1. Ensure proper documentation and data base for Indigenous knowledge systems.
2. Commercial collecting of bio-resources from tribal habitats should be restricted.
3. Local indigenous people should not be forced to give up control of forest lands.
4. Integrating current scientific perspectives with indigenous knowledge is crucial for improving outcomes.

Challenges in implementing JFM

The implementation of JFM was not successful in this district due to a number of problems, including the availability of forest resources for human use, a lack of awareness, unsettled land status, a low population, community ownership, and so on. However, with appropriate modifications suited to the needs of this district, JFM was not able to bring about a rapid shift in people's mental attitudes about protecting forest resources. JFM is a decentralized, people-oriented forestry management approach that empowers citizens and strengthens democracy. This investigation also revealed some limitations in the area where JFM operates. They are:

1. One of the problems that forest officers and other government personnel experienced was a lack of knowledge of the socioeconomic and cultural value systems of the people who lived there.
2. Conflicts that had been found both within and outside of the villages, which are causing the process of implementing the JFM to be interrupted.
3. The absence of formal authority to the locally based institution. During the process of implementing the JFM into effect, the local authorities were not entrusted with adequate power.
4. Because of a lack of awareness, the JFM has become lacking in terms of the meaningful engagement of the people who are a part of it.
5. The topography of this district is characterized by expanses of countryside that are characterized by a low population density in communities.
6. Due to the abundance of forest resources in this district, the council is encountering difficulties in implementing the JFM project because of the broad areas and low population density.

7. Due to of the ambiguous legal standing of Un-classed State Forests (USF) lands, the community perceives it as their own property. There is a prevailing apprehension that the land will eventually be acquired by the government or Department.
8. There was a lack of non-governmental organizations (NGOs) operating in this district to effectively educate the local population, specifically regarding forestry practices.

Suggestions

The forest officials proposed the following proposals to ensure the successful execution of the JFM program. However, these recommendations did not yield positive results.

1. The JFM could have been implemented in the peripheral areas of the forest, within a radius of 5-10 km, where the local population still relies on the forest for their needs. Participation in such a program can provide alternative work opportunities and help develop new skills.
2. The effectiveness of JFM relies on an integrated development approach that takes into account other issues beyond only forestry. In order to instil confidence in the people, it was important to establish a set of procedures that allow the department to obtain approval from the Council authority for all the necessary provisions requested by the people.
3. The establishment of District Forest Development Agencies could effectively address numerous issues. This agency could be employed in the extraction of bamboo, MFP (Minor Forest Products), and other forest products to improve the livelihoods of people.
4. A non-governmental organization (NGO) could be established with the purpose of raising awareness among the population.
5. The comprehensive plantation program currently executed by the Forest/Soil Conservation department should be placed under the jurisdiction of the Joint Forest Management (JFM) system, with active participation from the local community.
6. The complete centrally supported system might likewise be executed via JFM.
7. The bamboo operation is a significant forestry activity carried out in this district. It can be implemented through JFM after carefully evaluating the advantages and disadvantages of such an operation with the involvement of the people.

Current Status of the JFM Scheme

Due to the non-applicability of the Forest Rights Act (FRA), 2006, and the Panchayat Extension to Scheduled Areas (PESA) Act, 1996 in the sixth schedule areas of northeast India, the Joint Forest Management (JFM) initiative has faced a serious threat to its existence, as is the case in the fifth schedule areas of India. However, since 2011, there has been a prevailing belief among policy makers that laws such as the Forest Rights Act (FRA) of 2006 and the Panchayat Extension to Scheduled Areas (PESA) Act of 1996 have been enacted, granting rights to indigenous people and those living in forests to access and manage forest resources. On the other hand, communities have asked for the substantial amounts that forest departments owe them as part of the scheme. There is debate on whether the program should be eliminated (Jishnu 2011). In 2011, a high-level group and the politically influential National Advisory Council proposed significant modifications to the program. The National Forest Rights Act Committee (NFRAC), established to assess the execution of the FRA, proposed the elimination of JFM committees in areas where community forest rights are acknowledged under the Act. The recommendation was to transfer the powers and resources of JFM committees to the committees of Gram Sabhas established under the Forest Rights Act (FRA). In addition, the National Advisory Council (NAC) proposed that in all forest villages, the responsibility for managing communal forest resources should be voluntarily transferred to the Gram Sabha, while the forest department should just serve as a facilitator. This implies a significant reduction in the size of JFM. Out of the 20 members of the NFRAC, ten members who disagreed proposed the elimination of JFM and the development of a different model based on the forest rights law for regions where community claims are rejected. It is worth noting that the Autonomous District Councils, as outlined in the sixth schedule of the Indian constitution, have been recommended to adopt alternative schemes similar to JFM by utilizing development blocs or other similar frameworks inside the JFM structure (Jishnu 2011). In 2008, the Indian Council of Forestry Research and Education in Dehradun conducted a mid-term evaluation

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of the National Afforestation Programme, which is an important source of funding for JFM. The evaluation found that JFM did not aim to fundamentally change the system of forest governance to prioritize the rights of communities while also achieving conservation goals. These programs were primarily designed to encourage local participation in predetermined objectives of traditional conservation by offering some concessions or labor incentives. The FRA signifies a shift in the framework governing forest governance. According to Madhu Sarin from the advocacy group Campaign for Survival and Dignity, the existence of JFM committees is now deemed redundant and potentially illegal, as communities now possess a legal entitlement to safeguard and oversee forests (Jishnu 2011). She argues that promoting JFM will undermine the management of community forests. N.C Saxena, the chairman of the committee responsible for implementing the Forest Rights Act, views FRA and JFM as mutually supportive. According to the FRA, communities are granted ownership rights solely to the community forest resources that they have traditionally utilized. Such areas are limited. In the remaining areas, JFM grants a certain degree of decision-making power to the communities, he argued. He also mentioned that the concept of JFM is not unfavourable. Instead of discarding it, one should consider eliminating the issues that afflict JFM (Jishnu 2011). Chetan Agarwal (2011), an expert on social forestry, supports that the FRA should take precedence over JFM in regions where it is appropriate. Additionally, a more enhanced version of JFM should be devised for the other areas, which can eventually transition into community forest management. He cautions that the implementation of the community forest rights clause of the FRA is challenging. Agarwal notes that the method for documenting these rights in forest and revenue records has not yet been determined in most states, and communities must struggle at each stage to secure their rights. Also, he states that ownership of timber in community forest rights is implicit rather than explicitly defined under FRA. Subsequently, the JFM scheme in the sixth schedule areas, including Karbi Anglong, have been declared invalidated.

CONCLUSION

After the implementation of the National Forest Policy in 1952, the Government of India grew more concerned with environmental exploitation, ecological deterioration, and our responsibility to all species on Earth. Subsequently, the preamble of the National Forest Policy 1988 reflects this shift in priority. It acknowledges that forest resources have become increasingly threatened due to relentless pressures arising from ever-increasing demand for fuelwood, fodder and timber; inadequacy of protection measures; diversion of forest lands to non-forest uses without ensuring compensatory afforestation and essential environmental safeguards; and the tendency to look upon forests as revenue-earning resource. Keeping in mind the objectives of the National Forest Policy of 1988, JFM has proposed by the policy maker as an essential intervention in forest management. In several parts of India, small village groups have begun to safeguard and reclaim degraded forestlands via collective action. The Joint Forest Management plan aims to foster collaboration between local community organizations and state forest agencies in order to manage public forest resources in a sustainable and mutually beneficial manner.

The fundamental goal of JFM is to guarantee that forests are used sustainably to meet local needs in an equitable manner while also ensuring environmental sustainability. Assam initiated the JFM initiative in 2000 with the aim of reducing encroachment into forest areas and improving the socioeconomic conditions of the rural poor. There was no scope or need for intrusion in designated areas because the emphasis was on community control and social fencing. However, ground realities were completely different especially in the case of Karbi Anglong. While implementing the JFM, a major issue faced by forest authorities and government staff was their inadequate knowledge of the socioeconomic and cultural value systems of the local villagers in Karbi Anglong. This lack of knowledge ultimately resulted in the failure of the scheme. While implementing the JFM, the local authorities were not given adequate power and also because of the uncertain legal status of Un-classed State Forests (USF) lands, the community regards them as their own property. There was a widespread concern among the local people that the government or Department will eventually take ownership of the land. Since 2011, policy makers have widely held the belief that laws such as the Forest Rights Act (FRA) of 2006 and the Panchayat Extension to Scheduled Areas (PESA) Act of 1996 have been implemented, providing indigenous people and forest dwellers with the rights to access and control forest

resources. However, these acts have not been applicable to the areas governed by the sixth schedule in Assam. The overlapping between FRA and the management of the JFM scheme at the village level had a crucial role in causing the crisis of the JFM system, ultimately resulting in its disappearance. After the disappearance of the JFM at the national level in India due to the FRA, initiatives to implement social forestry or community forestry at the village level in Karbi Anglong have also been unsuccessful due to the framing of alternative schemes on the similar line of the JFM initiatives in the sixth schedule areas of Assam.

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Table: 1 An Overview of Joint Forest Management until 2000

S.No.	State	Total Forest Area (Sq.Km)	Area under JFM (Ha.)
1	Andhra Pradesh	63,814	1,632,190.00
2	Arunachal Pradesh	51,540	5,285.00
3	Assam	30,708	3,060.00
4	Bihar	29,226	935,065.50
5	Gujarat	19,393	91,071.25
6	Himachal Pradesh	35,407	62,000.00
7	Haryana	1,673	60,733.58
8	Jammu & Kashmir	20,182	79,273.00
9	Karnataka	38,724	12,800.00
10	Kerala	11,221	4,000.00
11	Madhya Pradesh	154,94	5,800,000.00
12	Maharashtra	63,842	94,727.99
13	Mizoram	15,935	5,870.00
14	Nagaland	8,629	627.00
15	Orissa	57,184	419,306.00
16	Punjab	2,901	38,991.42
17	Rajasthan	31,700	235,634.00
18	Sikkim	2,650	2,191.00
19	Tamil Nadu	22,628	224,382.00
20	Tripura	6,292	16,227.30
21	Uttar Pradesh	51,663	34,569.36
22	West Bengal	11879	490,582.00
	Total	**731,688**	**10,248,586.40**

Source: Sahays (2003).

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Table:2 Area under the JFM Scheme in Karbi Anglong (2008)

S.No	Name of the Reserve Forest (RF)	Net area
1	Kaliyani R.F (East Division)	2,08,961.00 hac.
2	Jungthung R.F(East Division)	3.256.00 hac.
3	Sildharampur (East Division)	1,575.00 hac.
4	Nambor(West)R.F(East Division)	1,66,325.00 hac.
5	Jamuna DCRF (East Division)	11,30 sq km.
6	Patradisa DCRF (East Division)	67,339 sq km.
7	Longnit DCRF (East Division)	117,625 sq.km.
8	Hidipi DCRF (East Division)	20.080 sq.km.
9	Khonbamon DCRF (East Division)	165.496 sq km.
10	Mahamaya R.F(East Division)	22.65 sq km.
11	Amreng R.F (Hamren Division)	5694 hac.
12	Kolonga R.F(Hamren Division)	1735 hac.
13	Amreng (Hamren Division)	580 hac.

Source: WPKAED, 2008

RESEARCH ARTICLE

Identification of Potential Compounds from the Indian Medicinal Edible Mushroom for the Treatment of Lung Cancer – An *In silico* Approach

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ABSTRACT

Lung cancer remains a global health concern, representing a significant portion of cancer cases and deaths worldwide. In this study, 44 compounds were selected from *Laetiporus versisporus* for potential lung cancer treatment. Utilizing PubChem and SwissADME, compounds adhering to the Lipinski Rule of Five were chosen. The target protein, PKCiota kinase (UniProt ID: 3A8W), underwent docking studies with the compounds using PyRx 0.8. Ten compounds exhibited significant binding affinity, surpassing Selpercatinib. ADMET properties, evaluated with SwissADME, indicated favorable results, with compounds adhering to Lipinski's rule and showing diverse absorption patterns. The Boiled Egg image analysis highlighted compounds passive absorption and Blood-Brain Barrier permeation. Results demonstrated that 25-Hydroxyvitamin D2, Eburicoic acid, and (24RS)-28, 28, 28-trifluoro-25-hydroxyvitamin D2 exhibited the highest binding affinity with PKCiota kinase, outperforming Selpercatinib. Toxicity studies suggested low toxicity for the identified compounds, supporting their potential in lung cancer therapy. This study concludes that these compounds from *Laetiporus versisporus*, notably 25-Hydroxyvitamin D2, Eburicoic acid, and (24RS)-28, 28, 28-trifluoro-25-hydroxyvitamin D2, hold potential for the treatment of lung cancer.

Keywords: Lung cancer, Molecular Docking, PyRx, Discovery Studio, ADMET properties

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INTRODUCTION

Cancer is the appearance of aberrant cells that grow abnormally and also infect the neighboring cells of the body at any age and in both men and women. There are more than 200 types of cancer and the disease process begins at different locations and the causes are diverse [1]. The majority of the population lives in rural areas, where agriculture is their main source of income and ethnic medicinal herbs are their only source of revenue [2]. However, due to a lack of possible therapeutic targets, there are no effective medications. Broad-spectrum anti-inflammatory and anti-fibrotic drugs are the most often used corticosteroids, which invariably cause serious side effects such as TB infection, osteonecrosis, and gastrointestinal complaints during long-term clinical usage [3-5]. Lung cancer poses a significant threat to human survival, claiming numerous lives annually. Timely identification of pulmonary nodules is crucial for enhancing patient survival rates. Nodules, abnormal tissue growths, can manifest in various body areas, including deep skin tissues and internal organs. In the lungs, these growths are termed pulmonary nodules. Those with a diameter of three centimeters or lessare classified as tumors. Early detection becomes pivotal in the battle against lung cancer, as it enables swift intervention and improves the prospects of successful treatment, offering hope for those grappling with this formidable disease [6]. Tumors are broadly categorized as malignant, or cancerous, and benign, non-cancerous growths. Malignant tumors possess the ability to grow and metastasize throughout the body, posing a severe health risk. Conversely, benign tumors typically exhibit slow growth or remain static, often not recurring after removal. In the context of lung nodules, approximately 95% are benign, indicating a low cancer probability. However, larger nodules, exceeding 30 millimeters in diameter, heighten the likelihood of malignancy. Distinguishing between these tumor types is crucial for effective medical intervention, as it indicates the appropriate course of action and influences patient outcomes in the complex landscape of lung diseases [7]. Lung cancers are divided into NSCLC (non-small cell lung cancer) which represents 80%-85% of cases and SCLC (small cell lung cancer) which represents 10%-15% of cases. [8].Lung cancer has a poor overall survival rate, which raises the number of cancer diagnoses and fatalities worldwide, especially in developing countries with low economic status. Lung cancer is prevalent in men, constituting 17% of new cancer cases and 23% of cancer-related deaths.

Unfortunately, 70% of diagnoses occur at an advanced stage, resulting in a 5-year survival rate of about 16%. Early detection is crucial, offering a 70% 5-year survival rate. Smoking is a primary cause, though non-smokers can also be affected by various environmental factors [9]. Mushrooms, ubiquitous macrofungi, thrive in woodlands and cultivated farmland. Varieties of mushrooms exhibit medicinal prowess, showcasing anticancer, antioxidant, antimicrobial, antidiabetic and antiarthritic properties[10]. *Laetiporus versisporus*, commonly known as the "chicken of the woods" mushroom, is a fascinating fungal species with distinctive features and culinary significance. This mushroom, belonging to the family Polyporaceae, is renowned for its vibrant appearance, unique growth pattern, and ability to mimic the taste and texture of chicken when cooked. The mushroom typically forms large, overlapping clusters resembling shelves or rosettes on the bark of hardwood trees. It has been explored for its potential health benefits and medicinal properties. Some studies suggest that mushrooms, including certain species within the *Laetiporus* genus, may possess immunomodulatory and anti-inflammatory properties. These properties are attributed to bioactive compounds like polysaccharides and beta-glucans found in mushrooms [11].In an experimental study, it was shown that there was an increase in the expression of caspase-3 and caspase-9 after treatment with LVEE (*Laetiporus versiporus* ethanolic extract), which plays an important role in apoptosis. It was revealed that LVEE activated the p53 gene, causing a series of events that led to the activation of caspase-3 and finally apoptosis [12].Moreover, it exhibits a reduction in the expression of Bcl-2 signaling molecules, which has been reported as an anticancer mechanism in diverse types of cancer [13]. In the last 10 years, the use of the *in silico* method as an initial step in anticancer drug discovery and development has increased, especially the use of the molecular docking simulation method. The high number of docked molecules through *in silico* studies requires further research (*in vitro, in vivo*, and clinical trials) to obtain a new drug that has better performance than current therapy [14]. In the present study, the wild mushroom *Laetiporus versisporus* species was used to find bioactive compounds for the treatment of lung cancer.

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MATERIALS AND METHODS

Ligand selection

Using literature and the IMPPAT database [15], around 44 compounds were selected from the Indian medicinal mushroom *Laetiporus versisporus* to find potential compounds for treating lung cancer. The 3D structure of compounds was retrieved from the PubChem database [16], and using SwissADME [17],they were subjected to the Lipinski Rule of Five. From the results, 44 compounds obeyed the Lipinski Rule of Five and these compounds were taken for further study.

Target protein selection

The target protein PKCiota kinase to the 3A8W gene was found in the literature for lung cancer. The 3D structure of this target protein was obtained from the Uniprot database [18] as a modeled protein. The UniProt ID for this target protein was noted. Further, the modeled structure was evaluated using the SAVES v6.0 online server [19] and a Ramachandran plot was taken using this server.

Docking studies

Docking studies for the modeled target protein PKCiota kinase and the compounds (ligands) were done using the PyRx 0.8 software [20]. The target protein was further prepared for docking studies using this software. All the ligands were uploaded using the Open Babel option in PyRx 0.8. The grid was generated and the docking studies were performed using the Vina wizard option in PyRx 0.8. The values of binding affinity were saved in an XL file. The results were analyzed using Discovery Studio 2021 and the 2D and 3D docked images were taken. In the results, the lowest binding affinity indicates a good result.

ADMET and CYP properties

ADMET and CYP properties were tested for all the best-interacted compounds using SwissADME. Lipinski, BBB (Blood-Brain Barrier), HIA (Human Intestinal Absorption), PGP (P-glycoprotein), XLogP3, TPSA (Topological Polar Surface Area), LogS, Fraction Csp3, Rotatable bonds, CYP enzyme inhibitor properties, Skin permeation and Bioavailability score were evaluated for all the best-interacted compounds.

RESULTS AND DISCUSSION

Ligand and Target Protein selection

The 3D structure of ligands (compounds) was retrieved from the PubChem database. The 3D structure of the modeled target protein PKCiota kinase was obtained from the Uniprot database and its UniProt ID is 3A8W. The 3D structure of the modeled target protein is shown in Figure 1.

Docking studies

Docking studies were done for the compounds from the Indian medicinal mushroom *Laetiporus versisporus* and the target protein PKCiota kinase using PyRx 0.8 software to find the potential drug candidate for lung cancer. For this, 44 compounds that passed the Lipinski Rule of Five interacted with the target protein using this software. The results were analyzed using this software and Discovery Studio 2021 and binding affinity values were noted. In which, 10 compounds showed very good results with the target protein. Further, the synthetic drug Selpercatinib was also taken to find the interaction with the target protein. All the docking results are shown in Table 1. The 2D and 3D interactions of the compounds and the synthetic drug Selpercatinib with the target protein are shown in Figures 2-9. From the results (Table 1), among other compounds, 10 showed very good results with the target protein. Of which, the compound 25-Hydroxyvitamin D2 showed very good binding affinity (-9.6Kcal/mol) with the amino acid residues CYS 498, PRO 492, LYS 493, PHE 423 and ASN 358 of the target protein. The compound Eburicoic acid also had a very good binding affinity (-9.4 Kcal/mol) with the amino acid residues GLY 422, SER 424, ASP 420, ASN 358, PRO 500 and LYS 493. The binding affinity(-9.2 Kcal/mol) was observed between the compound (24RS)-28,28,28-

trifluoro-25-hydroxyvitamin D2 and the amino acid residues ASN 358, PHE 423, HIS 361, TRP 427, GLY 497 and PRO 492 of the target protein. Among the ten compounds, the lowest binding affinity (-8.1 Kcal/mol) was observed between the compound Versisponic acid E and the amino acid residues ASN 542, GLY 539, LEU 376, LEU 260, LYS 258, VAL 322 and PHE 297 of the target protein. Besides, the binding affinity of the synthetic drug Selpercatinib with the target protein was -8.4Kcal/mol and the interacted amino acid residues were HIS 499, PRO 500, GLY 497, ASN 358, GLU 362, GLY 394, ARG 396 and PHE 423. In the results of the present study, when compared to the synthetic drug Selpercatinib, most of the compounds showed very good binding affinity with the target protein PKCiota kinase.In the present *in silico* docking studies, the compound 25-Hydroxyvitamin D2, Eburicoic acid and (24RS)-28,28,28-trifluoro-25-hydroxyvitamin D2 from *Laetiporus versisporus* showed the highest binding affinity with the target proteinPKCiota kinase.

ADMET and CYP Properties

In the present study, ADMET properties were tested for the best-interacted compounds and the synthetic drug Selpercatinib using SwissADME and the results were tabulated (table 2). From the results, all the best-interacted compounds and synthetic drug obey the Lipinski rule of five. Most of the compounds did not cross Blood–Brain Barrier (BBB) and had High Intestinal Absorption (HIA). Many compounds were predicted not to be effluated from the CNS by P-glycoprotein. Similarly, few compounds are predicted to be effluated from the CNS by P-glycoprotein. Among the 10 compounds, the XLogP3 value of only 3 compounds was within the range. TPSA (Topological Polar Surface Area) and Log S values of all the compounds were within the limit. In the Fraction Csp3 value of all the compounds, only 1 compound was less than 0.25 and the value of other compounds was above this limit. The rotatable bonds of the compounds were within the limit. From the results of the Boiled Egg image of the compounds (Figure 10), the compound Deoxysappanone B 7,3'-Dimethyl Ether is located in the Egg-yolk region, which means the compounds are passively absorbed by the gastrointestinal tract and can also permeate through the blood-brain barrier and the compounds 25-Hydroxyvitamin D2,VD 2736, Versisponic acid A and Coumarine, 3-(2,4-dinitrophenyl)- are located in the Egg-white region, which means they are passively absorbed by the gastrointestinal tract but cannot permeate through the blood-brain barrier. Moreover, the compounds VD 2736, Versisponic acid A and Versisponic acid D are predicted to be effluated from the central nervous system by the P-glycoprotein and the compounds 25-Hydroxyvitamin D2, Eburicoic acid, Coumarine, 3-(2,4-dinitrophenyl)- and Deoxysappanone B 7,3'-Dimethyl Ether are predicted not to be effluated from the central nervous system by the P-glycoprotein. In the results of CYP properties (table 3), most of the compounds do not inhibit the CYP enzymes and do not give any adverse reactions. But, the compound 25-Hydroxyvitamin D2,VD 2736, Coumarine,3-(2,4-dinitrophenyl)-, Cholesterol sulfate and Versisponic acid E inhibits CYP2C9 and Deoxysappanone B 7,3'-Dimethyl Ether inhibits all the CYP enzymes respectively. The value of log Kp (Skin Permeant) is good for all compounds and A Bioavailability Score (ABS) is good for all the compounds.

CONCLUSION

In the present study, around 44 compounds were selected from the Indian medicinal mushroom and the target protein PKCiota kinase was subjected to *in silico* docking analysis to find the potential compounds for treating lung cancer. From the results, 6 compounds showed better results than the synthetic drug Selpercatinib. Among them, 10 compounds showed very good binding affinity with the target protein. Of which, the compounds 25-Hydroxyvitamin D2, Eburicoic acid and (24RS)-28,28,28-trifluoro-25-hydroxyvitamin D2 showed the highest binding with the target protein PKCiota kinase. Toxicity studies were also done for the 10 best-interacted phytocompounds and the results showed that the compounds had very less toxicity. Hence, the present study concludes that 25-Hydroxyvitamin D2, Eburicoic acid and (24RS)-28,28,28-trifluoro-25-hydroxyvitamin D2 from *Laetiporus versisporus* may have a potential ability in the treatment of lung cancer.

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Table 1: Interaction of compounds with the Target Protein

S.No	PubChem (CID)	Compound Name	Binding Affinity (Kcal/mol)	No. of Bonds	Interacting Residues	Bond Length (Å)
1.	5710148	25-Hydroxyvitamin D2	-9.6	6	CYS 498 PRO 492 LYS 493 PHE 423 PHE 423 ASN 358	5.07 4.85 5.32 4.95 5.07 2.23
2.	73402	Eburicoic acid	-9.4	7	GLY 422 SER 424 ASP 420 ASN 358 PRO 500 LYS 493 LYS 493	1.92 2.59 2.99 2.34 4.99 3.95 4.66
3.	9547226	(24RS)-28,28,28-trifluoro-25-hydroxyvitamin D2	-9.2	8	ASN 358 PHE 423 HIS 361 HIS 361 TRP 427 GLY 497 GLY 497 PRO 492	2.95 5.01 4.80 2.51 4.96 3.39 3.55 4.84
4.	24779637	VD 2736	-8.9	2	PHE 504 PHE 423	2.15 4.92
5.	139585362	Versisponic acid A	-8.9	4	HIS 361 TRP 427 PHE 423 GLU 419	5.40 2.19 4.87 2.60
6.	596144	Coumarine,3-(2,4-dinitrophenyl)-	-8.8	2	HIS 361 PHE 426	1.75 5.01

7.	16667741	Deoxysappanone B 7,3'-Dimethyl Ether	-8.3	9	PRO 492 CYS 498 GLY 497 PRO 500 GLY 422 HIS 361 ASN 358 PHE 423 PHE 423	4.97 3.56 3.73 3.33 2.22 3.61 2.47 4.79 5.04
8.	139585978	Versisponic acid D	-8.3	3	LEU 260 PHE 547 LEU 540	2.27 4.87 3.36
9.	65076	Cholesterol sulfate	-8.3	2	PHE 423 PHE 423	4.87 4.69
10.	139587892	Versisponic acid E	-8.1	7	ASN 542 GLY 539 LEU 376 LEU 260 LYS 258 VAL 322 PHE 297	3.54 2.83 4.88 2.53 3.80 3.73 3.77
Synthetic Drug						
11.	134436906	Selpercatinib	-8.4	13	HIS 499 PRO 500 GLY 497 GLY 497 ASN 358 GLU 362 GLY 394 ARG 396 ARG 396 ARG 396 ARG 396 ARG 396 PHE 423	4.96 3.68 3.20 3.38 3.40 3.48 3.55 3.44 3.53 3.52 3.97 3.69 5.17

Table 2: ADMET Properties of Compounds

S,No	PubChem (CID)	Compound Name	Lipinski	BBB	HIA	PGP-	XLOGP3	TPSA (Å)	Log S (ESOL)	Fraction Csp3	Rotatable Bonds
1.	5710148	25-Hydroxyvitamin D2	Yes	No	High	Yes	6.03	40.46	-5.87	0.71	5
2.	73402	Eburicoic acid	Yes	No	Low	Yes	8.00	57.53	-7.40	0.84	6

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3.	9547226	(24RS)-28,28,28-trifluoro-25-hydroxyvitamin D2	Yes	No	Low	NA	6.60	40.46	-6.50	0.71	6
4.	24779637	VD 2736	Yes	No	High	No	5.03	60.69	-5.35	0.60	7
5.	139585362	Versisponic acid A	Yes	No	High	No	4.87	97.99	-5.54	0.83	6
6.	596144	Coumarine, 3-(2,4-dinitrophenyl)-	Yes	No	High	Yes	3.20	121.85	-4.11	0.00	3
7.	16667741	Deoxysappanone B 7,3'-Dimethyl Ether	Yes	Yes	High	Yes	2.95	64.99	-3.77	0.28	4
8.	139585978	Versisponic acid D	No	No	Low	No	7.23	83.83	-7.15	0.82	8
9.	65076	Cholesterol sulfate	Yes	No	Low	NA	8.16	71.98	-7.41	0.93	7
10.	139587892	Versisponic acid E	No	No	Low	NA	7.14	80.67	-7.35	0.80	9
Synthetic Drug										
1.	134436906	Selpercatinib	Yes	No	High	No	2.50	112.04	-4.54	0.38	8

Note: Obey Lipinski: Yes means 0 violation & good, BBB (Blood - Brain Barrier): Yes means good, HIA (Human Intestinal Absorption): High means good, PGP- (Molecules predicted not to be effluated from the CNS by P-glycoprotein): Yes means good, Lipophilicity: XLOGP3 value between −0.7 and +5.0 means good, Polarity: TPSA between 20 and 130 Å^2 means good, Water Solubility (Log S scale: Insoluble < -10 < Poorly < -6 < Moderately < -4 < Soluble < -2 < Very < 0 < Highly): Log S value not higher than 6 means good, Saturation (Fraction Csp3): Fraction of carbons in the sp3 hybridization not less than 0.25 means good, and Flexibility (Rotatable bonds): No more than 9 rotatable bonds means good.

Table 3: Cytochrome P450 properties of compounds

S. No	PubChem (CID)	Compound Name	CYP1A2 inhibitor	CYP2C19 inhibitor	CYP2C9 inhibitor	CYP2D6 inhibitor	CYP3A4 inhibitor	Log K_P(Skin permeation) (cm/s)	A Bioavailability Score (ABS)
1.	5710148	25-Hydroxyvitamin D2	No	No	Yes	No	Yes	-4.54	0.55
2.	73402	Eburicoic acid	No	No	No	No	No	-3.49	0.85
3.	9547226	(24RS)-28,28,28-trifluoro-25-	No	No	No	No	Yes	-4.46	0.55

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		hydroxyvitamin D2							
4.	24779637	VD 2736	No	No	Yes	No	Yes	-5.49	0.55
5.	139585362	Versisponic acid A	No	No	No	No	Yes	-5.82	0.56
6.	596144	Coumarine, 3-(2,4-dinitrophenyl)-	Yes	Yes	Yes	No	No	-5.93	0.55
7.	16667741	Deoxysappanone B 7,3'-Dimethyl Ether	Yes	Yes	Yes	Yes	Yes	-6.12	0.55
8.	139585978	Versisponic acid D	No	No	No	No	Yes	-4.39	0.56
9.	65076	Cholesterol sulfate	No	No	Yes	No	No	-3.35	0.85
10.	139587892	Versisponic acid E	No	Yes	Yes	No	No	-4.42	0.56
Synthetic Drug									
11.	134436906	Selpercatinib	No	No	Yes	Yes	Yes	-7.73	0.55

Note: No means good, the compound does not inhibit the CYP450 enzymes and does not give any adverse reactions; Yes means the compound inhibits the CYP450 enzymes and gives unanticipated adverse reactions; The more negative the log K_P, the less skin permeant is the molecule; ABS 0.55 means it passes the rule of five & 0.17 means it fails the rule of five.

Figure 1: The 3D Structure of the modelled target protein PKCiota kinase	Figure 2: The 2D Interaction of compound 25-Hydroxyvitamin D2 with the Target Protein
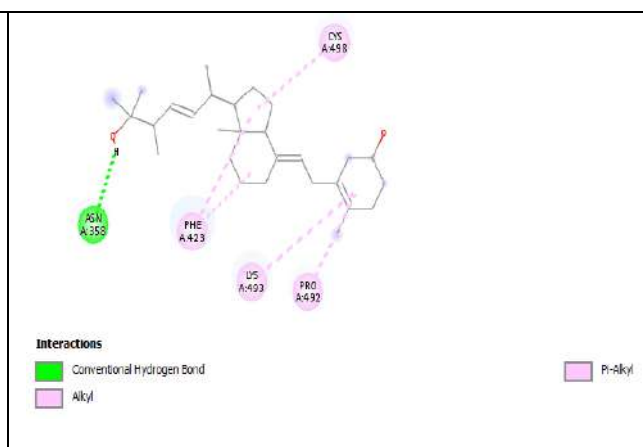
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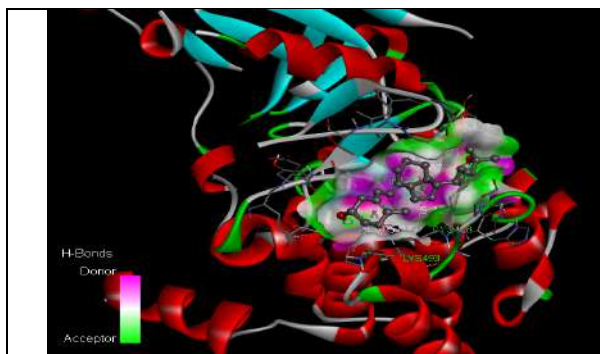
Figure 3: The 3D Interaction of compound 25-Hydroxyvitamin D2 with the Target Protein
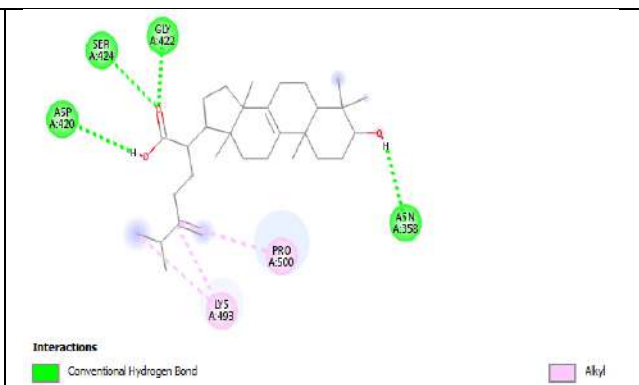
Figure 4: The 2D Interaction of compound Eburicoic acid with the Target Protein
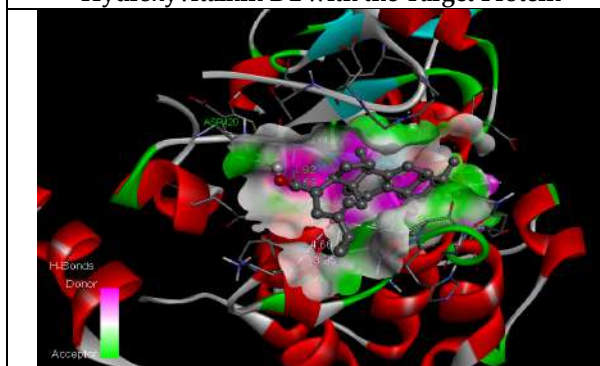
Figure 5: The 3D Interaction of compound Eburicoic acid with the Target Protein
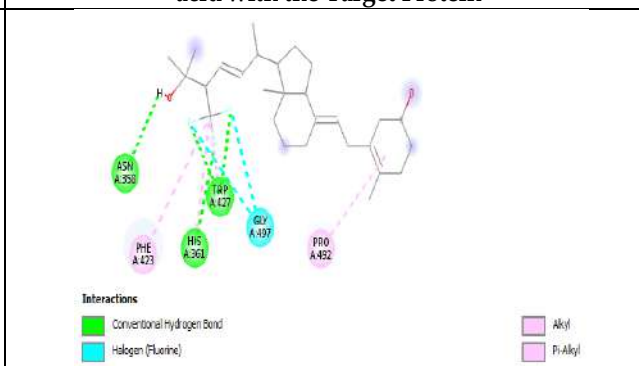
Figure 6: The 2D Interaction of compound (24RS)-28,28,28-trifluoro-25 hydroxyvitamin D2 with the Target Protein
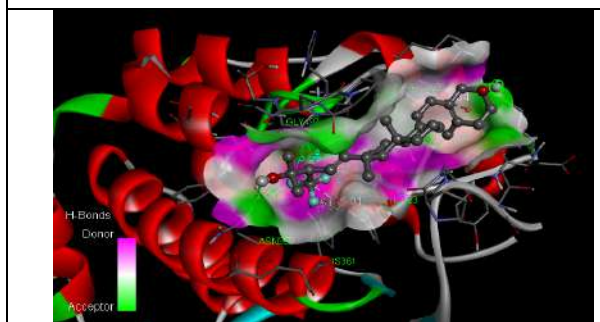
Figure 7: The 3D Interaction of compound (24RS)-28,28,28-trifluoro-25-hydroxyvitamin D2 with the Target Protein
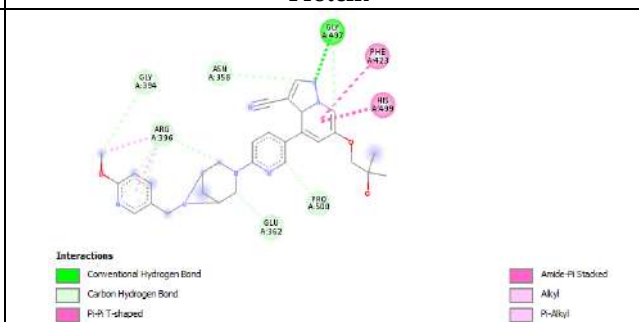
Figure 8: The 2D Interaction of compound Selpercatinib with the Target Protein

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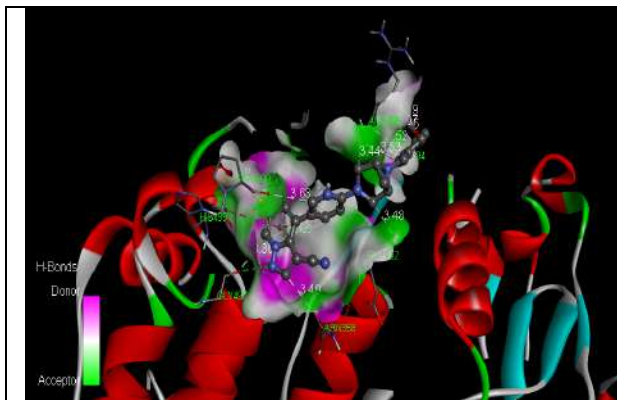
Figure 9: The 3D Interaction of compound Selpercatinib with the Target Protein	Figure 10: ADMET - Boiled Egg image of the best compounds
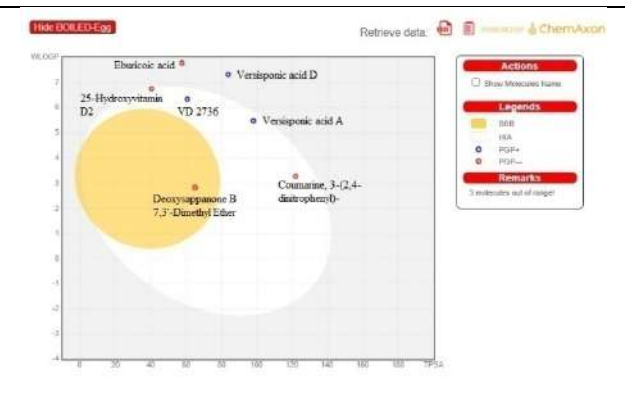
RESEARCH ARTICLE

Medical Visual Question Answering: Current Approaches, Datasets, and Performance Parameters

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ABSTRACT

Medical Visual Question Answering (MedVQA) has emerged as a critical research area, leveraging the synergy between medical imaging and natural language processing. This survey paper provides a comprehensive overview of the recent advancements in the field of MedVQA, highlighting key methodologies, datasets, challenges, and applications. The survey begins by introducing the motivation behind MedVQA, emphasizing the growing importance of combining medical image analysis with natural language understanding. Subsequently, we explore the methodologies used in existing literature. A significant portion of the survey is dedicated to reviewing benchmark datasets used in MedVQA research. Furthermore, we delve into the evaluation metrics commonly employed to assess the performance of MedVQA systems that capture both image understanding and natural language comprehension aspects. The paper concludes with an overview of potential future directions in MedVQA research. These include the integration of multimodal data sources, the incorporation of domain-specific knowledge, and the development of explainable and interpretable models. We emphasize the importance of collaborative efforts between the medical and computer science communities to accelerate progress and address real-world healthcare challenges. Overall, this survey serves as a valuable resource for researchers, practitioners, and healthcare professionals interested in understanding the current landscape, challenges, and opportunities in the rapidly evolving field of Medical Visual Question Answering.

Keywords: Medical Visual Question Answering(Med-VQA), Medical Image Classification, Natural Language Processing (NLP), Image encoding techniques, Text Encoding techniques

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INTRODUCTION

Medical Visual Question Answering (MedVQA) is an emerging research field that intersects medical imaging and natural language processing, aiming to enhance the interpretability and accessibility of medical image data[1]. This paper presents an overview of recent advancements in MedVQA methodologies, focusing on the integration of deep learning techniques to address the unique challenges posed by medical imagery. The study explores the application of convolutional neural networks (CNNs) for image feature extraction and recurrent neural networks (RNNs) or transformers for natural language understanding[2]. We delve into the significance of MedVQA in clinical decision-making, radiology reporting, and medical education, emphasizing its potential to assist healthcare professionals in extracting valuable insights from complex medical images[3]. Through a comprehensive review of existing literature and methodologies, this paper highlights the current state of MedVQA, discusses its applications, and outlines potential avenues for future research, including the incorporation of multimodal data and addressing ethical considerations. The advancement of MedVQA holds promise for revolutionizing medical image interpretation, fostering collaboration between healthcare professionals and intelligent systems for improved patient care and diagnostic accuracy[4]. Designing a Medical Visual Question Answering (MedVQA) system involves integrating various modules that collectively enable the model to understand, interpret, and respond to questions related to medical images. There are mainly four modules in any VQA model. Image feature extraction module, Question Feature extraction module, Feature fusion module, Classification/Answer generation module[5]. Image feature extraction module extract meaningful features from medical images using CNN, Pre-trained transfer learning models such as ResNet, VGG etc[6]. Question feature extraction module extracts features from questions using word embedding (e.g. Word2Vec, GloVe), RNN, LSTM[7]. Feature fusion module combine features from the input image and question modalities using concatenation or element wise multiplication of image and question features. Fusion of features can also be done using attention mechanism or joint embedding learning. Classification/Answer generation module will classify/generate correct answers using classifier or generative AI[8].

RELATED WORK

Medical Visual Question Answering (MedVQA) encompasses a diverse range of research efforts aimed at advancing the understanding and interaction with medical images through question answering. Early research in MedVQA focused on rule-based systems and handcrafted feature extraction methods. These approaches often relied on domain-specific knowledge bases and heuristic rules to generate answers to medical questions. While these approaches laid the groundwork for MedVQA research, they were limited in their scalability and generalization capabilities, as they heavily relied on manual engineering and lacked the ability to learn from data. The advent of deep learning has revolutionized MedVQA research by enabling end-to-end learning from raw data. Deep learning models, such as convolutional neural networks (CNNs), recurrent neural networks (RNNs), and transformer-based architectures, have shown promising results in effectively integrating visual and textual information for answering medical questions[9]. Here we give critical review of few research papers published in the year 2020 to year 2023.

By identifying the need of question classification, [10] proposed hierarchical deep multi modal network. Two level hierarchical model is introduced, in first level question segregation is done by TF-IDF word frequency method and SVM classifier to identify question type (Yes/No or other). For question feature extraction Bi-LSTM and Image feature extraction Inception-Resnet-V2 is used. Both the features are fused using batch normalization. In the second level, answer prediction, either of two models are used based on the type of question. For close ended questions (Yes/NO) fully connected layer with softmax activation function is used as two class (yes/no) classification model to predict answer. For open ended questions answer generation model with multi label class model is used. Separate word-index dictionary is created for answer. Softmax function with recursive prediction procedure is used to predict answer. Cross Entropy loss function is used in both the models. The proposed model applied to VQA-RAD and Image CLEF 2018 VQAMed dataset. Paper shows that QS model for 'Yes/No' type questions improves precision by

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0.3, recall by 0.1 and f1-score by 0.2 on RAD dataset and precision by 0.3, recall by 0.5 and f1-score by 0.2 on ImageCLEF 2018 VQAMed dataset. [11]proposed self-supervised transformer architecture with multihead attention. Similar to CGMVQA ResNet152 used for image feature extraction and BERT wordpiece tokenizer for question tokenization. The pair of 5 question token and image features given to BERT. Mask language modeling is applied to predict medical words from the caption provided by the dataset. Model was pre trained on ROCO dataset with masked language modeling and image features. A MultiView Attention Based Model[12]is proposed to embed higher level semantics of question and medical image. Multiview attention is guided by question importance learning. Due to small unlabeled dataset constrain, Model Agnostick Meta Learning (MAML) Model is used for image feature extraction and Convolutional De-noising Auto Encoder used for initializing weights. GloVe (Global Vector) Word embedding and GRU (Gated Recurrent Unit) is used for question feature extraction. For giving more attention on question two attention mechanism, Word-to-text and Image to Question attention, is applied. This result into accurately defining relationship between Image and Question. Composite loss function (classification loss + Image Question complimentary loss) is used to improve accuracy. Author also corrected VQA-RAD dataset and develop new VQA-RADph dataset for improving quality of data. [13]Author proposed separate module for question type reasoning to deal with specific task. This module initializes Separate methodology for open ended and close ended questions. Image feature extraction is done by MAML and convolutional unsupervised auto encoder (CDAE) and question feature extraction is done by LSTM encoder. Then these multimodal features are used in appropriate question type module. In both question type module fusion features are generated using elementwise multiplication method. Final answer is classified by MLP classifier. The proposed model achieved overall 71.6%, open-ended 60% and close ended 79.3% accuracy on VQA-RAD dataset. [14]proposed Medical VQA model that uses ViT32 model, transformer based image encoder and BERT like language encoder to extract image and question features. Both the features are concatenated using concatenation operator. The contrastive Language Image Pretraining (CLIP) model is used to jointly train multimodal features with goal to maximize similarity of truly corresponding image-text pair. The generative auto regressive decoder model is used to generate answer from concatenated multimodal features. [15]proposed model that uses recent CNN image encoder EfficientNetV2 as image feature extractor and BERT used for word embedding of questions. RealFormer architecture used for Mutimodal future extraction. proposed Question-Type Reasoning (QTR) and semantic space constraint (SSC) modules in MedVQA model. MTPT model, Multi-task pre-training (MTPT) model used for image feature extraction. This model is pretrained on various MRI, X-Ray and CT type of medical images. BioWordVec pre-trained model and LSTM used for question feature extraction. Both features are embedded using CMSA-cross-modal self-attention module. A question Type reasoning module used to guide model based on semantics of question information. Semantic constrain space define the similarity between the answers and high attention words from answers having higher correlation. Semantic loss function is calculated from predicted answers and reference answers given in dataset. "[17]proposed two branch hierarchical model, one is parallel structure model and second is image retrieval model. Author categorizes each type of question into further candidate answer types. a) If the current type of medical question has few candidates answer types, then it is passed to the parallel structure model. In parallel structure model transformer is used for classification. Image feature is extracted using ResNet152 and GRU. Spatial feature of medical image is extracted by CNN and sequence features are extracted by RNN. Question features are extracted using three-layer word embedding depending on PubMed corpus. Both image and question features are given to single transformer parallel. Self-attention module and feed forward network is used to combine the features of Image and Question. b) If the question type has more candidate answer types or complex for classification task then it is transferred to the image retrieval modal. This model will predict the answer for those questions whose answer is irregular, open ended or have many different answers possible. VGG 16 pre trained network without fully connected network layer is used to extract image features from last convolutional layer. Overall, these model increases results by 0.2%, 1.4% and 1.1% for datasets ImageCLEF 2018 VQA-MED, ImageCLEF 2019 VQA-MED, VQA-RAD respectively. [18]proposed MedFuseNet MedVQA model in which ResNet-152 model used for image feature extraction and BERT used for question feature extraction. Multimodal Factorized Bilinear Pooling (MFB) used for feature fusion. Power normalization and L-2 normalization is used to normalize output of MFB.Image attention and Image-Question attention mechanism is applied to identify important part of medical image form important word of questions to predict correct answer. Then classification module is applied to find loss and update model parameters as per requirement. LSTM based

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decoder model is use for answer generation module. MedFuseNet answer categorization model achieved accuracy score 0.84 for Modality category, 0.78 for plane category and 0.746 for organ category question of MED-VQA 2019 dataset, as well as accuracy score 0.636 on Yes/No question of PathVQA dataset. MedFuseNet answer generation model achieved 0.276 BLEU score on abnormality category question of MED-VQA 2019 dataset and 0.605 BLEU score on PathVQA dataset.[16]proposed CFF – Corresponding feature Fusion method. This method fused image features and question features of corresponding type (Organs such as chest, brain, abdomen) of images from SLAKE and VQARAD dataset. CNN based type classifier is used to classify input image and question. Then three ResNet-34 models separately used for feature extraction from three types of images. Pre-trained 200-D Bio Word Vec word embedding and LSTM is used to extract question features. Semantic attention is used for further semantic feature representation of specific type of questions. Then joint feature representation of image features and semantic features is passed to the answer prediction classifier to predict correct answer. The sum of cross entropy loss of answer prediction of three types of organs and loss of type classifier module is combined to calculate final loss for the modal evaluation.

From the above literature review, the above MedVQA models leverage techniques such as attention mechanisms, multimodal fusion, and transfer learning to achieve state-of-the-art performance on MedVQA tasks. Multimodal fusion techniques play a crucial role in MedVQA by integrating information from multiple modalities, such as images and text. Fusion strategies include early fusion, late fusion, and attention-based fusion, among others. These techniques aim to leverage the complementary nature of visual and textual information to improve the accuracy and robustness of MedVQA models, especially in scenarios where one modality may provide additional context or clarification for answering medical questions. Attention mechanisms have been widely adopted in MedVQA models to selectively focus on relevant regions of images or words in text when generating answers. These mechanisms enable models to dynamically allocate attention to informative regions or concepts, enhancing their interpretability and performance. Different attention mechanisms, such as self-attention, cross-modal attention, and graph attention, have been explored in the context of MedVQA, each offering unique advantages for capturing semantic relationships and context[19].Transformer-based architectures have been adapted for MedVQA tasks, where they excel in modeling the complex relationships between medical images and textual questions.These architectures can effectively process both image features extracted from convolutional neural networks (CNNs) and textual features obtained from pre-trained language models[20], such as BERT (Bidirectional Encoder Representations from Transformers)[21].Multimodal transformer architectures extend the transformer model to handle multiple modalities, such as images and text[18]. These architectures incorporate mechanisms for fusing visual and textual features at different layers of the transformer. Multimodal transformers leverage techniques such as cross-modal attention, where the model learns to attend to relevant visual and textual information simultaneously, enhancing its ability to generate accurate answers to medical questions[14].

BENCHMARK DATASETS
There are many different datasets are found in the literature reviews. The ImageCLEF (Image Retrieval in CLEF) MedVQA (Medical Visual Question Answering) challenge is an annual event organized as part of the Cross-Language Evaluation Forum (CLEF). It provides a platform for showcasing state-of-the-art techniques and fostering innovation in the development of intelligent systems for medical image analysis. Participants are provided with a dataset consisting of medical images along with associated textual questions. These questions typically inquire about various aspects of the images, such as identifying anatomical structures, diagnosing medical conditions, or interpreting medical findings. This challenge provided following datasets to the participants that are openly available for research: VQA-MED-2018, VQA-MED-2019, VQA-MED-2020, VQA-MED-2021[22], and MEDVQA-GI-2023. VQA-RAD and PathVQA datasets are also majorly used and publically available for research purpose.

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ImageCLEF VQA-MED Dataset

- The very first dataset available in medical VQA is VQA-Med-2018. Total 2866 images from PubMed central Articles and 6413 Question Answer pairs are available in this dataset. Total four categories question are present in this dataset. The categories of questions are Location Finding, Yes/No, Other[23].
- In ImageCLEF-VQA Med 2019 challenge VQAMed 2019 dataset was given to the competitors. This dataset is categorized in four type of questions - modality, plane, organ system and abnormality. The dataset contains a training set of 3200 images, 12792 QA pairs, a validation set of 500 images, 2000 QA pairs and a test set of 500 images, 500 QA pairs. [11].
- In ImageCLEF 2020 challenge VQA-Med-2020 [13] is published with 1001 medical images and 2400 questions. All question is of abnormality category. In this challenge VQG (Visual Question generation) task is first time introduced in the Medical VQA field.[23]
- In the ImageCLEF 2021 challenge VQA-Med-2021 dataset was published. This dataset is based on the same methodology of VQA-MED-2020 Visual Question Generation [23].
- In the year 2023 ImageCLEF medVQA challenge MEDVQA-GI 2023 dataset published to identify lesions in endoscopy image. This dataset contains development set and test set of 3949 image samples (based on Hyper Kvasir dataset) with 18 question answer pair per image. Questions categorized in to 18 categories with multiple possible answers. The images are taken by gastroscopy, colonoscopy and capsule endoscopy that include entire gastrointestinal tract, from mouth to anus, and also include abnormalities, surgical instruments, and normal findings[24].

VQA-RAD Dataset

VQA-RAD dataset provides 315 images and 3515 question answer pair for Med-VQA task. These questions answer pair can be broadly categorized into open ended and close ended with different 11 categories (As per Table-2). Images of this dataset contains of head, chest and abdomen organ. Table-2 shows detail categorization of training set and test set of VQA-RAD dataset[12].

PathVQA

PathVQA dataset contains 4998 images collected from two pathology textbooks: "Textbook of Pathology" (Muir et al., 1941) and "Basic Pathology" (Robbins et al.,1981), and PEIR1 digital library. Total 32,795 question-answer pairs are generated using 8 categories of questions such as what, where, when, whose, how, why, how much/how many, and yes/no. Table-3 shows summary of each category. Total 16,466 questions fall in first 7 categories are open-ended and remaining questions are close-ended (yes/no) questions[25].

The creation of large-scale datasets specifically designed for MedVQA has been instrumental in driving research progress in the field. Datasets such as MedVQA, VQA-RAD, PathVQA provide annotated pairs of medical images and questions, enabling researchers to train and evaluate MedVQA models. These datasets vary in terms of imaging modalities, question types, and annotation methodologies as shown in Table-4, catering to different research needs and scenarios in medical imaging and question answering.

EVALUATION PARAMETERS

The Medical VQA task can be categorized broadly in two types: i) Classification ii) Answer generation. In classification type of Medical VQA task following evaluation parameters or matrices are used:

- **Precision (P):** In VQA, precision measures the accuracy of the model's answers when it predicts a certain class or label for a question. Precision in VQA can be calculated by considering the number of correct answers provided by the model divided by the total number of answers predicted by the model for which it claims to be correct[10].
- **Recall (R):** In VQA, recall measures the model's ability to provide correct answers for all relevant questions. It indicates how well the model can capture the correct answers among all the possible correct answers for a

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given question[10]. Recall in VQA can be calculated by considering the number of correct answers provided by the model divided by the total number of correct answers for the questions asked.

- **F1-score (F1):** The F1 score in VQA combines both precision and recall into a single metric to provide a balanced evaluation of the model's performance. It takes into account both false positives (incorrect answers predicted by the model) and false negatives (missed correct answers).F1 score is particularly useful when there is an imbalance between the number of positive and negative instances, which is often the case in VQA datasets. F1 score [10]in VQA can be calculated using the formula

$$F1 = \frac{2 \times Precision \times Recall}{Precision + Recall} \quad (1)$$

- **Accuracy (A):** Accuracy in VQA measures the overall correctness of the model's answers across all questions. It indicates the proportion of correctly answered questions out of the total number of questions asked[10]. A model with high accuracy provides correct answers to a large majority of questions asked about the images. Accuracy in VQA can be calculated by considering the number of correct answers provided by the model divided by the total number of questions asked.

$$Accuracy = \frac{\#correctly\ anwered}{\#total\ questions} \quad (2)$$

In answer prediction or generation type of Med VQA task following evaluation parameters are widely used:

- BiLingual Evaluation Understudy (BLEU)) In MedVQA, BLEU can be used to measure the similarity between the answers generated by the model and the reference answers provided by human experts/ Ground truth given in test dataset. It works by comparing n-grams (sequences of n words) between the model's answer and the reference answer[10]. In medical terminology often more than one word is used for some organ or symptom or disease. In such cases BLEU score is not effective. For example for lungs the other word lobe may also be used.
- Word-based Semantic Similarity (WBBS) WBBS measures the similarity between words or phrases based on their semantic meaning[10]. In the context of MedVQA, WBBS can be used to assess how closely related the model's answers are to the reference answers in terms of their underlying medical concepts and semantics. One way to compute WBBS is by using pre-trained word embedding or language models to represent words or phrases as dense vectors in a high-dimensional space. Similarity between words or phrases can then be calculated using measures such as cosine similarity. WBBS provides a more nuanced understanding of the semantic similarity between answers, which is crucial in medical applications where precise and contextually relevant answers are essential. In summary, while BLEU score can provide a basic evaluation of textual similarity in MedVQA, WBBS offer more nuanced assessments of semantic similarity and relevance, which are crucial for evaluating the quality of answers in medical contexts. These metrics can complement each other to provide a comprehensive evaluation of MedVQA systems.

CONCLUSION AND FUTURE WORK

This paper presented an advancements in the field of Medical visual question answering. Comprehensive review of the latest medical VQA approaches, datasets, challenges and evaluation parameter are presented in this paper. We reviewed recent medical VQA papers and datasets majorly used by researcher for Med-VQA task. Along with this we comprehended challenges faced by researchers in this multimodal task. These challenges are always being thrust for researchers. From the literature review we observed that the available Med-VQA datasets are very small in size and poorly annotated. Medical image datasets are hard to generate because it needs a lot of professional rather medical expertise to label them[26]. To increase the performance of a small dataset data augmentation or transfer learning may be used in Med-VQA approach[27]. Attention mechanism may improve multimodal feature extraction and concatenation based on semantics of question and important region of medical image[18]. CNN models requires a large amount of labelled training data, and the available datasets are relatively small and mis-labelled or not labelled[28]. The accuracy of Medical VQA is still lacking behind the level of human doctors. Open ended questions should be focused more in future work for finding abnormality in images. Answer classification accuracy is still more than the answer generation mechanism. So generative models should be enhanced to improve overall accuracy of

MedVQA. Future work should focus on addressing the pressing issues of multimodal integration, interpretability, robustness, and generalization. The seamless integration of various data modalities, including textual reports and patient records, could significantly enhance the holistic understanding of medical contexts. Multi modal vision language transformers may be used for better results in future work[15]. As well as pre trained text encoders trained on medical data such as PubMed library of medical sciences can be used in future work[29].

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Table 1. Performance comparison of different models

Model	Dataset	Performance
GUPTA ET AL., 2021	• VQA-MED 2018 • VQA-RAD	• BLEU: 0.132, WBBS: 0.162 • BLEU: 0.411, WBBS: 0.437
KHARE ET AL., 2021	• VQA-MED 2019 • VQA-RAD	• Accuracy: 67.2, BLEU: 69.0 • Accuracy:72.0
PAN ET AL., 2021	• VQA-RAD	• Accuracy: 74.28
ZHAN ET AL., 2020	• VQA-RAD	• Accuracy: 71.6
BAZI ET AL., 2023	• VQA-RAD • PathVQA	• Accuracy: 78.9 • Accuracy:73.11
SILVA ET AL., 2023	• VQA-MED 2019	• Accuracy: 62.8, BLEU:64.32
WANG ET AL., 2022	• VQA-RAD	• Accuracy: 74.1
S. LIU ET AL., 2022	• VQA-MED 2018 • VQA-MED 2019	• WBBS:0.188, BLEU:0.162 • Accuracy:0.654, BLE:0.687

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	• VQA-RAD	• Accuracy:0.727, BLEU0.753
ZHU ET AL., 2022	• VQA-RAD	• Accuracy:75.4

Table 2. VQA-RAD: category wise training and test set question answer pair count

Category	Modality	Plane	Organ	Abnormal	Presence	Position
Training Set	154	94	49	317	1232	506
Test Set	33	26	10	56	167	60

Table 3. PathVQA: category wise training and test set question answer pair count

Category	Yes/No	What	Where	How	How Much/ Many	Why	When	Whose
Total Questions	16,329	13,401	2,157	595	139	114	51	9

Table 4. Details of different MedVQA dataset[23]

Dataset	No. of Images	No. of QA Pair	Question Categories	Image Source
VQA-Med-2018	2866	6143	Location, Yes/No, Other	PubMed Articles
VQA-Med-2019	4200	15292	Modality, Plane, Organ system, Abnormality	MedPix
VQA-Med-2020	5000	5000	Abnormality	MedPix
VQA-Med-2021	5000	5000	Abnormality	MedPix
VQA-Med-2023	3949	71082 (Approx)	abnormalities, surgical instruments, normal findings and other artefacts	HyperKvasir
VQA-RAD	315	3515	Modality, Plane, Organ system, Abnormality, object Condition/presence, position, color, Size, Attribute, Counting, Other	MedPix
Path-VQA	4998	32799	Color, Location, Appearance, Shape etc.	Pathology textbooks
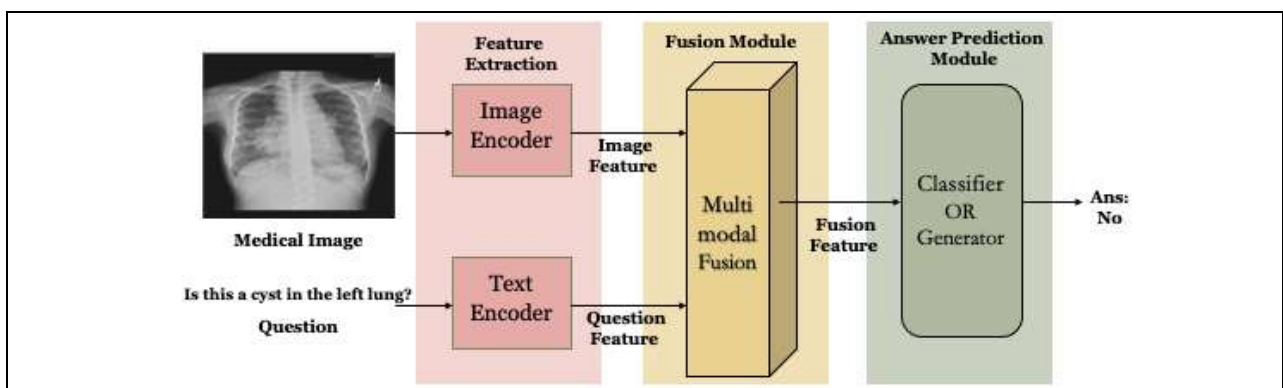
Fig.1. MedVQA framework.

RESEARCH ARTICLE

Hydroxyurea Therapy Alters the Subcellular Localization of Inducible Nitric Oxide Synthase in the Blood Cells of Sickle Cell Disease Patients: An Immunogold Labeling and Morphometric Study

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ABSTRACT

Hydroxyurea (HU) is a United States Food and Drug Administration (FDA) oral medication available with proven disease-modifying benefits for sickle cell disease (SCD) therapy. HU increases the bioavailability of nitric oxide (NO) through the action of enzyme nitric oxide synthase (NOS). Since NO cannot be stored in cells, it must be synthesised freshly in order to function. NO is highly diffusible, its presence at the right time, in right amount at right place is important and thus subcellular distribution of inducible NOS (iNOS) in blood cells of SCD patients is therefore a key factor in NO production. Immunogold labeling studies of iNOS subcellular distribution in the neutrophils, platelets, and red blood cells (RBCs) of SCD patients was done post hydroxyurea therapy and blood cells were observed under transmission electron microscopy. The morphometric analysis was done to determine the comparative distribution of iNOS in subcellular compartments of neutrophils, platelets, and red blood cells of SCD patients and the patients on hydroxyurea treatment (SCD-HU) as compared to controls. HU treatment significantly increased the iNOS expression in blood cells. This immunogold electron microscopic study provides the first evidence of alteration in subcellular distributions of inducible NOS in the blood cells post HU treatment.

Keywords: Inducible nitric oxide synthase, hydroxyurea, sickle cell disease, neutrophils, erythrocytes, platelets

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INTRODUCTION

Sickle cell disease (SCD) is a hereditary hemoglobinopathy which is caused due to a single amino acid substitution in β-haemoglobin chain causing deformability of RBC, increased cellular adhesion and obstruction in microcirculation [1]. RBC containing sickle hemoglobin have the typical biconcave discoid shape when combined with oxygen, but after removal of oxygen, a sudden change in the cell occurs, often giving it a sickle shape. Sickled RBC either block the normal circulation or destroy themselves [2]. Neutrophils are leucocytes that participate and initiate the vaso-occlusive process, once recruited to the activated endothelium, they attach themselves to circulating erythrocytes and establish adhesive interactions with them. Reduced blood flow results from trapped sickled red blood cells. In order to promote vaso-occlusion, activated platelets attach themselves to leukocytes, sickle erythrocytes, and endothelium [3]. Around 250 million people worldwide currently carry the gene that causes hemoglobin disorders such as SCD [4]. Hydroxyurea (HU) is the drug approved by United States Food and Drug Administration (FDA) for SCD therapy. It effectively raises hemoglobin and fetal hemoglobin (HbF) levels. The exact mechanism by which HU raises HbF levels appears to be mediated by erythroid cells' soluble guanylyl cyclase being activated in a NO-dependent manner [5,6]. HU has additional effects, including increasing NO production [7], improving RBC hydration [8], decreasing RBC adhesiveness to the endothelium [9], inhibiting platelet aggregation [10] and adhesion molecule's action on leukocytes and endothelial cells [11]. The control of arginase activity and the concurrent stimulation of iNOS activity, which results in an increase in NO generation, may be two of the advantageous effects of HU *in vivo*. Individuals with SCD tend to have a lower NO bioavailability and hindered NO-dependent blood flow [12]. Electron microscopy has been used to explore the three-dimensional structure of tissues or cells, the molecular basis and causes of disease, and the structure of viruses and proteins [13]. Immuno gold labeling and morphometric analysis have been used to identify specific antigens in the different subcellular compartments of cells [14]. Previous studies involving immune gold labeling and morphometric analysis have revealed iNOS subcellular localization in neutrophils and eosinophils subcellular compartments [15,16]. Subcellular compartmentalization locales of peroxisomal proteins, GABA-immunoreactive (GABA-IR) terminals, interendothelial junctions, secretory granules in rat pancreas have been determined by their immunolabeling density with gold particles in previous studies [17-21]. The goal of the current investigation was to determine the presence and alteration of subcellular distribution of iNOS in blood cells after hydroxyurea treatment. The rate and effectiveness of the enzyme iNOS catalysis are determined by the microenvironment of the subcellular organelles. This, in turn, affects the synthesis of NO at different intracellular locations. The goal of the current work was to evaluate the intracellular distribution of the iNOS isoform using transmission electron microscopy and morphometric analysis of the blood cells of SCD and SCD-HU patients.

MATERIALS AND METHODS

Antibodies and Reagents
Monoclonal antibodies to iNOS (N-9657), were purchased from Sigma-Aldrich (St. Louis, MO). Uranyl acetate was procured from Polaron Equipment (Watford, UK). Monoclonal anti-human iNOS (C-11) was obtained from Santa Cruz (USA). Goat anti-rabbit and goat anti-mouse protein A gold were purchased from Amersham Pharmacia Biotech (Uppsala, Sweden). All other chemicals were procured from Sigma-Aldrich (St. Louis, MO).

Human Subjects
Research included SCD patients which were diagnosed as hemoglobin S (HbS) homozygous (using HPLC and Hb electrophoresis technique), in a steady diseased state (attended by Haematology and Haemotherapy Center, University of Campinas, Campinas, Brazil) and SCD patients on HU treatment (20-30mg/kg/day for a minimum of 3 months). A group of healthy volunteers (age group 18-50 yrs of either sex), composed of students/members of staff of the UNICAMP were used as controls. Informed consent was obtained from all patients and controls, and the study was approved by the Ethics Committee of the University of Campinas (UNICAMP), in accordance with the Helsinki Declaration of 1975.

Isolation of cells from peripheral blood of subject:

Blood was collected in sodium citrate (0.129 M, 9:1 v/v, pH 6.5). As previously reported, the buffy coat was purified from human blood [16, 22]. In brief, blood was centrifuged at 250 g for 20 minutes at 20°C in order to extract platelet-rich plasma (Sigma Centrifuge, Germany). The platelet-poor plasma (PPP) above the buffy coat was removed until about 1 ml of PPP remained after centrifuging the remaining blood at 1000g for 20 min, 20°C. The buffy coat was then left to fix for 8–12 hours after 1 ml of 2X (4% paraformaldehyde and 1% gluteraldehyde) fixative was gradually added to the side of the test tube. After careful removal of the fixative, the buffy coat was taken out using a spatula. Tiny pieces of fixed buffy coat (approx. 1 mm^3) were chopped with a sharp blade and washed with PBS two times before processing them for observation under electron microscopy.

Observation of Blood cells under Transmission Electron Microscope

Using transmission electron microscopy (TEM), platelets, erythrocytes, and neutrophils in a buffy coat were identified. Pieces of the buffy coat were thoroughly cleaned five times in PBS. After three hours of fixing in buffered 1% osmium tetroxide, they were dried in an ascending series of ethanol, and at last, they were embedded in Epon and Araldite plastic resin [23]. Ultra Cut ultramicrotome (Leica, Austria) was used to cut ultrathin sections (80–100 nm), which were then contrasted with lead citrate and uranyl acetate before observing them at 80 kV using an FEI Philips Transmission Electron Microscope (Tecnai- SPIRIT).

Immuno gold electron microscopy of Blood cells

The buffy coat was fixed with 1% (v/v) glutaraldehyde and 2% (w/v) paraformaldehyde in PBS (pH 7.4) overnight at 25°C. After cutting the fixed buffy coat into tiny pieces with a razor, the pieces were given thorough washing in PBS five times, gradually dehydrated in an ascending series of ethanol, and were then embedded in LR White resin [16]. Blood cells embedded in resin were cut into ultrathin sections (80–100 nm) and collected on nickel grids using the Ultra Cut ultramicrotome (Leica, Austria). After blocking the sections for 30 minutes in PBS containing 0.1% BSA (w/v), 0.1% Teleost Fish gelatin, and 0.05% (v/v) Tween-20, the sections were incubated with antibodies against iNOS (1:200 dilution in the blocking solution) overnight. The sections were blocked five times with blocking buffer, then treated for two hours at 37°C with a 10 nm gold-coupled goat anti-rabbit secondary antibody (1:20). They were then contrasted with lead citrate and uranyl acetate and viewed with an 80 kV FEI Philips Transmission Electron Microscope (Tecnai SPIRIT). The primary antibody incubation stage was omitted for the negative controls.

Morphometric examination of Blood cells

A quantitative assessment of the gold particle density was made in platelets, erythrocytes, and neutrophils in steady state SCD patients, and patients on hydroxyurea therapy compared to controls. iNOS antibodies and a polyclonal secondary antibody coupled to 10-nm gold particles were used to immunogold label the cells. For this analysis, a total of six grids from three separate experiments with label iNOS were included. As previously mentioned, electron micrographs were taken at a magnification of 11000X for the morphometric study [15, 24, 25]. The Scion Image processing program 4.0.3.2 was used to calculate the labeling density of iNOS (number of gold particles/µm^2). In control cell preparations; negligible gold particles were found in the cells. The paired t-test was used to statistically compare the data to the nonspecific labeling densities.

Statistical Evaluation

The mean+S.E.M. of 20 cells from five separate tests in each group was used to express the results. Unpaired "t" tests were used to compare the two groups. At $p<0.001$, the results were considered significant.

RESULTS

Electron microscopic examination of the buffy coat made possible exploration of various blood cells with minimal processing to avoid stimulation and reduce the time taken to isolate the cells. The study was done mainly in platelets,

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erythrocytes, and neutrophil cells utilizing electron microscopy and a morphometric analysis of the expression of the iNOS isoform (expressed as number of gold particles/area of the cells).

iNOS immunegold labeling in erythrocytes of SCD and SCD-HU patients

iNOS immunolabeling was observed to be less in steady state SCD patients compared to controls. Fig 1 shows the immunogold labeling of iNOS isoforms in the normal RBC (Fig 1, a, b) and sickled RBC from SCD patients (Fig 1 c, d). Magnified view of part of RBC (Fig 1a) has been shown in Fig 1b. The gold particle corresponding to the iNOS protein inside the cell have been shown by arrows (Fig 1). Fig 1c shows a sickled RBC from SCD patients, iNOS immunolabeling was found to be decreased in sickled RBC from SCD patients. Magnified view of a part of RBC from SCD patients (Fig 1c) has been shown in Fig 1d. Figs 1 e, 1f demonstrate iNOS labeling in the RBC from SCD patients on hydroxyurea treatment. iNOS immune staining in the RBC of SCD-HU patients was found to be more compared to RBC of SCD patients without hydroxyurea treatment (Fig 1 f, d respectively).

iNOS immunogold labeling in platelets of SCD and SCD-HU patients

Fig 2 shows the immunogold labeling of iNOS isoform in platelets. Similar pattern of decreased immunostaining was observed in the platelets of individuals with steady sickle cell disease (Fig 2b) compared to controls (Fig 2a), which was seen to be increased in patients on HU treatment (Fig 2c). The gold particle corresponding to the iNOS protein inside the cell have been shown by arrows (Fig 2 a,b,c). iNOS immunostaining in platelets from SCD-HU patients was found to be increased compared to SCD patients without hydroxyurea treatment (Fig 2 c, b respectively).

iNOS immunogold labeling in neutrophils of steady state SCD patients and SCD-HU patients

Labeling of iNOS is clearly visible in the nucleus as well as in the cytoplasm (Fig 3). iNOS immunostaining in control neutrophils is also shown in Fig 3. The localization of iNOS was also evident in the close proximity of the nuclear membrane (Fig 3). Figure 4a shows the subcellular distribution of iNOS in neutrophils of steady state SCD patients. iNOS staining were found to be decreased in the cytoplasmic compartment. However, not much difference in immunostaining of iNOS was evident in the nuclear compartment of neutrophils in the diseased condition as seen in Fig 4a. iNOS staining was also observed in the mitochondria as shown in Fig 4a. iNOS immunolabeling were observed to be increased in SCD-HU patients (Fig 4b). Closer examination revealed that iNOS is present in both the nuclear and cytoplasmic compartments in controls (Fig 3) as well as in patients (Fig 4a, 4b). The cytoplasm of neutrophils from SCD-HU patients showed enhanced immunostaining (Fig. 4b), whereas neutrophils from SCD patients showed decreased immunostaining (Fig. 4a). iNOS staining was prominent near the nuclear membrane (Fig 4b, arrowheads) and was visible in the nuclear compartment as well (Fig 4b, white arrows) after HU treatment.

Morphometric analysis of iNOS immunolabeling in SCD

Evaluation with 5 nm gold particles was obscure and difficult to differentiate from electron dense granules scattered in the cytoplasm and heterochromatin region of the nuclear lobes. Experiments were therefore conducted with 10 nm gold particles which were distinct, easier to count, and more convenient for morphometric analysis. Table 1 shows the morphometric analysis of the iNOS distribution in platelets, erythrocytes, and neutrophils of patients with steady state sickle cell disease and patients on hydroxyurea therapy compared to controls. No appreciable binding was seen in case of labeling only with secondary antibody (coupled with 10 nm gold particles).

DISCUSSIONS

SCD is a life-threatening condition that is characterized by hemoglobin polymerization leading to erythrocyte rigidity, hemolysis, and vaso-occlusion. The disease is characterized by the sickle shaped RBC, which poses multiple threats to human health, causing reoccurring pain, mainly in bones and joints and intermittent vaso-occlusive crises [26]. The goals for the treatment of sickle cell disease primarily include prevention and control of symptoms and complications. HU, a preventive drug approved by FDA for use in adults with SCD, is the drug proven to modify the disease process by improving hematologic parameters and hospitalization [27]. HU, as a source of NO plays an

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important role and has drawn considerable interest as a sickle cell disease treatment [28]. Hydroxyurea increases total hemoglobin and HbF in SCD, inhibits HbS polymerization, reduces gelation and sickling of erythrocytes [29]. Studies have demonstrated the metabolism and formation of NO from hydroxyurea in human blood [30, 31]. It is known that L-arginine, a substrate of NOS increases serum NO metabolite production in sickle cell patients in combination with hydroxyurea. This suggests hydroxyurea induced NOS mediated NO production in SCD patients. It has also been demonstrated that HbF levels correlate with the level of arginase and NOS activities with or without HU treatment [32]. It is reported that the cofactor of NOS, calmodulin, colocalizes with NOS in RBC, suggesting that RBC have the ability to synthesize their own NO [33, 34]. RBC deformability is affected by RBC-NOS mediated NO, which is produced at a baseline rate which is increased in normal RBC under shear stress. The analysis of the metabolism of NO is important to monitor in patients with SCD and can be associated with disease progression. This represents the most important advancement in understanding the pathogenesis, contributing to a more accurate management of patients [35]. iNOS gene expression was substantially greater in SCD neutrophils than in normal individuals [36]. Patients receiving HU reportedly had decreased iNOS gene expression [37]. It has been inferred that the reduced bioavailability of NO is a key factor in the pathophysiology of SCD [38, 39]. In prior studies, both the isoforms eNOS as well as iNOS were reported to be inactive. However, later it was found that human RBC express functional eNOS, which was mainly distributed in their cytoplasm and plasma membrane [15, 40].

Studies till date regarding data on the NOS isoform, its localisation, and its functional activity inside RBC are inconsistent [41]. Prominently, the relation of NOS with the generation and release of NO-related species from RBC has not been shown yet. Therefore, RBC-specific strategies must be developed to enable the detection and localisation of iNOS and its control. Proteins present in human RBC were shown to be immunoreactive to iNOS and eNOS where the concentration of the former was greater than the latter. It has been demonstrated that RBC expresse an active and functional NOS enzyme (RBC-NOS) localized in its membrane and cytoplasm. The properties of this enzyme were found to be similar to eNOS in terms of phosphorylation sites controlling enzymatic activity and the dependence of its activity on intracellular calcium and L-arginine concentrations [42]. Hydroxyurea treatment makes RBC bigger and prevents them to attain a sickle shape [43]. Effect of HU and L-arginine on the production of NO in cultures of normal and sickle erythrocytes demonstrated that HU increases NO but does not require NOS activity [7]. One of the beneficial effects of HU may involve the regulation of arginase activity and a concomitant induction of NOS activity, which may lead to an increased production of NO. It indicated towards the development of improved NO-based treatments for SCD [44]. The study provides the first evidence of alterations in the subcellular distribution of iNOS post-hydroxyurea treatment in blood cells of SCD patients. Studying the alteration in the subcellular distribution of iNOS in pathological conditions and the regulatory components of this rearrangement could be interesting therapeutic targets. The results of the current study support the NO-based therapeutic strategies for SCD and management of this disease.

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CONFLICT OF INTEREST
The authors declare no competing or financial interests.

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ETHICS STATEMENT

The study was conducted in accordance with the local legislation and institutional requirements. Informed consent was obtained from all patients and controls and the study was approved by the Ethics Committee of the University of Campinas (No. 1144/2010), in accordance with the Helsinki Declaration of 1975.

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Table 1: Morphometric analysis of iNOS distribution as number of gold particles/μm^2 in the platelets, erythrocytes and neutrophils of control, SCD patients and SCD patients with HU treatment (SCD-HU)

	CONTROL	SCD	SCD-HU
ERYTHROCYTES	5.6 ± 2.1	4.3 ± 1.5*	7.5 ± 2.2*
NEUTROPHILS	4.7 ± 1.2	3.4 ± 1.3*	6.8 ± 1.4*
PLATELETS	5.0 ± 0.6	3.5 ± 1.1*	6.2 ± 1.6*

* $p < 0.001$, in comparison to control.
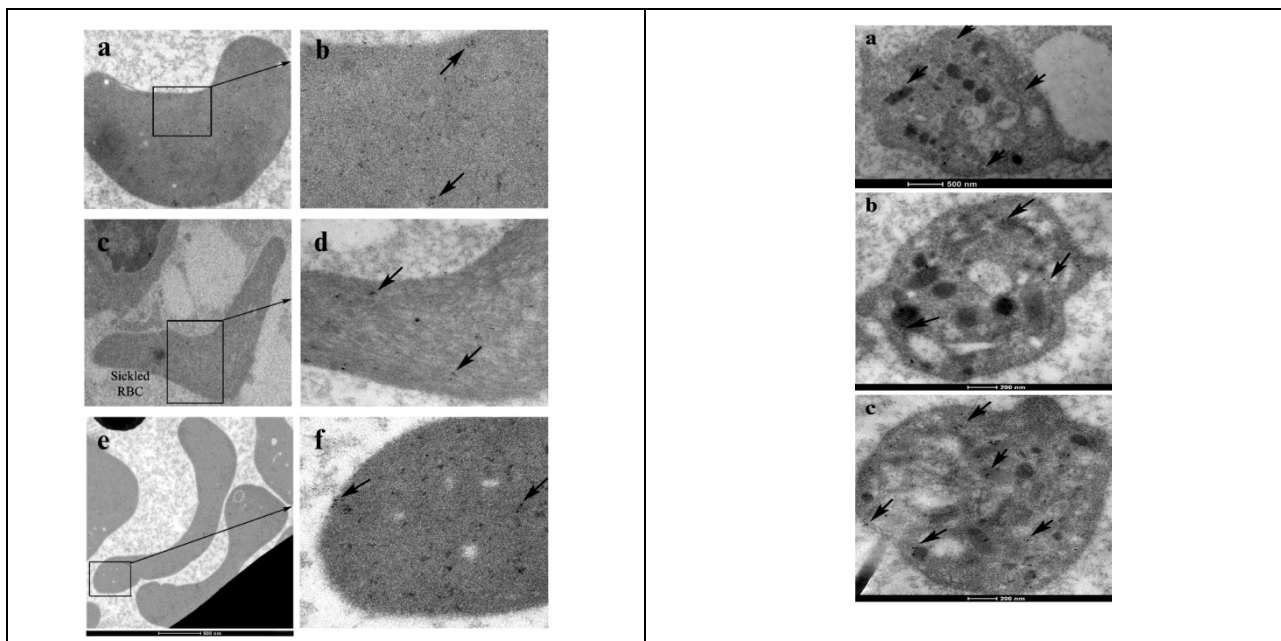
Fig 1: iNOS immunolabeling in the RBC of SCD patients and SCD patients with HU therapy (a) Control RBC, (b) Magnified view of part of RBC from (a) showing immunostaining of iNOS, arrows indicate the gold particles representing iNOS. (c) Sickled RBC from steady state SCD patient, (d) Magnified view of part of RBC from (c) showing immunostaining of iNOS (indicated by arrows), (e) RBC from SCD patient post-hydroxyurea treatment, (f) Magnified view of part of RBC from (e) showing iNOS immunolabeling (arrows).	**Fig 2: iNOS immunolabeling in the Platelets of SCD patients** (a)Immunostaining of iNOS in control platelets, arrows indicate the gold particles representing iNOS, (b) Immunostaining of iNOS (indicated by arrows) in the platelet from steady state SCD patient, (c) iNOS immunolabeling (arrows) in the platelet from SCD patient on hydroxyurea treatment

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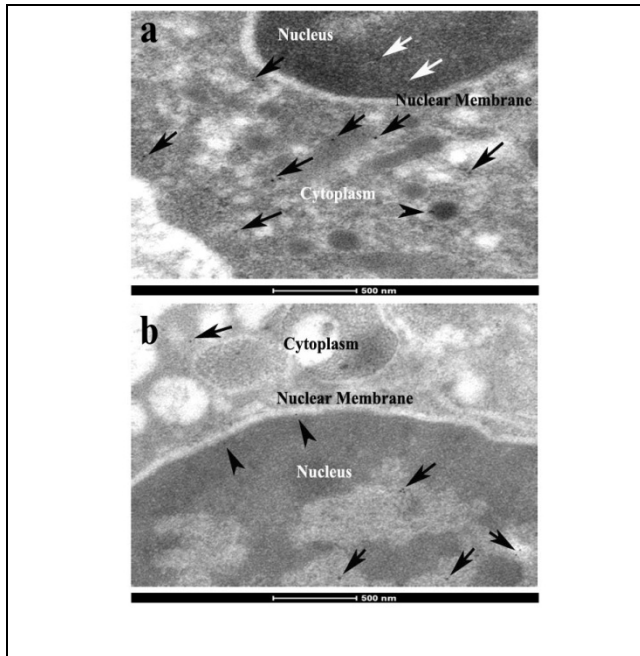
| Fig 3: Electron microscopy of immunogold-labeled secondary antibody to iNOS antibody in control neutrophils. (a) Immunostaining of iNOS in the cytoplasm and nucleus of neutrophils, arrows indicate the gold particles representing iNOS protein in the cells.(b) Immunostaining of iNOS in the cytoplasm, nucleus and in proximity to the nuclear membrane (arrowheads). | Fig 4: Electron microscopy of immunogold-labeled secondary antibody to iNOS antibody in neutrophils of steady state SCD patients and SCD patients on hydroxyurea therapy (a)Immunostaining of iNOS in neutrophils of SCD patients seen in the nucleus (white arrows) and cytoplasm (black arrows), arrows indicate the gold particles representing iNOS. iNOS is visible in the nuclear membrane (NM) as well as in the mitochondria (M) as shown by arrows (b) Immunostaining of iNOS in neutrophils of SCD patients on hydroxyurea therapy seen in the nucleus (white arrows) and cytoplasm (black arrows). Arrowheads represent the localization of iNOS near the nuclear membrane. |
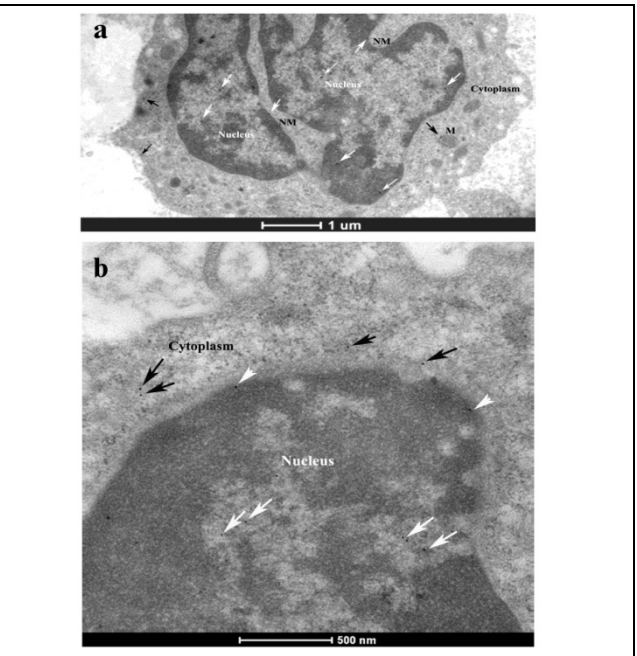
RESEARCH ARTICLE

Exploring the Phenomenon of the Green Halo Effect: Leveraging Eco-Friendly Product Promotion As A Strategy for Environmental Conservation

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ABSTRACT

This study delves into the phenomenon of the "Green Halo Effect" and its impact on consumer behaviour towards eco-friendly products, aiming to promote environmental conservation. Through a comprehensive survey, the research investigates consumer perceptions, purchase decision, and the influence of environmental awareness campaigns on eco-friendly product adoption. Findings reveal a significant positive perception among respondents towards eco-friendly products, indicating a widespread acceptance of sustainability initiatives. Moreover, environmental impact emerges as the primary driver of purchase decisions, followed by product quality and pricing considerations. Despite consumer scepticism towards green claims, environmental awareness campaigns have proven effective in shaping consumer behaviour towards sustainable choices. Strategic marketing approaches, such as social media campaigns, product labelling, and celebrity endorsements, play pivotal roles in promoting eco-friendly products and mitigating greenwashing concerns. Overall, this study underscores the importance of leveraging the Green Halo Effect to encourage sustainable consumption practices and safeguard the environment.

Keywords: Green Halo Effect, eco-friendly products, consumer behaviour, environmental awareness campaigns, sustainability, marketing strategies.

INTRODUCTION

In recent years, the discourse surrounding environmental conservation and sustainability has gained significant momentum, prompting both individuals and corporations to reassess their impact on the planet. Amidst this global shift towards eco-consciousness, businesses have increasingly adopted environmentally friendly practices and marketed products as "green" or "eco-friendly." This trend is driven not only by a genuine concern for the environment but also by consumer demand for sustainable options. As a result, the concept of the "green halo effect" has emerged as a topic of interest in consumer behaviour research. The term "green halo effect" refers to the phenomenon wherein consumers perceive a company or its products more favourably due to its perceived environmental responsibility or sustainability efforts. This positive perception extends beyond the specific eco-friendly aspects of the product or company, influencing overall attitudes and purchasing behaviour. Auger, Devinney, and Louviere (2008) examined the influence of environmental labelling on consumer preferences, revealing that products labelled as environmentally friendly were perceived more positively by consumers, even when the environmental attributes were not the primary focus of the product. This suggests that the mere presence of eco-friendly labelling can create a halo effect, enhancing perceptions of the product and the company as a whole.

Furthermore, research by Luchs, Naylor, Irwin, and Raghunathan (2010) delved into the psychological mechanisms underlying the green halo effect, proposing that consumers may engage in "ethical balancing" wherein they justify purchasing non-environmentally friendly products from companies with strong environmental credentials. This phenomenon highlights the complex interplay between consumers' environmental values and their purchasing decisions, emphasizing the importance of understanding the underlying motivations driving green halo effects. Given the growing emphasis on sustainability in both consumer preferences and corporate strategies, investigating the green halo effect has significant implications for businesses seeking to promote eco-friendly products and safeguard the environment. By understanding how environmental responsibility influences consumer perceptions and behaviours, companies can develop more effective marketing strategies to capitalize on the green halo effect while fostering genuine sustainability initiatives. This study seeks to delve deeper into the Green Halo Effect and its implications for promoting eco-friendly products to safeguard the environment. This research aims to contribute to a better understanding of consumer behaviour and the effectiveness of environmental awareness campaigns.

REVIEW OF LITERATURE

In recent years, there has been a growing interest in the promotion of eco-friendly products as a means to mitigate environmental degradation and promote sustainable consumption. Central to this discourse is the concept of the "green halo effect," wherein consumers' perceptions of a company or individual are positively influenced by their perceived environmental responsibility. This literature review seeks to explore the phenomenon of the green halo effect, its implications for marketing eco-friendly products, and its potential role in safeguarding the environment.
The term "green halo effect" was first introduced by researchers Griskevicius, Tybur, and Van den Bergh (2010) in their seminal study examining how pro-environmental behaviour can influence perceptions of a person's other unrelated traits. They found that individuals engaging in environmentally friendly behaviours were perceived as more altruistic, cooperative, and trustworthy, thus benefiting from a positive halo effect. Subsequent research by Bille, Kudryavtsev, and Bjerke (2017) extended this concept to the domain of consumer behaviour, demonstrating how companies promoting eco-friendly products could similarly benefit from a halo effect, leading to increased consumer trust and loyalty. The promotion of eco-friendly products has become a key strategy for businesses seeking to appeal to environmentally conscious consumers. A study by Ottman, Stafford, and Hartman (2006) revealed that consumers are increasingly inclined to purchase products that are marketed as environmentally friendly, even if they come at a premium price. This highlights the potential profitability of catering to green consumers and leveraging the green halo effect in marketing strategies. However, research by Montoro-Ríos, Luque-Martínez, and Fernández-Sabiote (2018) cautioned against the pitfalls of greenwashing – the deceptive practice of presenting a company as

more environmentally friendly than it actually is – which can undermine consumer trust and lead to backlash. Understanding the green halo effect and its implications for consumer behaviour has significant implications for environmental conservation efforts. By capitalizing on the halo effect through effective marketing strategies, companies can not only enhance their brand image but also promote sustainable consumption patterns. Moreover, by fostering a culture of environmental responsibility, the green halo effect may encourage individuals and organizations to adopt more sustainable practices beyond consumer behaviour, thereby contributing to broader environmental conservation goals.

RESEARCH PROBLEM

The green halo effect poses a significant challenge in accurately assessing consumers' attitudes and behaviours towards eco-friendly products. While there's growing interest in sustainability and environmental protection, it's crucial to understand whether consumers' positive perceptions of eco-friendly products genuinely translate into increased purchase intentions and long-term adoption. Additionally, the influence of various marketing strategies, corporate social responsibility initiatives, and environmental awareness campaigns on shaping consumers' perceptions and behaviours remains a complex and multifaceted issue that requires further investigation. Therefore, the research aims to delve deeper into these aspects to provide valuable insights for businesses and policymakers striving to promote sustainability and safeguard the environment.

RESEARCH OBJECTIVES

1. To investigate the extent to which consumers perceive eco-friendly products positively due to the "Green Halo Effect."
2. To identify the factors influencing consumers' purchase intentions towards eco-friendly products.
3. To assess the impact of environmental awareness campaigns on consumer behaviour and the adoption of eco-friendly products.
4. To explore the effectiveness of different marketing strategies in promoting eco-friendly products and mitigating potential scepticism or greenwashing concerns.

Hypothesis
H0: There is no significant relationship between perception of eco-friendly products and scepticism towards environmental claims by companies promoting eco-friendly products.
H1: There is a significant relationship between perception of eco-friendly products and scepticism towards environmental claims by companies promoting eco-friendly products

MATERIALS AND METHODS

The study employed a rigorous methodology to investigate the phenomenon of the green halo effect in consumer behaviour. To collect primary data, the researchers conducted an online survey, utilizing the convenience and accessibility of the internet to reach a broad audience. The sample size consisted of 225 respondents from India, selected through a simple random sampling method to ensure representativeness and minimize bias. Participants were presented with questions aimed at assessing their perceptions and behaviours regarding eco-friendly products. The collected data were analysed using statistical tools such as percentages to quantify responses and chi-square tests to identify potential relationships and associations between variables. By employing these analytical techniques, the study aimed to provide valuable insights into how consumers' perceptions of environmental friendliness impact their purchasing decisions and overall marketing strategy, thereby contributing to our understanding of sustainable consumption behaviour.

RESULTS AND DISCUSSIONS

The majority of respondents, constituting 57%, exhibited a very positive perception of eco-friendly products. This significant portion suggests a strong inclination towards favouring environmentally conscious choices. Additionally, 24% of the respondents demonstrated a positive perception, indicating a considerable portion of the population acknowledging the benefits of eco-friendly products. Furthermore, 19% of respondents held a somewhat positive perception, highlighting a notable portion with a moderate stance towards eco-friendly products. These findings collectively emphasize the widespread acceptance and recognition of the importance of eco-friendly products in safeguarding the environment. The table no. 2 illustrates the agreement levels regarding the environmental benefits associated with eco-friendly products. Among the respondents surveyed, a significant portion, comprising 58%, expressed strong agreement with the assertion that eco-friendly products generally contribute positively to environmental preservation compared to non-eco-friendly alternatives. An additional 21% of respondents expressed agreement with this statement, indicating a substantial consensus on the perceived environmental advantages of eco-friendly products. Conversely, 21% of respondents remained neutral on the matter, suggesting a segment of the population that may require further education or persuasion regarding the environmental benefits of eco-friendly products. These findings underscore the potential influence of the green halo effect in shaping consumer perceptions and attitudes towards sustainability initiatives. According to the findings of the study, the primary factor influencing the decision to purchase eco-friendly products is their environmental impact. This underscores consumers' increasing awareness and concern for environmental conservation and sustainability. Following closely behind environmental impact, product quality emerges as the second most significant factor shaping consumers' decisions. This suggests that while consumers prioritize environmentally friendly options, they are also unwilling to compromise on the quality and performance of the products they purchase. Despite the importance placed on environmental impact and product quality, price remains a crucial consideration for consumers when selecting eco-friendly products. This highlights the need for businesses to strike a balance between offering sustainable options and maintaining competitive pricing to attract environmentally conscious consumers.

Overall, these findings shed light on the intricate interplay between environmental concerns, product attributes, and pricing strategies in influencing consumers' decisions to embrace eco-friendly alternatives. Understanding these dynamics is essential for businesses seeking to leverage the green halo effect to promote sustainable consumption and contribute to environmental stewardship. The majority of respondents (47%) expressed being somewhat likely to choose an eco-friendly option over a non-eco-friendly one when the price is higher. Additionally, 40% of respondents indicated a likelihood of purchasing eco-friendly products under these circumstances, while 10% expressed a very high likelihood. These findings underscore the potential influence of the green halo effect, wherein consumers prioritize environmental considerations in their purchasing decisions, even when faced with increased costs. According to the findings of the research, a significant majority, comprising 76% of respondents, acknowledged that environmental awareness campaigns have had a discernible impact on their purchasing behaviour. This suggests a notable influence of such campaigns in shaping consumer choices towards eco-friendly products, underscoring the potential effectiveness of leveraging the "green halo effect" in promoting environmentally sustainable practices. The table no.6 illustrates the impact of environmental awareness campaigns on consumer behaviour. Among the respondents, 43% indicated that these campaigns were somewhat effective in influencing their behaviour. Additionally, 38% found them to be effective, while 14% deemed them highly effective. Only a small minority, comprising 5% of the respondents, considered the campaigns to be ineffective. The majority (70%) of respondents expressed scepticism towards environmental claims made by companies promoting eco-friendly products, indicating a cautious attitude towards such claims. Conversely, only 30% of respondents did not feel scepticism, suggesting a notable level of trust or acceptance in these environmental claims. The chi-square analysis yielded a value of 8.735 with 2 degrees of freedom. With a p-value of 0.013, which falls below the conventional significance threshold of 0.05, we reject the null hypothesis and accept the alternative hypothesis. This indicates a statistically significant relationship between individuals' perception of eco-friendly products and their scepticism towards environmental claims made by companies promoting such products.According to the findings, the most potent strategy for

promoting eco-friendly products is a robust social media campaign, which demonstrates significant effectiveness in engaging consumers and fostering awareness. Following closely behind is product labelling, serving as a tangible means to communicate sustainability features directly to consumers. Additionally, celebrity endorsements emerge as another influential tactic, leveraging the star power to enhance the appeal and visibility of eco-friendly products. These findings underscore the importance of strategic marketing initiatives in driving consumer adoption of environmentally responsible choices, ultimately contributing to safeguarding the environment.

CONCLUSION

The study illuminates several critical insights into consumer perceptions and behaviours regarding eco-friendly products. Firstly, the significant portion of respondents exhibiting positive perceptions towards eco-friendly products underscores a widespread inclination towards environmentally conscious choices. This inclination is further supported by the consensus on the environmental benefits associated with such products, emphasizing their role in environmental preservation .Moreover, the study highlights consumers' prioritization of environmental impact alongside product quality, suggesting a nuanced approach to purchasing decisions. While consumers value sustainability, they also demand quality and performance from eco-friendly products. The findings also reveal the importance of pricing in consumer decisions, indicating a need for businesses to balance sustainability with competitive pricing to attract environmentally conscious consumers effectively. Crucially, the study underscores the potential influence of the green halo effect in shaping consumer perceptions and behaviours. Despite scepticism towards environmental claims by companies, consumers show a notable willingness to embrace eco-friendly alternatives, particularly when supported by robust marketing campaigns, social media engagement, and clear product labelling. In conclusion, the study emphasizes the intricate interplay between environmental concerns, product attributes, pricing strategies, and marketing initiatives in driving consumer adoption of eco-friendly products. By understanding and leveraging the green halo effect, businesses can not only promote sustainable consumption but also contribute significantly to environmental stewardship.

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Table 1:Perception of Eco-Friendly Products

Particulars	Frequency	Percent
Very positively	128	57

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Positively	54	24
Somewhat positively	43	19
Total	225	100.0

Source: Primary Data

Table 2: Agreement Levels Regarding the Environmental Benefits of Eco-Friendly Products

Particulars	Frequency	Percent
Strongly agree	130	58
Agree	48	21
Neutral	47	21
Total	225	100

Source: Primary Data

Table 3: Factors Influencing Decision to Purchase Eco-Friendly Products

Particulars	Frequency	Percent
Brand reputation	11	5
Environmental impact	84	37
Personal values	10	4
Price	38	18
Product quality	72	32
Social responsibility of the company	10	4
Total	225	100

Source: Primary Data

Table 4: Likelihood of Purchasing Eco-Friendly Products vs. Non-Eco-Friendly Alternatives at a Higher Price

Particulars	Frequency	Percent
Somewhat likely	106	47
Likely	91	40
Unlikely	7	3
Very likely	21	10
Total	225	100

Source: Primary Data

Table 5: Impact of Environmental Awareness Campaign on Purchasing Behaviour

Particulars	Frequency	Percent
No	54	24
Yes	171	76
Total	225	100

Source: Primary Data

Table 6: Effectiveness of Environmental Awareness Campaigns in Influencing Consumer Behaviour

Particulars	Frequency	Percent
Highly effective	32	14
Effective	85	38
Somewhat effective	97	43
Not effective	11	5
Total	225	100.0

Source: Primary Data

Table 7 :Scepticism Towards Environmental Claims by Companies Promoting Eco-friendly Products

Particulars	Frequency	Percent
No	68	30
Yes	157	70
	225	100.0

Source: Primary Data

Table 8: Relationship Between Perception of Eco-Friendly Products and Scepticism Towards Environmental Claims

Perception of Eco-Friendly Products	Scepticism Towards Environmental Claims		Total
	No	Yes	
Very positively	21	22	43
Positively	14	40	54
Somewhat positively	33	95	128
	68	157	225
Chi-square value: 8.735, p value:0.013, df:2		Source: Primary Data	

Table 9: Effective Marketing Strategies for Promoting Eco-Friendly Products

Particulars	Frequency	Percent
Celebrity endorsements	48	21
Partnerships with environmental organizations	13	6
Product labelling	58	26
Social media campaigns	102	45
Transparency in manufacturing processes	4	2
Total	225	100

Source: Primary Data

RESEARCH ARTICLE

A Study on Challenges Faced by the Custom House Agent on Custom Clearance with Reference to Blue Bharat Exim Pvt. Ltd

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ABSTRACT

This study focuses on the difficulties encountered by the custom house agent, specifically in relation to Blue Bharat Exim Private Limited (Egmore), a company situated in Chennai. Customs house agents (CHAs) are essential in facilitating international trade by effectively managing the intricate customs regulations and procedures. This study investigates the numerous obstacles faced by CHAs (Customs House Agents) during the process of custom clearance, providing insight into the complex concerns that hinder effective trade facilitation. The research used a mixed-methods approach, which involves qualitative interviews with CHAs, customs officials, and industry stakeholders, as well as quantitative data analysis using customs clearance records and regulation documentation. This comprehensive approach enables a detailed comprehension of the difficulties encountered by CHAs during various phases of the clearing procedure. In addition, the research reveals systemic problems like as corruption and collusion, which weaken the integrity of the clearance process and destroy trust among CHAs, customs authorities, and stakeholders. These illegal activities not only disrupt the functioning of the market but also inflict a substantial financial burden on lawful enterprises. The findings have significant implications that require legislative interventions and systemic reforms to improve customs operations, increase transparency, and address the issues encountered by CHAs. It is crucial to make strategic investments in technology, capacity building programs, and stakeholder collaboration in order to modernize customs operations and create a favorable climate for trade facilitation.

Keywords: Certificates of origin, Compliance documents, Custom Clearance, Customs House Agents, Bill of Lading.

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INTRODUCTION

In India, a customs house agent (CHA) is licensed to act as an agent for transaction of any business relating to the entry or departure of conveyances or the import or export of goods at a customs station. CHAS maintain detailed, itemized and up-to-date accounts. A CHA license may be temporary or permanent. The clearance of goods on Import or Export, including unaccompanied baggage, involves quite a lot of procedural formalities under Section 46, 47, 50, 51 etc., These formalities have to be observed by Importer / Exporter / Passenger, as the case may be. But in most cases the Customs station would be far away and it may not be possible for the Importer / Exporter/ Passenger to attend to such work promptly. The charges levied by Custom House Agents from the Client should be at such rates as notified by the Commissioner from time to time which is done under Rule 25(b). The same rule, sub section (2) requires that Customs House Agents should control as members of the registered Custom House Agents Association of the Port. The Custom House Agents can avail transactional services for Imports & Exports. The services available includes E-Filing of Import & Export documents, A Customs House Agent can attend to the Custom work himself or employ persons to assist him. Custom House Agent has to be not only well informed of the Customs laws and procedures and A documentation, but has to be alert all the time, closely following the instructions or change in the public notices, issued from time to time. His is a very peculiar position in that, though he is employed by the Importers/Exporters, he is licensed by the department and hence he can satisfy them only to the extent the law permits and within the procedures laid down by the Customs House. A Custom House Agent has to be not only well informed of the Customs laws and procedures and documentation, but has to be alert all the time, closely following the instructions or change in the public notices, issued from time to time. His is a very peculiar position in that, though he is employed by the Importers/Exporters.

STATEMENT OF THE PROBLEM
Customs regulations are complex and subject to frequent changes, posing challenges for CHAs to stay updated and compliant with the latest requirements. Customs clearance involves extensive documentation, including invoices, bills of lading, certificates of origin, and compliance documents. Managing and verifying this paperwork is time-consuming and prone to errors. Many customs clearance processes still rely on outdated manual procedures, leading to inefficiencies and delays.

SIGNIFICANCE OF THE STUDY
Custom clearance is a crucial part of international trade facilitation. CHAs act as intermediaries between importers/exporters and customs authorities, streamlining the clearance process. Identifying and addressing challenges they face can significantly improve the efficiency and effectiveness of trade facilitation efforts.

OBJECTIVES OF STUDY
- Identify the key challenges faced by customs house agents (CHAs) during the customs clearance process.
- Explore potential solutions or strategies to mitigate the identified challenges.
- Understand the impact of these challenges on the efficiency and effectiveness of customs clearance operations.
- To study the Customs clearances process of Custom House Agent

SCOPE OF THE STUDY
The study will examine various supply chain processes, including procurement, production, inventory management, logistics, and distribution. Overall, the scope of the study will provide a comprehensive understanding of the impact of the challenges that are faced by the custom house agent and offer valuable insights for the CHA's seeking to improve their performances.

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LIMITATIONS OF THE STUDY

The study on challenges faced by customs house agents may have limitations stemming from sample bias, as it might predominantly include agents from specific regions or with particular experiences. Data collection methods like surveys may introduce response biases. Additionally, the study may lack comprehensive insight due to its focus on current challenges, neglecting historical or systemic factors. Limited generalizability could arise from variations in regulations and practices across jurisdictions. Moreover, the dynamic nature of the customs industry might render findings outdated quickly.

RESEARCH METHODOLOGY

Research design

The research design is the blueprint for the fulfillment of objectives and answering questions.It is a master plan specifying the method and procedures for collecting analyzing needed information.

Sampling Technique - Simple Random Sampling
Sampling method - To obtain the representative sample, convenience sampling method is used for selecting the sample.
Sample size - 50 Respondents.
Period of study - The study has been taken for 2 months period in Blue Bharat exim prt ltd.
Data collection method
The source of the data includes primary and secondary data sources.

Primary sources

Primary data has been collected directly from sample respondents through questionnaire and with the help of service technician.

Secondary sources

Secondary data has been collected from standard textbooks, Newspapers, Magazines & Internet.

DATA ANALYSIS AND INTERPRETATION

Nearly half (64%) of respondents are males, indicating male dominance in the logistics department.
Similarly, 80% fall in the below 30 age range, suggesting a significant portion of respondents are in this bracket.
48% are from the students, showing high interest of young generation in logistics.
42% of the respondents agree that the interaction with the customs official is the main obstacle for the CHAs.
36% of people responds "GOOD" for the effective of the procedures used by the CHAs.
36% experience with insufficient cooperation with relevant parties.
36% are asking the custom authorities for assisting them.
34% agree with customs clearing software in technical resources used by the CHAs.
44% agree with the fostering a rapport with customs officiers.
30% are accepting both the consistent training sessions and industry publication subscription.

FINDINGS

- Nearly half (64%) of respondents are males, indicating male dominance in the logistics department.
- Similarly, 80% fall in the below 30 age range, suggesting a significant portion of respondents are in this bracket.
- 48% are from the students, showing high interest of young generation in logistics.
- 42% of the respondents agree that the interaction with the customs official is the main obstacle for the CHAs.
- 36% of people responds "GOOD" for the effective of the procedures used by the CHAs.
- 36% experience with insufficient cooperation with relevant parties.
- 36% are asking the custom authorities for assisting them.
- 34% agree with customs clearing software in technical resources used by the CHAs.

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- 44% agree with the fostering a rapport with customs officiers.
- 30% are accepting both the consistent training sessions and industry publication subscription.
- 32% are accepting the stricter regulatory clearance for the CHAs.
- 34% are keeping the lines of the communication open with customs officials.
- 36% agree that one possible solution could be to have CHAs & customs official meet regularly.
- 30% accept in offering cultural sensitivity training.
- 32% willing for the improved data exchange between stakeholders.
- 28% are undertaking comprehensive evaluations of financial risk.
- 38% are imposing to simplifying documentation procedures.
- 32% are giving their suggestion in increasing restrictions ad trade barriers.
- 32% agreeing in forming relationship with international logistics providers & using software for cross-border transaction.
- 34% are ensuring adherence to security procedures.
- 34% are educating staff members about ethics.
- 36% will be finding pattern and trends in clearance data.
- 28% are regularly auditing clearance procedures.

SUGGESTIONS
- **Complex Regulatory Environment:** Customs regulations are intricate and subject to frequent changes. CHAs must stay updated with these changes to ensure compliance, but navigating the evolving regulatory landscape can be daunting and time-consuming.
- **Documentation Requirements:** Custom clearance involves extensive paperwork, including invoices, bills of lading, packing lists, and customs declarations. Errors or discrepancies in documentation can lead to delays or even penalties. CHAs face the challenge of accurately preparing and verifying these documents for each shipment.
- **Tariff Classification and Valuation:** Determining the correct tariff classification and valuation of goods is crucial for calculating duties and taxes. However, the classification system can be complex, and valuation methods may vary based on the type of goods and transaction. CHAs must possess in-depth knowledge and expertise to ensure accurate classification and valuation, minimizing the risk of disputes with customs authorities.
- **Customs Duties and Taxes:** Calculating customs duties and taxes involves considering various factors such as the value of goods, country of origin, trade agreements, and applicable exemptions or preferences. CHAs must navigate these complexities to determine the correct duty rates and ensure that clients comply with their tax obligations.
- **Customs Inspections and Audits:** Customs authorities conduct inspections and audits to verify compliance with regulations and detect any discrepancies. CHAs may face challenges when goods are selected for inspection, as this can lead to delays and additional scrutiny. They must cooperate with customs officials and provide necessary documentation to facilitate the inspection process efficiently.
- **Communication and Coordination:** Effective communication and coordination are essential for smooth custom clearance processes. CHAs liaise with various stakeholders, including importers, exporters, shipping lines, and customs authorities. Language barriers, time zone differences, and differing communication protocols can pose challenges, requiring CHAs to employ effective communication strategies and tools.
- **Technology and Automation:** The customs clearance process is increasingly reliant on technology and automation tools for tasks such as electronic data interchange (EDI), online submissions, and electronic payments. While these technologies streamline processes and improve efficiency, CHAs must invest in appropriate infrastructure and training to leverage them effectively.
- **Global Trade Dynamics:** Global trade dynamics, including geopolitical tensions, trade disputes, and economic uncertainties, can impact custom clearance processes. CHAs must stay informed about geopolitical developments and their potential implications for international trade to effectively navigate these challenges.

CONCLUSION

Customs house agents (CHAs) play a crucial role in facilitating international trade by managing customs clearance procedures on behalf of importers and exporters. However, they encounter numerous challenges in performing their duties efficiently. The conclusion drawn from an analysis of these challenges underscores the need for strategic solutions to enhance the effectiveness of CHAs and streamline customs clearance processes. One of the primary challenges faced by CHAs is the constantly evolving regulatory environment. Customs regulations vary between countries and are subject to frequent changes, posing a significant hurdle for CHAs to stay updated and compliant. This challenge is compounded by the complex nature of trade agreements and tariff classifications, which require CHAs to possess in-depth knowledge and expertise. Another key issue is the proliferation of documentation requirements. Customs clearance involves a plethora of paperwork, including invoices, bills of lading, certificates of origin, and various permits. Managing and processing these documents accurately and efficiently can be overwhelming for CHAs, leading to delays and potential errors in customs clearance procedures. In conclusion, the challenges faced by CHAs in customs clearance underscore the need for proactive measures to enhance efficiency and effectiveness in international trade facilitation. This includes investments in technology and infrastructure, ongoing training and capacity building for CHAs, harmonization of customs regulations, and greater collaboration between public and private sectors. By addressing these challenges collectively, stakeholders can unlock the full potential of CHAs in facilitating smooth and expedited customs clearance processes, thereby promoting trade facilitation and economic growth.

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Table 1: Gender of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	Male	32	64.0%
2	Female	18	36.0%
	TOTAL	**50**	**100.0%**

Table 2: Age of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	below 30 years	40	80.0%
2	30-40 years	7	14.0%
3	40-50 years	2	4.0%
4	Above 50 years	1	2.0%
	TOTAL	**50**	**100.0%**

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Table 3: Employment status of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	employed	7	14.0%
2	unemployed	11	22.0%
3	self-employed	8	16.0%
4	student	24	48.0%
	TOTAL	**50**	**100.0%**

Table 4: Main obstacle to customs clearance for Custom House Agents (CHAs) of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	adherence to regulation	9	18.0%
2	Mistakes in the documentation	13	26.0%
3	Interaction with customs officials	21	42.0%
4	Difficulties with logistics	5	10.0%
5	Other	2	4.0%
	TOTAL	**50**	**100.0%**

Table 5: Effective of the procedures used by CHAs for customs clearance of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	Outstanding	16	32.0%
2	Good	18	36.0%
3	Equitable	16	32.0%
4	Inadequate	0	0.0%
	TOTAL	**50**	**68.0%**

Table 6: Typical difficulty that CHAs run into when clearing customs of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	Insufficient use of technology	8	16.0%
2	Limited understanding of customs laws	12	24.0%
3	Insufficient cooperation with relevant parties	18	36.5%
4	All of the above	11	22.5%
5	others	1	1.0%
	TOTAL	**50**	**100.0%**

Table 7: CHAs normally handle inconsistencies or mistakes in the paperwork of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	Correct and resubmit documents	13	26.0%
2	Ask customs authorities for assistance	18	36.0%
3	Interact with clients to address concerns	10	20.0%
4	Disregard little errors	9	18.0%
5	Additional	0	0.0%
	TOTAL	**50**	**100.0%**

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Table 8: Technical resources or platforms are used by CHAs to expedite the process of clearing customs of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	Blockchain technology	8	16.0%
2	Customs clearing software	17	34.0%
3	Electronic data interchange (EDI)	13	26.0%
4	All of the above	12	24.0%
5	Other	0	0.0%
	TOTAL	**50**	**100.0%**

Table 9: Tactics do CHAs use to minimize customer delays and speed up the clearance process of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	Accurately preparing papers ahead of time	11	22.0%
2	fostering a close rapport with customs officers	22	44.0%
3	utilizing expedited clearance programs	10	20.0%
4	all of the above	7	14.0%
5	Additional	0	0.0%
	TOTAL	**50**	**100.0%**

Table 10: CHAs remain informed about modifications to customs laws and guidelines of the respondents

S no	Particulars	No of Respondents (n=50)	Percentage (100%)
1	Consistent training sessions	15	30.0%
2	Industry publications subscriptions	15	30.0%
3	Customs authorities' updates monitored	10	20.0%
4	All of the above	10	20.0%
5	Other	0	0.0%
	TOTAL	**50**	**100.0%**

RESEARCH ARTICLE

A Study on the Role of Customs House Agent Onimports in Sri Janani Shipping Services Private Limited

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ABSTRACT

A customs house agent (CHA) is licensed to act as an agent for transaction of any business relating to the entry or departure Customs house agent is very much important for the import and import of the goods. Customs house agent intermediate to the customs and exporters, importers to clearance of documentation. For the transports of goods to all the countries, and most importantly to avoid the illegal activities done through the Airways, ports and road ways. It's helpful to improve the country economies development and to develop the healthy relationship between two countries. They make proper bills of entry and shipping bills that are crucial for clearance of proper goods or conveyances.

Keywords: Bills of entry, Customs House Agent, Freight Forwarders, Shipping Bills, Shipping Services.

INTRODUCTION

A Custom House Agent (CHA) is a licensed individual or firm appointed by the owner of goods or a carrier to act as an agent for the clearance of goods through customs. The primary role of a Custom House Agent is to facilitate the import and export of goods across international borders by completing the necessary legal and regulatory procedures.
The Custom House Agent is responsible for ensuring that all customs documentation, including bills of entry, shipping bills, and other necessary documents, are prepared and submitted to the customs authorities. They also coordinate with the shipping companies, freight forwarders, and other related agencies to ensure that the goods are transported smoothly to their destination.

NEED FOR THE STUDY
• To study the operational features of the CHA in their examination of various products

- To analyze the nature of work / business process of CHA
- To understand the essential endorsements and documents obtained by CHA

OBJECTIVES OF THE STUDY

- To study on the role of Custom House Agent on handling Imports .
- To study about CHA and identify their functions.
- To study the various products handled by Sri Janani Shipping Services Private Limited.
- To examine the various facilities provided by the CHA to the customer.
- To analyze the problems faced by the CHA.
- To study the operational features of the CHA in their examination of various Products.
- To understand the essential endorsements and documents obtained by CHA.

SCOPE OF THE STUDY

- Srijanani Shipping Services Private Limited have been going through a wide range of Improvements in terms of cost competitiveness & operational aspects.
- The scope of research magnifies the purpose and skills in the Customs House Agency which plays an important role as backbone in the Import Trade.
- This research implies us to study related topics to CHA and its role in   handling The EXIM cargo at Gateway Ports.
- Know how about processing of Cargo Documents with Customs, Various Authorities, Container Lines, Inland Container Depot and Container Freight Station.
- To study the operational features of the CHA in their examination of various products
- To analyze the nature of work / business process of CHA
- To understand the essential endorsements and documents obtained by CHA.

LIMITATIONS OF THE STUDY

- Collecting data properly from importers become difficulty due to the resource constraint.
- The sample of this study is only 65.
- There is a chance for baise in the information given by the respondents.
- The sample size of the project may be limited due to various reasons such us time, resources, and access to participants.
- Data collected may be limited due to various reasons such us incomplete or inaccurate responses from participants.
- It may not be possible to cover all aspects of the topic or to include all relevant variable due to resource constrains.

RESEARCH METHODOLOGY

RESEARCH DESIGN
The current research paper adopts analytical research design ant has the primary objective as to know the role of customs broker at importers and identify the problems. And in order to carry out the present study in a meaningful manner an adequate amount of data and information has been collected.

Descriptive research design
As their name implies descriptive research design, are designed to describe something. For example, the characteristics of users of a given product, the degree to which product use varies with income, age, sex etc.

Sampling Technique
Simple Random Sampling

Sampling method
To obtain the representative sample, convenience sampling method is used for selecting the sample.

Sample size – 65   Respondents
Period of study
The study has been taken for 2months period in Srijanani Shipping Services Private Limited.

Data collection method
The source of the data includes primary and secondary data sources.

Primary sources
Primary data has been collected directly from sample respondents through questionnaire and with the help of service technician.

Secondary sources
Secondary data has been collected from standard textbooks, Newspapers, Magazines &Internet.

Statistical Tools Adopted
Chi-Square Test

DATA ANALYSIS AND INTERPRETATION
A chi-square test is a statistical test used to determine whether there is a significant association between two categorical variables.

Interpretation
Since the p-value is greater than the significance level (0.05%), we fail to reject the null hypothesis, indicating no significant difference between tracking system and service level. (x^2-25.217, df-9, p-.003).

FINDINGS OF THE STUDY
- Majority (71.7%) of the respondents are male.
- Majority (76.9%) of the respondents are PG.
- Majority (40%) of the respondents are 1-3 years experienced.
- Majority (56.9) of the respondents are agree clearance in export is adequate.
- Majority (60%) of the respondents are strongly agree documentation for clearance is manageable.
- Majority (38.5) of the respondents are strongly agree charges provided by Srijanani Shipping Services Private Limited is flexible.
- Majority (47.7%) of the respondents are strongly agree procedure followed by Srijanani Shipping Services Private Limited is genuine.
- Majority (43.1%) of the respondents agree forwarding in Srijanani Shipping Services Private Limited is upto par.
- Majority (38.5%) of the respondents agree fumigation in Srijanani Shipping Services Private Limited is fine.
- Majority (41.5%) of the respondents are strongly agree liner service inSrijanani Shipping Services Private Limited is convenient.
- Majority (43.1%) of the respondents agree textile handled by Srijanani Shipping Services Private Limited is competent.

- Majority (43.1%) of the respondents agree Srijanani Shipping Services Private Limited has the experienced operation team to handle any type of cargo.
- Majority (44.6%) of the respondents agree Srijanani Shipping ServicesPrivate Limited handle your customs documentation ease and care.
- Majority (46.2%) of the respondents are strongly agree Srijanani Shipping Services Private Limited handle cargo with care without any damages.
- Majority (43.1%) of the respondents agree Srijanani Shipping Services Private Limited tracking system is useful.
- Majority (69.2%) of the respondents are strongly disagree, they ever witness delay in handling shipment in Srijanani Shipping Services Private Limited.

SUGGESTIONS

- Consider strategies to attract more female respondents or understand why the majority are male. This could involve targeted outreach or creating a more inclusive environment.
- Since most respondents are postgraduates, you could tailor your services or communications to reflect this level of education, potentially by providing more detailed or technical information.
- Recognize that a significant portion of respondents are relatively new to the industry (1-3 years). This could inform training programs or support for those early in their careers
- Continue to prioritize and maintain the efficiency of clearance processes and documentation management, as the majority find these aspects manageable or adequate.
- Acknowledge and maintain the flexibility in charges and procedures that respondents appreciate. This could involve periodic reviews to ensure competitiveness and responsiveness to customer needs.
- Since respondents generally agree on competence in handling textiles, consider highlighting this expertise in marketing materials or targeting clients in the textile industry.
- Reinforce the perception of an experienced operation team, possibly through highlighting team expertise or providing additional training to maintain high service standards.
- Strengthen customer care and attention to detail in customs documentation and cargo handling, as respondents value ease, care, and damage-free handling.
- Continue to invest in and improve the tracking system, as the majority find it useful, which can enhance customer experience and trust.
- Although most respondents have not witnessed delays, it's crucial to address any instances promptly and transparently to maintain trust and satisfaction levels.

CONCLUSION

Based on the study conducted on the role of Customs House Agents (CHAs) on imports in Sri Janani Shipping Services Private Limited, several key conclusions can be drawn: CHAs play a crucial role in facilitating the import process by acting as intermediaries between importers and customs authorities. Their expertise and knowledge help expedite clearance procedures and ensure compliance with regulations. The study highlighted that CHAs contribute significantly to the efficiency of import operations. Their expertise in customs regulations and documentation processes streamlines clearance procedures, reducing delays and costs for importers. CHAs play a vital role in ensuring importers comply with customs regulations and manage risks associated with imports. Their understanding of regulations helps prevent delays, fines, and other compliance-related issues. While CHAs charge fees for their services, the study suggests that their involvement ultimately leads to cost savings for importers. The efficiency and expertise they bring to the import process can help avoid costly delays and errors. The study recommends that Sri Janani Shipping Services Private Limited continue to collaborate closely with CHAs to enhance

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their role in import operations. This could include providing additional training and resources to CHAs to further improve efficiency and compliance.

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Table 1: Forwarding in Srijanani Shipping Services Pvt.Ltd is Up to the Par in Srijanani Shipping Services Pvt ltd Tracking System is Useful

		In Srijanani Shipping Services Pvt.Ltd tracking system is useful				Total
	Agree	**Agree**	**Disagree**	**Neutral**	**Strongly agree**	
Forwarding in Sri Janani		16	0	8	4	28
Shipping Services pvt.ltd is up to the par	Disagree	1	0	2	1	4
	Neutral	6	1	3	1	11
	Strongly agree	5	1	1	15	22
Total		28	2	14	21	65

Table 2: Chi-Square Tests

	Value	Df	Asymptotic Significance (2sided)
Pearson Chi-Square	25.217[a]	9	.003
Likelihood Ratio	26.363	9	.002
N of Valid Cases	65		

RESEARCH ARTICLE

A Study on Impact of Supply Chain Quality Management System on - On Time Delivery with Referance to Pudupakkam Butterfly Gandhimathi Appliances

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ABSTRACT

The efficient management of supply chain quality is critical for businesses to ensure timely delivery of products to customers. This project investigates the impact of supply chain quality management systems on on-time delivery performance within the context of Butterfly Gandhi Mathi Appliances. Through data analysis and inference drawn from various aspects of the supply chain, including gender distribution, age demographics, departmental distribution, and feedback from respondents, insights are gained into the strengths and areas for improvement within the supply chain. Positive conclusions highlight the organization's commitment to leveraging technology, enhancing supplier relationships, prioritizing customer satisfaction, and recognizing opportunities for growth. These findings underscore the significance of effective supply chain quality management systems in driving on-time delivery performance and ultimately contributing to business success.

Keywords: Inventory, Logistics, On Time Delivery Performance, Real Time Monitoring, Supply Chain Quality Management System.

INTRODUCTION

In the contemporary business landscape, where competition is fierce and customer expectations are constantly evolving, organizations face immense pressure to deliver products and services on time while maintaining high standards of quality. Effective supply chain management has emerged as a critical determinant of organizational success, with a focus on optimizing processes, reducing lead times, and ensuring timely delivery to meet customer

demands. Central to this is the implementation of Supply Chain Quality Management Systems (SCQMS), which aim to streamline operations, enhance efficiency, and uphold quality standards throughout the supply chain.

STATEMENT OF THE PROBLEM

To find out the impact of supply chain quality management system on-on time delivery with reference to Pudupakkam Butterfly Gandhimathi Appliances.

OBJECTIVES OF STUDY

• To assess the effectiveness of Supply Chain Quality Management System (SCQMS) implementation in improving time delivery performance within the supply chain.
• To evaluate the overall impact of SCQMS on enhancing supply chain efficiency and meeting customer delivery expectations.

SCOPE OF THE STUDY

The study will examine various supply chain processes, including procurement, production, inventory management, logistics, and distribution. Overall, the scope of the study will provide a comprehensive understanding of the impact of SCQMS on time delivery performance within the supply chain and offer valuable insights for practitioners and managers seeking to improve supply chain operations.

LIMITATIONS OF THE STUDY

• The findings of the study may not be generalizable to all industries or organizations due to variations in supply chain structures, processes, and contexts.
• The study's findings may be limited by the availability and accessibility of data related to supply chain quality management practices and time delivery performance metrics.
• The study's sample size may be limited, impacting the representativeness and statistical power of the findings.
• The study may be constrained by time limitations, affecting the depth and breadth of data collection, analysis, and interpretation.

RESEARCH METHODOLOGY

The purpose of methodology section is describing the research design procedure. This includes the overall research design. The sampling procedure-collection method the field methods and analysis procedure.

Research design
The research design is the blueprint for the fulfillment of objectives and answering questions. It is a master plan specifying the method and procedures for collecting analyzing needed information.

Descriptive research design
As their name implies descriptive research design, are designed to describe something. For example, the characteristics of users of a given product, the degree to which product use varies with income, age, sex etc.

Sampling Technique
Simple Random Sampling

Sampling method
To obtain the representative sample, convenience sampling method isused for selecting the sample.

Sample size -100 Respondents.

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Period of study
The study has been taken for 2months period in Butterfly Gandhimathi Appliances.

Data collection method
The source of the data includes primary and secondary data sources.

Primary sources: Primary data has been collected directly from sample respondents through questionnaire and with the help of service technician.

Secondary sources: Secondary data has been collected from standard textbooks, Newspapers, Magazines & Internet.

Statistical Tools Adopted
•   Chi-Square Test
•   ANOVA

Interpretation
The calculated value is less than the table value. So, there is no significant difference between age and tracking on time delivery.

Interpretation
The calculated value is less than the table value. So, there is no significant difference between Age tracking on time delivery improving on time delivery.

FINDINGS
•   Nearly half (48%) of respondents are males, indicating male dominance in the logistics department.
•   Similarly, 48% fall in the 31-40 age range, suggesting a significant portion of respondents are in this bracket.
•   35% are from the production department, showing high manpower capacity.
•   The majority (87%) agree that the supply chain has sufficient transportation.
•   Conversely, 81% see no flaws in the company's flow of information, money, and materials.
•   75% report no incidents of late delivery of raw materials by the production department.
•   69% periodically collect customer feedback after delivery.
•   63% have sufficient inventory for production.
•   46% cite a lack of visibility into supplier lead time, impacting prediction due to transportation risks.
•   50% face dispatch errors due to human error.
•   62% experience wrong product deliveries, often leading to returns.
•   41% conduct periodic manual checks for on-time delivery tracking.
•   44% rely on robust contingency plans for unexpected disruptions.
•   41% view technology & automation as essential for improving on-time delivery.
•   35% maintain successful on-time delivery through (KPI) Key performance indicators.
•   33% observe effective logistics in intercompany operations.
•   37% encounter disruptions or bottlenecks in the supply chain rarely.
•   31% believe implementing quality management practices significantly improves ontime delivery.
•   56% rate transportation availability as excellent.
•   52% find the delivery performance of the supply chain department excellent.
•   41% suggest increased investment in technology for enhanced on-time delivery.
•   45% attribute most delivery delays to communication breakdowns.
•   51% prioritize promptly investigating and addressing root causes of issues.
•   65% acknowledge gaps in communication and coordination.
•   69% strongly believe on-time delivery impacts customer satisfaction positively.

SUGGESTIONS

- Since 41% of respondents view technology and automation as essential for improving on-time delivery, consider investing in advanced software solutions, such as supply chain management systems, to enhance visibility, tracking, and coordination across the supply chain.
- Address the concerns raised by 25% of respondents regarding lack of supplier reliability. Establishing stronger relationships with suppliers through regular communication, collaboration, and possibly even joint planning can help mitigate delays caused by supplier issues.
- 13% of respondents suggest streamlining processes through lean principles. Implementing lean practices such as reducing waste, optimizing workflows, and standardizing processes can lead to more efficient operations and fewer delays.
- With 29% of respondents emphasizing the importance of employee training and development, invest in training programs to enhance employees' skills and knowledge in supply chain management, communication, and problem-solving.
- Given that 45% of respondents attribute most delivery delays to communication breakdowns, prioritize improving communication channels and practices within the organization and with external stakeholders. This could involve implementing better communication tools, establishing clear communication protocols, and fostering a culture of transparency and collaboration.
- Since 44% of respondents rely on robust contingency plans for handling unexpected disruptions, ensure that the organization has well-defined contingency plans in place to address potential disruptions in the supply chain promptly and effectively.
- With 51% of respondents prioritizing the investigation and prompt addressing of root causes of delivery delays, establish a formal process for identifying, analyzing, and resolving issues that lead to delays in the delivery process.
- Address the challenges identified by 11% of respondents related to poor inventory management. Implement inventory optimization strategies, such as demand forecasting, safety stock management, and inventory visibility tools, to ensure adequate inventory levels and minimize stockouts.
- Since 35% of respondents use on-time delivery percentage as a key performance indicator, continue to monitor and measure on-time delivery performance using relevant KPIs to track progress and identify areas for improvement.
- Recognize the strong correlation between on-time delivery and customer satisfaction, as indicated by 69% of respondents. Prioritize on-time delivery as a critical component of customer satisfaction and strive to consistently meet or exceed customer expectations in this regard.

CONCLUSION

The data from Butterfly Gandhi Mathi Appliances provides valuable insights into the current state of the supply chain management system. Most respondents exhibit confidence in various aspects of the supply chain, indicating a strong foundation for further improvement.

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Table 1: **Age and Tracking on Time Delivery**

			Age		Total	
		< 30Years	31-40 Years	41-50 Years	Above 51 Years	
Track on time delivery	Real-time monitoring KPIs	30	4	0	0	34
	Periodic manual checks	0	31	10	0	41
	No systematic tracking	0	6	11	8	25
Total		**30**	**41**	**21**	**8**	**100**

Table 2:Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	116.726[a]	6	.000
Likelihood Ratio	127.706	6	.000
Linear-by-Linear Association	68.482	1	.000
N of Valid Cases	100		

Table 3:Improving on Time Delivery and Gender Cross Tabulation

			Gender		Total
			Male	Female	
Improving on time delivery	Essential		37	4	41
	Beneficial		30	3	33
	Neutral		8	7	15
	Insignificant		8	3	11
		Total	83	17	100

Table 4:Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.167[a]	3	.004
Likelihood Ratio	11.238	3	.011
Linear-by-Linear Association	6.585	1	.010
N of Valid Cases	100		

Table 5:Anova - Age and Track on Time Delivery

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	57.580	2	28.790	112.016	.000
Within Groups	24.930	97	.257		
Total	82.510	99			

RESEARCH ARTICLE

A Study on Material Handling Storage and Packaging Challenges at Butterfly

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ABSTRACT

Customer satisfaction is the study of how individual customers, group or organization select by use and dispose product and reviews to satisfy their needs and wants. It refers to the actions of the customers in the marketplace and the underlying motives for those actions. Marketers export that by underlying what causes the customers to buy particular product, they will able to determine-which products are needed in the market place, which are obsoletes and how best to present the goods to the customers. It gives a brief report on the profile of the Butterfly Gandhimathi Appliances Limited. About history, current status its achievement's as a firm in the Butterfly Gandhimathi Appliances. This project also speaks on its various product and its future plans. The major objective of the project is to measure the level of customer satisfaction of the customer in the region Chennai. The descriptive study is used for the research. Hypothesis was developed and testing using the statistical tools (chi-square test, ANOVA). Primary data for the study was collected from the sample of 100 customers using a well- structured questionnaire, which suits all categories of customers. Respondents were met and interviewed to collect the information.

Keywords: Customer Satisfaction, Material Handling, Manufacturing, Packaging, Storage.

INTRODUCTION

The wealth of a country is measured by its gross national product the output of goods and services produced by the nation in a given time. Goods are physical objects, something we can touch, feel, or see. Services are the performance of some useful function such as banking, medical care, restaurants, clothing stores, or social services. But what is the source of wealth is measured by the amount of goods and services produced, but where does it come from Although

we may have rich natural resources in our economy such as mineral deposits, farmland, and forests, these are only potential sources of wealth.

NEED FOR THE STUDY
The study provides information to those interested in the Logistics activity. It provide insight into the challenges and potential benefits of Material handling management. It mainly focuses on safety of materials.

OBJECTIVES OF THE STUDY
- To identify the problems faced in Material handling.
- To find out the critical factors influencing various stages of material handling.
- To reveal the measures to improve the flow of material handling for effective work condition.

SCOPE OF THE STUDY
- The study restricted to the employees in manufacturing industries.
- The study measures data only through questionnaire

LIMITATIONS OF THE STUDY
The study suffers from certain limitations which are stated as follows:
- The findings and conclusions drawn are from samples taken from the employees.
- Sample size of the study is only 126.
- Some respondents hesitated and carelessly filled the questionnaire.

RESEARCH METHODOLOGY

Descriptive research is a study designed to depict the participants in an accurate way. More simply put, descriptive research is all about describing people who take part in the study.

Sample Design
The sampling technique undergone for this study is Convenience sampling. Convenience sampling is a type of non-probability sampling in which sample being drawn from that part of the population that can be reached.

Sample Size
A questionnaire was circulated to through Google forms for which 126 responded for the survey.
Sample size   : 126
Location   : Chennai
Target people   : Employee
Type of industry : Manufacturing

Data Collection
Primary data was collected by giving questionnaire to the employees. The completed questionnaires in all respects were taken for the study. Questionnaire used which consist of 20 questions.

Secondary data used was the literature given which were reviewed for the purpose of attaining knowledge on the topic.

Statistical Tools used for data analysis
In this study, It has various statistical tools like percentage analysis and statistical test like Correlation, One way ANOVA & Independent sample T-Test.

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DATA ANALYSIS AND INTERPRETATION

Here p value is -.118 Hence there is negative correlation between age and problem facing frequently while handling the materials.

Null hypothesis H0: There is no significance difference between Gender and improvements in material handling

Alternate Hypothesis H1: There is significance difference between Gender and improvements in material handling.

Here p value is 0.852 which is greater than 0.05, so accepting Null Hypothesis. Hence there is no significance difference between Gender and improvements in material handling.

Null hypothesis H0: There is no significance difference between Educational qualification and Critical factor in material handling

Alternate Hypothesis H1: There is significance difference betweenEducational qualification and Critical factor in material handling

Here p value is 0.094, 0.470 and 0.939 which is greater than 0.05, so accepting Null Hypothesis. Hence there is no significance difference between Educational qualification and Critical factor in material handling.

FINDINGS

- In correlation test there is negative correlation between age and problem facing frequently while handling the materials.
- In Independent sample T – test it proves that Experience have no impact on improvements in material handling.
- In one way anova test it proves that Educational qualification have no impact on Critical factor in material handling.
- Majority (44%) of the respondents are age between 21-30 years.
- Majority (91%) of the respondents are Male.
- Majority (49%) respondents is Undergraduate
- Majority (53%) respondents has 1 – 10 years of experience.
- Majority (63%) of respondents choosen the power trolleys.
- Majority (59%) of respondents said their current racking system as pallet racking.
- Majority (78%) of the respondents preferred automated.
- Majority (70%) of respondents said that its takes 15 -30 min to load and unload 400 pices of materials.
- Majority (44%) of respondents said that the equipment is more safety for handling materials is power trolleys.
- Majority (42%) of respondents are satisfied with storage method.
- Majority (37%) of respondents said none of the problem facing frequently.
- Majority (53%) of respondents Agree that they are satisfied with the equipments used in the company.
- Majority (34%) of respondents modern equipment requirement requirement is Bay crane.
- Majority (37%) disagree the critical factor as ordering system.
- Majority (46%) neutral that the factors as lack of information.
- Majority (38%) neutral that the trouble in equipments
- Majority (48%) neutral that lack of equipments
- Majority (42%) neutral about the route damage.
- Majority (59%) of respondents Agree that they need alternative methods in material handling.
- Majority (63%) of respondents confirmed that 2 feet is effective for material movement.
- Majority (34%) agree the difficulties faced as driver shortage.
- Majority (32%) strongly agree as safety of materials.
- Majority (56%) strongly agree that the environmental control.
- Majority (56%) neutral that route optimisation.
- Majority (48%) neutral about the driver behaviour.
- Majority (40%) of respondents agree that improvements has more equipment needed.

SUGGESTION

- Make a plan use as a team approach to design the material handling system.

- Standardize the consistent in your choise of storage equipment, including bins, shelves and racks as well as equipment used to transport materials.
- Reduce, combaine or eliminate as much movement as possible.
- Wherever possible, move full pallets or containers to improve efficiency and reduce effort.
- Working in an organized space is more efficient than working around clutter.
- Employ automation wherever possible. Think of automated picking and putaway technologies.

CONCLUSION

A recent study on material handling practices revealed that the majority of respondents were male (91%) aged between 21 to 30 years (44%). The largest educational group was undergraduates (49%), and most had 1-10 years of experience (53%). Power trolleys were the most commonly used equipment (63%), with pallet racking being the predominant racking system (59%). Notably, a significant majority (78%) preferred automated material handling systems. Despite overall satisfaction with current practices, a key challenge highlighted was a shortage of equipment supply (12%). The findings suggest a strong inclination towards automation and emphasize the importance of addressing equipment availability to optimize material handling processes effectively.

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Table 1: Analysis Using Correlation

Correlations			
		Which problem you are facing frequently while handling the materials	Age
Which problem you are facing frequently while handling the materials	Pearson Correlation	1	-
	Sig. (2-tailed)		.187
	N	126	126
Age	Pearson Correlation	-.118	1
	Sig. (2-tailed)	.187	

	N	126	126

Table 2:Analysis Using Independent Sample T-Test

Group Statistics					
	Gender	N	Mean	Std. Deviation	Std. Error Mean
What are the improvements should be made?	Male	114	2.09	1.102	.103
	Female	12	2.08	1.165	.336

Table 3: Independent Samples Test

Independent Samples Test									
	Levene's Test for Equality of Variance		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2tailed)	Mean Difference	Std. Error Difference	95%Confidence Interval of the Difference
									Lower	Upper
What are the improvements should be made?	Equal variances assumed	.035	.852	.013	124	.990	.004	.336	-.661	.670
	Equal variances not assumed			.012	13.159	.990	.004	.352	-.754	.763

Table 4:Analysis Using One Way Anova

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
What do you consider to be the critical factor in material handling [Ordering system]	Between Groups	6.494	3	2.165	2.182	.094
	Within Groups	121.006	122	.992		
	Total	127.500	125			
What do you consider to be the critical factor in material handling [Lack of equipment]	Between Groups	1.669	3	.556	.849	.470
	Within Groups	79.990	122	.656		
	Total	81.659	125			
What do you consider to be the critical factor in material handling [Trouble in equipment]	Between Groups	.312	3	.104	.135	.939
	Within Groups	93.688	122	.768		
	Total	94.000	125			

RESEARCH ARTICLE

A Study on Impot and Export with Refference to Shellam Soap Manufacturing Industry

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ABSTRACT

This project is all about to know about export import procedure/ documentation of shipment. This project puts more focus on to know custom clearness, to make export - import invoice, to get shipping bill number from custom department etc. This project will also find out how Gray grain polymer rubber industry could sustain in the competitive world by providing vast range of cargo handling through all instruments which flexible prompt and innovative in meeting the requirement of the customer. The purpose of the study was to know about export – import documentation of seaway in the Shellam Soap Industry.

Keywords: Export, Import, Manufacturing Industry, Soap Industry, Tripoli Phosphate Poses.

INTRODUCTION

This paper is all about to know about export import procedure / documentation of shipment. This project puts more focus on to know custom clearness, to make export - import invoice, to get shipping bill number from custom department etc. This project will also find out how Gray grain polymer Soap industry could sustain in the competitive world by providing vast range of cargo handling through all instruments which flexible prompt and innovative in meeting the requirement of the customer. The purpose of the study was to know about export – import documentation of seaway in the Shellam soap industry.

PROBLEMS OF THE STUDY
Soap industry faces some problems in case of raw materials. The major ingredients are soap ash, linear alkyl, benzene& sodium. Tripoli phosphate poses number of serious problems in terms of availability. The demand supply

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gap for vegetable oil is 1.5 to 2 lakh tons & is met through imports. In recent times, caustic soda and soap ashes in the cheaper varieties of soaps are quite high.

OBJECTIVE OF THE STUDY
➢   To know about export import process.
➢   To know what are the documents required before and after sailing the cargo.
➢   To know different type of container used in shipment.
➢   ToacquainttheparticipantswithvariousExport-Importnorms,proceduresand documentation

SCOPE OF THE STUDY
➢   Types of consumers that compromise present and potential markets.
➢   Buying habits and pattern of consumption
➢   Size and location of different markets, not only in India but also overseas.
➢   The prospects for growth or construction for the current markets being served.
➢   New mantras of emerging segments.
➢   Marketing and manufacturing capabilities of competitors.
➢   Most suitable entry timing.
➢   The current and prospective competitive position.
➢   Chances of improvement of current channels.

RESEARCH METHODOLOGY

The data has been collected from two sources of data that is primary and secondary data. Primary data Questionnaire methods are used to elicit information from employees of various hierarchy departments. Primary data are those which are gathered especially for the project at hand is directly through questionnaire & personal interaction. Primary data is collected by administering the questionnaire& personal interaction. Secondary data has been collected from different books and company files and website. The secondary data has been collected by an individual from different sources. Sampling size: The study was taken on 100 respondents. Data presentation Data was presented with the help of tables, charts; interpretation and observation were noted below each table/charts. Data analysis Data was analyzed by simple qualitative analysis for the study.

DATA ANALYSIS AND INTERPRETATION

INTERPRETATION
The above table it can be observed that the position held of the respondent is 18% of the respondent are proprietor and 29% of the respondent are managing director, 11% of the respondent are manager, 21% of the respondent are any others and 21% of the respondent are partners.

INTERPRETATION
The above table it can be observed that the gender of the respondent is 52% of the respondent are male and 48 % of the respondent are female.

INTERPRETATION
The above table it can be observed that the age of the respondent is 18% of the respondent are 20-30 and 30 % of the respondent age group is 30-40, 16 % of the respondent are 40-50,16 % of the respondent age group are 50-60and 19% of the respondent age group are 60and above.

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INTERPRETATION

The above table it can be observed that the qualification of the respondent is 32 % of the respondent education qualification is degree, 43 % of the respondent education qualification is pg and 25 % of the respondent education qualification is professional.

INTERPRETATION

The above table it can be observed that the religion of the respondent is 28 % of the respondent is Hindu, 43 % of the respondent is Muslim and 25 % of the respondent is Christian.

INTERPRETATION

The above table it can be observed that the experience of the respondent is 19% of the respondent are working experience less than 10 years, 37 % of the respondent are working experience less than 10 20 years, 18 % of the respondent are working experience less than 20-30 years, 28 % of the respondent are working experience 30 years and above.,

INTERPRETATION

The above table it can be observed that the finance related problems is 19% of the respondent are says that Delay in export realization, 30 % of the respondent are says that High rate of interest, 17% of the respondent are says that Too many formalities followed, 15% of the respondent are says that Shortage of working capital problems and 18 % of the respondent are says that Not applicable.

INTERPRETATION

The above table it can be observed that the infrastructure problems faced by your firm is 15 % of the respondent are says that Transportation, 25 % of the respondent are says that Water, 14% of the respondent are says that Electricity problems, 14% of the respondent are says that road problems, 18% of the respondent are says that port problems and 14% of the respondent are says that shipping problems.

INTERPRETATION

The above table it can be observed that the opinion about exchange rate related problems faced by your firm, 19% of the respondent are says that Highly Affected, 34% of the respondent are says that Affected, 14% of the respondent are says that neutral, 15% of the respondent are says that unaffected and 19% of the respondent are says that Highly unaffected.

INTERPRETATION

The above table it can be observed that the opinion about labor related problems affect your firm Is 20% of the respondent are says that Highly Affected, 32% of the respondent are says that Affected, 10% of the respondent are says that neutral, 17% of the respondent are says that unaffected and 21% of the respondent are says that Highly unaffected.

FINDING

- The position held of the respondent is 18% of the respondent are proprietor and 29% of the respondent are managing director, 11% of the respondent are manager, 21% of the respondent are any others and 21% of the respondent are partners
- The gender of the respondent is 52% of the respondent are male and 48 % of the respondent are female.
- The age of the respondent is 18% of the respondent are 20-30 and 30 % of the respondent age group is 30-40, 16 % of the respondent are 40-50, 16 % of the respondent age group are 50-60and 19% of the respondent age group are 60and above.
- The qualification of the respondent is 32 % of the respondent education qualification is degree, 43 % of the respondent education qualification is pg and 25 % of the respondent education qualification is professional

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- The religion of the respondent is 28 % of the respondent is Hindu, 43 % of the respondent is Muslim and 25 % of the respondent is Christian.
- The experience of the respondent is 19% of the respondent are working experience less than 10 years, 37 % of the respondent are working experience less than 10 -20 years, 18 % of the respondent are working experience less than 20-30 years, 28 % of the respondent are working experience 30 years and above.,
- The finance related problems is 19% of the respondent are says that Delay in export realization, 30 % of the respondent are says that High rate of interest, 17% of the respondent are says that Too many formalities followed, 15% of the respondent are says that Shortage of working capital problems and 18 % of the respondent are says that Not applicable.
- The infrastructure problems faced by your firm is 15 % of the respondent are says that Transportation, 25 % of the respondent are says that Water, 14% of the respondent are says that Electricity problems, 14% of the respondent are says that road problems, 18% of the respondent are says that port problems and 14% of the respondent are says that shipping problems
- The opinion about exchange rate related problems faced by your firm, 19% of the respondent are says that Highly Affected, 34% of the respondent are says that Affected, 14% of the respondent are says that neutral, 15% of the respondent are says that unaffected and 19% of the respondent are says that Highly unaffected.
- The opinion about labor related problems affect your firm
- Is 20% of the respondent are says that Highly Affected, 32% of the respondent are says that Affected, 10% of the respondent are says that neutral, 17% of the respondent are says that unaffected and 21% of the respondent are says that Highly unaffected.
- The opinion about storage problems affect firm is 19 % of the respondent are says that Highly Affected, 36 % of the respondent are says that Affected, 12 % of the respondent are says that neutral, 14 % of the respondent are says that unaffected and 19 % of the respondent are says that Highly unaffected.
- The opinion about The effect of legal and government policies is 20 % of the respondent are says that Highly Affected, 32% of the respondent are says that Affected, 11% of the respondent are says that neutral, 18% of the respondent are says that unaffected and 19 % of the respondent are says that Highly unaffected.
- The opinion about through proper planning of export and import transactions is 18 % of the respondent are says that strongly agree, 33% of the respondent are says that agree, 10% of the respondent are says that neutral, 14% of the respondent are says that disagree and 25 % of the respondent are says that strongly disagree.
- The opinion about AGMARK labeled products are given tax rebate is 18 % of the respondent are says that strongly agree, 35% of the respondent are says that agree, 11% of the respondent are says that neutral, 16% of the respondent are says that disagree and 20% of the respondent are says that strongly disagree.
- The opinion about good manufacturing practices help in exporting is 18 % of the respondent are says that strongly agree, 34% of the respondent are says that agree, 14% of the respondent are says that neutral, 13% of the respondent are says that disagree and 21 % of the respondent are says that strongly disagree.
- The opinion about Financial institutions are the backbone of your business is 24 % of the respondent are says that strongly agree, 36% of the respondent are says that agree, 12 % of the respondent are says that neutral, 14% of the respondent are says that disagree and 14% of the respondent are says that strongly disagree
- The opinion about Export Credit Guarantee Corporation is 24 % of the respondent are says that highly satisfied, 28% of the respondent are says that satisfied, 12 % of the respondent are says that neutral, 18% of the respondent are says that dissatisfied and 18 % of the respondent are says that highly dissatisfied .
- The opinion about Standard Input Output firm is 21% of the respondent are says that highly satisfied, 36% of the respondent are says that satisfied, 14% of the respondent are says that neutral, 14 % of the respondent are says that dissatisfied and 16 % of the respondent are says that highly dissatisfied .
- The opinion about Export Inspection Council is 20% of the respondent are says that highly satisfied, 36% of the respondent are says that satisfied, 14% of the respondent are says that neutral, 16 % of the respondent are says that dissatisfied and 16 % of the respondent are says that highly dissatisfied .
- The opinion about Export Promotion Board is 17% of the respondent are says that highly satisfied, 38 % of the respondent are says that satisfied, 13 % of the respondent are says that neutral, 15% of the respondent are says that dissatisfied and 16 % of the respondent are says that highly dissatisfied .

- The opinion about South Asia Free Trade Area financial is 17% of the respondent are says that highly satisfied, 39 % of the respondent are says that satisfied, 10% of the respondent are says that neutral, 17% of the respondent are says that dissatisfied and 16 % of the respondent are says that highly dissatisfied .
- The opinion about any incentives, assistance, or subsidies financial is 13 % of the respondent are says DEPB, 18% of the respondent are says that satisfied, 12% of the respondent are says VKGUY interest benefit, 22% of the respondent are says Duty drawback, 12% of the respondent are says IT benefit / VAT benefit and 11% of the respondent are says STPI
- The opinion about of prospects for the export / import of your product is 18 % of the respondents are says that High prospects, 29 % of the respondents are says that Moderate, 15% of the respondents are says that Neutral, 18 % of the respondents are says that Less prospects, 19 % of the respondents are says that No prospects

SUGGESTION

- Fewer but larger customers
- Increasing costs (labeling, raw materials)
- Tightened supplies
- A shift in consumer diet demands and product preferences
- Customer mandates
- Soap product safety compliance
- The processed Soap industry is less developed as a result of logistical and distribution problems
- Agriculture remains inefficient and is vulnerable to climatic changes.
- Despite rapid economic growth, India remains a very poor country.
- India's infrastructure is notoriously inadequate. A 500km road journey can take as much as 24 hours owing to poor road conditions, congestion and tolls.

CONCLUSION

Soap Products Industries continued their strong performance in 1996. The demand for Soap products is primarily dependent on the production of vehicles as well as international trade developments. More recently, various global environment initiatives have also affected the performance of Soap products industries as manufacturers continue to seek alternatives to the recycling of Soap. Perhaps the best solution to environmental and health concerns associated with manufacturing Soap products would be good engineering control for producing and compounding powdered chemicals used in Soap compounds, and recycling programmes for all uncured and cured Soap process scrap and products. The powdered chemicals collected in dust-collector systems could be added back to Soap compounds with the appropriate engineering controls, which would eliminate the land filling of these chemicals. Controlling the environmental and health issues in the Soap industry can be done, but it will not come easy or be free. The cost associated with controlling environmental and health problems must be added back to the cost of Soap products.

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Table 1: Position Held of the Respondent

	Frequency	Percent	Valid Percent	Cumulative Percent
Proprietor Managing Director Valid Manager	20 32 12	18.0 28.8 10.8	18.2 29.1 10.9	18.2 47.3 58.2
Any other	23	20.7	20.9	79.1
Partners	23	20.7	20.9	100.0
Total	110	99.1	100.0	

Table 2: Gender Status of the Respondents

	Frequency	Percent	Valid Percent	Cumulative Percent
Male Valid Female	57 53	51.4 47.7	51.8 48.2	51.8 100.0
Total	110	99.1	100.0	

Table 3: Age of the Respondent

	Frequency	Percent	Valid Percent	Cumulative Percent
20-30	20	18.0	18.2	18.2
30-40	33	29.7	30.0	48.2
40-50 Valid	18	16.2	16.4	64.5
50 -60	18	16.2	16.4	80.9
60 and above	21	18.9	19.1	100.0
Total	110	99.1	100.0	

Table 4: Qualification of the Respondent

	Frequency	Percent	Valid Percent	Cumulative Percent
Degree PG Valid	35 47	31.5 42.3	31.8 42.7	31.8 74.5
Professional	28	25.2	25.5	100.0
Total	110	99.1	100.0	

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Table 5: Religion

	Frequency	Percent	Valid Percent	Cumulative Percent
Hindu	31	27.9	28.2	28.2
Muslim Valid	50	45.0	45.5	73.6
Christian	29	26.1	26.4	100.0
Total	110	99.1	100.0	

Table 6: Experience in this Field

	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 10 years 10-20 years Valid 20-30 years	21	18.9	19.1	19.1
	41	36.9	37.3	56.4
	20	18.0	18.2	74.5
30 years and above	28	25.2	25.5	100.0
Total	110	99.1	100.0	

Table 7: Please Specify the Finance Related Problems

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Delay in export realization	21	18.9	19.1	19.1
	High rate of interest	33	29.7	30.0	49.1
	Too many formalities	19	17.1	17.3	66.4
	Shortage of working capital	17	15.3	15.5	81.8
	Not applicable	20	18.0	18.2	100.0
	Total	110	99.1	100.0	

Table 8: Infrastructure Problems Faced by your Firm

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Transportation	16	14.4	14.5	14.5
	Water	27	24.3	24.5	39.1
	Electricity	16	14.4	14.5	53.6
	Road	16	14.4	14.5	68.2
	Port	20	18.0	18.2	86.4
	Shipping	15	13.5	13.6	100.0
	Total	110	99.1	100.0	

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Table 9: Exchange Rate Related Problems Faced by your Firm

	Frequency	Percent	Valid Percent	Cumulative Percent
Highly Affected	21	18.9	19.1	19.1
Affected	37	33.3	33.6	52.7
Neutral Valid	15	13.5	13.6	66.4
Unaffected	16	14.4	14.5	80.9
Highly unaffected	21	18.9	19.1	100.0
Total	110	99.1	100.0	

Table 10: How do the Labour Related Problems affect your Firm?

	Frequency	Percent	Valid Percent	Cumulative Percent
Highly Affected	22	19.8	20.0	20.0
Affected	35	31.5	31.8	51.8
Neutral Valid	11	9.9	10.0	61.8
Unaffected	19	17.1	17.3	79.1
Highly unaffected	23	20.7	20.9	100.0
Total	110	99.1	100.0	

RESEARCH ARTICLE

A Study on Consignment Handling Optimisation in Freight Forwarding Operations in Freight Consolidators Private Limited

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ABSTRACT

This study examines the optimization of consignment handling operations within Freight Consolidators Private Limited, a company operating in the logistics and transportation industry. Through a descriptive research approach and convenience sampling method, data were collected from 120 employees directly involved in consignment handling processes. The findings reveal insights into demographic characteristics, employee perceptions, and operational effectiveness. Key findings include a predominant representation of mid-level and management roles within the workforce, as well as varying levels of satisfaction with delivery assurance, communication transparency, expedited shipping options, warehouse operations, employee training, tracking system usability, and customer feedback management. Based on these findings, seven recommendations are proposed to enhance consignment handling efficiency, improve customer satisfaction, and maintain competitiveness. This study contributes to the body of knowledge in logistics and supply chain management by providing actionable insights for Freight Consolidators Private Limited and similar organizations seeking to optimize their consignment handling operations.

Keywords: Communication, Consignment Handling Operations, Logistics, Tracking System Usability, Warehouse.

INTRODUCTION

The study on consignment handling optimization in Freight Consolidators Private Limited emerges from the growing imperative within the logistics industry to enhance operational efficiency amidst increasing demands for timely and cost-effective freight services. With globalization driving complex supply chains and heightened customer

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expectations for quick and reliable delivery, freight forwarding companies face mounting pressure to streamline their processes. Freight Consolidators Private Limited, like many in the industry, recognizes the need to re-evaluate its consignment handling procedures to remain competitive. This study aims to delve into the intricacies of the company's current practices, identifying bottlenecks, inefficiencies, and areas for improvement. By understanding the challenges and opportunities within consignment handling operations, the company can implement targeted strategies to optimize transit times, minimize costs, improve tracking accuracy, and ultimately elevate customer satisfaction. The background of this study underscores the company's commitment to staying at the forefront of industry standards, ensuring continued success in an ever-evolving logistics landscape.

NEED FOR THE STUDY
The study on consignment handling optimization in Freight Consolidators Private Limited is essential for several reasons. Firstly, in today's fast-paced logistics industry, efficiency is paramount for remaining competitive. By streamlining consignment handling processes, the company can reduce transit times, lower costs, and ultimately improve profitability. Secondly, optimizing these operations can lead to enhanced customer satisfaction, as timely and reliable delivery is crucial for maintaining positive relationships with clients. Additionally, with the increasing complexity of global supply chains, improving the accuracy and reliability of tracking and tracing consignments is essential for meeting regulatory requirements and ensuring transparency throughout the shipping process. Overall, this study addresses the pressing need for Freight Consolidators Private Limited to adapt and excel in an ever-evolving freight forwarding landscape.

OBJECTIVES OF THE STUDY
Primary objective
To optimize consignment handling processes in Freight Consolidators Private Limited.

Secondary objectives
- To reduce transit times for consignments.
- To minimize storage and handling costs.
- To enhance accuracy and reliability of tracking and tracing consignments.
- To improve customer satisfaction through timely and efficient delivery.

SCOPE OF THE STUDY
The scope of the study on consignment handling optimization in Freight Consolidators Private Limited encompasses a comprehensive analysis of all aspects related to the handling of freight. This includes but is not limited to, examining current processes, identifying bottlenecks, evaluating technology utilization, assessing workforce efficiency, and scrutinizing the effectiveness of existing logistics strategies. Additionally, the study will explore potential areas for improvement such as automation implementation, route optimization, inventory management enhancements, and customer communication enhancements. By examining these facets, the study aims to provide actionable insights and recommendations to enhance the efficiency, reliability, and cost-effectiveness of consignment handling operations within the company. Moreover, the scope extends to considering industry best practices and benchmarking against competitors to ensure that Freight Consolidators Private Limited remains at the forefront of innovation and excellence in the freight forwarding sector.

LIMITATION OF THE STUDY
1. Limited availability of historical data for analysis.
2. Potential resistance to change from existing workforce.
3. Constraints in budget allocation for implementing proposed improvements.
4. Inability to control external factors such as weather disruptions or regulatory changes.
5. Scope limited to internal operations, excluding external factors like supplier reliability or customer demand fluctuations.

REVIEW OF LITERATURE

Aptaguna & Pitaloka (2016), expectations' manifestation depends on how customers perceive and interpret the environmental factors influencing the formation of expectations. Some factors may be controlled by a company, foreseen and be prepared for, but other factors depend on the clients in a larger extent (psychological, cultural, social), therefore logistics companies face a huge challenge to understand their customer, find out his needs and strive to meet customer expectations. Considering this, logistics companies need to keep in mind that seeking competitive advantage and customer circle's growth, they must immediately ensure the customer's acknowledgement as a service provided one time is remembered for a long time and the fact whether it was qualities or no further will determine the client's choice; and this means to the logistics company whether it was able to attract or retain a customer or not. Banjarnahor (2017), analyzing customer satisfaction, indicates that customers comprise the aim of the company's activity, i.e., he focuses the fact that not service users and customers depend on the company, but the company's performance depends on its existing customers. Dawi et al Eds. (2018) also stresses that customer satisfaction becomes the key element companies' focus on seeking to promote repeated business relationships and increase long- term profitability. Lamai et al Eds. (2020) stated that that in the current competitive environment it is dangerous to be a non-customer-oriented company. Most of the companies are competitive, and in order to stay in the market, they must provide high-quality services that would make customers satisfied and loyal. It also should be considered that logistics service companies should know their customers because the company, having sufficient information and knowledge about its customers, has more opportunities to make right decisions on the needs of the client, which allows companies to develop new services that provide real value to customers as well as to assess quantitatively the values desired by customers. Bell (2000) generally defines customer satisfaction as a customer assessment in terms of whether the service meets the customer's needs and expectations. It is important to note that each client's expectations are (or may be) different. This may depend not only on the personal interests, butalso on the environment, area, the type of business in which those expectations are formed. Thus, companies' ability to be flexible and adapt may help to gain an advantage over other business entities. Examining logistics services, flexibility is a particularly important aspect. Flexibility in logistics is a possibility to a company to quickly and effectively respond to the changing needs of the client.

Laurent and Martinez-Simon (2012) found that the service provided is usually best when a close relationship is built between the forwarder and the customer, since this facilitates the exchange of information so that each can better understand the needs and motivations of the other party. This allows problems to be solved and the optimal logistical solutions to be found. Knigge (2014) concur, citing the need to respond quickly to any issues or communication requests during the logistics process. The key components of this factor include on-time performance, quick response to complaints, provision of electronic freight tracking, attitude towards complaints or requests, and the provision of an electronic payment interface. The findings presented in a study by Goh and Pinaikul (1998) revealed that in Thailand, import/export companies were more likely to select freight forwarders who were highly responsive. Lamai et al Eds. (2020) compared the opinions of customers with those of the freight forwarders, and discovered that the freight forwarders believed cost to be the most important factor in the decision making process, while the customers in contrast would look at lead time and quality as their key issues. Lai and Cheng (2004) reports the results of a study of the freight forwarding industry in Hong Kong. A survey questionnaire was administered to over 1,100 companies in the industry, examining their demographic profiles, capability in providing different types of logistics services, service performance and the perceived prospects of the industry. Based on 221 valid survey responses, the study results show that the industry consists mainly of small and medium-sized companies (i.e. number of employees ≤50). Furthermore, freight forwarding services contribute more than 60% of revenue in over 70% of the respondent companies. While many freight forwarders in Hong Kong are highly capable of providing freight forwarding and many traditional logistics services, they seem to lack the ability to provide other value-added services. Nevertheless, their self-assessments indicate that they perform well in different logistics services and that they are inclined to transform themselves into third-party logistics providers. A discussion of the findings and implications of the results are provided. Diefenbach (2023) stated that the air freight supply chain

consists of several agents. Among them are truckers, who ship freight between customers and airports, and airlines, who transport the freight in-between airports. Handling agents link the two: they receive freight from truckers, consolidate it and forward it to the airlines and vice versa. They need to organise and execute processes efficiently. Digitalisation offers great potential in this context. Furthermore, handling agents' workers handle most of the freight manually. The resulting elevated levels of physical strain make workers prone to muscular-skeletal disorders. Based on a case study at two handling agents, we first investigate the handling agents' process chain from an economic perspective. We identify shortcomings and present countermeasures with an emphasis on digitalisation. Second, we analyse the physical strain on the workers and evaluate devices that could improve ergonomics. The paper concludes with a discussion of recommended means for economic and ergonomic improvement.

RESEARCH METHODOLOGY

The research adopts a descriptive research design to systematically examine the current practices and identify opportunities for optimizing consignment handling processes within the company. Descriptive research allows for the detailed description and analysis of existing phenomena without manipulating variables. This design is suitable for investigating the various aspects of consignment handling operations and deriving meaningful insights to enhance efficiency.

Target population
The target population for this study is the employees directly involved in consignment handling operations within Freight Consolidators Private Limited. This includes managers, supervisors, and frontline staff responsible for various tasks related to receiving, storing, packing, labeling, transporting, and delivering consignments.

Sampling Technique
Convenience sampling method is employed in this study due to its practicality and accessibility. Convenience sampling involves selecting participants based on their availability and accessibility. In this case, employees directly involved in consignment handling operations, including managers, supervisors, and frontline staff, will be invited to participate in the study. This sampling technique facilitates efficient data collection while ensuring representation from key stakeholders within the organization.

Sample size
The sample size for this study is 120 respondents, drawn from the target population of employees within the company. This sample size is chosen to ensure adequate representation across different levels of the organization and to achieve a statistically significant sample for analysis.

Sample area
The sample area for data collection is the premises of Freight Consolidators Private Limited, where the employees engaged in consignment handling operations are located. This may include warehouses, offices, and other facilities where logistics activities are carried out.

Data collection methods
The study utilizes both primary and secondary data sources to gather relevant information. Primary data will be collected through structured questionnaires administered to employees involved in consignment handling processes. The questionnaire will include demographic questions, Likert-scale statements related to the study objectives, and open-ended questions for additional insights. Secondary data will be obtained from company records, reports, and existing literature on logistics and supply chain management.

Data collection instrument

The data collection instrument for this study is a structured questionnaire. The questionnaire comprises demographic questions to gather information about the respondents' characteristics (e.g., age, gender, position), as well as Likert-scale statements and open-ended questions related to the study objectives. The questionnaire is designed to collect both quantitative and qualitative data, allowing for a comprehensive analysis of consignment handling processes and employee perceptions.

Data Analysis

Quantitative data collected through the questionnaires will be analyzed using statistical techniques such as descriptive statistics, frequency distribution, and correlation analysis. Likert-scale responses will be aggregated and summarized to assess the level of agreement or disagreement with each statement. Qualitative data from open-ended questions will be subjected to thematic analysis to identify recurring themes and patterns. The integration of quantitative and qualitative findings will provide a comprehensive understanding of consignment handling processes and inform recommendations for optimization.

Statistical tools used

- Correlation analysis
- Chi-Square Test

DATA ANALYSIS AND INTERPRETATION
CORRELATION

Null Hypothesis: There is no relation between job position and the opinion that the company effectively utilizes route optimization techniques to minimize transit times

Alternative Hypothesis: There is a relation between job position and the opinion that the company effectively utilizes route optimization techniques to minimize transit times.

INTERPRETATION

From the above table it is understood that the significant at 0.05 levels. Hence, null hypothesis is rejected and there isrelation between job position and the opinion that the company effectively utilizes route optimization techniques to minimize transit times.

CHI-SQUARE TEST

Null Hypothesis: There is no relation between experience and the satisfaction with the level of service provided by the company in terms of delivery efficiency

Alternative Hypothesis: There is a relation between experience and the satisfaction with the level of service provided by the company in terms of delivery efficiency

INTERPRETATION

As per the table, it is inferred that the P value is 114.761, it is significant to 5% significant level. The maximum expected count is 1.87. thus, null hypothesis is rejected and There is relationship between experience and the satisfaction with the level of service provided by the company in terms of delivery efficiency.

FINDINGS OF THE STUDY

- 54% were Female, while 46% were male.
- About 30% of the respondents are below 25 years of age, 25% of the respondents are between 26 to 35 years of age, about 34% of the respondents are between 36 – 45 years of age, 8% of the respondents are between 46 – 55 years of age and 3% of the respondents are above 55 years of age.
- The company's workforce is predominantly composed of mid-level and management roles, collectively making up 76% of positions. Senior-level roles constitute a modest 7%, while entry-level positions occupy 12%. The

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remaining 5% is designated for specialized positions. This distribution underscores a hierarchical structure with an emphasis on mid-level and managerial responsibilities.

- 37%, possesses 4 to 6 years of experience, followed closely by 32% with 1 to 3 years. Those with less than 1 year of experience constitute 18%, while individuals with 7 to 9 years make up 13% of the workforce.

- 12% engage daily, while 35% do so weekly. A smaller proportion, 5%, interacts monthly, with a significant 41% reporting rare interactions. 7% of employees never engage in these processes.

- 19% strongly agree with the company's ability to ensure prompt deliveries, while 36% simply agree. 28% remain neutral, neither affirming nor contesting the efficiency of delivery assurance. On the contrary, 15% express disagreement, and a mere 2% strongly disagree with the notion.

- A notable 36% strongly agree with its effectiveness, while 31% simply agree. Twenty percent remain neutral, neither confirming nor disputing its efficiency. Conversely, 12% express disagreement, and only 1% strongly disagree.

- 13% strongly agree that communication is transparent, with an additional 28% expressing agreement. Meanwhile, 27% remain neutral, neither confirming nor disputing the transparency of communication. Disagreement is expressed by 22% of respondents, with 10% strongly disagreeing with the notion.

- 23% strongly agree with the concept, while 28% simply agree. 32% remain neutral, neither confirming nor disputing the effectiveness of expedited shipping. On the contrary, 15% express disagreement, with 2% strongly disagreeing with the notion.

- 14% strongly agree with the concept, while 25% simply agree. 33% remain neutral, neither confirming nor disputing the effectiveness of delivery assurance. On the other hand, 18% express disagreement, with 10% strongly disagreeing with the notion.

- 15% strongly agree with the effectiveness of minimizing storage costs, while 28% simply agree. 26% remain neutral, neither confirming nor disputing the efficiency of warehouse operations. On the other hand, 25% express disagreement, with 6% strongly disagreeing with the notion.

- 11% strongly agree with the effectiveness of reducing labor costs, while 29% simply agree. 28% remain neutral, neither confirming nor disputing the efficiency of streamlined handling. On the other hand, 23% express disagreement, with 9% strongly disagreeing with the notion.

- 3% strongly agree with the effectiveness of minimizing manual handling, while 28% simply agree. 33% remain neutral, neither confirming nor disputing the efficiency of automated processes. On the other hand, 14% express disagreement, with 12% strongly disagreeing with the notion.

- 11% strongly agree with the effectiveness of reducing costs through consolidated shipments, while 32% simply agree. 28% remain neutral, neither confirming nor disputing the efficiency of this approach. On the other hand, 19% express disagreement, with 10% strongly disagreeing with the notion.

- 13% strongly agree with the competitiveness of these costs, while 33% simply agree. 27% remain neutral, neither confirming nor disputing the competitiveness of storage & handling costs. On the other hand, 18% express disagreement, with 9% strongly disagreeing with the notion.

- 13% strongly agree with the effectiveness of these updates, while 48% simply agree. 14% remain neutral, neither confirming nor disputing the effectiveness of real-time tracking. On the other hand, 14% express disagreement, with 11% strongly disagreeing with the notion.

- 12% strongly agree with their accuracy and reliability, while 43% simply agree. 25% remain neutral, neither confirming nor disputing the accuracy and reliability of the updates. On the other hand, 12% express disagreement, with 8% strongly disagreeing with the notion.

- 16% strongly agree with the availability of such opportunities, while 46% simply agree. 19% remain neutral, neither confirming nor disputing the presence of collaboration and teamwork opportunities. On the other hand, 11% express disagreement, with 8% strongly disagreeing with the notion.

- 20% strongly agree with the effectiveness of resolving discrepancies swiftly, while 43% simply agree. 17% remain neutral, neither confirming nor disputing the efficiency of swift resolution. On the other hand, 13% express disagreement, with 7% strongly disagreeing with the notion.

- 21% strongly agree with the user-friendliness of the navigation, while 43% simply agree. 22% remain neutral, neither confirming nor disputing the intuitiveness of the tracking system. On the other hand, 10% express disagreement, with 4% strongly disagreeing with the notion.
- 8% strongly agree that consignments are consistently delivered on time, while 35% simply agree. 24% remain neutral, neither confirming nor disputing the consistency of on-time deliveries. On the other hand, 14% express disagreement, with 19% strongly disagreeing with the notion.
- 14% strongly agree that notifications are timely, while 27% simply agree. 22% remain neutral, neither confirming nor disputing the timeliness of notifications. On the other hand, 32% express disagreement, with 5% strongly disagreeing with the notion.
- 18% strongly agree with the availability of flexible options, while 37% simply agree. 19% remain neutral, neither confirming nor disputing the flexibility of delivery choices. On the other hand, 21% express disagreement, with 5% strongly disagreeing with the notion.
- 11% strongly agree with the effectiveness of proactive management, while 34% simply agree. 26% remain neutral, neither confirming nor disputing the effectiveness of customer feedback management. On the other hand, 22% express disagreement, with 7% strongly disagreeing with the notion.
- 12% strongly agree with their satisfaction, while 37% simply agree. 17% remain neutral, neither confirming nor disputing their satisfaction with the service. On the other hand, 22% express disagreement, with 12% strongly disagreeing with the notion.
- there is relation between job position and the opinion that the company effectively utilizes route optimization techniques to minimize transit times.
- There is relationship between experience and the satisfaction with the level of service provided by the company in terms of delivery efficiency.

SUGGESTION

- Strengthen efforts to ensure prompt deliveries by implementing proactive measures such as optimizing delivery routes, coordinating with transportation partners, and investing in real-time tracking technologies to minimize delays and improve delivery reliability.
- Foster transparent communication channels between the company and its employees, ensuring that updates on consignment status, delivery schedules, and any operational changes are effectively communicated to all stakeholders in a timely manner.
- Review and enhance expedited shipping options to better meet customer needs and expectations. This may involve streamlining processes, negotiating partnerships with express delivery providers, and offering flexible delivery schedules to accommodate urgent shipments.
- Implement measures to minimize storage costs and improve warehouse efficiency. This could include optimizing inventory management systems, investing in automation technologies for handling and storage, and exploring opportunities for consolidating shipments to maximize warehouse utilization.
- Provide ongoing training and development opportunities for employees at all levels to enhance their skills and expertise in consignment handling processes, customer service, and technology utilization. This will empower employees to perform their roles more effectively and contribute to overall operational excellence.
- Improve the user-friendliness and intuitiveness of the tracking system to ensure that employees can easily navigate and utilize it to access real-time updates on consignment status. This may involve conducting usability testing, gathering feedback from users, and implementing enhancements based on their input.
- Establish a robust system for collecting, analyzing, and acting upon customer feedback to identify areas for improvement and drive continuous enhancement of service quality. This could include implementing feedback mechanisms such as surveys, complaint resolution processes, and regular customer engagement initiatives

CONCLUSION

The findings of this study shed light on various aspects of consignment handling optimization within Freight Consolidators Private Limited. The analysis reveals insights into demographic characteristics, employee perceptions, and operational effectiveness, providing valuable information to guide strategic decision-making and process improvement initiatives. The study highlights opportunities for enhancing delivery assurance, communication transparency, expedited shipping options, warehouse operations, employee training, tracking system usability, and customer feedback management. By implementing the recommendations derived from these findings, the company can strengthen its consignment handling operations, improve customer satisfaction, and maintain a competitive edge in the logistics industry. Moreover, the study underscores the importance of continuous evaluation and refinement of processes to adapt to evolving market dynamics and customer expectations. Overall, this study serves as a valuable resource for Freight Consolidators Private Limited in its pursuit of operational excellence and service quality enhancement.

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Table 1: Descriptive Statistics

	Mean	Std. Deviation	N
POSITION	2.79	1.194	120
EFFICIENT ROUTE OPTIMIZATION	2.13	1.081	120

Table 2: Correlations

		POSITION	EFFICIENT ROUTE OPTIMIZATION
POSITION	Pearson Correlation	1	.222[*]
	Sig. (2-tailed)		.015
	N	120	120
EFFICIENT ROUTE OPTIMIZATION	Pearson Correlation	.222[*]	1
	Sig. (2-tailed)	.015	
	N	120	120
*. Correlation is significant at the 0.05 level (2-tailed).			

Table 3: Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
EXPERIENCE * SATISFACTION WITH THE LEVEL OF SERVICE	120	99.2%	1	0.8%	121	100.0%

Table 4: Experience and Satisfaction with the Level of Service

			SATISFACTION WITH THE LEVEL OF SERVICE					Total
			Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	
EXPERIENCE	Less than 1 year	Count	2	3	10	5	2	22
		Expected Count	2.6	8.1	3.9	4.8	2.8	22.0
	1-3 years	Count	4	31	0	2	1	38
		Expected Count	4.4	13.9	6.7	8.2	4.8	38.0
	4-6 years	Count	8	9	11	4	12	44
		Expected Count	5.1	16.1	7.7	9.5	5.5	44.0
	7-9 years	Count	0	1	0	15	0	16
		Expected Count	1.9	5.9	2.8	3.5	2.0	16.0
Total		Count	14	44	21	26	15	120
		Expected Count	14.0	44.0	21.0	26.0	15.0	120.0

Table 5: Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	114.761[a]	12	.000
Likelihood Ratio	107.967	12	.000
Linear-by-Linear Association	8.024	1	.005
N of Valid Cases	120		
a. 10 cells (50.0%) have expected count less than 5. The minimum expected count is 1.87.			

RESEARCH ARTICLE

From Tradition to Modernity : A Study of the Dard Tribe's Socio-Cultural Adaptation in the Kashmir Valley

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ABSTRACT

The study examines the socio-cultural adaptation of the Dard tribe in the Kashmir Valley from tradition to modernity. The study aims to explore the evolution of traditional customs and practices of the Dard tribe and investigate the socio-economic factors that have influenced their adaptation to modernity, including education, employment, and access to resources. The paper also analyzes the impact of modernization on the Dard tribe's social and cultural values, including changes in gender roles, family structures, and religious beliefs. The study assesses the challenges and opportunities faced by the Dard tribe in adapting to modernity, including issues related to identity, cultural preservation, and social integration. Finally, the paper identifies potential strategies for promoting sustainable development and cultural preservation among the Dard tribe, while also supporting their adaptation to modernity. The research findings contribute to a better understanding of the Dard tribe's socio-cultural adaptation in the Kashmir Valley and provide insights into the challenges and opportunities for sustainable development and cultural preservation in the region. The Dard tribe, a historically marginalized and indigenous community, has been living in the remote and rugged terrains of the Himalayan region for centuries. However, with the advent of modernity, driven by socio-economic, technological, and environmental changes, the Dard tribe faces challenges and opportunities that demand a reevaluation of their cultural heritage and practices. The study employs a multidisciplinary approach, combining anthropological, historical, and sociological methodologies to investigate how the Dard tribe navigates the complex terrain of cultural preservation and adaptation. By examining their changing livelihoods, language, traditions, and relationships with the surrounding society, the study aims to provide insights into the mechanisms and strategies that underlie their adaptation to modernity.

Keywords: Dard Tribe, Customs, Cultural, Indigenous People, Traditions

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INTRODUCTION

The Dard tribe is one of the indigenous communities inhabiting the Kashmir Valley in India. The tribe has a rich cultural heritage and traditional customs that have been passed down from generation to generation. However, with the advent of modernization, the Dard tribe has been undergoing a socio-cultural adaptation process. The study aims to explore the evolution of traditional customs and practices of the Dard tribe and investigate the socio-economic factors that have influenced their adaptation to modernity, including education, employment, and access to resources. The paper also analyzes the impact of modernization on the Dard tribe's social and cultural values, including changes in gender roles, family structures, and religious beliefs. Furthermore, the study assesses the challenges and opportunities faced by the Dard tribe in adapting to modernity, including issues related to identity, cultural preservation, and social integration. Finally, the paper identifies potential strategies for promoting sustainable development and cultural preservation among the Dard tribe, while also supporting their adaptation to modernity. The Dard tribe is a unique community with a distinct cultural identity. They have their own language, music, dance, and traditional customs that are deeply rooted in their history and heritage. However, with the changing times, the Dard tribe has been facing a number of challenges in preserving their cultural identity and adapting to modernity. The socio-economic factors such as education, employment, and access to resources have played a significant role in shaping the Dard tribe's adaptation process. The tribe has been undergoing a gradual transformation in their social and cultural values. The traditional gender roles and family structures have been changing, and there has been a shift towards a more egalitarian society. The younger generation is more open to new ideas and has been embracing modern lifestyles. However, this process of adaptation has not been without its challenges. The Dard tribe has been struggling to strike a balance between preserving their cultural identity and adapting to modernity. One of the major challenges faced by the Dard tribe is the issue of identity. The tribe has been struggling to maintain their distinct cultural identity in the face of modernization. The younger generation is more exposed to outside influences and has been adopting new cultural practices. This has led to a sense of cultural dislocation among the older generation, who fear that their cultural heritage is being eroded. Another challenge faced by the Dard tribe is the issue of cultural preservation. The tribe has been struggling to preserve their traditional customs and practices in the face of modernization. There is a fear that the younger generation may lose touch with their cultural heritage, which could lead to the loss of their identity. Despite these challenges, the Dard tribe has also been presented with opportunities for growth and development. The access to education and employment has opened up new avenues for the younger generation, and there has been a growing sense of empowerment among them. The tribe has also been able to adapt to modern lifestyles without completely abandoning their traditional customs and practices. The socio-cultural adaptation of the Dard tribe in the Kashmir Valley is a complex process that involves a number of factors. This research paper aims to explore the evolution of traditional customs and practices, socio-economic factors influencing adaptation, impact on social and cultural values, challenges and opportunities, and potential strategies for sustainable development and cultural preservation. The findings of this study are expected to contribute to a better understanding of the Dard tribe's socio-cultural adaptation process and provide insights into the challenges and opportunities for sustainable development and cultural preservation in the region.

REVIEW OF LITERATURE

The paper "Profile of Marriage in Dard Tribe: A Study" by Husain and Husain provides an insightful analysis of the marriage practices among the Dard tribe in Pakistan. The authors have conducted an ethnographic study to explore the various aspects of marriage in the Dard tribe, including the process of mate selection, rituals and customs associated with marriage, and the role of family and community in the process. One of the strengths of this paper is the detailed description of the cultural practices and beliefs of the Dard tribe regarding marriage. The authors have provided a comprehensive overview of the rituals and customs associated with marriage, such as the role of matchmakers, dowry, and wedding ceremonies. The authors have discussed the importance of family and community in the process of mate selection and the impact of social and economic factors on the marriage practices

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of the Dard tribe. Another notable aspect of the paper is the use of qualitative data to support the arguments presented. The authors have used interviews and observations to collect data, which has been analyzed using thematic analysis. This approach has enabled the authors to provide rich and detailed insights into the marriage practices of the Dard tribe. The authors have successfully highlighted the unique features of the marriage practices of the Dard tribe and have contributed to the existing literature on the topic. This paper would be useful for researchers and scholars interested in the study of marriage practices in different cultures. Dar (2018) in his article explores the changes in lifestyle among the Dard tribe in Jammu and Kashmir. This article focuses on how modernization and globalization have impacted the traditional way of life of the Dard tribe, and how these changes have affected their social, economic, and cultural practices. The Dard tribe is an indigenous community living in the mountainous region of Jammu and Kashmir. They have a unique culture, language, and way of life, which is deeply rooted in their history and traditions. However, with the advent of modernization and globalization, the Dard tribe has been exposed to new ideas, technologies, and ways of life. Dar (2018) argues that the changes in lifestyle among the Dard tribe have been both positive and negative. On the one hand, modernization has brought new opportunities for education, employment, and economic growth. On the other hand, it has also led to the erosion of traditional values, customs, and beliefs. The article highlights the impact of modernization on the Dard tribe's economy, education, health, and social relations. For instance, the author notes that the introduction of cash crops and modern farming techniques has led to an increase in agricultural productivity and income. However, it has also resulted in the loss of traditional crops and practices, which were better suited to the local environment. In terms of education, the article shows that modernization has led to an increase in literacy rates and access to formal education. However, it has also led to the decline of traditional knowledge and skills, which were passed down through generations. The article provides a comprehensive analysis of the changes in lifestyle among the Dard tribe in Jammu and Kashmir. It highlights the complex interplay between modernization, globalization, and traditional practices, and the challenges and opportunities that arise from these changes.

Z. Iqbal's book (2020) "Dardistan: The Unknown Tribe with Unknown Country" is a fascinating exploration of the little-known region of Dardistan, located in the northernmost part of Pakistan and in Indian side Gurez and Drass.The book provides a detailed account of the history, culture, and traditions of the Dardic people who inhabit this remote region. The author begins by tracing the origins of the Dardic people and their migration to the region. He then goes on to describe their way of life, including their customs, beliefs, and social structures. The book also explores the unique linguistic and cultural heritage of the Dardic people, which has been largely overlooked by mainstream scholarship. One of the key strengths of the book is the author's use of primary sources, including interviews with local residents, historical documents, and personal observations. This gives the reader a firsthand account of life in Dardistan and helps to paint a vivid picture of the region. Another notable aspect of the book is its focus on the role of women in Dardic society. The author highlights the important contributions of women to the community and challenges the common perception that women in this region are passive and subservient. The study is a valuable contribution to the study of the Dardic people and their culture. It provides a wealth of information for scholars and researchers interested in this region, as well as for general readers seeking to learn more about this fascinating and often overlooked part of the world. The study conducted by Atta, Islam, and Shah (2018) aimed to identify the socio-economic profile of the Shina Community, which subsists on non-timber forest products (NTFPs) in Figurez Valley of Kashmir. The researchers used a survey questionnaire to collect data from 150 households, and the data were analyzed using descriptive statistics. The findings of the study revealed that the Shina Community heavily relies on NTFPs for their livelihoods, and the majority of their income is generated from the sale of these products. The study also found that the community faces several challenges, such as limited access to markets, lack of storage facilities, and inadequate transportation infrastructure, which hinder their ability to sell their products at a fair price. Moreover, the study identified that the Shina Community has a low level of education, and the majority of the households are headed by males. The researchers also found that the community lacks basic amenities such as electricity, clean drinking water, and proper sanitation facilities. The study provides valuable insights into the socio-economic profile of the Shina Community, which subsists on NTFPs in Gurez Valley of Kashmir. The findings of the study can be used to develop policies and programs that aim to improve the livelihoods of the Shina Community by addressing the challenges they face and providing them with better access to markets

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and basic amenities. The article "Nature and Role of Family in Dard Tribe: A Study" by Hussain and Hussain (2018) explores the significance of family in the Dard tribe. The authors begin by providing a brief background on the Dard tribe and its history. They then delve into the family structure and dynamics, highlighting the importance of extended families and the role of kinship ties in maintaining social order.The authors also discuss the gender roles within the Dard tribe, where men are expected to be the primary breadwinners while women take care of the household and children. However, the study also reveals that women have a significant role in decision-making processes within the family, particularly in matters related to marriage and inheritance.The article further explores the impact of modernization and globalization on the traditional family structure of the Dard tribe. The authors argue that while modernization has brought about changes in the family structure, the Dard tribe still places a strong emphasis on family values and kinship ties.The article provides valuable insights into the nature and role of family in the Dard tribe. It highlights the significance of extended families, gender roles, and the impact of modernization on traditional family structures. The study is well-researched and provides a comprehensive understanding of the Dard tribe's family dynamics.

RESEARCH OBJECTIVES

The study to explore the evolution of traditional customs and practices of the Dard tribe in Kashmir Valley and the impact of modernization on their social and cultural values. It investigates the socio-economic factors that have influenced the tribe's adaptation to modernity and assess the challenges and opportunities faced by them in this process, including issues related to identity, cultural preservation, and social integration. The study also identifies potential strategies for promoting sustainable development and cultural preservation among the Dard tribe, while also supporting their adaptation to modernity. This will involve exploring the establishment of cultural centers and museums, promoting traditional crafts and practices, and developing tourism initiatives that showcase the tribe's unique cultural heritage. The study focuses on providing access to education, healthcare, and other basic services, as well as promoting economic development opportunities that are compatible with the tribe's traditional way of life. The research aims to support the Dard tribe in finding a balance between preserving their cultural identity and adapting to the challenges.

METHODOLOGY

The study adopted historical and documentary research methods, using secondary sources such as articles, books, state and national published and unpublished reports, and websites. Qualitative data analysis, specifically thematic analysis of trends and patterns, was employed to identify patterns and themes in the data collected from secondary sources. The use of secondary sources is a common approach in historical research, and qualitative data analysis is a method of examining non-numerical data to identify patterns and themes. The study used thematic analysis to identify trends and patterns in the data collected from secondary sources.

RESULT AND DISCUSSION

Evolution of Traditional Customs and Practices of Dard Tribe in Kashmir Valley
The Dard tribe is a unique and distinct ethnic group that has inhabited the Kashmir Valley for centuries. The tribe is known for its rich cultural heritage, which includes a unique language, traditional customs, and religious practices. In this essay, we will examine the historical and cultural background of the Dard tribe in the Kashmir Valley, and how their traditional customs and practices have evolved over time. The Dard tribe is believed to have migrated to the Kashmir Valley from Central Asia over 2,000 years ago. They are thought to be descendants of the ancient Indo-Aryan civilization, which flourished in the region during the Vedic period. The Dard tribe is also believed to be closely related to the Nuristani people of Afghanistan, who share many cultural and linguistic similarities with the Dard. Over time, the Dard tribe developed a unique culture and way of life in the Kashmir Valley. They developed their own language, known as Shina, which is still spoken by members of the tribe today. The Dard also developed a

rich tradition of music, dance, and storytelling, which they used to pass down their cultural heritage from one generation to the next. One of the most important aspects of Dard culture is their religious practices. The Dardsof Gurez are sunni Muslims. As the Kashmir Valley became more connected to the outside world, the Dard tribe began to adapt to modernity. This process of adaptation has been gradual and has taken place over several generations. For example, many members of the Dard tribe have begun to adopt modern clothing, such as jeans and t-shirts, instead of traditional dress. They have also started to use modern technology, such as mobile phones and computers, to communicate with each other and the outside world . However, despite these changes, the Dard tribe has managed to maintain many of its traditional customs and practices. For example, they still celebrate traditional festivals, such as shishrilouni, bundaree, gurez festival and continue to perform traditional music and dance. They also continue to practice their unique form of animism, which is an important part of their cultural heritage. The Dard tribe is a unique and distinct ethnic group that has inhabited the Kashmir Valley. They have developed a rich cultural heritage, which includes a unique language, traditional customs, and religious practices. While the Dard tribe has adapted to modernity over time, they have managed to maintain many of their traditional customs and practices. The Dard tribe's ability to adapt to modernity while still preserving their cultural heritage is a testament to their resilience and strength as a people.

Socio-economic factors influencing Dard tribe's adaptation to modernity
The Dard tribe, also known as the Brokpa people, is an ethnic group residing in the remote regions of the Himalayas. Over the years, the tribe has faced various socio-economic challenges that have influenced their adaptation to modernity. In this essay, we will investigate the factors that have shaped the Dard tribe's adaptation to modernity, including education, employment, and access to resources.Education is a significant factor that has influenced the Dard tribe's adaptation to modernity. Historically, the tribe's education system was informal and revolved around traditional practices such as oral storytelling, apprenticeships, and on-the-job training. However, with the advent of modern education, the Dard tribe has gradually adopted formal education systems. This has enabled them to acquire knowledge and skills that are essential for modern living.For instance, the Dard tribe's literacy rate has increased over the years, with more children attending schools. This has enabled them to access information and knowledge that was previously unavailable. As a result, the Dard tribe has been able to adapt to modernity by embracing modern technologies, such as mobile phones and the internet Employment is another factor that has influenced the Dard tribe's adaptation to modernity. Historically, the tribe's main source of livelihood was agriculture and animal husbandry. However, with the changing times, new employment opportunities have emerged, such as tourism, handicrafts, and government jobs.For example, the Dard tribe has been able to adapt to modernity by engaging in tourism-related activities. This has enabled them to showcase their culture and traditions to the outside world, generating income for the community. Additionally, some members of the tribe have secured jobs in the government sector, enabling them to access modern amenities such as healthcare and education. Access to resources is another critical factor that has influenced the Dard tribe's adaptation to modernity. Historically, the tribe relied on natural resources such as forests, rivers, and land for their livelihood. However, with the changing times, access to these resources has become limited, and new resources have emerged.For example, the Dard tribe has adapted to modernity by embracing modern technologies such as solar power and biogas. This has enabled them to access energy sources that are sustainable and environmentally friendly. Additionally, the tribe has also embraced modern agricultural practices, such as greenhouse farming, enabling them to increase their crop yields. The Dard tribe's adaptation to modernity has been influenced by various socio-economic factors, including education, employment, and access to resources. The tribe has been able to adapt to modernity by embracing modern technologies, engaging in new employment opportunities, and accessing new resources. However, there is still a need for more support to enable the Dard tribe to adapt fully to modernity and enjoy the benefits that come with it.

Impact of Modernization on Dard Tribe's Social and Cultural Values
The Dard tribe is a group of people who live in the mountainous region of Gurez in Kashmir valley .They have a rich culture and history, but with modernization, their social and cultural values have been impacted. Here we will explore the impact of modernization on the Dard tribe's social and cultural values, including changes in gender roles, family structures, and religious beliefs. One of the most significant changes that modernization has brought to the

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Dard tribe is the shift in gender roles. Traditionally, women in the Dard tribe were expected to be homemakers and take care of the family. However, with modernization, women are now receiving education and have greater access to job opportunities. This has led to a change in traditional gender roles, with women now playing a more active role in society. As women become more educated, they are also gaining more independence. They are no longer confined to domestic duties and are now participating in activities outside the home. This has led to a change in the traditional power dynamic between men and women in the Dard tribe. Women are now seen as equal partners in the family and in society. Another significant change brought about by modernization is the shift in family structures. Traditionally, the Dard tribe had a joint family system, where several generations lived together in one household. However, with modernization, there has been a move towards smaller nuclear families. This is due to the increasing mobility of people and the desire for more privacy. The shift towards smaller families has also led to changes in the way families are organized. In the past, the eldest male member of the family was the head of the household and made all the decisions. However, with smaller families, decision-making is now more democratic. Family members have more say in the decisions that affect their lives. Religious beliefs have also been impacted by modernization. The Dard tribe has traditionally followed a mix of Islam and animism. However, with increased exposure to the outside world, there has been a decline in traditional religious practices. Many people are now adopting more modern and secular beliefs. This shift towards more secular beliefs has led to a change in the way people approach life. In the past, the Dard tribe had a strong sense of community and relied on each other for support. However, with the decline in traditional religious practices, people are now more individualistic. They are more focused on their own goals and aspirations, rather than the needs of the community. Modernization has had a significant impact on the social and cultural values of the Dard tribe. It has led to changes in gender roles, family structures, and religious beliefs. Women are now more educated and have greater access to job opportunities, which has led to a change in traditional gender roles. The traditional joint family system is slowly giving way to smaller nuclear families, and decision-making is now more democratic. With increased exposure to the outside world, there has been a decline in traditional religious practices, and people are now adopting more modern and secular beliefs. These changes have led to a shift towards more individualistic values, which has had a significant impact on the traditional sense of community in the Dard tribe.

Challenges and Opportunities for the Dard Tribe in Adapting to Modernity.
The Dard tribe is an ethnic group of people who reside in the Gurez Valley in Kashmir. The Dard tribe is known for their unique culture and traditions, which have evolved over several centuries. However, the Dard tribe, like many other indigenous communities, is facing significant challenges in adapting to modernity. Here we will discuss the challenges and opportunities faced by the Dard tribe in adapting to modernity, including issues related to identity, cultural preservation, and social integration. One of the primary challenges faced by the Dard tribe is related to their identity. The Dard tribe has a distinct identity, which is rooted in their language, customs, and traditions. Due to migration of people from Gurez to other parts of Kashmirmany Dard people feel that their identity is under threat, and they are struggling to maintain their cultural heritage. Another significant challenge faced by the Dard tribe is related to cultural preservation. The Dard tribe has a rich cultural heritage, which includes music, dance, art, and literature. However, the rapid pace of modernization has led to a decline in traditional cultural practices. Many young Dard people are more interested in modern forms of entertainment, such as television and social media, than in traditional cultural practices. This has led to a decline in the transmission of cultural knowledge from older to younger generations, which could have significant implications for the future of the Dard tribe. Despite these challenges, there are also opportunities for the Dard tribe to adapt to modernity. One of the most significant opportunities is related to education. Education can play a vital role in helping the Dard tribe to preserve their culture while also adapting to modernity. By providing education in both traditional cultural practices and modern subjects, the Dard people can develop the skills and knowledge necessary to succeed in a rapidly changing world.Another opportunity for the Dard tribe is related to social integration. The Dard people have historically been isolated from mainstream Kashmiri society, which has made it difficult for them to access resources and opportunities. However, with the increasing connectivity of the world, there are now more opportunities for the Dard people to connect with other communities and access resources. By building bridges with other communities, the Dard people can access new ideas and technologies while also preserving their cultural heritage. The Dard tribe is facing significant challenges in adapting to modernity. These challenges are related to issues of identity, cultural

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preservation, and social integration. However, there are also opportunities for the Dard people to adapt to modernity. By providing education and building bridges with other communities, the Dard people can preserve their cultural heritage while also adapting to the rapidly changing world. Ultimately, the future of the Dard tribe will depend on their ability to navigate these challenges and seize these opportunities. Strategies for Sustainable Development and Cultural Preservation among the Dard Tribe The Dard tribe is one of the indigenous communities in the northern areas of Pakistan. They have a unique culture and way of life, which has been preserved for centuries. However, with the advent of modernity, the Dard tribe is facing challenges in adapting to the changing world while also preserving their cultural heritage. In this context, it is important to identify potential strategies for promoting sustainable development and cultural preservation among the Dard tribe. One of the key strategies for promoting sustainable development among the Dard tribe is to focus on ecotourism. The northern areas of Pakistan are known for their scenic beauty and natural resources. By promoting ecotourism, the Dard tribe can leverage their natural resources to create sustainable economic opportunities. This can be achieved by developing eco-lodges and promoting cultural tourism. The Dard tribe can showcase their unique culture and way of life to tourists while also generating income for themselves. This strategy can help the Dard tribe to preserve their cultural heritage while also adapting to modernity. Another potential strategy for promoting sustainable development among the Dard tribe is to focus on education. Education is a powerful tool for empowering communities and promoting sustainable development. By providing education to the Dard tribe, they can learn new skills and knowledge that can help them to adapt to the changing world. This can be achieved by setting upschools and vocational training centers in the Dard region. The education system can be tailored to meet the unique needs of the Dard tribe, such as teaching them about sustainable farming practices and environmental conservation.

In addition to promoting sustainable development, it is also important to focus on cultural preservation among the Dard tribe. One potential strategy for cultural preservation is to document the Dard culture and way of life. This can be achieved by setting up a cultural museum or archive that showcases the history and traditions of the Dard tribe. The museum can also serve as a platform for educating the younger generation about their cultural heritage. This strategy can help to preserve the Dard culture for future generations while also promoting cultural tourism. Another potential strategy for cultural preservation is to promote traditional Dard arts and crafts. The Dard tribe has a rich tradition of arts and crafts, such as weaving, embroidery, and wood carving. By promoting these traditional crafts, the Dard tribe can generate income while also preserving their cultural heritage. This can be achieved by setting up cooperatives that produce and sell traditional Dard crafts. The cooperatives can be supported by the government and international organizations, which can provide training and marketing support. Promoting sustainable development and cultural preservation among the Dard tribe is a complex challenge that requires a multi-faceted approach. The strategies outlined above, such as promoting ecotourism, education, cultural museums, and traditional crafts, are potential ways to achieve these goals. However, it is important to note that these strategies should be implemented in consultation with the Dard tribe and should be tailored to meet their unique needs and aspirations. By working together, we can promote sustainable development and cultural preservation among the Dard tribe while also supporting their adaptation to modernity.

Recommendations
The Dard tribe, being a marginalized community, often faces discrimination and exclusion in accessing these resources. To address the challenges faced by the Dard tribe, the following recommendations are proposed:
1. Preservation of traditional knowledge and practices: Efforts should be made to preserve the traditional knowledge and practices of the Dard tribe. This can be done through documentation, training programs, and community-based initiatives.
2. Access to education and healthcare facilities: Steps should be taken to improve access to education and healthcare facilities in the region. This can be done through the establishment of schools and healthcare centers in the area.
3. Promotion of sustainable livelihoods: The Dard tribe should be provided with opportunities for sustainable livelihoods. This can be done through the promotion of eco-tourism, handicrafts, and other income-generating activities that are compatible with the region's natural resources.

4. Land ownership and resource management: The Dard tribe should be given equal rights to access and manage the natural resources in the region. This can be done through the implementation of policies that promote equitable distribution of resources and protect the rights of marginalized communities.

5. Empowerment of women: Women in the Dard tribe should be empowered through education and training programs. This will enable them to participate in decision-making processes and contribute to the economic development of the community. The Dard tribe's socio-cultural adaptation in the Kashmir Valley provides valuable insights into the challenges faced by marginalized communities in adapting to modernity. The recommendations proposed in this study aim to address the challenges faced by the Dard tribe and promote their sustainable development. It is essential to recognize the importance of preserving traditional knowledge and practices while providing opportunities for economic development and access to education and healthcare facilities. By implementing these recommendations, we can ensure the sustainable development of the Dard tribe and other marginalized communities in the region.

CONCLUSION

The study explored the socio-cultural adaptation of the Dard tribe in the face of modernization. The research objectives include examining the evolution of traditional customs and practices, assessing the impact of modernization on social and cultural values, identifying socio-economic factors that influence adaptation, assessing challenges and opportunities faced by the tribe, and identifying potential strategies for promoting sustainable development and cultural preservation. Through this study, we hope to gain a better understanding of the challenges faced by the Dard tribe in adapting to modernity, including issues related to identity, cultural preservation, and social integration. By identifying potential strategies for promoting sustainable development and cultural preservation, we can support the Dard tribe in their adaptation to modernity while also preserving their unique cultural heritage. Ultimately, this study will contribute to a broader understanding of the socio-cultural adaptation of indigenous communities in the face of modernization. The Dard tribe is an indigenous community that has inhabited the Kashmir Valley for centuries. They have a unique culture and way of life that has been shaped by their environment and history. However, in recent years, the Dard tribe, like many other indigenous communities around the world, has faced a number of challenges as they attempt to adapt to modernity. One of the main challenges facing the Dard tribe is the impact of modernization on their traditional customs and practices.

As modernization has spread throughout the Kashmir Valley, the Dard tribe has had to navigate a rapidly changing social and cultural landscape. This has led to a number of changes in their traditional customs and practices, as they attempt to adapt to new ways of life. For example, many Dard people have begun to adopt more modern forms of dress and have started to use modern technology, such as smartphones and computers. However, the impact of modernization on the Dard tribe's social and cultural values has not been entirely positive. Many Dard people are concerned that modernization is eroding their traditional way of life and cultural heritage. They worry that their children will not learn the traditional customs and practices that have been passed down through generations, and that their unique cultural identity will be lost. Another challenge facing the Dard tribe is the socio-economic factors that influence their adaptation to modernity. Many Dard people live in poverty and lack access to basic resources and services, such as healthcare and education. This makes it difficult for them to adapt to modern ways of life and to take advantage of the opportunities that modernization can offer. Despite these challenges, the Dard tribe has also faced opportunities as they adapt to modernity. For example, modernization has brought new economic opportunities to the Kashmir Valley, such as tourism and the growth of the service sector. This has provided new opportunities for the Dard tribe to earn a living and improve their standard of living. Overall, the study "From Tradition to Modernity: A Study of the Dard Tribe's Socio-Cultural Adaptation in the Kashmir Valley" is an important contribution to our understanding of the challenges and opportunities facing indigenous communities as they adapt to modernity. By identifying the challenges and opportunities facing the Dard tribe, we can develop strategies to support their adaptation to modernity while also preserving their unique cultural heritage. This will

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require a collaborative effort between the Dard tribe, policymakers, and other stakeholders to ensure that the Dard people are able to adapt to modernity in a way that is sustainable and preserves their cultural identity.

Implications of the study

The study can provide insights into the social changes that occur when traditional societies adapt to modernity. This can be useful in understanding the impacts of globalization and modernization on traditional societies. It can also contribute to promoting cultural diversity by highlighting the importance of preserving and respecting traditional cultures. This can be useful in promoting intercultural understanding and reducing cultural conflicts. Further it can inform development initiatives by providing insights into the socio-cultural context of the Dard tribe and how they have adapted to modernity. This can be useful in designing development programs that are culturally sensitive and responsive to the needs of traditional societies. The study can contribute to the academic knowledge on socio-cultural adaptation and traditional societies. This can be useful in advancing the field of anthropology and providing a deeper understanding of human societies and cultures.

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RESEARCH ARTICLE

A Study on Supply Chain Management with Regard to the Chennai City's Select Automobile Sector

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ABSTRACT

There are differences between supply chain management and traditional logistics concepts. The term "logistics" usually refers to operations that take place inside the walls of a single company, whereas the term "supply chain" describes a network of businesses that collaborate and coordinate their efforts to get a product to market. Logistics concentrates its emphasis on tasks including inventory management, maintenance, distribution, and purchase. In addition to acknowledging all aspects of traditional logistics, supply chain management (SCM) now covers tasks like marketing, financing, new product development, and customer support. The supply chain is made up of all the steps that are either directly or indirectly involved in completing a customer's request. It's a multi-stage system where materials, information, and products are constantly moving between stages. The roles that each link in the supply chain fulfills are distinct. The chain's intricacy might differ between sectors and between companies. Because of the rising competitiveness, supply chain performance has become a crucial concern in many businesses.

Keywords: Automobile Sector, Casual Loop Diagram, Logistics, Supply Chain Management, Total Cycle Time.

INTRODUCTION

Maximizing the total value created is the aim of any supply chain. The discrepancy between the final product's value to the client and the effort the supply chain expends to fulfill the request is determined by the value of the supply chain. Value and supply chain profitability are typically tightly correlated in commercial supply chains. The discrepancy between the customer's initial revenue and the total cost incurred during the supply chain. The entire

profit to be divided throughout all supply chain phases is known as supply chain curativeness. The more profitable the supply chain is, the more successful it is. The information, product, and financial flows in the supply chain are the source of expenses. These suggest that distinct businesses should coordinate and integrate their efforts with those of other businesses along the material flow in order to accomplish the goals of supply chain management. They should also concentrate their combined efforts on the end user. For businesses to succeed, they must consider developing unique capabilities that are focused on delivering greater value to the end user, identifying potential, delivering value to target segments, and efficiently utilizing capabilities at the most appropriate points along the chain. These are very remarkable tasks. Businesses can no longer think about participating based on power positions with customers and suppliers.

REVIEW OF LITERATURE

Mishra and Patel (2017) to analyze the supply chain network and find successful chain redesign solutions. According to their opinion, uncertainty impairs chain-wide performance, which may be brought about by the customer's choice for order stock capacity, process information, technical efficiency, and ownership structure. They recognized collaboration with important suppliers and customers as one of the potential strategies to lessen unpredictability and complexity. Jeong and Hong in 2017 to satisfy the demands of various consumers regarding quality, delivery, and cost, a customer-driven network attitude, or customer closeness, flexibility, and accessibility, is necessary for a customer-oriented business. The IT infrastructure's robust communication links, resource planning, and relationship tools enable creative, prompt, and cooperative problem solutions. Information outcomes (capabilities for creative, prompt, and collaborative problem solving), operation outcomes (capabilities for competitiveness in terms of cost, time, and quality), and customer outcomes (satisfaction, retention, and loyalty) are produced by the model's performance when driven by the two variables mentioned above. Ohdar and Ray (2018) conducted a thorough survey on 150 Indian manufacturing businesses to evaluate the state and use of supply chain management strategies. They discovered that 81% of the responding businesses had improved customer satisfaction and reduced total cycle time (TCT) by implementing supply chain management techniques. To assess the effectiveness of their supply chain, these businesses chose to employ a multi-dimensional performance assessment system, enterprise resource planning, electronic data interchange, and other cutting-edge communication tools. The study recommended that in order to create efficient supply chain management techniques in the industrial sectors, there should be a significant emphasis on information sharing and the building of partnerships with upstream and downstream stakeholders. Balan et al. (2018). The dynamic interactions between the Indian automobile industry's suppliers and customers allowed for the collection of data. The survey's findings on supply chain issues include a lack of data, a professional shortage, technical difficulties, subpar infrastructure, the complexity of the supply chain network, cultural mentality, etc. The flow diagram and the system equations, which are based on the casual loop diagram (CLD), were used to further analyze the dynamic interaction among supply chain variables. According to the study's findings, supply chain efficiency is increased by functional excellence and technological integration.

STATEMENT OF THE PROBLEM
The majority of supply chain management study examines wealthy nations. As a result, research on supply chain management in developing nations is lacking. There is little research on the maintenance of car spare parts in the field of supply chain management. Furthermore, the supply chain is expanding quickly in a number of developing nations, including India. The goal of this project is to create and implement a unified framework for measuring supply chain performance that integrates supplier, customer, and internal relationship management at the strategic, tactical, and operational levels.

OBJECTIVES OF THE STUDY
1. To investigate the relationship between the performance of the supply chain and its retail supply of parts for particular auto brands.

2. To comprehend the influence on particular car brands in Chennai city and the management of the supply chain among the merchants.
3. To identify any shortcomings in supply chain management and make recommendations for enhancing its effectiveness.

SCOPE OF THE STUDY

Owing to intense rivalry in the business world, companies are trying to elevate their standing by focusing on several functional areas. It has been determined that supply chain management has a considerable deal of potential for advancement in the expansion of businesses. A survey of the literature showed that supply chain management performance is only measured for individual components. Since a supply chain is made up of several business links, it is imperative to measure the performance of the link that connects the components rather than the component itself. There is a detailed list of performance metrics in the literature that can be applied to supply chain measurement. It is also frequently observed that multiple components work together to accomplish a certain task. Despite the fact that the supply chain is made up of various parts that each carry out a distinct function, research has shown that only the provider is given priority. It is true that for improved performance, the complete supply chain must be taken into account rather than just one provider. All the links must cooperate.

RESEARCH METHODOLOGY

Data collection

The study is mainly based on primary data collected directly from the select respondents through well-structured questionnaire. The use of secondary data were collected from Journals, Magazines, Publications, Reports, Books, Dailies, Periodicals, Articles, Research Paper, Websites, Annual Reports, of Social Organization, Manuals and Booklets.

Sample size

The number of samples determined for the study is 430. The sample size is covering different age groups, brand, and occupational status of customers, and from the selected brand executive managers. These samples were chosen at random

Data collection method

A printed questionnaire consisting of more than 32 questions were served with select 430 respondents by conducting oral survey on them these samples were chosen at random. Five executive questionnaires consisting of more than 30 questions were served with select brand managers by direct interview method. Convenient sampling method was adopted for data collection.

DATA ANALYSIS AND INTERPERTATION
DESCRIPTION OF CHI-SQUARE ON THE BASIS OF SUPPLY CHAIN PERFORMANCE
To examine the Relationship between ensuring car breakdowns \accident at any point with brand level the following hypothesis has been formulated.
Null Hypothesis (Ho): There is no association between the ensuring car breakdowns \accident at any point with brand level.
Alternative Hypothesis (H1): There is an association between the ensuring car breakdowns \accident at any point with brand level. As can be seen from the above table, 65.1 percent of Hyundai brand customers and 46.7 percent of Fiat brand customers reported that their cars were towed in for repairs. Furthermore, 33.3% of Ford brand consumers said that there was no causality in a serious collision. Given that the P value (.0001) is likewise below 0.05. At a 5% level of confidence, the null hypothesis is rejected, leading to the conclusion that there is a relationship between brand level and guaranteed auto breakdowns at any time.

To examine the Relationship between ensuring car break down/ accident at any point of time and good supply chain management system in service area, the following hypothesis has been formulated.

Null Hypothesis (Ho): There is no association between the ensuring car break down/ accident at any point of time and good supply chain management system in service area.

Alternative Hypothesis (H1): There is an association between the ensuring car break down/ accident at any point of time and good supply chain management system in service area. Relationship between the ensuring car break down/ accident at any point of time and good supply chain management system in service area. The aforementioned data shows that 100% of consumers reported that the car was held for more than a month, and that the businesses had store ledgers and all necessary regulations. Additionally, 73.1% of consumers said that their car was held for longer than a month. Given that the P value is less than 0.05 (.0001). The conclusion is that there is a correlation between a good supply chain management system in the service sector and the guarantee that cars break down or have accidents at any moment, as the null hypothesis is rejected at a 5% level of confidence. To examine the Relationship between ensuring any defective goods supplied by the dealer with brand level the following hypothesis has been formulated.

Null Hypothesis (Ho): There is no association between ensuring any defective goods supplied by the dealer with brand level.

Alternative Hypothesis (H1): There is an association between the ensuring any defective goods supplied by the dealer with brand level. As can be seen from the above table, 53.4 percent of Ford brand customers and 65.4 percent of Hyundai brand customers claimed that the product was completely defect-free. Additionally, 63.8 percent of Fiat brand consumers claimed that the form was rarely defective. Given that the P value (.0001) is likewise below 0.05.

To examine the Relationship between ensuring customers justify seller's behavior with brand level the following hypothesis has been formulated.

Null Hypothesis (Ho): There is no association between ensuring customers justify seller's behavior with brand level.

Alternative Hypothesis (H1): There is an association between the ensuring customers justify seller's behavior with brand level. Relationship between the ensuring customers justify seller's behavior The aforementioned chart shows that 54% of Hyundai brand customers thought the seller behaved extremely well. Customers of the Fiat brand reported that seller behavior is neutral in 47.0% of cases. Additionally, 46.2% of Nissan brand customers expressed satisfaction with the seller's behavior. Given that the P value (.0001) is likewise below 0.05. At a 5% level of confidence, the null hypothesis is rejected, leading to the conclusion that there is a relationship between brand level and making sure customers defend the actions of the seller.

FINDINGS

❖ Customers' allegiance to a specific brand and their information to the journal go hand in hand, indicating that brand loyalty is still prevalent in Indian conditions. There are still Fiat enthusiasts that are devoted to the brand, like the Fiat cars that once dominated the auto industry.

❖ This survey is legitimate since, in particular, we observe that manufacturers in India greatly wait when a spare is needed. However, nearly 50% of respondents indicated that the supply chain is operating efficiently. We have 249 respondents who have stated that the dealer moved out with other dealers in the area to obtain spare parts needed to finish the job. As a result, 32 respondents, or 7.5%, have acknowledged that even local vendors are taken into consideration. A sizable portion of respondents have stated that we are permitted to buy replacement parts for the job, which is excellent.

❖ The study concludes that inventory management and supply chain management are critical, with good inventory management and upkeep being key components of this supply chain. According to the study, firm services, such as installing authentic spares, oil, and other parts that are unavailable in the appropriate location, are nevertheless guaranteed despite the cost. Thus, it can be said that the coupons are distributed by standard guidebook procedures rather than advertisements, which is a smart logistical move.

- ❖ The study comes to the conclusion that SCM plays a significant part in managing stores that now use SCM. A total of 303 customers have made mention of it in the samples.
- ❖ Given that the P value (.0001) is likewise smaller than 0.05. It is determined that there is a correlation between brand leave and guaranteed auto breakdowns at any time once the null hypothesis is rejected at the 5% level of confidence.
- ❖ The four brands included in our analysis—Hyundai, Mahindra, Nissan, and Ford—stated that they uphold commitment, trust, and cooperation by striving to "meet day-to-day promises." The Fiat management also stated that they are upholding commitment, trust, and cooperation by keeping their daily promises and sharing information. The majority of respondents were found to be preserving cooperation, commitment, and trust through information sharing. All of these occurred via the SCM, which expedites the procedure.
- ❖ The majority of service managers, who work for three different brands—Holden, Mahindra, and Nissan—state that decisions on transportation have an impact on overhead expenses. Road tax is impacted by transportation costs, according to managers at Fiat and Ford. The majority of respondents felt that their choice of transportation affected their overhead costs, it is concluded.

CONCLUSION

This chapter wraps up the investigation, which began with the analysis and interpretation of the data in the preceding chapter. The study aimed to investigate the relationship between supply chain management and its performance by means of the retail supply of replacement parts for specific car brands. The study aimed to achieve the first objective by asking pertinent questions, analyzing and interpreting the results, constructing null hypotheses, and empirically studying the relationships. These objectives' framing makes it evident that there are opposing consequences on them. The findings indicated that there was no correlation between SCM's performance and its influence on the retail supply of spare parts for specific automobile brands in Chennai.

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Table: 1

S.No	Car breakdowns\Accident(If yes)	Brands					Total	P Value
		Nissan	Ford	Hyundai	Mahindra	Fiat		
1	A major accident no causality	7	9	5	7	8	36	
		24.2%	33.4%	11.5%	25.9%	26.8%	23.1%	
2	Minor accident with damages	2	7	3	5	2	19	
		6.8%	25.9%	7.0%	18.5%	6.7%	12.2%	
3	Minor accident with injuries	8	5	5	7	6	31	.0001
		26.6%	18.5%	11.6%	25.9%	21.0%	19.8%	
4	He rushed with his team to the sp	0	0	2	3	0	5	
		.0%	.0%	4.6%	11.1%	.0%	3.2%	
5	The car was toed for repair.	12	6	28	5	14	65	
		41.4%	22.2%	65.1%	18.5%	46.7%	41.6%	
	Total	29	27	43	27	30	156	
		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

Table 2

S. No	Car break down/ accident at any point of time	Good supply chain management system in service area					Total	P Value
		Yes he was having good stores with SCM	The stores had all codification	The stores had stores ledger	The stores were maintained by a stores keeper	The supply chain was well maintained and managed		
1	The insurance person also did not attend properly	0	0	0	1	0	1	.0001
		.0%	.0%	.0%	1.9%	.0%	1.1%	
2	There was a lethargy in attending my car	1	0	0	13	2	16	
		50.0%	.0%	.0%	25.0%	100.0%	17.0%	
3	There was always a reply of the non-availability of parts	1	0	0	0	0	1	
		50.0%	.0%	.0%	.0%	.0%	1.1%	
	My car was detained for more than a month	0	36	2	38	0	76	
		.0%	100.0%	100.0%	73.1%	.0%	80.9%	
	Total	2	36	2	52	2	94	
		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

RESEARCH ARTICLE

Studies on Isolated Constituents of *Hemigraphis alternata* (Burm. F.) T. Anders and *In Vitro* Evaluation of Anticancer Activity

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ABSTRACT

Research with plants and plant derivatives are increasing day by day for the discovery of therapeutic and nutraceutical agents from them and due to the versatile applications of those beneficial agents. The purpose of present work was to evaluate invitro anticancer, antioxidant, antifungal, antibacterial activities of ethanolic leaf extract of *Hemigraphisalternata*. EEHA was subjected to phytochemical screening and EFHA was subjected to column chromatography for the isolation of HA1. The in-vitro anticancer activity was performed by means of MTT assay using EAC cell lines. The antioxidant activity was performed by DPPH assay using Ascorbic acid as a standard. Antifungal activity was done by Cup plate method using Fluconazole as standard. The Antibacterial activity was evaluated quantitatively through minimum inhibitory concentration (MIC) using Azithromycin as standard. Preliminary phytochemical screening confirmed the presence of alkaloids, glycosides, phenolics, flavanoids, carbohydrates etc. in the EEHA. HA1 showed good anticancer effect on EAC cell line than the EEHA in MTT assay. The isolated compound HA1 was found to exhibit the potential antioxidant activity in a dose dependent manner.The HA1was active against the bacterial and fungal strains. The results suggested that the HA1 exhibits significant anticancer, antioxidant, antifungal and antibacterial activities. Further studies are needed to isolate the phytoconstituents from the plant and find out their mechanism of action.

Keywords: *Hemigraphisalternata*, Anticancer activity, MTT assay

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INTRODUCTION

In our fast mechanical lifestyle, allopathic medicines are given importance due to their fast action to health problems for quick relief, but people have not only realized the high cost of the medicines, but also realized the dangerous side effects of the body. Therefore, the focus of the health care, turn around to the naturally grown traditional medicinal plants and now at present all attention to the herbals. Besides the popularity of herbal medicines are due to their action in the root levels of the diseases that causes complete cure, easy availability of drugs from natural sources and freedom from approaching various specialists. The plant Hemigraphisalternata is a versatile tropical low creeping perennial herb that reaches a height of 15 to 30cm, which is the native of tropical Malaysia. It is a prostate growing plant with spreading, rooting stems. Its stainy leaves are slender and lance shaped with toothed, scalloped, or lobed margins. They are greyish green stained with red purple above and darker purple beneath. The tiny white flowers intermittently throughout the year. Literally, hemigraphis means 'half writing' because the filament of stamen bear brushes. The plant is known by several names such as Aluminium plant, Cemetery plant, Metal leaf, Red flame Ivy, Waffle plant, Java Ivy etc. In kerala, the plant is popular in the name 'Murikootti' or 'Murianpacha' because of its incredible potency to heal wounds. This plant possesses various medicinal properties, only a few are reported like, the wall plant or leaves are used to treat fresh wound, cuts ulcers, inflammation and in folk medicines, it is used internally to cure anaemia, gallstone, diuretic, hemorrhoids, diabetic mellitus. Cancer can be defined as a disease in which a group of abnormal cells grow uncontrollably by disregarding the normal rules of cell division. Normal cells are constantly subject to signals that dictate whether the cell should divide, differentiate into another cell or die. Cancer cells develop a degree of autonomy from these signals, resulting in uncontrolled growth and proliferation is allowed to continue and spread, it can be fatal. In fact, almost 90% of cancer-related deaths are due to tumour spreading a process called metastasis. **A**ntioxidants play an important role for chronic diseases including cancer and heart disease. Primary sources of naturally occurring antioxidants are whole grains, fruits and vegetables. Plant sourced antioxidants like vitamin C, vitamin E, carotenes, phenolic acids etc. have been recognized as having the potential to reduce disease risk.fungal infections are prolonged treatment regimen with combination of drugsassociated with significant toxicity and emergence of multi- drug resistant (MDR) bacteria and fungi causing morbidity and mortality in immunocompromised hosts. The necessity for effective theray has stimulated research into the design and synthesis of novel compounds which can treat both mycobacterial and fungal infections. The antibacterial activities of plant origin are associated with lesser side effects and have an enormous therapeutic potential to heal many infectious diseases. The potential for developing antibacterial from higher plants appears rewarding as it will lead to the development of a phytomedicine to act against microbes. Nowadays a number of clinically efficacious antibiotics are becoming less effective due to development of resistance.

MATERIALS AND METHODS

Collection of plant material
Hemigraphisalternata is widely distributed in our local areas and fresh leaves was collected in the month of October and authenticated (Specimen No.148226) by A. K. Pradeep, Herbarium Curator, Department of Botany, University of Calicut, Thenhipalam, Kerala, India. The specimen voucher was deposited in the Department of Botany, University of Calicut, itself.

Preparation of solvent extraction
The dried leaves of *Hemigraphisalternata* (Burm) was cleaned and dried under shade at room temperature and powdered to get a coarse powder using a mixer grinder. The alcoholic leaf extract was prepared by continuous hot extraction method for 72hrs by using a Soxhlet apparatus. A sample extract was prepared with powdered plant material (25gm) in 70% ethanol, and was subjected to phytochemical analysis. Based on the phytochemical analysis, bulk extract was prepared with plant material (1 Kg) by continuous hot extraction method. The extract was concentrated to a dry mass by evaporating solvent. The chlorophyll of leaf portion are removed by adding diethyl ether by using separating funnel. Again crude extract was filtered and concentrated under vaccum and controlled

temperature. After complete drying, the crude extract was weighed and the extractive value in percentage was calculated with reference to the air-dried sample.

Isolation of the compound by column chromatography

A column of suitable size (1 m × 1.5 inch) was chosen and packed with silica gel 100-200 mesh by adding slurry of the adsorbent in petroleum ether. EFHAwas dissolved in ethyl acetate, and mixed with silica gel (100-200 mesh) and fed to the column through a funnel. Ethyl acetate was added to the column and kept aside without disturbance for overnight for the settlement of the extract. Maximum precautions were taken to remove the air bubbles. The column was eluted with different organic solvents ethyl acetate, and ethanol. Fractions showing similar R_f value and identification test, were pooled together and solvents evaporated to get residues.

Thin layer chromatography

Thin layer chromatography is an analytical method that is widely used for the identification, separation, isolation and quantification of components in a mixture. The selection of a solvent for application of the sample can be a critical factor in achieving reproducible chromatography with distortion free zones. In general, the application solvent should be a good solvent for the sample and should be as volatile as possible and more non polar. Silica gel was chosen as stationary phase, since it is an efficient adsorbent for the TLC separation of most of the plant extracts and plant drug products.

Anticancer Assay by MTT Method

Fifteen mg of MTT (Sigma, M-5655) was reconstituted in 3 ml PBS until completely dissolved and sterilized by filter sterilization. After 24 hours of incubation period, the sample content in wells were removed and 30μl of reconstituted MTT solution was added to all test and cell control wells, the plate was gently shaken well, then incubated at 37°C in a humidified 5% CO_2 incubator for 4 hours. After the incubation period, the supernatant was removed and 100μl of MTT Solubilization Solution (Dimethyl sulphoxide,DMSO, Sigma Aldrich, USA) was added and the wells were mixed gently by pipetting up and down in order to solubilize the formazan crystals. The absorbance values were measured by using microplate reader at a wavelength of 540 nm.

RESULTS

Table 1: percentage yield obtained from Hemigraphisalternata. Table 2: preliminary phytochemical studies on hemigraphisalternata. Table 3: solvents used in column chromatography of hemigraphisalternata. Table 4: TLC study on extract of hemigraphisalternata. Table 5: TLC study on isolated compound of hemigraphisalternata. Table 6: physical examination of isolated compound. Table 7: Percentage inhibition of EEHA and HA1 in *invitro* anticancer study. Fig 1:Concentration v/s percentage inhibition graph showing anticancer activity on EAC cell line.

DISCUSSIONS

The authenticated plant material (leaf) was dried, powered and subjected to continuous hot percolation by using Soxhlet extractor for the preparation of hydro- alcoholic extract leaf extract. The solvent was evaporated under reduced pressure. The percentage yield of extracts of *Hemigraphisalternata* showed the presence of phytoconstituents such asalkaloids,glycosides,steroidsandterpenoids,tannins,flavanoids,saponinsproteinsandaminoacids. Out of the various mobile phase combinations tried, TLC that was developed using Chloroform:ethanol (5:5)has shown spots for the extract. The crude hydro alchohol extract was subjected to analytical column chromatography containing silica gel G(100-200 mesh) as stationary phase. The elution of column by gradiant elution technique with different mobile phase in the order of increasing polarity led to the isolation of phyto constituents. After chromatographic separation and TLC studies the fraction showing similart spots were pooled together. Then the solvents where evapurated off.   One major fraction was obtained.   It was a yellow crystalline compound from

ethylacetate:chloroform (60:40) fraction.The isolated compound was named as HA1 having yield of 600mg. TLC was developed using chlorofom:methanol(8:2) for isolated compound of hemigraphis alternata and its $R_f$value was found to be 0.71. It was identified as a green fluorescent in UV chamber. The phyto chemical studies of isolated compound of hemigraphis alternata has showed the presence of phyto constituents such as Flavanoids. The purified compound was elucidated by means of IR,^{1}H NMR,^{13}C NMR and LC-MS spectral studies. There is an intene peak at region 3625cm^{-1}which indicates the presence of hydroxyl group in the isolated compound. The peak in the region 1740 cm^{-1}indicate C=O group and 1590 cm^{-1} indicate the presence of C-C stretching in the ring. From these IR data it is clear that it contains functional group OH and aromatic ring. ^{1}H NMR spectra was used to find the number of proton present in a chemical compound. The sample is dissolved in DMSO and value is measured in δ ppm. ^{1}H NMR spectral analysis of isolated compound showed peak at Peak at δ 6.60, δ 6.69, δ 7.725 indicate H of aromatic ring. Peak at δ 4.98 and δ 5.01(d) H of Aromatic OH. Peak at δ 2.186(s) indicate H of glycone OH group. Peak at δ 3.572, δ 3.712(d) indicate H of glycone moiety. In ^{13}C NMR spectral analysis of isolated compound shows peaks at δ 164.6 indicate C of Aromatic ketone. Peak at δ 148.18, δ 154.59, δ 161.20 indicates C attached to OH group of Aromatic ring. Peak at δ 117.24, δ 120.4, δ 124.4 indicate C of Aromatic ring. Peak at δ 73.51, δ 73.92, δ 92.73 indicates C attached to OH group of glycone moiety. Mass spectra of isolated compound showed the base peak at 156 and molecular ion peak [M$^+$] at 464. Molecular mass of the HA1 was found to be 464.38.Molecular formula of HA1 was found to be $C_{21}H_{20}O_{12}$ (Quercetin-3-O-sglucopyranoside).From the spectral analysis of IR, ^{1}H NMR,^{13}C NMR and Mass spectra of the isolated compound, We can assume that the isolated compound is a newer compound having mplecular mass 464.38. As per the MTT assay, the percentage inhibition increased in adose dependent manner. 5-FU inhibits the process (50%) at a concentration of 100.72 μg/ml.Atthesameextendthe EEHA and H A 1 inhibits the process at 167.27μg/ml, 138.11μg/ml respectively. It indicates that the HA1 possess better cytotoxic effect than the EEHA. So the EEHA may contain potential compounds or active principles which might render the plants with anticancer proliferative activities.

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Table 1: Percentage yield of extract

Sl.no	Extract	Percentage yield
1	Ethanolic leaf extract	26.6%w/w

Table 2: Preliminary phytochemical studies on *Hemigraphisalternata*

Sl.No	Phytoconstituents	Ethanolic extract	Isolated compound
1	Carbohydrates	+	-
2	Glycosides	+	-
3	phenolic glycosides	-	-
4	Coumarin	+	-
5	Flavanoids	+	+
6	Tannins	+	-
7	Saponins	+	-
8	Alkaloids	+	-
9	Sterols and antriterpenoids	+	-
10	Proteins and Amino acids	+	-

Table 3: Solvents employed in analytical column chromatography.

Fraction No	Mobile phase	Chemical test	TLC report	Nature of residue
1-22	Ethyl acetate: Ethanol(100:0)	-	-	-
23-38	Ethylacetate:Ethanol(90:10)	-	-	-
39-52	Ethylacetate:Ethanol(80:20)	-	-	-
53-60	Ethylacetate:Ethanol(70:30)	-	-	-
61-75	Ethylacetate:Ethanol(60:40)	+	+	Yellow
76-89	Ethylacetate:Ethanol(50:50)	-	-	-
90-99	Ethylacetate:Ethanol(40:60)	-	-	-
100-121	Ethylacetate:Ethanol(30:70)	-	-	-
122-130	Ethylacetate:Ethanol(20:80)	-	-	-
131-138	Ethylacetate:Ethanol(10:90)	-	-	-
139-147	Ethylacetate:Ethanol(0:100)	-	-	-

Table 4:TLC Study on Extract of *Hemigraphis alternate*

Mobile phase	Detecting agent	R f value
Chloroform:Ethanol (5:5)	Iodine chamber	0.46, 0.92, 0.48
Peteroleumether:Chloroform (7.5:2.5)	Iodine chamber	0.63, 0.74

Table 5: TLC Study on Isolated Compound of *Hemigraphisalternata*

Sl.No	Mobilephase	Fraction	Rfvalue
1	Chloroform:Methanol	Ethyl acetate: Ethanol (60:40)	0.71

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				0.68

Table 6: Solvents employed in Preparative Column Chromatography.

Fraction No	Mobile phase	Chemical test	TLC report	Nature of residue
1-6	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue
7-15	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue
16-24	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue
25-28	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue
29-32	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue
33-42	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue
43-48	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue
49-62	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue
63-75	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue
76-80	Ethyl acetate: Ethanol (60:40)	+	+	Yellow residue

Table 7: Physical examination of Isolated Compound

Colour	Yellow
Chemical test	Flavanoids
Stationay phase	Silica gel G
Mobile phase	Chloroform: Methanol (8:2)
Rf value	0.71
Solubility	DMSO
Yield	600 mg

Table 8: Percentage inhibition of EEHA and HA1 in *invitro*anticancer study.

Samples	%inhibition(mean±SEM)					IC50(μg/ml)
	Concentration(μg/ml)					
	12.5	25	50	100	200	
5-FU	20.62±0.010	25.41±0.015	45.14±0.211	57.72±0.017	70.84±0.012	100.72
EEHA	5.14±0.023	16.2±0.116	24.52±0.014	39.2±0.216	54.62±0.153	167.27
HA1	8.60±0.018	20.13±0.017	31.45±0.225	44.86±0.121	63.21±0.021	138.11

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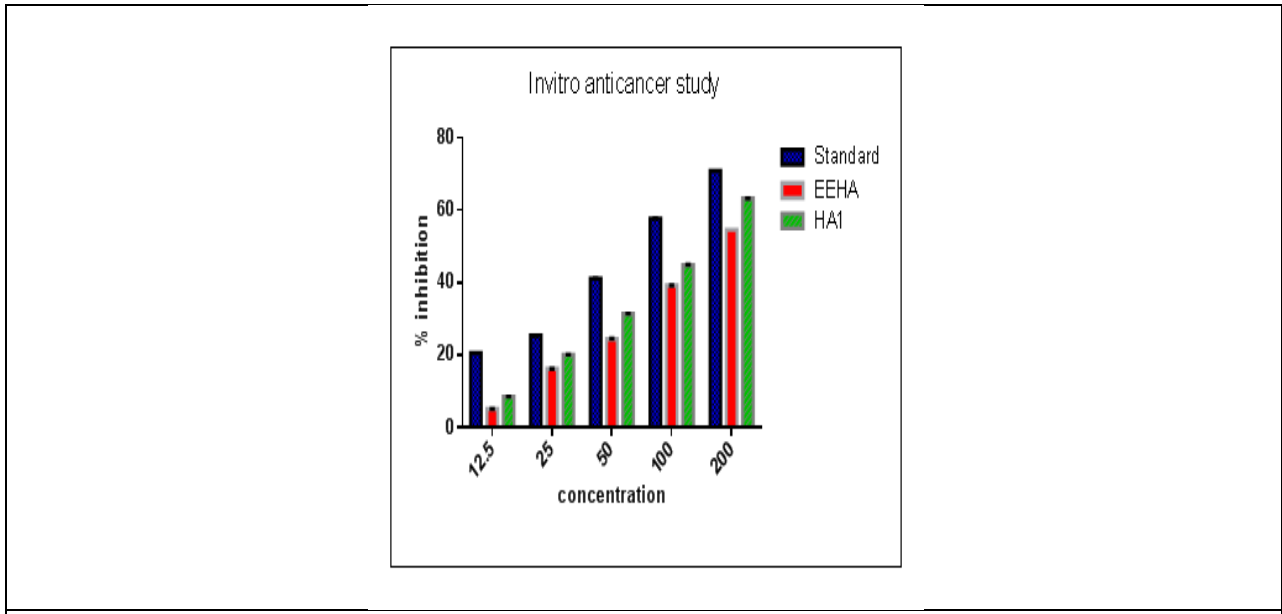
Fig:1 Concentration v/s percentage inhibition graph showing anticanceractivity on EAC cell line.

RESEARCH ARTICLE

Exploring the Potential of Passiflora: A Review on the Formulations using Its Extracts for Therapeutic Applications

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ABSTRACT

Passiflora, thrives in tropical and subtropical areas and serves multiple purposes. Beyond its consumption as a fresh fruit, it is extensively utilized in processed food products. Extracts, juices, and isolated components derived from passion fruit exhibit diverse health benefits and physiological actions, including antioxidative, anti-inflammatory, calming, and neuroprotective properties. This study investigates the formulations of Passiflora extracts, focusing on their potential applications in various industries. Passiflora, commonly known as passion fruit, is abundant in tropical and subtropical regions, offering a rich source of bioactive compounds with numerous health benefits. The formulations of Passiflora extracts encompass a wide range of techniques, including solvent extraction, maceration, and advanced extraction methods such as supercritical fluid extraction. These formulations aim to concentrate and preserve the bioactive constituents present in Passiflora, including phenolic compounds, flavonoids, and vitamins. Furthermore, the study explores the incorporation of Passiflora extracts into different delivery systems, such as encapsulation in nanoparticles, emulsions, and solid dosage forms, to enhance their stability, bioavailability, and efficacy. The potential applications of Passiflora extracts in functional foods, pharmaceuticals, cosmetics, and nutraceuticals are discussed, highlighting their antioxidant, anti-inflammatory, sedative, and neuroprotective properties. Overall, this review sheds light on the diverse formulations of Passiflora extracts and their promising applications across various industries.

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Keywords: Passiflora, Extracts, Formulations, Bioactive compounds, Phytoconstiutents.

INTRODUCTION

The Passiflora genus, encompassing over 550 species known as passion vines or passion flowers, exhibits diverse characteristics, ranging from herbs to woody trees and vines with tendrils. It falls under the Order Malpighiales and the Family Passifloraceae.[1] Traditional medicinal practices have utilized these plants for a wide array of health conditions, including gastrointestinal, neurological, cardiovascular issues, inflammation, and anxiety, primarily due to their rich composition of active compounds like phenolic compounds, alkaloids, glycosides, flavonoids, and saponins. Among the numerous species in this genus, six species and one subspecies stand out for their documented medicinal properties: P. alata, P. caerulea, P. edulis, P. foetida, P. incarnata, and P. ligularis.[2] Passion fruit is renowned not just for its distinctive and exotic taste and fragrance but also for its exceptional nutritional and medicinal qualities. Plantations are done for commercial purpose in various regions including Australia, Hawaii, the USA, India, New Guinea, Kenya, South Africa, Sri Lanka, and Costa Rica. In India, it grows naturally in many parts of the Western Ghats such as Nilgiris, Wynad, Kodaikanal, Shevroys, Coorg, and Malabar, as well as in Himachal Pradesh and northeastern states like Meghalaya, Mizoram, Manipur, Nagaland, and Sikkim. People are fond of this fruit because of its delightful aroma, intense flavor, abundant yield, and its ability to be highly profitable even with minimal care. Additionally, it is well-suited for hill farming systems.[3] The yellow passion fruit, a sub-species of P. edulis Sims f. Flavicarpa, holds substantial traditional medicinal value. Passiflora alata, known as the winged-stem passion flower, is an evergreen vine that can grow over 6 meters.

The plant's fruits, leaves, and seeds possess various medicinal properties. Extracts from its fruits are recognized for containing polyphenols and flavonoids, displaying antioxidant properties. Studies have identified that leaf extracts from P. alata Curtis demonstrate gastroprotective and neuroprotective activities. These extracts have been specifically examined for their ability to safeguard both the Central Nervous System and the digestive system, attributed to their neuroprotective and anti-ulcer properties. The fruit of P. caerulea contains notable quantities of polyphenols like catechin, resveratrol, epigallocatechin gallate, rutin, and quercetin. These polyphenols are acknowledged for their potential protective effects against chronic neurodegenerative diseases. Additionally, Passifilin, a protein found in the seeds of P. edulis Sims, exhibits anti-fungal activity.[4] Alkaloids, phenols, glycosyl flavonoids, and cyanogenic compounds are identified within the Passiflora genus. Extensive literature research has highlighted numerous studies on Passiflora incarnata and Passiflora edulis, while only occasional mentions exist regarding other Passiflora species. Flavonoids stand out as the primary phytoconstituents in P. incarnata. These encompass apigenin, luteolin, quercetin, kaempferol, schaftoside, isoschaftoside, and swertisin. Furthermore, P. incarnata contains simple indole alkaloids constructed upon the -carboline ring system, specifically harman, harmol, harmine, harmalol, and harmaline. Passiflora edulis, on the other hand, is notably rich in glycosides, specifically flavonoid glycosides such as luteolin-6-C-chinovoside, luteolin-6-C-fucoside, cyclopentenoid cyanohydrin glycosides like passicapsin and passibiflorin, as well as cyanogenic glycosides including passicoriacin, epipassicoriacin, and epitetraphyllin.[5]

Phytoconstituents and uses:
Alkaloids, phenols, glycosyl flavonoids, and cyanogenic compounds have been identified in the Passiflora genus. Existing literature predominantly focuses on Passiflora incarnata and Passiflora edulis, with only occasional reports available for other Passiflora species.

Phyto-constituents of P. incarnata
Flavonoids
Flavonoids, specifically apigenin, luteolin, quercetin, and kaempferol, are identified as the primary phytoconstituents in P. incarnata. The leaves exhibit the highest accumulation of flavonoids, with isovitexin reaching its peak concentration during the pre-flowering to flowering stages. Comparative studies indicate that the ethanol-free liquid extract of P. incarnata contains higher flavonoid levels than commercially available preparations.[6]

Alkaloids

Passiflora incarnata is found to possess simple indole alkaloids characterized by the -carboline ring system, specifically harman, harmol, harmine, harmalol, and harmaline. Medicinal fluid extract of P. incarnata contains 10–20 g/100 ml of harman and harmine, determined through direct spectrofluorimetric methods on TLC plates.[7]

In terms of quantitative measurements, vegetative parts of P. incarnata cultivated in greenhouses were found to contain 0.012% and 0.007% of harman and harmine, respectively. In contrast, the content of these alkaloids in field-grown plants was reported as 0.005% and nil, respectively.[8]

Phyto-constituents of Passiflora edulis
Glycosides

Passiflora incarnata's methanol extract from air-dried leaves yielded a cyclopropane triterpene glycoside named Passiflorine. Chemically identified as (22R),(24S)-22,28-epoxy-24-methyl-1,3,24,28-tetrahydroxy-9,19-cyclo-9-lanostan-4-oic acid-d-glucosylester.[9] In the case of Passiflora edulis, it has been reported to be abundant in various glycosides. These include flavonoid glycosides like luteolin-6-C-chinovoside and luteolin-6-C-fucoside.[10] Additionally, cyclopentanoid cyanohydrin glycosides such as passicapsin and passibiflorin have been identified. Passiflora edulis also contains cyanogenic glycosides like passicoriacin, epipassicoriacin, and epitetraphyllin B, as well as cyanogenic-rutinoside other glycosides present in Passiflora edulis include amygdalin, prunasin, mandelonitrile rhamnopyranosyl- -d-glucopyranoside, sambunigrin, benzyl alcohol, and 3-methyl-but-2en-1-ol. Moreover, there are -d-glucopyranoside of methyl salicylate, and -d-glucopyranoside of eugenol.[11]

Alkaloids

The alkaloids identified in the plant include harman, harmine, harmaline, and harmalol, the leaves contain the highest concentration of harman alkaloids, with a reported peak of 0.12 mg%.[12] Other Passiflora species along with their Physical constituents were mentioned in the Table 1[13-27]

FORMULATIONS

Passiflora extracts, derived from the passionflower plant, are gaining recognition for their potential health benefits. Abundant in bioactive compounds like flavonoids and alkaloids, these extracts are utilized in various formulations. Known for their anxiolytic, sedative, and anti-inflammatory properties, Passiflora extracts are incorporated to address conditions such as anxiety, sleep disorders, and inflammation. Their antioxidant-rich nature also contributes to potential cognitive support and overall well-being. Various formulations were developed using the Passiflora extracts and some of them are mentioned in various tables based on the plant extracts

Formulations based on Seed extracts

Daniela A. Oliveira et al, study delved into Nano encapsulating passion fruit extracts using the emulsion/solvent evaporation method, focusing on valorizing agricultural waste. Both PLGA formulations (50:50 and 65:35) yielded spherical nanoparticles, enabling a controlled release of antimicrobial extracts to prevent bacterial growth. The adapted Gompertz model accurately predicted the extract release from PLGA polymers, suggesting PLGA 65:35 as more suitable despite lower entrapment efficiency due to reduced interaction with the hydrophobic seed cake extract. Encapsulation significantly amplified antimicrobial activity, slashing required concentrations by up to 95%, potentially offering a natural, effective alternative to chemical disinfectants in aqueous environments, promising enhanced control over pathogens.[28] Karolline Krambeck et al, a Nanostructured Lipid Carrier (NLC), NLCP, harnessing passion fruit seed oil, a by-product from Madeira Island's food industry. NLCP exhibited enduring physical and chemical stability during storage, showcasing exceptional encapsulation efficiency for piceatannol and heightened tyrosinase inhibitory activity compared to free oil. Confocal laser scanning microscopy highlighted effective cutaneous penetration. The derived NLC-based hydrogel, NLCP_GEL, remained stable over a year at varied temperatures, maintaining consistent pH, color, texture, and viscosity. Incorporating Poly (acrylic acid), this gel facilitated piceatannol permeation into the viable epidermis, crucial for antioxidant and depigment effects, ensuring prolonged skin contact. Cytotoxicity studies on HaCat cells affirmed the formulations' safety even at concentrations up to 100 µg/mL, a finding corroborated across multiple assays, solidifying the safety profile of these

innovative formulations [29-30] Myla Lôbo de Souza et al explained that Limited research has focused on exploring the therapeutic properties of oils derived from wild Passiflora species. This study presents previously undisclosed data on the characterization of these oils, their biological effects, and the design of appropriate nano-carriers. The findings indicate that oils extracted from seeds of new Passiflora varieties are rich in unsaturated fatty acids, including essential ones, known for their nutritional and healing properties. The observed physicochemical properties suggest chemical stability, making them suitable as raw materials for both laboratory and industrial formulations. Moreover, in vitro assessments demonstrate the potential of these oils to serve as active ingredients that stimulate keratinocyte proliferation, suggesting applications in both therapeutic and cosmetic formulations. Additionally, Nano emulsions emerge as a promising carrier system for Passiflora oils, offering a viable option for topical administration in healing formulations.[31] Dewi NK et al explained the application of extract from the seeds of the purple variant of passion fruit (Passiflora edulis Sims var. edulis) topically has been found to enhance the condition of acne vulgaris. This improvement is evidenced by a decrease in noninflammatory, inflammatory, and overall acne lesions, as well as a reduction in UVRF spot quantity and percentage area. The study highlights the potential therapeutic use of passion fruit purple variant seeds extract for treating acne vulgaris. However, further prospective research is essential to establish the safety and efficacy of this extract compared to standard acne vulgaris treatments.[32] Puneet Gupta et al expalined that the inflammatory response orchestrates cellular processes crucial for wound repair. Emulgel facilitates wound healing by inhibiting reactive oxygen species and cytokine production while promoting fibroblast and keratinocyte proliferation. Histopathological studies indicate emulgel's superiority over alternative treatments, suggesting its potential to enhance wound healing in a concentration-dependent manner.[33]

Formulations based on leaf extract

Thomas B et al This study outlines a simple, eco-friendly method to create stable silver nanoparticles using Passiflora edulis f. flavicarpa leaf extract. This process is swift, doesn't require external stabilizers or reducing agents, and yields stable nanoparticles. Even at a low concentration, these nanoparticles displayed substantial antibacterial effectiveness against E. coli, indicating their promise as potent antibacterial agents. Additionally, they showcased remarkable ability in environmentally friendly degradation of organic dyes, offering potential solutions for water contamination issues arising from industrial activities. These nanoparticles hold significant promise in addressing challenges related to clean drinking water, wastewater treatment, catalytic degradation of pollutants, and as potent free radical scavengers, potentially serving as natural antioxidants with diverse applications.[34] J. Santhoshkumar et al, in their investigation, zinc oxide nanoparticles were synthesized using a plant leaf extract in a green and environmentally friendly approach that minimizes chemical usage. The leaf extract's phytochemicals played a pivotal role in facilitating oxidation and reduction reactions crucial for nanoparticle synthesis, primarily through functional groups like amines and alkanes found in secondary metabolites such as terpenoids, flavonoids, and alkaloids.

Confirmation of rapid ZnO nanoparticle synthesis was achieved via UV-Visible spectroscopy, showing maximum absorbance at 380 nm. X-ray diffraction (XRD) affirmed their crystalline nature, while energy-dispersive X-ray (EDX) analysis confirmed the presence of zinc and oxide ions. Scanning electron microscopy (SEM) revealed nanoparticle sizes ranging approximately from 30 to 50 nm. Importantly, these ZnO nanoparticles exhibited potent antibacterial activity, particularly against urinary tract infections, suggesting their potential as effective antibacterial agent.[35] Echeverry Gonzalez et al, achieved a successful formulation of PLE-SEDDS (self-emulsifying drug delivery system). This system comprised castor oil, Cremophor® EL, propylene glycol, and PDMSHEPMS in specific proportions (31:120:80:30) with a payload of 20%. In terms of pharmacological effects, PLE-SEDDS demonstrated a reduction in blood glucose levels in mice compared to PLE alone. As a result, PLE-SEDDS shows promise as a formulation worthy of further investigation in chronic models of diabetes mellitus.[36] Strasser et al, explained that Antiulcerogenic activity was observed in three extracts from Passiflora serratodigitata L. – crude (DCE), ethyl acetate (EAF), and residual water fraction (RWF). Significantly, Nano encapsulated forms of these extracts (NDC and NEAF) exhibited enhanced antiulcerogenic activity compared to their conventional counterparts. This study underscores the positive impact of nanoencapsulation on both the physicochemical properties and the effectiveness of herbal formulations. Consequently, both free and encapsulated extracts emerge as potential candidates for drug design, holding promise

for the therapeutic management of ulcers.[37] Lade et al explored the leaf extract of P. foetida as a source for efficient silver nanoparticle (SNP) production, with sunlight-induced synthesis emerging as the most effective method. UV-spectroscopic analysis revealed distinctive peaks for sunlight, room temperature, and microwave-induced SNPs. Compound identification through FTIR highlighted specific molecules responsible for reducing silver nitrate to SNPs. Optimal SNP fabrication occurred at an alkaline pH of 11, showcasing stable nanoparticle production. SEM and TEM analyses confirmed sizes of 13.60 nm for microwave-induced, 14.96 nm for sunlight-induced, and 31 nm for room temperature-induced SNPs. Sunlight-induced SNPs demonstrated antimicrobial potential against E. coli and S. aureus at a minimum inhibitory concentration (MIC) of 50 µg/ml. SEM showcased unique morphologies resembling coral reefs, small rocks, and mountains for microwave, sunlight, and room temperature conditions, with consistently small particle sizes. The plant extract-based sunlight-induced SNPs exhibit promising prospects for integration into pharmaceutical applications.[38] Lade et al in the study identified P. foetida leaf discs, specifically 2 cm in diameter, as an effective medium for synthesizing stable silver nanoparticles (Ag-NPs). UV–Vis spectroscopy validated this method's proficiency in reducing silver ions to silver atoms using the 2 cm leaf discs. Notably, leaf discs at pH 7 proved ineffective, while an alkaline pH of 11 successfully facilitated Ag-NP synthesis. The synthesis process initiated within 24 hours at room temperature and a mere 10 minutes under sunlight conditions, with the sunlight reaction demonstrating a distinct UV–Vis absorbance peak, indicating its preference for Ag-NP synthesis over dark and UV conditions. FTIR analysis confirmed the involvement of various functional groups from the leaf, such as alkanes, alkyne, amines, aliphatic amine, carboxylic acid, nitro-compound, alcohol, saturated aldehyde, and phenols, in silver reduction. SEM analysis revealed a clustered, bread-like morphology of the nanoparticles.[39]

Gowrishankar L et al, explained that Plumeria Rubra and Passiflora Incarnata are recognized as rich sources of micronutrients, boasting significant quantities of vitamins, polyphenols, and dietary minerals. Previous research has delineated three distinct herbal tea formulations, each showcasing unique compositions. Sensory evaluation of samples HT 1, 2, and 3 indicated that HT 2 received notably high recommendations, prompting its selection for proximate analysis. This analysis unveiled elevated levels of antioxidants, phenols, and vitamin C in HT 2. Toxicity analysis of HT 2 revealed a mild toxin presence of 21% Subsequent investigations are slated to explore the product's efficacy in managing diabetes and identify suitable primary and secondary packaging materials. Furthermore, the study aims to assess shelf life and nutritional degradation rates under varying temperatures, particularly those akin to hot beverage temperatures.[40] da Cunha Rodrigues L et al, explained that Pressurized Liquid Extraction (PLE) with 70% ethanol yielded 33.1% extractable solids from passion fruit leaves, surpassing percolation's 21.8%. Optimized PLE conditions involved 100°C temperature, 120% rinse volume, and four cycles. PLE's efficiency, faster processing, and reduced solvent usage make it advantageous over percolation. Fick model effectively predicted extraction kinetics, aiding in equipment scale-up. Intermittent purging in PLE extracted larger quantities in shorter durations, enhancing industrial applicability. PLE and percolation extracts showed similar isovitexin levels and antioxidant activity, yet PLE's time and solvent-saving nature make it preferred.[41]

Formulations based on other parts of the plant

Soares   et al in their study developed a stable chitosan hydrogel incorporating flavonoids from Passiflora edulis leaves, suitable for wound dressing. Cell viability tests confirmed safety, while in vitro release studies demonstrated rapid flavonoid release. Histological and macroscopic evaluations revealed wound healing properties, particularly in the initial healing phase, with enhanced antioxidant defense stimulation in animals treated with the hydrogel containing flavonoids. Results suggest potential for treating diabetic rat skin lesions, highlighting the hydrogel's efficacy in the early stages of wound healing and its promise for wound dressing applications.[42] Daniela Borrmann et al, explained in their study that researchers explored the microencapsulation of passion fruit juice using n-octenylsuccinate-derivatised starch through the spray-drying process. Notably, the utilization of n-OSA starch preserved the taste and aroma of passion fruit, enabling easy dilution in cold water post-spray-drying and storage. The outcome was highly stable microcapsules, presenting as a uniform white powder. Remarkably, the efficacy of n-OSA starch as a guardian of vitamin C stood out, retaining nearly all the vitamin C content in the samples throughout extended storage. This encapsulation method allows passion fruit to be conveniently transported and stored as a powder without significant degradation of its nutritional qualities, maintaining a robust and delightful

passion fruit aroma. Reconstituting the juice from this powdered form is straightforward, underscoring its industrial processing potential. [43] Manokari et al in their research, Zinc oxide nanoparticles were produced through the synthesis of Zinc Nitrate hexahydrate solution, combined with extracts from the leaves, stems, and flowers of P. edulis. The process, involving the plant extracts, is an environmentally benign method for the biosynthesis of nanoparticles. The completion of the reaction was observed within two hours when employing different plant part extracts. The plant extracts contain diverse phytochemicals that serve as both reducing and stabilizing agents, facilitating the formation of zinc oxide at the nano scale.[44] According to Frank Mayta-Tovalino et al, the dentifrice formulated from the pulp of Passiflora mollissima demonstrated superior antimicrobial efficacy compared to the peel-based dentifrice. However, certain microbial strains like Actinomyces, C. albicans, S. sanguinis, and S. oralis exhibited greater susceptibility to the peel-based dentifrice. Overall, our findings suggest that our dental formulation is as effective as or even surpasses commercial toothpastes in terms of antimicrobial activity. This underscores the potential of this Peruvian natural resource, opening up promising avenues for further research in this domain.[45]

Viganó J, Meirelles AAD et al, explained that Microparticles of alginate aerogels loaded with gallic acid (GA) and passion fruit bagasse extract (PFBE) were produced using emulsion gelation and internal setting methods, followed by wet impregnation and supercritical CO_2 drying. Optimal GA loading (0.83 g/g raw alginate) was achieved with 1 wt% alginate solution. PFBE loading reached 0.62 g/g raw aerogel, with preserved antioxidant capacity post-impregnation and drying. Total phenolic and piceatannol loadings were 10.77 mgGAE/g and 741.85 µg/g raw aerogel, respectively, with loading efficiencies of 47.1% and 34.7%. The study demonstrates the suitability of impregnated alginate aerogel microparticles for drug delivery, with potential for controlled release of PFBE.[46]My et al explained that the research introduced an eco-friendly method utilizing waste Passiflora edulis peel to synthesize silver and gold nanoparticles, offering vast potential across pharmaceutical and environmental domains. The produced nanoparticles, averaging 25 nm for silver and 7 nm for gold, displayed spherical structures. Particularly impressive was the robust antibacterial activity of silver nanoparticles against multiple bacterial strains, consistently inhibiting them at a minimum concentration of 0.5 mM. Moreover, both types of nanoparticles showcased remarkable catalytic abilities, efficiently reducing nitrophenols and degrading four toxic dyes. This environmentally conscious approach not only synthesizes nanoparticles but also demonstrates their multifaceted potential in combating bacterial infections and addressing environmental challenges related to pollutant degradation.[47]

CONCLUSION

In conclusion, Passiflora species have long held a significant place in traditional medicine due to their diverse therapeutic properties. Through modern scientific exploration, we have uncovered a wealth of phytoconstituents within these plants, including flavonoids, alkaloids, and phenolic compounds, among others. These compounds exhibit various biological activities, such as anxiolytic, sedative, and antioxidant effects, which have been extensively studied and validated. The extraction of these phytoconstituents has led to the development of numerous formulations, including tinctures, teas, capsules, and creams, catering to different consumer preferences and therapeutic needs. These formulations offer a convenient and accessible means of harnessing the potential health benefits of Passiflora species. Furthermore, the utilization of advanced extraction techniques has allowed for the isolation and concentration of specific bioactive compounds, enhancing the efficacy and consistency of Passiflora-based products. This has facilitated their integration into mainstream healthcare practices, complementing existing treatment modalities for various conditions such as anxiety, insomnia, and inflammation. However, despite the promising therapeutic potential of Passiflora species and their extracts, further research is warranted to fully elucidate their mechanisms of action, optimize extraction methods, and explore potential synergistic effects with other herbal remedies or pharmaceutical agents. In essence, the study of Passiflora species and their extracts represents a captivating intersection of traditional wisdom and modern scientific inquiry, offering a rich tapestry of therapeutic possibilities for improving human health and well-being.

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Table 1: Various species, Chemical constituents and uses of Passiflora

S. No.	Species	Part of Plant	Chemical constituents	Used for
1.	P.alata	Fruit	Polyphenols and flavonoids	• Alzheimer's disease, • Cancer, • Parkinson's disorder.[13]
		Leaves	Phenolic compounds like catechin, epicatechin, and rutin	• Gastroprotective • Neuroprotective properties. • Neuroprotective • Anti-ulcer [14] • anti-diabetic effects.[15]
		Seed		• Antioxidant properties.[16]
2.	P. caerulae	Fruit	Polyphenols like catechin, resveratrol, epigallocatechin gallate, rutin, and quercetin.	• Chronic neurodegenerative disease.[17]
		Leaf	Existence of fatty acids, esters, sterols, and hydrocarbons isoorientin, vitexin, isovitexin, and vicenin-2	• Gastrointestinal tract-related disease.[18]
		Fruit		• Anxiety and Insomnia.[19]

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3.	P. edulis	Leaf	Cycloartane triterpenoid saponins, encompassing cyclopassifloside XII and XIII, along with six additional cycloartane triterpenoids	• Antidepressant.[20]
		Seed		• Anti-fungal activity.[21]
		Stem	Cycloartane triterpenoids.	• Anti-depressant.[22]
4	P. incarnata	Flower		• General anaesthesia.[23]
		Leaves	Alkaloids, phenols, glycosyl flavonoids, and cyanogenic compounds	• Dyslipidemia • Hypertrophy, • Hepatic oxidative stress.[24]
		Seeds	Steroid, β-Sitosterol	• Hypercholesterolemia.[25]
5.	P. ligularis	Fruit	alkaloids and flavonoids	• Anti-diabetic.[26]
		Leaf	alkaloids, glycosides, tannins, steroids, terpenoids, and flavonoids	• Anti-inhibitory activity of the extract.

Table 2: Formulations based on seed extracts of Passiflora

S. No	Formulation	Part of plant	Activity	Materials used	Technique employed	Reference
1	Nano encapsulation (controlled release)	Passion fruit seed oil by cold pressing.	Antimicrobial activity	PLGA, with dl-lactide to glycol-ide copolymer ratios of 50:50 PVA, or polyvinyl alcohol	solvent/emulsion evaporation technique	Daniela A. Oliveira et al;2017
2	Lipid carriers-based hydrogels with nanostructure	Passiflora edulis seeds	Depigmenting agent.	Tween 80, or glyceryl distearate Polysorbate 80 Bromide of alkyl trimethylammonium Carbopol 940, Cetrimide Poly(acrylic acid)	Sonication technique at high volumes Glyceryl distearate, a solid lipid, and passion fruit seed oil, a liquid lipid, were combined	Karolline Krambeck et al;2021
3	Lipid carriers with nanostructure	Passiflora edulis seeds oil	Designed to be applied on skin	Cetyl palmitate, Glyceryl dibehenate (Compritol 888 ATO), Glyceryl distearate (Precirol ATO5), and Tween 80	Using various solid lipids, ultrasonication and high-pressure homogenization	Karolline Krambeck et al;2019[43]

4	Inclusion in Nano emulsions is a creative way to produce dermatological nanotechnological products.	Seed oils of wild Passiflora (Passiflora spp.)	Dermalogical preparations	Methyl chloro isothiazolinone, propylene glycol, glycerin, polysorbate 80 (Tween 80; HLB 15), and sorbitan oleate	The various seed oils required different Nano emulsions to be synthesised.	Myla Lôbo de Souza et al;2022
5	Topical cream	Extract from the seeds of the purple variety of passion fruit	Used for treatment for acne vulgaris	0.5% cetyl alcohol, 5% sorbitol, 3% propylene glycol, 1% triethanolamine, and 12% stearic acid.	Extracting and obtaining prepare topical cream The extract was combined with the cream base to produce 10% cream.	Dewi NK et al;2020
6	Emulgel	Passiflora edulis seed oil	Healing potential	Propolis extract	Emulsification	Puneet Gupta et al;2022

Table 3: Formulations based on leaf extract of Passiflora

S No	Formulation	Part of plant	Activity	Materials used	Technique employed	Reference
1	Nanoparticles	Passiflora caerulea fresh leaf extract	urinary tract infection	20 mL of NaOH, 50 ml of Milli-Q water, and 1 mM zinc acetate	Centrifugation was used to separate the precipitate from the reaction solution for 15 minutes at 60°C and 8000 rpm.	Thomas B et al;2019
2	Silver-colored particles	Aqueous Leaf Extract	Activity of Antioxidants and Photocatalysis	Aqueous silver nitrate at 2 mM	Green Synthesis Was Mediated by Aqueous Leaf Extract	J. Santhoshkumar et al;2017
3	self-emulsifying drug delivery system (SEDDS)	Extract from Passiflora ligularis leaves	Hypoglycemic activity	Transcutol P, propylene glycol, and Lutrol 400), surfactants (Cremophor EL, Cremophor ELP, and Tween 80), and co-solvents	Following dissolving in the co-solvent with a vortex mixer, PLE was submerged for 15 minutes in the ultrasonic cleaner bath.	Echeverry Gonzalez et al;2021

4	Nano encapsulated	Extracts from Passiflora serratodigitata leaves	Potential Activity of Antiulcerogenic	Standard quercetin, poly(epsilon-caprolactone) (PCL), and sorbitan monostearate (span 60). 0.3 M hydrochloric acid, Polysorbate 80 ethyl acetate, acetone	Ethyl acetate fraction, dry crude extract (DCE), and polymeric Nano capsule filled with EAF method	Strasser et al;2014
5	SNPs, silver nanoparticles	Passiflora Foetida Linn Leaf Extract	Anti-microbial activity	Silver nitrate, 0.1 mM NaOH solution.	Stable NPs were produced by synthesising 1 mM AgNO3 in 95 ml of leaf extract and 5 ml of alkaline pH 11 solution.	Lade et al;2022
6.	Silver nano fabrication	Extract from Passiflora leaves.	Anti-microbial activity	AgNO3	The Passiflora species leaf disc is ready and dipped in 100 millilitres of 1 milligram AgNO3.	Lade et al;2017
7	Herbal Tea	Passiflora Incarnata and P. Rubra Leaves	Antioxidant activity		Extract was combined with tea powder together with P. Incarnata and P.Rubra.	Gowrishankar L et al;2023
8	Hydroalcoholic Extract (Tincture)	Passiflora edulis leaves	Antioxidant activity	Alcohol phenol solution (2 M) and anhydrous gallic acid (99% purity)	Pressurized Liquid Extraction (PLE)	da Cunha Rodrigues L et al;2023

Table 4: Formulations based on other plant extract of Passiflora

S No	Formulation	Part of plant	Activity	Materials used	Technique employed	Reference
1.	Chitosan Hydrogel	Passiflora edulis leaves	Antioxidant and wound healing properties	Chitosan, glycerin, and acetic acid; methylparaben propylparaben ethyl acetate butanol polyethylene glycol	Maceration	Soares et al;2019

			40 (PEG40) hydrogenated castor oil sodium thiopental.		
2.	Food microencapsulation	Passion fruit juice	Food storage shelf life. vitamin C for extended periods of storage.	Using starch derivatized from n-octenyl succinate	Passion fruit juice encapsulation and spray-drying have shown to be a cost-effective substitute for freeze-drying while maintaining vitamin C content.	Daniela Borrmann et al;2012
3.	Nanoparticles of zinc oxide	Extracts from different sections of the passion fruit, Passiflora edulis Sims. f. flavicarpa Deg.		Ethanol Zinc Nitrate hexahydrate {Zn(NO3)2.6H2O}	Leaf, stem, and flower extracts were combined with zinc nitrate hexahydrate solution to create zinc oxide nanoparticles	Manokari et al;2016
4.	Dentifrice	Passiflora Mollissima Pulp and Fruit	Antibacterial activity	Tetrasodium pyrophosphate, AEROSIL	Sowing method	Frank Mayta-Tovalino et al;2019
5.	Alginate aerogel microparticles	Passion fruit bagasse	Antioxidant activity	Alginate (1, 2, 3 wt%) Gallic acid (GA)	Emulsion-gelation method, sub mitted to solvent exchange, wet impregnation (WI) and supercritical drying	Viganó J, Meirelles AAD et al;2020
6.	Metallic nanoparticles	Waste Passiflora edulis peels	Antibacterial effect and Catalytic activity	AgNO3, HAuCl43H2O, NaBH4, methyl orange (MO), rhodamine B (RhB), rhodamine 6G (Rh6G)	The optimal colloidal solutions were obtained by optimising.	My My et al;2021

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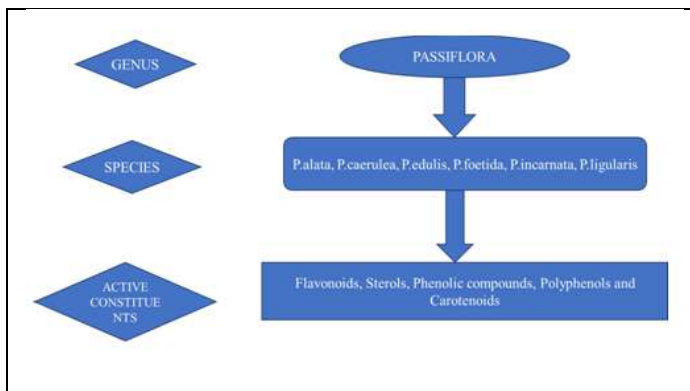
Fig 1. Flowchart of species and its Phytoconstituents of Passiflora	**Fig 2. Images of Plant parts of various species of Passiflora**

RESEARCH ARTICLE

Importance of Studying Chaos in MEMS/NEMS Resonators

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ABSTRACT

This research article delves into the impact of nonlinearity on mechanical oscillators, scrutinizing its effects on stability, resonance, damping, and energy transfer. Nonlinearity, a prevalent characteristic in mechanical systems, profoundly influences the behavior and performance of oscillators. Through a combination of experimental and computational studies, diverse types of nonlinearities are analyzed, unraveling their intricate implications for oscillator design and optimization. By comprehensively examining the interplay between nonlinearity and oscillator dynamics, this research sheds light on fundamental aspects crucial for enhancing the performance and reliability of mechanical oscillators in various applications. Understanding and effectively managing nonlinearity is paramount for advancing the design and optimization of mechanical oscillators, ultimately facilitating their broader utilization across a spectrum of engineering disciplines.

Keywords: Nonlinearity, Mechanical oscillators, Stability, Resonance, Damping, Energy transfer

INTRODUCTION

The field of micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS) has undergone remarkable advancements, revolutionizing various technological domains with their compact size, low power consumption, and high performance. Among the myriad components within these systems, resonators play a pivotal role, serving as fundamental building blocks for a wide array of applications, ranging from sensing and signal processing to communication and beyond. The micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS) resonators are small-scale mechanical devices that vibrate at specific frequencies, commonly used in various applications such as sensors, filters, oscillators,timing references, sensing, signal processing, and communication systems. These resonators exhibit nonlinear dynamics and chaos under certain conditions, which can have both beneficial and detrimental effects on their performance. Despite their small size, they can exhibit complex dynamical behaviors due to nonlinearities inherent in their design and operation. Understanding nonlinear dynamics and chaos in MEMS/NEMS resonators is crucial for optimizing their performance and exploring new functionalities. In recent years, there has been a burgeoning interest in understanding the nonlinear dynamics and chaos inherent in MEMS/NEMS resonators. This interest stems from the recognition that while linear analysis has provided valuable insights into the behavior of these systems, it often falls short in capturing the intricate dynamics exhibited under certain conditions. Nonlinear dynamics, characterized by the interplay of multiple forces and nonlinearities, introduces complexities that can significantly influence the behavior. These complexities manifest in various forms, including bifurcations, limit cycles, and chaotic motion. Understanding and harnessing these nonlinear phenomena are crucial for optimizing the performance and reliability of MEMS/NEMS devices. Chaos, a fascinating yet often perplexing phenomenon, has garnered particular attention within the realm of MEMS/NEMS resonators. Despite its inherently unpredictable nature, chaos has been shown to offer both challenges and opportunities in system design and operation. From enhancing sensing capabilities to enabling secure communication protocols, chaos has emerged as a powerful tool for exploiting the inherent nonlinearities in MEMS/NEMS resonators. However, navigating the realm of nonlinear dynamics and chaos in MEMS/NEMS resonators poses significant challenges. Existing analytical and numerical techniques, while valuable, may fall short in accurately predicting and controlling chaotic behavior under realistic operating conditions. Consequently, there is a pressing need for advanced methodologies and theoretical frameworks that can elucidate the intricate dynamics of these systems and provide practical insights for their design, optimization, and control.

Due to breakthroughs in nanotechnology, diminutive devices like micro- and nano-electro-mechanical systems (MEMS/NEMS) have witnessed widespread utilization across various domains of science and engineering. Extensive research endeavors have been dedicated to numerically and analytically exploring diverse behaviors and modeling intricacies of these systems [1,2]. In this review, we delve into the fascinating world of nonlinear dynamics and chaos in MEMS/NEMS resonators. We explore the underlying principles governing their behavior, examine existing research endeavors, and highlight emerging trends and future directions in this rapidly evolving field. Through a comprehensive synthesis of theoretical insights, experimental findings, and practical applications, we aim to shed light on the intricate interplay between nonlinear dynamics and chaos in MEMS/NEMS resonators and their implications for next-generation technological innovations.

DIFFERENTIATING MEMS AND NEMS: A COMPARATIVE ANALYSIS

MEMS and NEMS resonators are both types of resonant devices used in various applications, but they differ mainly in their size and scale.

Size and Scale

- MEMS: MEMS devices typically have dimensions ranging from micrometers (10^{-6} meters) to millimeters (10^{-3} meters). These devices are larger in scale compared to NEMS devices.

- NEMS: NEMS devices, as the name suggests, operate at the nanometer (10^-9 meters) scale. They are significantly smaller compared to MEMS devices and can even have dimensions on the order of a few nanometers.

Fabrication Techniques
- MEMS: MEMS resonators are typically fabricated using traditional semiconductor manufacturing techniques such as photolithography, etching, and deposition. These techniques are well-established and widely used in the semiconductor industry.
- NEMS: NEMS resonators require more advanced nanofabrication techniques due to their smaller size. Techniques such as electron beam lithography, nanoimprint lithography, and atomic layer deposition are often employed to fabricate NEMS devices with precision at the nanoscale.

Resonant Frequencies
- MEMS: Due to their larger size, MEMS resonators typically have resonant frequencies ranging from kilohertz (KHz) to megahertz (MHz). These frequencies are suitable for various applications such as timing devices and inertial sensors.
- NEMS: NEMS resonators, being much smaller, exhibit higher resonant frequencies compared to MEMS resonators. They can resonate in the gigahertz (GHz) range and even higher, enabling applications in fields such as nanoelectronics and quantum computing.

Material Selection
- MEMS: MEMS resonators can be fabricated from a variety of materials including silicon, silicon dioxide, and various thin films. Silicon-based MEMS resonators are widely used due to the compatibility with existing semiconductor processes.
- NEMS: NEMS resonators often utilize novel nanoscale materials such as carbon nanotubes, graphene, and nanowires. These materials possess unique properties at the nanoscale and enable functionalities not achievable with traditional MEMS materials.

Applications
- MEMS: MEMS resonators find applications in diverse fields such as consumer electronics (e.g., timing devices in smartphones), automotive (e.g., airbag deployment systems), aerospace (e.g., gyroscopes for navigation), and healthcare (e.g., biomedical sensors).
- NEMS: NEMS resonators are still emerging but hold promise for advanced applications such as nanoelectronics (e.g., nanoscale logic circuits), quantum computing (e.g., qubit control), sensing at the nanoscale (e.g., detecting single molecules), and nanomedicine (e.g., targeted drug delivery).

Energy Consumption and Efficiency
- MEMS: MEMS resonators often consume more energy due to their larger size and mass, which may limit their use in low-power applications.
- NEMS: NEMS resonators, being smaller and having higher resonant frequencies, can potentially offer lower energy consumption and higher efficiency, making them suitable for energy-efficient and miniaturized devices.

NONLINEAR EFFECTS IN MEMS/NEMS RESONATORS
Nonlinearity in micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS) resonators is a critical aspect that significantly influences their behavior and performance. Nonlinearity emerges from various factors, including geometric imperfections, material nonlinearities, and electrostatic forces, which can lead to complex and often unexpected responses. Understanding and managing nonlinearity is essential for optimizing device performance and ensuring reliable operation.

1. **Geometric Imperfections**: MEMS and NEMS resonators are fabricated using micro- and nano-scale manufacturing processes, which inherently involve imperfections in the device's geometry. These imperfections can lead to asymmetries in the resonator structure, irregularities in the mass distribution, and non-uniformities in the stiffness properties. As a result, the resonator's response deviates from the ideal linear behavior, introducing nonlinear effects such as frequency shifts and mode coupling.

2. **Material Nonlinearities**: The mechanical properties of the materials used in MEMS and NEMS resonators can exhibit nonlinear behavior under certain conditions. This nonlinearity arises due to phenomena such as material fatigue, plastic deformation, and stress-dependent stiffness. For example, in micro-scale structures, material properties may vary with strain, leading to nonlinear stress-strain relationships. Material nonlinearity can cause changes in resonance frequencies, damping characteristics, and mode shapes, affecting device performance and reliability.

3. **Electrostatic Forces**: Electrostatic actuation and sensing are commonly employed in MEMS and NEMS resonators due to their compatibility with microfabrication processes and low power consumption. However, electrostatic forces between the resonator and surrounding electrodes can induce nonlinearities in the system. At large displacement amplitudes, nonlinear electrostatic forces can distort the resonator's motion, leading to amplitude-dependent resonance frequencies and mode coupling phenomena. Moreover, nonlinearities in the electrostatic force may result from factors such as fringing fields, non-uniform dielectric properties, and nonlinear capacitance-voltage characteristics.

The presence of nonlinearities introduces several challenges and opportunities in the design and operation of MEMS and NEMS resonators:

1. **Complex Dynamics**: Nonlinear systems exhibit rich and complex dynamics, including phenomena such as frequency mixing, subharmonic resonances, and chaotic behavior. Understanding these dynamics is crucial for predicting device behavior accurately and exploiting nonlinear effects for novel applications such as frequency synthesis and signal processing.

2. **Nonlinear Control**: Traditional linear control techniques may not be sufficient for stabilizing and controlling nonlinear MEMS and NEMS resonators. Advanced control strategies, such as adaptive control, feedback linearization, and sliding mode control, are required to mitigate the effects of nonlinearities and enhance device performance.

3. **Design Optimization**: Designing MEMS and NEMS resonators with reduced nonlinearities requires careful consideration of geometric, material, and electrostatic factors. Optimization techniques, such as topology optimization, parameter tuning, and sensitivity analysis, can help minimize nonlinear effects and improve device linearity and sensitivity.

4. **Harmonic Generation and Mixing**: Nonlinear MEMS and NEMS resonators can serve as efficient sources of harmonic generation and mixing, enabling applications in frequency multiplication, signal modulation, and frequency conversion. By exploiting nonlinear effects, these devices offer compact and energy-efficient solutions for RF and wireless communication systems.

DYNAMICAL BEHAVIOR AND RESONANCE
Dynamical behavior and resonance in MEMS/NEMS devices are crucial aspects that significantly impact their performance and applications. Let's delve deeper into these phenomena:

Frequency Response

*   **Nonlinear Dynamics:** MEMS/NEMS resonators exhibit nonlinear behavior in their frequency response due to various factors such as material properties, geometry, and fabrication imperfections. These nonlinearities can lead to deviations from the expected linear behavior predicted by classical models.

*   **Frequency Veering:** One notable effect of nonlinear dynamics is frequency veering, where resonance frequencies deviate from linear predictions as excitation parameters change. This deviation can occur as a result of various nonlinear mechanisms, such as nonlinear stiffness or damping effects.

- **Frequency Shifts and Broadening:** Nonlinear effects can cause shifts in resonance frequencies and broadening of resonance peaks in the response spectrum. This broadening occurs due to the interaction of multiple vibrational modes and energy transfer mechanisms within the resonator.
- **Higher Harmonics:** Nonlinearities can also lead to the appearance of higher harmonics in the response spectrum, which signifies the generation of additional frequency components beyond the fundamental resonance frequency. These harmonics contribute to the overall response and can impact device performance in certain applications.

Parametric Resonance

Parametric resonance occurs when a system's parameters vary periodically with time, leading to resonant amplification of oscillations. In the context of MEMS/NEMS resonators, parametric resonance typically occurs when the excitation frequency is twice the natural frequency of the device.

- **Large-Amplitude Oscillations:** Under parametric excitation, MEMS/NEMS resonators can exhibit large-amplitude oscillations far beyond what would be achievable under static excitation conditions. This phenomenon can result in enhanced sensitivity and improved signal detection capabilities in sensing applications.
- **Chaotic Behavior:** In certain cases, parametric resonance can lead to chaotic behavior characterized by irregular and unpredictable oscillations. While chaotic behavior may be undesirable in some applications, it can also offer opportunities for novel signal processing techniques and dynamic system control strategies.
- **Applications:** Parametric resonance has applications in signal amplification, energy harvesting, and dynamic signal processing. By harnessing the amplification capabilities of parametric resonance, MEMS/NEMS devices can achieve improved performance in various sensing, actuation, and communication systems.
- **Control Challenges:** However, controlling parametric resonance poses significant challenges, particularly in suppressing unwanted vibrations and ensuring stability in dynamic systems. Effective control strategies, such as feedback control and adaptive damping techniques, are essential for mitigating the adverse effects of parametric resonance and optimizing device performance.

BIFURCATIONS AND CHAOS

BIFURCATIONS

Bifurcations, in the context of nonlinear dynamics within micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS) resonators, represent pivotal points where the system's behavior undergoes abrupt qualitative changes due to variations in control parameters. These phenomena are fundamental in understanding and predicting the behavior of these resonators, which are crucial in numerous technological applications ranging from sensors to communication devices. One notable bifurcation phenomenon observed in MEMS/NEMS resonators is period-doubling bifurcation. This occurs when a system transitions from regular periodic motion to chaotic motion as a control parameter, such as driving voltage or frequency, is varied. Initially, the resonator oscillates with a fixed frequency in a predictable manner. However, as the control parameter is gradually increased, the oscillation period doubles, leading to a cascade of period-doubling events until chaotic behavior emerges. Chaotic motion is characterized by seemingly random and unpredictable oscillations, which can have significant implications for the device's performance and reliability. Another crucial bifurcation phenomenon is the saddle-node bifurcation, where abrupt changes in stability occur. In this case, as a control parameter crosses a critical threshold, the equilibrium points of the system collide and annihilate each other, causing the stability landscape of the system to change dramatically. This sudden transition can lead to unpredictable behavior, such as a shift from stable to unstable states or the emergence of new stable states. In MEMS/NEMS resonators, saddle-node bifurcations can manifest as sudden changes in resonance frequencies or amplitude of oscillations, affecting the device's operational characteristics and reliability. The impact of bifurcations on the operational characteristics and stability of MEMS/NEMS resonators cannot be overstated. Understanding these nonlinear dynamics is crucial for designing robust and reliable devices. Engineers and researchers must carefully characterize the bifurcation behavior of these

systems to ensure predictable and stable operation under varying conditions. Additionally, controlling and mitigating bifurcation effects can lead to the development of innovative strategies for enhancing the performance and functionality of MEMS/NEMS resonators in various applications. Thus, comprehensive study and analysis of bifurcation phenomena are essential for advancing the field of MEMS/NEMS technology.

CHAOS

MEMS and NEMS resonators are small-scale mechanical structures used in various applications ranging from sensors and actuators to communication devices and medical instruments. These resonators exhibit fascinating behaviors when subjected to certain conditions, among which is chaos – a phenomenon characterized by unpredictable yet deterministic motion. In the context of MEMS/NEMS resonators, chaos emerges when nonlinear dynamics lead to a highly sensitive dependence on initial conditions.

1. **Understanding Chaos in MEMS/NEMS Resonators**: MEMS/NEMS resonators are typically composed of tiny mechanical structures, such as beams, cantilevers, or membranes, that vibrate at specific frequencies when subjected to an external force or voltage. In linear systems, the response of the resonator is proportional to the input signal. However, when nonlinear effects become significant, the system can exhibit chaotic behavior.
2. **Nonlinear Dynamics and Sensitivity to Initial Conditions**: Nonlinear dynamics in MEMS/NEMS resonators arise due to factors such as mechanical stiffness, damping, and electrostatic forces. These nonlinearities can cause the resonator's response to become highly sensitive to initial conditions. This means that even minute differences in the initial state of the system can lead to drastically different trajectories over time. Such sensitivity is a hallmark of chaotic systems.
3. **Characteristics of Chaotic Oscillations**: Chaotic oscillations in MEMS/NEMS resonators exhibit several distinctive features:
   - **Broadband Frequency Spectra**: Unlike regular harmonic oscillations, chaotic motion results in a frequency spectrum that spans a wide range of frequencies. This broadband spectrum is a consequence of the irregular and seemingly random motion of the resonator.
   - **Complex Attractor Geometries**: Chaotic systems often converge to a strange attractor in phase space, which has a complex and intricate geometric structure. These attractors represent the long-term behavior of the system and can exhibit self-similar patterns and fractal properties.
4. **Implications of Chaos in MEMS/NEMS Devices**:
   While chaos in MEMS/NEMS resonators can pose challenges in terms of device performance and energy dissipation, it also presents opportunities:
   - **Degradation of Device Performance**: Chaotic behavior can introduce unwanted noise and jitter, reducing the accuracy and reliability of MEMS/NEMS devices. Additionally, chaotic motion may lead to increased energy dissipation, affecting the device's power efficiency.
   - **Random Signal Generation**: The unpredictability of chaotic motion can be exploited for random signal generation, which is useful in various applications such as cryptography, random number generation, and secure communication protocols. Chaotic signals have properties of randomness that can enhance the security of communication systems.

Chaotic behavior emerges in MEMS/NEMS resonators when nonlinear dynamics result in a highly sensitive dependence on initial conditions, leading to seemingly random yet deterministic motion. Chaotic oscillations exhibit broadband frequency spectra and complex attractor geometries. While chaotic motion can degrade device performance and increase energy dissipation, it also offers opportunities for random signal generation and secure communication.

APPLICATIONS AND CHALLENGES

Signal processing using chaos in MEMS and NEMS resonators represents a fascinating intersection of engineering and theoretical physics. MEMS and NEMS devices, being extremely small and highly sensitive to environmental conditions, exhibit nonlinear dynamical behaviors that can be exploited for various applications. Here's a deeper dive into how chaos in these resonators is utilized:

1. **Chaos in MEMS/NEMS Resonators:** MEMS and NEMS resonators are tiny mechanical structures that can vibrate at specific frequencies. Due to their small size, they are subject to nonlinear effects that can lead to chaotic behavior under certain conditions. Chaos in these resonators refers to a highly sensitive dependence on initial conditions, where tiny changes can lead to vastly different outcomes over time. This chaotic behavior can be harnessed for various applications in signal processing.

2. **Chaotic Signal Processing:** Chaos in MEMS/NEMS resonators offers unique capabilities for signal processing. Traditional signal processing techniques often rely on linear systems, but chaotic systems offer advantages in terms of unpredictability and nonlinearity. Chaotic signals generated by these resonators can be used for tasks such as encryption, where the complexity of chaotic signals enhances security. Additionally, chaotic signals can be utilized in communication systems for spread-spectrum techniques, enabling robust transmission in noisy or hostile environments.

3. **Encryption:** Chaotic signals generated by MEMS/NEMS resonators can serve as a basis for encryption algorithms. The inherent unpredictability and sensitivity to initial conditions make chaotic signals suitable for generating cryptographic keys or masking data. By utilizing the chaotic behavior of resonators, encryption schemes can achieve higher levels of security compared to traditional methods.

4. **Random Number Generation:** Chaotic resonators can also be employed for random number generation. The unpredictable nature of chaotic signals ensures that the generated random numbers are truly random, which is crucial for applications such as secure communication, Monte Carlo simulations, and cryptographic protocols. MEMS/NEMS resonators offer a compact and efficient platform for generating high-quality random numbers in various systems.

5. **Broadband Spectra for Spread-Spectrum Communication and Radar Systems:** The broadband spectra produced by chaotic MEMS/NEMS resonators are valuable for spread-spectrum communication and radar systems. Spread-spectrum techniques involve spreading the signal energy across a wide frequency band, making the signal more resistant to interference and interception. Chaotic signals with broadband spectra can enhance the performance and robustness of spread-spectrum communication systems, enabling reliable data transmission in challenging environments.

FREQUENCY TUNING AND CONTROL

Frequency tuning and control utilizing nonlinear dynamics in MEMS/NEMS resonators offer a promising avenue for various applications including vibration control and energy harvesting. Nonlinear effects in these systems can be exploited to achieve frequency tuning, enhance performance, and enable novel functionalities. However, harnessing these nonlinearities poses significant challenges in device design, modeling, and control.

1. **Nonlinear Effects Exploitation**: Nonlinear effects in MEMS/NEMS resonators can arise from various sources such as mechanical nonlinearity (e.g., geometric nonlinearities, material nonlinearities), electrostatic nonlinearity, and nonlinear damping. These effects can be harnessed to achieve frequency tuning and control. For instance, by exploiting nonlinear stiffness or damping characteristics, it becomes possible to tune the resonant frequency of the device under different operating conditions.

2. **Device Design**: Designing MEMS/NEMS resonators for effective frequency tuning and control requires careful consideration of the nonlinear dynamics involved. This includes optimizing the mechanical and electrical design parameters to enhance nonlinear behavior while maintaining device performance and reliability. Design strategies may involve incorporating nonlinear elements such as nonlinear springs, nonlinear capacitors, or exploiting inherent nonlinearities in the material properties.

3. **Modeling**: Accurate modeling of nonlinear dynamics is essential for understanding the behavior of MEMS/NEMS resonators and developing effective control strategies. Traditional linear models are often inadequate for capturing the complexities of nonlinear systems. Therefore, advanced modeling techniques such as nonlinear finite element analysis (FEA), reduced-order modeling, and analytical methods like perturbation techniques are employed to accurately represent the nonlinear behavior of the devices.

4. **Control Strategies**: Control of MEMS/NEMS resonators involves mitigating the effects of nonlinearities to achieve desired performance outcomes. Various control strategies such as feedback control, adaptive control, and nonlinear control techniques like sliding mode control and feedback linearization can be employed. These

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strategies aim to stabilize the device, suppress unwanted vibrations, and optimize energy harvesting efficiency while accounting for nonlinear effects.

5. **Experimental Validation**: Experimental validation plays a crucial role in verifying the effectiveness of frequency tuning and control techniques in real-world MEMS/NEMS devices. Experimental setups allow researchers to validate theoretical models, assess the performance of control algorithms, and identify practical challenges associated with nonlinear dynamics. Advanced measurement techniques such as laser interferometry, atomic force microscopy (AFM), and scanning electron microscopy (SEM) are often used to characterize the behavior of MEMS/NEMS resonators under different operating conditions.

CONTROL AND EXPLOITATION OF NONLINEAR DYNAMICS

Nonlinear Control Techniques: In the realm of MEMS/NEMS resonators, various control strategies like feedback control and adaptive tuning are instrumental in stabilizing or manipulating their nonlinear dynamics. These techniques are designed to counteract undesirable behaviors while simultaneously improving the performance of these miniature devices. By leveraging feedback mechanisms and adaptive algorithms, engineers can effectively manage the intricate nonlinearities inherent in MEMS/NEMS resonators, ensuring their reliable operation and enhancing their functionality across a wide range of applications.

Exploitation for Sensing and Signal Processing: In certain instances, the nonlinear dynamics and chaos exhibited by MEMS/NEMS devices can be leveraged to enhance their functionality. For example, chaotic oscillations offer opportunities for random number generation, secure communication, and chaotic sensing applications. By harnessing the inherent unpredictability and complexity of chaotic systems, these devices can perform tasks such as generating cryptographic keys or extracting useful information from noisy signals, thereby expanding their utility in various sensing and signal processing applications. Resonators serve as the foundational components within numerous MEMS-based systems, offering substantial advantages across a spectrum of applications ranging from sensing to signal processing and communication [3–6]. Typically, these systems comprise a single movable electrode stimulated by DC and AC voltages applied on one or both sides. There exists an upper limit to the applied voltage, beyond which the electrostatic force fails to counterbalance the elastic restoring force in the movable electrode, resulting in instability and the collapse of the system—a phenomenon known as pull-in instability. Given its critical implications for the structural integrity of MEMS/NEMS devices, the pull-in phenomenon must be meticulously considered during their design and testing phases [7]. Nonlinearities stemming from the electrostatic force, in addition to mid-plane stretching and squeezing film damping, engender complex dynamic behaviors, including frequency response bending, jump phenomena, bi-stability, and chaotic motion.

Chaos represents a form of nonlinear motion often deemed undesirable in the dynamic behavior of many systems. Nevertheless, its utility has been demonstrated across various applications, including sensing, fluid mixtures, and secure communication [8–10]. Given the dual nature of chaos - both advantageous and detrimental - influencing the performance of micro and nano resonators, it becomes imperative to anticipate its occurrence in the systems' dynamic responses. Accordingly, numerous studies have been dedicated to exploring chaos in nano resonators, aiming to delineate its effects comprehensively. The following section presents a selection of these research endeavors. In one of the pioneering studies, Wang et al. (1998) conducted both theoretical analysis and experimental investigations into the dynamic behavior of a bistable MEMS resonator. Their work conclusively demonstrated the presence of a strange attractor and chaos within MEMS devices [11]. Similarly, DeMartini et al. employed a variant of the Mathieu equation to characterize the governing equation of motion for MEMS oscillators. Utilizing the renowned Melnikov's method, they derived an inequality that delineates the parameter space where chaos manifests. Their study further corroborated these findings through experimental evidence, confirming the chaotic behavior exhibited by MEMS oscillators [12]. Haghighi and Markazi similarly employed the Melnikov method to predict chaos in resonators, subsequently implementing a robust adaptive fuzzy control algorithm to manage the chaotic motion effectively [13]. The study referenced as [14] delved into bifurcation and chaos within micromechanical resonators, incorporating additional nonlinear terms into their analysis. Employing the Melnikov method, they delineated the region of homoclinic and heteroclinic chaos within the system. Zhang et al. comprehensively explore the nonlinear

dynamics and chaotic behavior of resonators subjected to random excitation, employing both analytical and numerical techniques [15]. Through the random Melnikov approach, they identify the fundamental conditions necessary for chaos to manifest within stochastic systems. Meanwhile, Aghababa's study [16] focuses on examining the presence of chaos within a non-autonomous fractional-order micro-electro-mechanical resonator system, employing the maximal Lyapunov exponent criterion for analysis. Li et al. [17] provided a rigorous analytical demonstration regarding the presence of chaos within a generalized Duffing-type oscillator featuring fractional order deflection. They derived an analytical formula delineating the two homoclinic orbits and employed Melnikov's technique to establish criteria for the transversal intersection of stable and unstable manifolds. Despite significant strides in understanding the chaos region within micro-electro-mechanical resonators, challenges persist. As previously noted, most prior research has relied on the Melnikov method for chaos prediction, which offers a necessary but not sufficient condition for chaos. As elucidated in this paper, chaotic motion often occurs at large excitation amplitudes, whereas the conservative Melnikov criteria advocate for very small excitation amplitudes to avoid chaotic behavior. This inherent limitation underscores the need for further investigations into the nonlinear dynamics of micro and nano resonators, aiming to develop a more precise method for predicting chaos within these systems.

CONCLUSION

The exploration of chaos within micro-electro-mechanical (MEMS) and nano-electro-mechanical (NEMS) resonators represents a significant area of research with both challenges and opportunities. These resonators, vital components in various technological applications, exhibit complex dynamics that can lead to chaotic behavior under certain conditions. Understanding and harnessing chaos in MEMS/NEMS resonators have profound implications for device design, performance optimization, and innovative applications. Numerous studies have delved into the dynamics of MEMS/NEMS resonators, revealing the presence of chaos and its underlying mechanisms. From theoretical analyses to experimental validations, researchers have made strides in characterizing chaotic behavior and exploring its effects on device performance. Studies employing techniques like the Melnikov method have provided valuable insights into the conditions under which chaos manifests in resonators, paving the way for further exploration and control strategies. Despite these advancements, challenges persist in accurately predicting and controlling chaos within MEMS/NEMS resonators. Existing methods, while informative, may not fully capture the intricate dynamics of these systems under realistic operating conditions. As such, there is a need for more sophisticated theoretical frameworks and experimental approaches to elucidate the complexities of chaotic motion in resonators. Additionally, the presence of chaos presents both challenges and opportunities in the design and operation of MEMS/NEMS devices. While chaotic behavior can degrade device performance and increase energy dissipation, it also offers opportunities for random signal generation, secure communication, and novel signal processing techniques. By leveraging the inherent nonlinearities in resonators, engineers can explore new avenues for enhancing device functionality and enabling innovative applications. Moving forward, continued research into chaos in MEMS/NEMS resonators is essential for advancing the field and unlocking the full potential of these miniature devices. By addressing the challenges and harnessing the opportunities presented by chaos, researchers can pave the way for the development of next-generation MEMS/NEMS technology with enhanced performance, reliability, and functionality.

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RESEARCH ARTICLE

Economic Management Perspectives of E-Commerce - A Theoretic Approach

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ABSTRACT

Electronic commerce is a strategic approach that uses computer networks to enhance organizational performance, leading to improvements in customer service, increased profitability, market share, and faster product delivery. It covers every aspect of an entity's electronic correspondence with interested parties, including clients, vendors, government authorities, financial institutions, managers, employees, and members of the public. To succeed in the digital economy, organizations must consider the likelihood of internet usage among current or prospective customers and the cost of searching for goods or services. The digitization of trade and public services has made it possible to gain more correlations and information from data than ever before. This data serves as the foundation for new services, corporate strategies, and value creation. The role of platforms in e-commerce is crucial, with Amazon and Alibaba holding significant market shares. Platforms lower transaction costs for customers and make market information more accessible, helping micro, small, and medium-sized businesses (MSMEs) access the global market. However, many MSMEs struggle to use these platforms due to their large data collection capacity. User data is the primary economic resource in the Internet platform business model, which is gathered, processed, and made profitable through marketing and advertising. The European Union has passed laws aimed at levelling the playing field for big and small platforms participating in the digital economy and promoting competition. With a global market value of US$6.3 trillion, e-commerce is a major force behind economic expansion.

Keywords: E-Commerce, Global Market, E-Market Aggregators, digital revolution, Artificial Intelligence (AI)

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INTRODUCTION

Electronic commerce is revolutionising business operations. If organisations want to capitalise on new developments in Internet technology, they need to take a strategic approach. Stated differently, it is imperative to guarantee that both corporation strategy and electronic commerce strategy are closely aligned. Using computer networks to enhance organisational performance is known as electronic commerce. Electronic commerce can lead to improvements in customer service, increased profitability, increased market share, and faster product delivery, among other aspects of organisational performance. There is more to electronic commerce than just placing an online catalogue order. It covers every facet of an organization's electronic contacts with its stakeholders—the persons who influence decisions about the organization's future. Consequently, the development of an investor relations Web page or electronic correspondence with college-age job candidates are considered forms of electronic commerce. To put it plainly, electronic commerce is the application of information technology to improve interactions and exchanges among all stakeholders involved in an organisation. The public, management, employees, government regulators, financial institutions, suppliers, and customers are examples of these stakeholders.

Who is the right user of the Internet?

Every organisation should think about whether and to what degree it should be involved in the Internet community, as well as whether it should have a presence there. When responding to these inquiries, two important criteria need to be taken into account. First, what is the likelihood of Internet usage among current or prospective customers? An organisation should have a presence if a sizable fraction of its clientele uses the Internet and the cost of searching for the good or service is reasonably (even modestly) high. If not, it is losing out on a chance to communicate with and educate its audience. For many consumers, the Internet is a kind and incredibly practical source of knowledge. A business that lacks a website runs the risk of losing out to web-savvy competitors who already have a presence online.

Trade and the data economy going digital

Two parallel developments—the quickening pace of digitization, or the conversion of analogue data to digital form, and the "digital transformation" of societies, or the digitization of trade and public services—made feasible the digital economy. More correlations and information may be gleaned from data than ever before thanks to the simultaneous development in computer processing capacity. Data serves as the foundation for new services, corporate strategies, and value creation The process of digitization causes previously physical products—like books, movies, video games, and recorded music—to become less tangible. Additionally, data flows support and enable all other forms of traditional cross-border flow: customers are increasingly placing orders and making payments online, even when ships are transporting physical goods. The nature of global trade has also changed as a result of data flows. Nowadays, it's thought to be viable to trade services like healthcare and education that were formerly nearly difficult to give internationally. Simultaneously, there is an expanding trend of "servicification" in international trade, which is essentially the growing integration of services and goods. Services are becoming more and more integrated into manufactured items, and manufacturing organisations are buying, producing, and selling services to go along with their goods. Services that are offered to customers in conjunction with products, like applications that go along with exercise equipment and health trackers, are an example of servicification. As of right now, China leads the world's e-commerce sales rankings, with the US, UK, and Japan following closely behind.

The role of platforms in e-commerce

Digital platforms are the most obvious interfaces that link people to global flows. The two biggest online retailers in the world, Amazon and Alibaba, continue to hold sizable market shares. Platforms lower transaction costs for customers and make market information more accessible. They can also help micro, small, and medium-sized businesses (MSMEs) get access to the global market, which would democratise e-commerce. However, a lot of MSMEs have trouble using these platforms. MSMEs may find it challenging to compete with the platforms' own offerings, particularly if they gather a lot of data that can be turned into market intelligence. User data is the primary

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economic resource in the Internet platform business model; it is gathered, processed, and made profitable through marketing and advertising. Users share their "electronic footprint" when engaging and conducting information searches on the Internet. Internet businesses gather and examine this data in order to derive specifics about the habits and preferences of their users. Online retailers have a great degree of assurance about the purchases and actions of users who fit a particular profile. A number of nations and areas have passed laws aimed at levelling the playing field for big and small platforms participating in the digital economy and promoting competition. The EU's 2000 e-commerce directive was modernised in Europe with the Digital Services Act (DSA). It encompasses a broader spectrum of internet services, such as social networking platforms, online retailers, and other online service providers. The DSA seeks to level the playing field for businesses and safeguard users' fundamental rights. The European Union's Digital Markets Act (DMA) is an addition to the competition legislation in Europe. It controls the operations of "gatekeepers," or sizable online platforms that offer essential platform functions including messaging apps, app marketplaces, and internet search engines. Collectively, these standards seek to guarantee openness, improved consumer safety, distinct accountability, liability guidelines, and increased market participant rivalry. It is expected that a unified set of legislation spanning the entire EU would facilitate the growth of cross-border digital trade. Approximately 57% of internet users worldwide make at least one online purchase each week. Have you recently bought any digital goods like films, software, or e-books? or purchased tickets online? Did you place an online order and make a payment for a tangible item, like clothes? Have you placed an online order for a physical book and paid with cash when it arrived? These instances are all under the category of e-commerce. Approximately 2.64 billion people, or one-third of the world's population, made online purchases in 2023. With a global market value of US$6.3 trillion, e-commerce is a major force behind economic expansion. Examining e-commerce perspectives and its economic management to achieve economic growth is the goal of the current study.

LITERATURE SURVEY

Severin Borenstein and Garth Saloner (2001) opined Economics and Electronic Commerce. Electronic commerce will eventually just be commerce, of course. It will form an additional component of the vital infrastructure that business depends on, alongside other technologies like telephone communication, railway shipping, electrification of production processes, and others. But in the process, e-commerce will fundamentally alter businesses' capacity to generate and seize value and will cause a reorganisation of numerous markets, much as earlier technological revolutions had an effect on economic growth. Liu (2002) examined Privacy Policies in Fortune 500 Web Sites. Although concerns about the privacy of personal information have been for a while, the advent of e-commerce and its related technologies has renewed these issues. The Fortune 500 is a symbol of conventional leadership in business and technology applications. This initial analysis of Fortune 500 websites reveals that slightly over 50% of Fortune 500 websites have privacy policies available on their main page. It is less frequent to find comprehensive privacy rules that cover every privacy component recommended by the FTC. Zwass and Vladimir(2003) studied Electronic Commerce and Organizational Innovation: Aspects and Opportunities. In the last 10 years, electronic commerce built on the Web-Internet compound's technological underpinnings has spread into a wide range of organisational and social domains. To be completely understood and utilised, this widespread organisational and technological progress needs to be categorised. Five categories are used to categorise the main components of e-commerce: connection, computation, communication, cooperation, and commerce. These factors give rise to particular chances for innovation that can be used to address and organise markets, provide novel products, work with business partners, change corporate procedures, and plan the provision of information-system services. The end product is a thorough framework for understanding e-commerce as a technologically driven approach to corporate transformation and as a multidisciplinary area of study. Pujani V (2011) studied Use of Ecommerce Websites in Developing Countries. This study aims to investigate how Indonesia, a developing nation, uses e-commerce websites. It has been determined that e-commerce websites significantly influence corporate operations, especially when it comes to resolving geographical issues for islanded nations like Indonesia. One more time, the importance of websites as marketing tools is noted. The impact of features and quality on customer happiness and usage of e-commerce websites is examined in this study. A survey approach was used with 115 undergraduate Management Department students at Andalas

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University who were enrolled in the Management Information Systems (SIM) course. The Smart PLS programme is used to analyse the data using structural equation modelling, or SEM. This result showed that feature satisfaction, system and information quality, and system quality all have an impact on how e-commerce websites are used in Indonesian contexts. Vera et al (2011) studied Student Perspectives Toward the Quality of E-Commerce Website. Using electronic commerce, the way that businesses use the internet has rapidly transformed (E-commerce). A website that is present may execute online transactions in e-commerce. The The current study aims to investigate the effects of the quality aspect on e-commerce website usage. Based on student viewpoints that are researched, the system, information, and service are included as quality aspects in the uses of e-commerce websites. The-155 Students enrolling in the Management Department of Economics Faculty at Andalas University's MIS course are encouraged to participate as research participants. The data will be analysed using SmartPLS (Partial Least Square) software and structural equation modelling, or SEM. The study's findings indicated that the only factor significantly influencing the adoption of e-commerce websites was service quality. System and information quality had not had a substantial impact in the interim. As a result, this study provides a straightforward example of how e-commerce websites are used, showing how users are more concerned with service quality than with information and system quality. As a result, businesses ought to concentrate on the services they offer through their websites.

Lee et al (2011) studied the Framework for User Perception of Effective E-Tail Web Sites. The creation of an experimentally validated framework for users' perceptions of successful websites for retail e-commerce (E-tail) is presented in this study. Specifically, we tried to address the following primary study questions: Which are the main designs influencing the effectiveness of e-tail websites? In what ways do these designs aid the goals that people have when utilising the Web? We suggested that "effective designs for E-tail Web sites should support Web customers for their (a) information search, (b) pleasure, and (c) business transactions" based on the idea of "fitness for use" and the reasons why consumers use the Internet. Subsequently, 427 prospective Web consumers' survey responses were gathered. To improve the suggested framework and give the framework's constructs structure for further confirmatory analysis validation, an exploratory analysis was carried out. The findings indicate that 16 elements are key to determining the effectiveness of e-tail websites, and 64 web designs support the three main reasons why clients utilise the Internet. Albar et al (2013) examined A Prototype E-Commerce Website for SMEs in West Sumatera, Indonesia. One of the e-commerce technology applications that businesses use is the widespread usage of the internet for e-commerce activities since websites need to function. The remarkable advancements in internet and website technologies have demonstrated a noteworthy impact on businesses. Thus, in order to advance their company's operations and meet their goals, businessmen need also think about using technology. As a result, using a website for commercial purposes is becoming a more reliable marketing tool and a fresh way to advertise goods and services. By no means has Indonesian internet and website usage developed well yet. The reasons for this include the absence of infrastructure, a lack of knowledgeable human resources in the field of information technology (IT), the involvement of financial institutions, and the users' varying educational backgrounds.

In fact, technology will play a big enough role in the future development of small businesses. Putri et al (2019) studied the impact on Shopee customer loyalty in Padang City of perceived value, information quality, system quality, and e-service quality. Electronic commerce, or e-commerce, has expanded rapidly in Indonesia in recent years in an effort to broaden the audience for marketing and boost its efficacy and efficiency. This study aims to explore the relationship between perceived value to online loyalty and system, information, and e-service quality and how it affects Padang City Shopee customers. This study offers explanations through a quantitative method. 250 Shopee users who had made more than two purchases on the platform provided the data. The SEM-PLS with smart PLS 3 programme is used in this study. The findings indicate that online loyalty was positively and significantly influenced by perceived value, information quality, system quality, and e-service quality. Consequently, this study offers a summary of customers of e-commerce websites who are more concerned with website quality; as a result, businesses should concentrate on raising the calibre of e-commerce website design. Adel.A.Alyoubi (2015) examined Modern E-commerce Systems in Developing Countries. Rapid Internet growth gave rise to the concept and use of electronic commerce, or e-commerce, which is currently commonplace globally. The new commercial reality is that businesses and individuals operate through internet-based economic structures and information groupsenjoy buying

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goods and services abroad. Due to several barriers to e-commerce, most underdeveloped countries do not experience this. According to the study, the primary criticism of liberal markets and free trade is that they increase the gap between rich and poor countries. The rise of the Internet economy, which has brought to light the stark contrasts between nations with abundant and inadequate knowledge, has reinforced this criticism. Developing nations must create national e-commerce development strategies and regulations that are specific to their resources and circumstances since e-commerce has the ability to close the gap and offer them the opportunity to attain economic equality. Developing nations will become fierce e-commerce rivals thanks to this, as well as investments in telecommunications infrastructure, a supportive legal and regulatory environment, sensible institutional changes, and human resource development and education. Kurniawati et al. (2020) looked into e-commerce potential in the 4.0 era of Innovative Entrepreneurship Management Development. E-commerce is used by MSMEs in East Java. It is employed to seize opportunities for developing innovative entrepreneurial management. In the 4.0 era, innovation is essential to the survival of businesses, especially MSMEs. Utilising opportunities and innovations is essential to creating new products that guarantee the survival of MSMEs. It assessed how e-commerce prospects were perceived in terms of their ability to affect customer satisfaction and trust, deliver the best possible customer service, meet customer expectations, and pose hazards to MSMEs. In this work, a survey method was combined with a quantitative descriptive methodology. Pearson Correlation Product Moment analysis was used to examine the information acquired from surveys and interviews. The poll found that e-commerce has the potential to improve customer satisfaction and trust in transaction execution, provide the best service, meet customer expectations, and not pose a threat to MSMEs. The research findings indicate that e-commerce presents several opportunities for influencing consumer satisfaction and trust, offering the best customer service, meeting customer expectations, and not posing a threat to small and medium-sized enterprises (MSMEs).

In their 2021 study, Jong Woo Kang et al. assessed how technology adoption affected online B2C sales. The scenario for business-to-consumer (B2C) online commerce is evolving quickly because to technological advancements. Its spread is still concentrated in major, developed economies, though, and it is creating a digital divide that hurts low-income and small- and medium-sized businesses. The pandemic of the coronavirus disease (COVID-19) demonstrated the urgent necessity to bridge gaps within and between nations. This study produces important insights for businesses and policy makers and shows that financial inclusion, internet security, and internet access and speed all encourage online retail purchases. Governments must to consider them as significant obstacles in creating a supportive atmosphere that will help B2C e-commerce adapt to the post-COVID-19 world and guarantee that innovations present chances for everybody. According to this report, the extraordinary growth of m-commerce in Asia and the Pacific in recent years can be attributed to a number of factors, including financial inclusion, online security, and internet availability via fixed broadband connections and mobile broadband subscriptions. Additionally, as a result of the epidemic, more individuals are shopping for food, other needs, and other products using their smartphones. Even without significant government investment in telecommunications infrastructure, the emergence of wireless technologies, such as mobile phones, has resulted in an unprecedented boom in access to telecommunication services throughout Asia over the past 20 years or so. Disadvantaged populations, including rural residents with poor incomes and low literacy rates, can now take advantage of the mobility, simplicity of use, and comparatively low and declining costs of mobile phones. This emphasises how important it is for people on a tight budget to be able to take use of the advantages of B2C online commerce using reasonably priced wireless mobility devices and internet technology. It is expected that one long-term effect of the COVID-19 pandemic will be the pervasiveness of business-to-consumer (B2C) online shopping in all spheres of the economy and society. B2C online sales will have to keep changing to keep up with the challenges of the new normal. This study provides empirical support for the notion that factors related to financial inclusion and technology adoption are important for facilitating B2C online transaction. Then, in order to develop policies and legal frameworks that enable business-to-consumer (B2C) internet commerce, governments should take these important issues into consideration. This will help the industry adapt to the post-COVID-19 environment and make sure that it creates possibilities for everyone.

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Payal Goyal and colleagues (2022) investigated the Emerging Trends of E-Commerce from a Developing Country Perspective. As a result of the exposure of internet technologies like social media and e-commerce, many countries have become part of one massive economy in the age of globalisation, which is currently changing the structure of the world economy. All businesses have evolved into information-based operations, and significant advances in science and technology are signalling a shift in the nature of trade. At the same time, modern electronic commerce is causing massive economic disruptions that are impacting every area of the economy. When viewed globally, commerce, finance, and marketing are among the most significant occupations in the global marketplace. For this reason, the impact of e-commerce has been observed in the contemporary corporate environment. E-commerce, or electronic commercial transactions, is a relatively new concept that has the potential to upend traditional business practices and has already had a significant impact on major industries like banking and communications. Since it offers a broader viewpoint for getting to know and understand customers, electronic commerce is crucial in expanding the intersections of business and electronic commerce that bring in a new era of marketing. In the end, it transforms marketing and commerce by expanding the market to include both domestic and international markets. The study came to the conclusion that while e-commerce has improved the nation's economic standing and given SMEs services the opportunity to transact with overseas or international customers more directly, these benefits for developing countries are also accompanied by a number of challenges in the global market due to inaccurate information, outdated technology, social and cultural norms and regulations, and international laws and regulations.

Objectives
1.   The study is meant to explore the theoretic perspectives of E-Commerce Management;
2.   To ascertain the Economic management of perspectives of E-Commerce in digital era;
3.   To offer Suggestions.

Limitations
The study is theoretic and offer scope for further empirical research in the economic management of E-Commerce.

Perspectives evolved over a period of time in E-Commerce in the digital era
From a number of angles, e-commerce has significantly impacted economic management. Here are some important things to think about: E-commerce has improved economic management efficiency by optimising procedures including distribution, sales, and marketing. Companies that use online platforms instead of traditional brick-and-mortar storefronts can reach a larger audience for less money. Increased productivity, lower costs, and better profit margins are the results of this efficiency. It enables companies to reach customers across borders and enter foreign markets. By raising sales volumes and broadening the sources of income, this development can accelerate economic growth. Additionally, it gives small companies the chance to compete globally, promoting economic growth. The following diagram gives a glimpse of the process of Economic management of E-Commerce Technology.

The other Supportive Perspectives of E-Commerce Technology
1.   **Data analytics:** E-commerce generates large amounts of data that can be utilised to guide decisions about economic management. By evaluating sales patterns, market trends, and consumer behaviour to maximise their strategies, businesses can enhance their profits. Data-driven insights provide better resource allocation, inventory control, and forecasting.
2.   **Employment Creation:** Although automation in e-commerce may result in employment losses in some industries, it also opens up new career paths in customer service, digital marketing, e-commerce development, and logistics. In order to satisfy the needs of the digital economy and facilitate a seamless transition to new job responsibilities, economic management must prioritise upskilling the workforce.
3.   **Regulatory Challenges:** Taxation, consumer protection, and data privacy are some of the regulatory issues that e-commerce raises for economic management. Governments have to find a balance between encouraging innovation and safeguarding companies and customers. A fair playing field for all market players and the maintenance of confidence in the e-commerce ecosystem can be achieved through effective regulation.

4. **Supply Chain Optimisation**: Dropshipping, just-in-time inventory, and agile logistics are just a few of the ideas that e-commerce has brought to the forefront of supply chain management. These developments shorten lead times, increase product delivery efficiency, and save storage expenses. Supply chain optimisation should be the main goal of economic management in order to satisfy changing e-commerce consumer demands.

5. **SME Empowerment:** Small and medium-sized businesses (SMEs) may now compete with larger firms globally thanks to e-commerce. SMEs should be assisted by economic management in implementing e-commerce technology, obtaining funding, and developing their digital capacities. SMEs that are empowered experience increased entrepreneurship, innovation, and economic diversification.

6. **Market Disruption:** By permitting online marketplaces, peer-to-peer transactions, and direct-to-consumer sales, e-commerce upends conventional market dynamics. In order to respond to these disruptions, economic management must promote competition, stimulate innovation, and safeguard the interests of consumers. Reacting proactively and anticipating changes in the market are essential for long-term economic prosperity.

7. **Customer Experience:** Through individualised marketing, smooth transactions, and effective customer support, e-commerce places a high priority on the customer experience. These customer-focused tactics can be used by economic management to boost repeat business, foster brand loyalty, and raise customer lifetime value. In order to maintain long-term growth and profitability, firms should prioritise customer pleasure.

8. **Digital Payments:** To ensure safe and effective transactions, e-commerce depends on digital payment systems. To assist the expansion of e-commerce, economic management should encourage the use of mobile wallets, cryptocurrency possibilities, and secure and dependable payment channels. Promoting digital payments increases financial inclusion, boosts economic activity, and lessens the need for cash transactions.

AI and E-Commerce

Artificial Intelligence is transforming e-business operations. Artificial Intelligence (AI) has three primary applications in the e-commerce sector: transaction processing, marketing, and customer service. It might also help merchants predict demand and manage inventory.

AI's potential in online shopping

Artificial Intelligence holds great promise for internet-based businesses. Businesses can now customise advertising to customers' preferences by using algorithms, which are already widely used to analyse client behaviour. AI is also capable of projecting demand, which helps businesses better understand what things to supply and when. It can even generate product recommendations by evaluating the buying patterns of particular customers. This could help improve logistics' sustainability. Through price maximisation (automated dynamic pricing), which enables sellers to adjust in real-time to market trends, rival pricing, and consumer behaviour, AI may potentially help retailers increase their profitability. They can also help with fraud detection, payment optimisation, and invoicing. Digital assistants negotiate with customers one-on-one and frequently help transactions end successfully while offering continuous customer care to online shoppers. Natural language processing (NLP) makes it easier to interact with clients by interpreting and responding to voice. AI may also have an effect on customer service, relationship building andmaintenance, and customer redress in the event of a dispute. AI assistance is a useful tool for addressing customer problems since it is reliable, has no learning curve, and is consistent. Furthermore, AI can assess vast amounts of complaints, which helps businesses better allocate resources and detect and address issues before they become more serious.

AI dangers that could affect online sales

Larger e-commerce companies with the financial means to invest in cutting-edge AI capabilities benefit from the competitive advantage that AI technology offers. This could result in even more market concentration, which would hinder the ability of smaller companies to compete and possibly limit consumer choice. AI technology implementation and upkeep can be expensive, requiring large infrastructure investments, access to high-quality data, hiring qualified personnel, and ongoing research. There could be a barrier to entry or growth in the industry if smaller companies or startups with limited funding are unable to compete with larger organisations that can afford

significant expenditures in AI. A growing percentage of businesses are rejecting to transition to human contact in favour of AI-only customer support. This is a bad trend that could result in poor customer experiences and service denials if the automated assistant is unable to adequately solve a customer's issue.

CONCLUSION

E-commerce has changed economic management in a number of ways, from increasing productivity and reach internationally to stimulating employment growth and market disruption. Economic managers must embrace digital transformation, deal with regulatory issues, optimise supply chains, empower SMEs, react to market upheavals, give priority to the customer experience, and encourage digital payments if they are to fully realise the potential of e-commerce. In the digital age, economic management can promote sustainable economic growth by taking a comprehensive strategy to e-commerce. On the other hand, one of the main concerns is data security. AI systems depend significantly on customer data, which is vulnerable to security lapses and illegal access. Furthermore, biases in AI decision-making processes that result from flawed algorithms or biassed training data can have negative effects. Moreover, the potential for cyber security risks poses a huge issue since malevolent actors may use AI system weaknesses to launch cyberattacks that mighthave catastrophic effects on companies.

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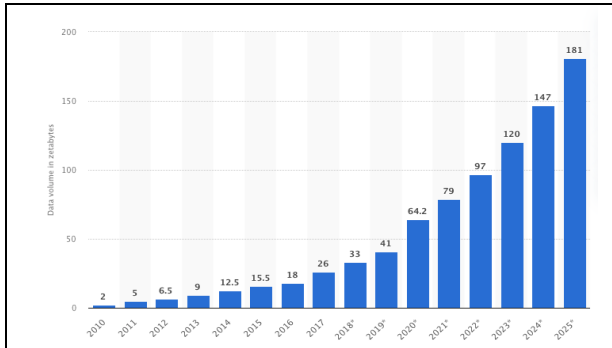
| **Fig: 1 Trade and the data economy going digital** Source: Volume of information generated, recorded, duplicated, and used globally between 2010 and 2025. As of 2022, Statista. | Fig 2: **Trade and the data economy going digital** source: Hinrich Foundation, 2024. |
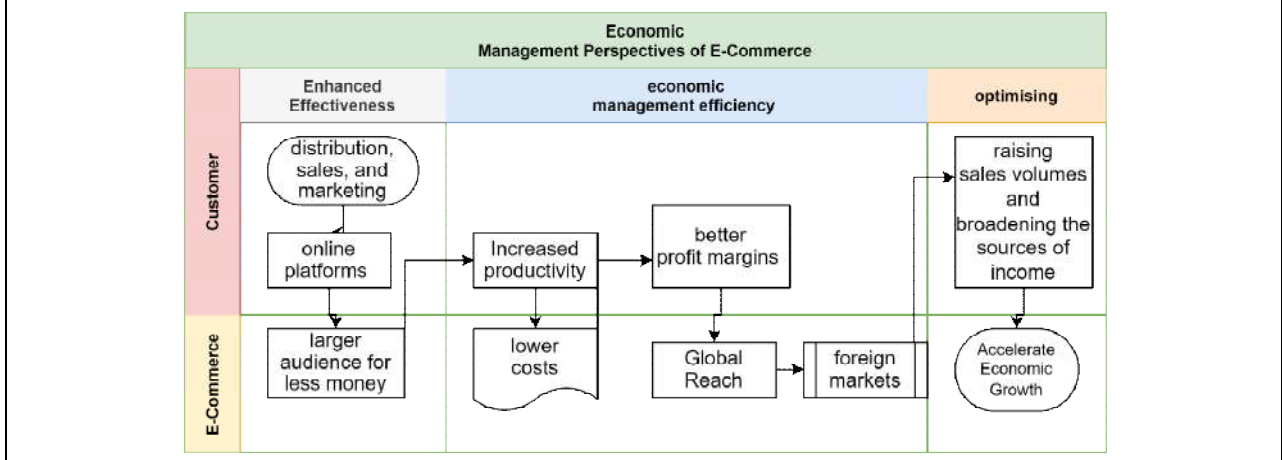
Fig 3: Perspectives evolved over a period of time in E-Commerce in the digital era

RESEARCH ARTICLE

Psychological Thoughts of 'New Woman' and Her Appearance in Shobha De's Select Novels

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ABSTRACT

The stretch 'New Woman' grew to signify the female's awakening towards comprehension of her dwelling and position in personal and social scene. Trendy Indian English language fabrication, womenfolk authors take mightily stated their objection in contrast to the male- controlled supremacy. Shobha Dee, a personality fashionable the monarchy of current side nonfiction fashionable Republic of India transcribes since a fixed womanlike view. She stays the unsurpassed vendor author besides a permanent playwright designed for more than a few correspondents in addition slicks. Moved done a certain innermost pressure to be discrete in her private precise, this original female takes stood tiresome nearby believer adult female true, position and influence by equivalence through males on the lands of 'equality of sexes.' In place of a writer, she stays ornamented thru unusual capacity near confer searching parts of anthropoid lifespan. Her all of it have a faithful dash and complex application. She debates transparently the snags, requests and objectives of women, expressly the built-up leader's importance in universal gender consciousness, self-definition, reality besides purpose. Shobha Dee partakes tolerant besides developed the gathering of Indian English illusory ecosphere through her excessive the lot. Her mélange of refrains, change of typescripts, distressingly appealing views, all are compellingly plus colourfully uttered in a lewd panache. This newspaper efforts to schoolwork the campaigner posture of Shobha Dee as it appears since her fabrication.

Keywords: Biosphere, Psychology, Sexuality, Stress, Uninhibited Behaviour.

INTRODUCTION

The 'New Woman' characteristically ethics self-fulfilment and individuality slightly than the stereotypically womanly idyllic of altruïsm; trusts in permissible and sensual parity; frequently leftovers solitary since of the struggle of uniting such parity through wedding; is additional uncluttered around her gender than the 'Old Woman'; is knowledgeable besides delivers an inordinate contract; has an occupation; is fit or then bodily energetic and, consequently, favours contented garments (sometimes male attire) to outdated female clothing. Repudiation besides rebuffing the ancient habits of parts achieved by the women, these females complete contemporary selections in command to fast their independence besides eccentricity. This new-fangled female needed a treat to like superior liberty to pursuit then achieves community characters in addition uniform exhibit her "sex appeal". While the exists of greatest nineteenth-century women - particularly bourgeois females nonetheless too national domestics and strives - inclined to rotate about homebased life, contemporary females offered hooked on jobs, politics, and ethos outdoor the national kingdom. The idea of "new woman" that primary arisen in the late-night nineteenth period container be occupied as an iconic alteration in gender standards. She challenged then ostracized the conventional gender characters allocated to her in addition consequently saw with aggression since menfolk and womenfolk who contrasting to the community company of females then offered this an aim for the decay in ethics. Pardon remained "new" around females in the initial twentieth century? The greatest protuberant alteration remained their amplified attendance in the community arena. This copy of novel lady discovers look in Indian English language works also, anywhere she brands her arrival in skin in addition gore in the stories of the females' authors majorly.

Numerous Indian females' writers consume travelled feminine bias in instruction to found an individuality that is not compulsory by male-controlled civilization. But the initial lenient speeches of complaint slowly twisted into a clear irritation and lastly removed the figure of an exposed revolt. After this opinion of sight, Shobha Dee, a commended activist author has tried to go this design advantage unhappy finished her the whole thing. They consume focused on ladies' glitches in their effort and are stating themselves easily and confidently and on diversity of melodies from a female judgement. These females' writers consume certainly dared the masculine ethos that triumphs in our republic. She trusts in honesty and sincerity in the tale of events. She knows the soul of a lady and masterfully grips it. Amongst the females' authors, Kamala Markandaya, Anita Desai, Shashi Deshpande, Ruth Prawer Jhabvala, Nayantara Sehgal, Namita Gokhale, Shobha Dee and Arundhati Roy are leading in the arena. She thus limits her narratives to the rich civilization and distillates on ladies' glitches and stretches a new method to them. In 1989, she inscribed her primary original 'Jetsetter Twilights'. Her additional the whole thing comprise "*Starry Nights', 'Sisters', 'Sultry Days', 'Strange Obsession', 'Snapshots', 'Second Thoughts', Uncertain Liaisons', 'Shooting from the Hip', 'Small Betrayals', 'Surviving Men', 'Selective Memory: Stories from my Life', 'Speed Post', 'Spouse', 'Superstar India: From Incredible to Unstoppable', 'Sandhya's Secret', 'Shobhaa at Sixty', 'Sethji', 'Shobhaa: Never a Dull De', 'Seventy and to Hell with It' and 'Lockdown Liaisons*". Shobha Dee figures her females in the again evolved compound number of current lady who, likes bodily autonomy, sex plus endurance, who cannister luckily syndicate desire, job and marriage. She does not have faith in recitation her women typoscripts as love-strivers or bitches or mere spouses at home. In her narratives she seemingly glasses her own activist and sexist attitude.

The performance of contemporary, ironic, cultured and self-confident women in De's fiction scripts an alteration from old-style ladies' snags. Their difficulties and anxieties remain dissimilar from persons of the commonplace, old-style, bourgeois women. Existence cultivated and rich, they have a relaxed admission to novel habits of life notifying women's individuality. Maximum of the womenfolk typoscripts portrayed by Shobha Dee, are mindful of their self-esteem since they are capable specialists employed bear to berm with their manly complements. From this viewpoint, the women in her the whole thing are extra commanding than men. Females are fundamentally signified sexually unconventional and unrestricted thoughtful and have develop known as the "New Women", in later 20th period fiction. This article is an effort to work activist carriage from dissimilar approaches of an adult female life: Wedding and Household, Man-Woman Affiliation and Performance of Womanly Sexuality as showed in De's fiction.

Sapna

IMAGINED BIOSPHERE

These womenfolk fit to from top to bottom humanity biosphere of lavishness, amorousness and theatre. Touching in the creation of autonomy and imaginary magnificence these women principal thin, fake life absent dash with exacting actualities of dull lifecycle. These womenfolk aim aimed at relaxed, well-appointed, care-free lifetime. They always meander in exploration of original knowledges and desire. The imagined biosphere of Shobha Dee is congested with females who lodge the dominant residence in all her stories. In her illusory biosphere females do not appear to participate slightly societal responsibilities or devastating manly ascendency that may confine their crusade or switch their common flexibility. These women's new found self-determination matures in them an odd boldness near wedding and family. Apart from freethinking contemporary females there are imposing aptitude cognizant 'corporate women'. As an alternative of actuality obedient and passive women in Dee's illusory ecosphere are self-confident and have faith in private accomplishment. They have critical occupational sense. Their difficult inspiring natures have an overwhelming impression on their male complements. A dump into diverse viewpoints as portrayed in Dee's imaginary creation will give us an interpretation of the culture developing in fresh eras. In malice of their mistreatment at the pointers of males these womenfolk make panicky pains to obtain a regulatory location in humanity. They bear a grudge and trial their edge space.

MARRIAGE AND FAMILY

Rigveda expresses of wedding as an amalgamation of two individuals of complete growth. The words jaya, jani and patni designate the well-thought-of place of womenfolk in the domestic. It is experimental, "jaya has the distinct intelligence of the partaker of the spouse's fondness and jani the mother of children and patni the partner in the recitals of sacrifices." With stretch, the copy of ladies kept altering and so her place in the family. From having highest place in the domestic of her spouse to achieving a secondary position, her status has abridged to an object of desire and ownership. But the 'New Woman' speeches a note of disagreement to this and bear a grudge to be quiet underneath the cruel boundaries. The women authors who once showcased female characters as silent-sufferer, ratifying various roles of a mother, a wife, a daughter and a sister—a part in the personal engine but never as a specific requesting her lifecycle to be her own have busy an intermediate try. In Dee's imaginary ecosphere the organization of wedding attitudes uncovered with all the emptiness besides insincerity loitering late it. Bridal is no lengthier careful a blessed pledge between two personalities that transports concord and agreement in separate as fit as community life. As a substitute of being a basis of serious harmony it converts a fight connecting families of control. As all the associations in the modern ecosphere of cash and resistor have been marketed, the organization of marriage also gets unfair by these reflections. These authors have revealed an estimable sympathetic of the difficulties and the quandaries of the females.

They slightly give opinion of the culture developing in current periods, with a transformed insight of separate behaviour and the communal organizations like wedding and domestic. In Religious, for instance, Mikky needs to wed Navin not out of need nonetheless as of his existence of use in greedy thoughts. She favours him as she thinks, "He may help me with Hiralal Industries" (p.62). Similarly, Binny Malhotra entraps Mikky in marriage to increase resistor over her wealth. The following words of Shobha De about human relations smear to nuptial as well, "Ultimately every association is an influence fight either on an overt or subliminal level". A predominantly hardheaded also worldly attitude towards marriage makes it dry, sterile and unattractive. In Dee's novels, Anjali and Karuna in *Socialite Evenings*, Aasha Rani in *Starry Nights*, Aparna, Surekha and Rashmi in *Snapshots,* Mikky in *Sisters* and Maya in *Second Thoughts* knowledge futility and sterility in their married life. The charm lessness and lack of demonstrative empathetic in nuptial, as portrayed in Dee's novels, cracks wedding into a societal agreement. In this world of private achievement and self-centred causes wedded fidelity, love for each other and expressive attachment have no expressive place at all. R.S.Pathak aptly remarks on the insolence of the unlike types towards nuptial in Dee's fabrication, "Marriage to them is barely more than a suitable contract to lead a contented in addition unrestrained life, which can be concluded at any time contingent upon the notions of the partners". Personal accomplishments and moral values have no consideration for such women. To these females, having sexual relationships with their husband seems 'boring' and sounds terrible, "Like eating dal-chaval day in and day out" (Snapshots p.152). These womenfolk do not vacillate in having sex before, later and through their connubial life with

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men other than their husbands. Traditional Indian marriage as a basis of family life and the progress of the system of affinity has no implication in De's fictional world. The new men and women in this creation do not baton to marriage for long. In these conditions the institution of family flops to fostering traditional standards. Progenies in such weddings are pickled as an obligation and a hindrance to social agility. Shobha Dee's demonstration of marriage with all its concavity, two-facedness plus triviality becomes more passionate and notable when she portrays the supposed modern nuptials. These nuptials are made-up to be based on reciprocated understanding, liberty of excellent and a close affiliation amongst two associates. People exercise their full autonomy yet they are unsuccessful to make their nuptial a joyful comradeship. In the transformed situations, noticeable by individual liberty and freedom of choice, people have developed unpremeditated in their behaviour towards nuptial and annulment. They no lengthier sense in the least essential to disseminate a wedding that does not reach to their hopes. If a self-sufficient female with a rooftop over her skull selects to wed, it is because she wants to share her life with someone in the fullest sense, not because she is looking for a life-long meal-ticket. Divorce, too, has to be viewed in this light." Shobha Dee, undoubtedly, expresses a dissatisfaction with traditional form of nuptial that inclines to periphery and overpower females. Rendering to Shobha Dee, "The terms underlying marriage have also been redefined in recent times with some amount of economic freedom, females have altered the rudimentary instructions somewhat. She fictionalises Maya's dilemma in wedding that consequences in her seclusion and sources mental pain. The unresponsive arrogance of her companion Ranjan towards her biological and emotive requirements makes her nuptial sterile. It makes her discover consolation in clandestine relationships with Nikhil. In the illusory world of Shobha Dee the perception of nuptial revelated marvellous modification from the old-style Indian weddings and relations. It displays the alteration apprising people's attitude in the direction of wedding in topical eras. A nuptial deficient of outdated holiness and reciprocated considerate consequences in flimsy matrimonial ties. The families grounded on the recent matrimonial offered in Dee's novels incline to crumble speedily creating their affiliates epicurean, discourteous and reckless. De seems to put a huge inquiry over the recent nuptials by screening the uselessness of such nuptials grounded on fleeting desires. In contrast, Dee also makes fun of current, unconventional women's non-serious also unpremeditated attitude towards nuptial. The impetuous verdicts of the society vis-à-vis wedding make a ridicule of it also prompt these people's catastrophe to comprehend the actual consequence of wedding owing to their misguided philosophies of modernism, liberty and true camaraderie.

MAN-WOMAN RELATIONSHIP

Females fast their revulsion, abhorrence and aversion for males in unmistakable terms. They reflect their masculine associates lying, self-centered, painful and self-obsessed, "Men are all the same—animals… and we women such fools" (Starry Nightsp.50). For Rashmi in Photos males are, "Intrinsically, instinctively, intuitively dishonest" (p.49). It leftovers fairly arresting and surprising that these females fast a specific taste for those very males about whom they bile malice. Gentleman-woman affairs present a stimulating characteristic of life in Dee's narratives. The portrayal of these affairs carries out the sarcastic countryside of the struggles seen here. A pattern of love-hate bond in scripts the understanding between males and females in Dee's fiction. For example, Aparna in Photos knew, "Rohit was a very selfish man… Selfish and vain" (p.21). But after his leaving she failures him forcefully and desires to have him over, "What she wanted was a steady, warm, attentive companion. No, if she were to be honest with herself, she'd admit it more readily… it wasn't just a man she missed… it was Rohit, her husband" (p. 24). In *Sisters*, Mikky's association with Binny Malhotra is also mysterious. She weds him and originates to know about his preceding companion and broods. In malice of his snub to permission his previous companion and broods and his unkind action of Mikky, she speaks, "It makes me happy that he is there in my life. That he is my man—at least in the eyes of the world" (p. 124). The inconsistency obvious in De's action of manwoman relations scripts Dee's mainly tongue-in-cheek posture regarding her imaginary fonts and their method of rational. Mikky is a contemporary cultured lady. She does not vacillate in selecting and altering sensual partners. Her boldness to her spouse, at the similar time, scripts the old-style countryside of her behaviour. In malice of all his disadvantages and brutalities exposed to her she reflects him 'my man'. This transports out the tongue-in-cheek countryside of her opinions. Womenfolk fonts look to be betrothed in a endless fight in contradiction of masculine supremacy. Shobha Dee appears to take that females are additional caring and subtle to their masculine associates in malice of their wanton, uninhibited behaviour. Their strange behaviour is occasionally an effort to list their attendance seeking credit and

sympathetic in the biosphere of males ruled by applied and sensual thoughts. Their altered insight brands them trust: The fake was to become them hooked. It is stimulating to letter that these womenfolk do not extra their womanly buddies too. Become an irredeemable custom in their petty, self-obsessed exists, get them so obliged that they supposed they could not live deprived of you—or more precisely—deprived of the facilities only you could deliver (Snapshots p.49) The nature of relational relations in Dee's imaginary biosphere transports out a thought-provoking facet of manwoman relations. They frequently go in contradiction of one another. On the other hand, the manly typoscripts are infrequently complicated in a unpleasant competition contrary to one extra. The dealings among diverse men are rarely spoiled by business rivalry or social and political considerations. The life showed in De's narratives does not notify any shared hominoid benefits. All the persons appear to be attentive in discrete achievement and self-seeking chases. This biosphere is absent from the normal domestic businesses, national glitches and the substances connected to way of life. The writer discovers the odd worries and practical boldness of the persons living her imaginary biosphere in over-all and the females connected to theatre in specific. These persons see, to be additional worried with physical achievement, lesson movement and charm. The biosphere of theatre is a remote, dreamlike biosphere constructed on impressions and technicoloured realism.

PRESENTATION OF SEX

A significant feature of Dee's imaginary biosphere that has produced far tremor to the detractors and asked harsh commentaries is the action of gender. Gender not escorted with darling and feelings develops motor and practical lone. This caring of erotic amalgamation discoveries looks in smooth the wedded lifetime of dissimilar fonts in De's falsehood. Gender goes obtainable to be an obsessive workout which is mentioned to as "duty fucking" (Snapshots p.108) by these fonts themselves. In place of if pleasure and desire the gender performance reasons prevention, disenchantment and disgrace to the feminine associates. Sensual contact for males develops an exertion and a representative performance to conquer females and to work out their switch ended the feminine form and attention. The performance of feminine sex in Dee's narratives is founded on the receipt of sensual wish in a lady as usual and usual. Females, in this biosphere, do not texture embarrassed of their sex. They do not try to supress their sensual need somewhat they want it content in their individual footings. For them the ideas of chastity and cleanliness have no meaning. Neither do they hurt from any intelligence of fault. Gender becomes a monotonous workout for them. Their boldness to gender scripts their dissimilar countryside. In its place of tiresome to imitate to the examples of Sita, Savitri and Anusuya, these females incline to make a biosphere allowed from all hangups.

These ladies' thoughts and their sensual behaviour scripts the boldness of so called generous-minded individuals to gender. It also procedures a method of their declaration for an independent individuality. These ladies' request for a distinct individuality and their assertion of feminine sex in the procedure of brazen chase of gender opinion out a novel consciousness amongst them. Dee herself is aware of the altered viewpoint around gender that becomes exposed in her narratives. She herself confesses, "Yes, the sex in the books is quite grim… Its unhappy sex seen from a fairly lonely woman's point of view. Some people, however, find sex seen from a woman's view point so threatening that it's much easier to dismiss it as sleaze". These words reveal the real purpose of the depiction of sex and sexual behaviour in Dee's novels. A near education of Dee's performance of sensual behaviour of males and females in her imagined biosphere discloses that her actual anxiety is to depiction the prevention, revulsion and disgusting countryside of wanton sensual tolerance. We, no hesitation, discovery a profusion of erotic, full images of sensual behaviour of the people obtainable in Dee's stories but this does not boundary her drive to the formation of extraordinary interpretation physical lone. She somewhat brands an endeavour to representation the uselessness and insignificance of this behaviour. She neither idealizes nor worships the gender lifetime practised by the fonts in her fabrication. Shobha Dee's females' fonts signify a factual depiction of the contemporary Indian females. Feminine sex discoveries new sizes, as females here are not happy with straight relations lone. Its discoveries look and consummation in lesbian relations and motorized approaches of rewarding the gender need. In their offer to discovery supernumerary incomes of sensual satisfaction that do not contain need on gentleman, females spoil in odd, appalling and astounding sensual does. In fact, Dee appears to pretend at the tall-lesson civilization females with their original originate sensual liberty. Dee demonstrates how the sexual activity entertainment converts pointless uniform hilarious after spoiled in deprived of any open add-on or sense of dear and sympathetic by these

womenfolk. The thorough report of erotic interaction as create in the stories show her purpose to clue the rib-tickling, horrible and hostile facet of such performance. In its place of by means of straight commentaries to depiction the offensive countryside of the gender performance Dee has revealed individuals pampering in abandoned, irregular, unusual and hostile sensual behaviour and strained to brand them finally understand the uselessness and attraction lessness of this performance. Shobha De appears to take to the so-named liberated females that tolerance in wanton gender and wicked violent behaviour does not funding actual contentment.

CONCLUSION

Females occasionally owed to the convincing state of their lifetime, are lacking into the remaining by their guards though at additional aeras their rising drive and determination to declare their liberty, receipts them into the channels of unconceivable sorrows. The writer deciphers her females' charms' spirits and expressive shocks in dissimilar habits and after numerous viewpoints. All these females fight for their excessive drives by altogether their forte in masculine conquered civilization. By consuming an impression of De's designated narratives, we discovery that as a activist writer, Shobha De has marvellous sympathetic of the soul of females and so, she travels the biosphere of city females with all its irresistible glitches and tests. She forcefully significances the opinion that smooth in contemporary aeras with all socio-political as healthy as, financial attainments, the chart of female's misuse is outrageously increasing. Stressed firm with adversities, opposite misuse and overthrow at dissimilar ladders, occasionally with waterworks full judgements though at additional aeras similar a tigress, they test the civilization to go the tide in their favour. As Shobha Dee's females don't trust in sorrow passively, they permission not at all pebble unturned to spread the top of happiness and achievement. Dee's falsehood fixes non effort to improvement the civilization but gifts it humorously in realistic footings lengthways by its peculiarities. The Tribune correctly detects: "She slaughters macho males with vengeance and rattle poisons her gender with disdain and disregard. She demolishes reputation and civilizations; with effortless grace and one thing she doesn't stomach is hypocrisy of any kind. She wields a powerful camera, and she needs to keep shooting that way whether anyone likes to photograph or not." She is Shobhaa De, and she is scintillating and straight. She is a ruthless writer with a ramrod of a pen, and a ranging urge to kill somebody.

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RESEARCH ARTICLE

Deciphering Financial Service Landscape: An Analytical Exploration

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ABSTRACT

The financial services sector is witnessing unprecedented transformations driven by technological innovations, particularly the proliferation of fintech solutions. This paper presents findings from a comprehensive study titled "Deciphering Financial Service Landscape: An Analytical Exploration," which explores key dimensions shaping contemporary financial service dynamics. Using empirical data and rigorous statistical analysis, the study examines the relationships between educational qualifications, income levels, interaction frequencies with financial services, and various aspects of user perceptions, motivations, challenges, and satisfaction with fintech solutions. Findings reveal nuanced insights: educational qualifications exhibit minimal correlation with financial service awareness, challenging traditional assumptions; income levels show weak associations with motivations for service usage, emphasizing the need for targeted marketing strategies; interaction frequencies with financial services demonstrate negligible impact on overall satisfaction with fintech solutions, highlighting the importance of service quality and user experience. The research underscores the complexity of factors influencing financial service behaviors and offers practical implications for stakeholders including financial institutions, fintech developers, policymakers, and researchers. By bridging empirical evidence with theoretical insights, this study contributes to enhancing strategic decision-making and fostering innovations that cater to diverse consumer needs within the evolving financial services landscape.

Keywords: Ecological Service Supply, Financial Technology, Financial Services, Fintech Solutions, Technological Innovation.

INTRODUCTION

In the ever-evolving landscape of financial services, characterized by rapid technological advancements and shifting consumer expectations, understanding the multifaceted dynamics that drive user behaviors and satisfaction is crucial for stakeholders aiming to navigate and thrive in this complex environment. This research paper, titled "Deciphering Financial Service Landscape: An Analytical Exploration," undertakes a thorough investigation aimed at unraveling key dimensions of the contemporary financial services sector. The advent of fintech solutions has significantly disrupted traditional models of financial service delivery, prompting a critical examination of factors influencing user awareness, motivations for service usage, challenges within market structures, and overall satisfaction with fintech innovations. Against this backdrop, this study employs rigorous empirical analysis to unearth nuanced insights that shed light on these pivotal aspects. By delving into the relationships between educational qualifications, income levels, interaction frequencies with financial services, and various facets of user experience, this research seeks to uncover underlying patterns and correlations. These insights are essential for stakeholders—ranging from financial institutions and fintech developers to regulatory bodies and academics—to formulate informed strategies that not only meet current consumer needs but also anticipate future trends and challenges. This study aims to make a significant contribution to the discussion of the current financial services ecosystem. By bridging empirical findings with theoretical frameworks, this study aims to provide actionable intelligence that enhances operational efficiencies, refines marketing strategies, and fosters innovations tailored to the diverse and evolving preferences of financial service consumers. Through a comprehensive exploration of these dimensions, this paper endeavors to equip stakeholders with the knowledge and insights necessary to navigate the complexities of the financial services landscape adeptly. By doing so, it aspires to catalyze advancements that drive greater inclusivity, efficiency, and satisfaction within the sector, ultimately shaping a more resilient and responsive financial ecosystem for all stakeholders involved.

LITERATURE REVIEW

Findings from 20 insurance-based programs in Australian organizations that help those who have suffered brain or spinal cord injuries find homes (ABI) were collated in this study. We reviewed and contrasted publicly accessible grey literature, which is mostly material found on scheme websites. Disability and workers' compensation rules vary from state to state. When the scheme's funds were distributed, the intended priorities were housing infrastructure and service delivery, not tenant relief. Those Australians who are unable to make adequate improvements to their homes, who are seeking to construct might buy a home, or who are lacking access to appropriate, alternative housing alternatives, whether for the short or long term, are the most marginalized in the present financing climate. If the individual's present living situation is untenable, they need aid with relocating to or remaining in a new residence, might aid animals, family supports, and case management, or are unable to provide Additional research is required to fully understand the relationships, ambiguities, inconsistencies, and gaps. Policymakers must be forthright on housing rights for ABI/SCI patients and their families, as this review has shown. Patients with traumatic brain injuries and spinal cord injuries may get more standardized treatment if housing and support services were financed under a consistent, evidence-based framework. (Wright et al., 2019) In particular, the financial services industry is seeing a sea change as a result of the internet. Examining the sector's development, Digital Finance lays down the groundwork for incorporating digital finance principles into more conventional financial systems. If you want to know how to incorporate digital finance into your company's structure, this book will show you what the most successful organizations are doing to make the most of this situation. Presenting concrete plans for the digital future, the authors also provide a plethora of case studies that delve into the characteristics shared by successful projects. To keep up with the ever-changing world of modern finance, Digital Finance comes with the author's website (PerryBeaumont.com) and connections to additional material that offers analysis, views, and informative articles. Digital Finance offers a wealth of background information that helps us make sense of the current state of the financial industry and prepares us to analyze and develop new financial innovations in the future. (Beaumont, 2019)

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The downgrade, downsizing, and degazettement (PADDD) of protected areas (PAs) threatens their long-term nature conservation and ecological service supply. Three well-known PAs, namely Yosemite National Park, Yasuní National Park, and Virunga National Park, were found to have 23 PADDD instances. The lack of comprehensive PADDD data makes understanding development pressures and their repercussions difficult. Future research should focus on developing national and regional profiles, evaluating PADDD-related risks, and implementing policy solutions like public tracking, collaboration across legal frameworks, and minimizing negative impacts.(Qin et al., 2019) The complicated ditches around highways have led to floods and water pollution in previously undetected ways. This study interviewed New York State town and county transportation professionals about ditch management. Of the 999 highway workers questioned, 41% were from the 54 state counties. 36.8% of agencies scraped or reshaped ditches without reseeding, and half scraped them every one to four years. About one-third to half of upstate New York roadside ditches are excellent to terrible. The outcome is hundreds of kilometers of open terrain that storms may contaminate and dump silt. The techniques utilized were justified by time, labor, equipment, and finances. Additional concerns included farm-field drainage, increased downpours, and rights-of-way disputes with landowners. Ditch rehabilitation requires a comprehensive, coordinated governmental effort. An effective toolkit should contain legal responsibilities, sanctions, financial aid, and training, including a ditch inventory system. State agencies and municipal governments should provide subsidies and shared services. Recognizing transportation department officials as water stewards and campaigning for ditch management alongside highways is an innovative technique to preserve New York State's water supplies. (Schneider et al., 2019)

Fairness in the distribution of financial services across different regions is the focus of this study. Many Americans with low to moderate incomes still don't have bank accounts or use them inadequately; they turn to check cashing businesses and payday lenders as their only options for inexpensive and accessible financial services. There is ongoing worry about the unequal distribution of financial services, even though economically deprived families are more likely to successfully create assets when they have geographic access to cheap goods and services. In certain parts of southeastern Pennsylvania, known as "financial deserts," businesses that cash checks are far more prevalent than banks. In this paper, we employ GIS and spatial binary logistic regression analysis to see whether there's a correlation between these deserts and factors related to mortgage lending and sociodemographics. (Dunham, 2019) In order to improve the curriculum by including primary care nursing education and practical experiences, nursing schools must adapt to new healthcare models and prepare for any challenges. If other schools are looking to create primary care curricula and academic-clinic cooperation models to encourage primary care clinical experiences in the community, this article will provide them some good ideas. (Watkins & Neubrander, 2020) The global food system causes environmental degradation and contributes to global warming. Insufficient diversity and fruit and vegetable supply are worsening a global health concern. There is a growing understanding that Earth's well-being and climate change slowing depend on the vast diversity of tropical tree species. They don't function well with food systems. Many tropical tree species can sustainably produce a range of crops, improving human nutrition, livelihoods, and ecological benefits. First, we include environmental, nutritional, and livelihood benefits.

Using data from seven nations, we show that rural populations consume more vitamins A and C and fruit from tree-sourced foods. The restrictions and risks of growing tropical tree-based food production are next. These include the importance of a varied manufacturing system and worldwide market supply issues. In conclusion, we will discuss strategies to increase tropical tree food production and consumption and overcome technological, money, politics, and consumer behavior challenges. This might accelerate global food system sustainability. See the article's Supporting Information for a free Plain Language Summary. (Jansen et al., 2020) It is debilitating how many options are available online. Internet services have expanded at an exponential rate in recent years, and it's inevitable that some of these services experience information overload, making it hard for consumers to locate the specific information they need. To help customers zero in on the products and services that pique their interest, recommender systems (RSs) provide tailored recommendations based on a predefined set of criteria. The majority of recommender systems are used for things like music, movies, jokes, restaurants, financial services, life insurance, Instagram, Facebook, and Twitter followers. Websites and e-commerce apps rely heavily on recommender systems because of this. An overview of recommender systems that use content-based filtering is provided in this publication.

We go on to detail the various recommendation techniques and the general strategies behind them. (Manamolela et al., 2020) The economic impact of joblessness on host countries is increasing, particularly for medical professionals. However, no comprehensive policies or initiatives exist to address this issue. A study aimed to find publicly and privately supported initiatives to help medical professionals, as part of a grey literature evaluation conducted by the Canadian Institute of Health Information. The study found that more IMG and ACP-specific policy and employment aid initiatives are needed, as well as increased research and development programs for foreign student athletes.(Turin et al., 2021) Advancements in cutaneous melanoma detection, staging, and treatment have improved, but healthcare decision-makers still lack cost-of-illness statistics. A cost-of-illness analysis for chronic musculoskeletal disease (CM) in Brazil included Health Management Organization (HMO) and Unified Health System (SUS) systems. The study found that patients with advanced disease spend more than those with early stage disease. In order to provide the optimal mix of healthcare goods and services, the health value chain has to be improved. This knowledge could aid in healthcare budget planning and resource allocation.(da Veiga et al., 2021) The Dutch "Krijtmolen Alliantie" is aiming to improve performance intelligence in a network that delivers health and social services by adopting a governance model that is driven by performance intelligence, as outlined in the Triple Aim.

Using financial incentives to encourage coordinated care and shared responsibility, the project intends to increase performance intelligence by merging data on expenditures per capita and each patient. It is being undertaken in Amsterdam Noord. To accurately represent treatment quality and patient experience, the alliance should combine outcome metrics with PX metrics. The research concludes that performance intelligence should be a part of regional social and health care delivery systems.(Bos et al., 2021) Global warming is causing changes in local precipitation, temperature, and extreme weather events (EWEs), which have severe socioeconomic and environmental impacts on agriculture and food production. A study in Zeeland, Netherlands, examined how potato and onion farmers have adapted to these changes. The research found that the frequency of extreme weather events has increased, with more frequent heat waves, droughts, and frosts. New Zealand farmers are well-informed about these changes and perceive them as a significant level of danger. The study supports the "National Strategic Plan" and "Rural Development Program" of the Netherlands, which seek to alleviate farmers' financial struggles.(van Tilburg & Hudson, 2022) Small firms in the EU are increasingly turning to crowdfunding as a means of raising capital, regardless of the severity of the outbreak. Online platforms that facilitate crowdsourcing of finances are analyzed and categorized in this study. Financial instruments and company loans via digital crowdfunding platforms have just had their first standardized framework going online. The future of financial technology will surely be altered by this framework, which is a component of a bigger initiative to promote the ongoing incorporation of new technologies into this industry.

The new legislative framework establishes a robust licensing across the European Union, in tandem with the integration of social media and the gradual development of pan-European one-stop-shop platforms with different financing mechanisms. With its advanced warning system, multi-tiered targeted transparency, and conflict-of-interest framework, this technology revolutionizes behavioral finance and investor protection. It guarantees that the platform is operating as a risk-neutral gatekeeper. Due to the existence of long-standing legal and supervisory hurdles on a national level, the verdict is still pending and several concerns remain unresolved, making the implementation of this new framework an uncertain prospect. (Valiante, 2022) A scoping study of peer-reviewed studies from 1970 to 2020 aimed to determine the feasibility, efficacy, and acceptability of non-pharmaceutical interventions (NPIs) in crisis and informal settlements. The study found that NPIs were generally accepted and successful, but faced challenges such as logistics, money, and people. Community engagement was crucial for the development of NPIs, and restrictions on burial practices, patient care, and case isolation were often well-received. The evidence base was contradictory, and a research program focusing on disadvantaged people is urgently needed to develop a robust evidence foundation for NPIs in these situations. (Polonsky et al., 2022) This book explores the ways in which Islamic financial institutions might benefit from the integration of blockchain, artificial intelligence, and machine learning into their operations. The book aims to automate, improve efficiency, and make informed decisions by analyzing massive information. With the growing number of Muslims worldwide, Islamic financial services have great growth potential, and this book provides guidance for governments, academic institutions, and businesses in combining tradition and technology in Islamic finance.(Irfan et al., 2023) Using the variety and worth of

ecosystem services as a lens, this research investigates whether ecological restoration is feasible in Inner Mongolia. To determine the sustainability of ecological restoration initiatives, the research used a "value-diversity-risk" framework. Results show regional and temporal variances, with only 5% of basins achieving monetary and ecological benefits. Urbanization and arable land demand could lead to a loss of ecological restoration benefits by 2050. The study suggests that ecological restoration efforts should consider ecosystem benefits, funding, and risk reduction to ensure a win-win situation.(C. Wang et al., 2023) Digital finance is transforming the financial industry by addressing information asymmetry and lack of collateral in agricultural, farming, and rural financial services. Findings from the 2019 China Household Finance Survey (CHFS) and the Peking University Digital Financial Inclusion Index of China (PKUDFIIC) are used to examine the effects of digital financial development on the asset portfolios of households in both urban and rural areas. The research finds that digital finance enhances the efficiency of financial asset portfolios owned by families in both urban and rural regions, but favors urban households more.

The study suggests bridging the digital divide to optimize investment portfolios and combining digital credit and digital finance to strengthen family financial asset portfolios. (X. Wang et al., 2024) The study examines the financial climate affecting Syringe Treatment Programs (SSPs) for drug users, focusing on financial and personnel issues. It found institutionalized discrimination, restricted resources, strict reporting requirements, and insufficient funding hindered program implementation. The study suggests political lobbying, clearinghouse programs, harm reduction finance, and technical help at the state level as potential solutions to improve implementation and health outcomes. (Akiba et al., 2024) This bibliometric study is to take stock of the current literature on AI and ML in BFSI institutions. Key research clusters are identified via the study's emphasis on Scopus-indexed papers. After filtering 39,498 articles according to the PRISMA methodology, 1045 papers were found to match the inclusion requirements. The titles and abstracts of the articles included 177 distinct words, as shown by the N-gram analysis. Technologies related to financial technology, risk management, and anti-money laundering, actuarial science, and eight other related fields were grouped together in nine separate clusters according to the co-occurrence study. A thorough picture of the complex research scene is provided by these groupings. The clusters that have been found may provide valuable guidance for future studies and research. Research gaps and opportunities are highlighted in the report, which might be useful for practitioners, policymakers, and academics in the BFSI industry. This research adds to the expanding body of bibliometric literature by shedding light on the BFSI industry's use and machine learning. This study's findings provide light on the practical uses of AI and ML may help both academic institutions and businesses. (Pattnaik et al., 2024)

Objectives
1. To know the awareness of financial service among the users.
2. To know the motivational factor for use of financial service
3. To analyze the challenges on market structure
4. To analyze satisfaction of impact of fintech on financial service

Hypothesis
1. H_0:There is no significant relationship between qualification and financial service awareness
2. H_1:There is a significant relationship between qualification and financial service awareness
3. H_0:There is no significant relationship between income level and motivation for use of financial services
4. H_1:There is a significant relationship between income level and motivation for use of financial services
5. H_0:There is no significant relationship between interact with service and satisfaction
6. H_1:There is a significant relationship between interact with service and satisfaction

RESEARCH METHODOLOGY

The financial service environment is investigated in this study using a mixed-methods research strategy, which combines quantitative surveys with qualitative interviews. A stratified random sample of 120 respondents was used to guarantee varied representation across demographics, with the target group being consumers of financial services. Awareness, motivating reasons, market obstacles, and satisfaction with fintech effect will be the areas of emphasis of the structured questionnaires used to gather quantitative data. The qualitative data will be collected from a subset of the survey participants via semi-structured interviews. The hypothesis will be tested using descriptive statistics and inferential analyses, including t-tests, Pearson correlation, chi-square tests, and analysis of variance. It will examine the relationship between income level and motivation, the coefficients of ease of use and market structure, and the interaction between satisfaction and financial service awareness. In order to get to the bottom of things, we'll be using theme analysis on qualitative data. Questions of informed permission, confidentiality, and the importance of voluntary involvement are all part of the ethical framework. The unique demographic emphasis limits generalizability, and there is a possibility of bias in the samples and the responses. In order to successfully test the hypotheses, this technique seeks to provide a thorough comprehension of the financial service environment.

ANALYSIS AND DISCUSSION

Finding out if there was a connection between qualification and understanding of financial services was the goal of the study, which included 120 participants. The Pearson correlation score of -0.003 indicates that the two variables are hardly related to one another. It would seem that one's familiarity with financial services is unrelated to their degree of education. Based on the data, the correlation coefficient is 0.974. If the observed association could have happened by chance alone, the p-value would show that. The significance level of 0.05 is widely acknowledged in the field of statistics. It is not possible to reject the null hypothesis with a p-value of 0.974 since it is significantly larger than 0.05. To rephrase, there is insufficient evidence in the data to accept the alternative hypothesis, which states that qualification and financial service awareness are significantly related. If there is a link, it is most likely attributable to chance rather than a genuine relationship, since the p-value is so high. We find that there is no significant relationship between an individual's degree of qualification and their knowledge of financial services within this sample. The consequences of this finding for anyone involved in the financial services industry are substantial. Since the research shows that awareness is not greatly impacted by qualification levels, efforts to enhance knowledge of financial services may need to concentrate on other variables.

In order to create more precise and efficient methods, more study should investigate other possible factors that affect financial service awareness. The primary objective of the study was to identify the factors that influence the connection between income and the desire to use financial services, with a particular emphasis on the role that convenience plays in this desire. This association has a Pearson correlation value of 0.102. This number suggests that there is a weakly positive link between income and the perceived ease of accessing financial services. In a nutshell, this indicates that, while the correlation is modest, considering convenience as a motivating factor grows somewhat with increasing money. With a p-value of 0.268, this link is statistically significant. If the observed association had happened by chance alone, the p-value would have shown it. The 0.05 level is a popular cutoff for statistical significance. We can't rule out the possibility of a null hypothesis since the p-value is much more than 0.05 (0.268). Therefore, the data does not lend credence to the counter-hypothesis, which states that a correlation between income and convenience-based financial service use is statistically significant. If there is a link, it is probably only due to chance rather than a real relationship, since the p-value is so high. According to these findings, there is no significant relationship between income level and the perception of convenience as a driving reason for utilizing financial services within this group. Financial services industry stakeholders may need to broaden their marketing strategy to target a wider audience, rather than just those with a certain income level, if they want to capitalize on ease. To get a more detailed understanding of the elements that motivate people to use financial services, future studies should

look at demographic demographics and other motivational factors. The purpose of the study was to look at how often people use financial services and how much happier they are overall as a result of fintech solutions. When looking at this connection, the Pearson correlation coefficient comes out as -0.041. This number points to a modest negative association between using financial services and happiness. This basically indicates that there is a small but significant negative correlation between increasing involvement with financial services and overall happiness. In this case, the p-value for the association is 0.660. The p-value represents the likelihood that the observed association happened randomly. The 0.05 level is often used to indicate statistical significance. We cannot rule out the possibility of a null hypothesis, as the p-value of 0.660 is far more than the significance level of 0.05. That being said, there isn't enough proof in the data to back up the counter-hypothesis, which states that customers are more satisfied overall as a result of fintech solutions when they connect with these services more often. Any association that may have been noticed is most likely attributable to chance rather than any real relationship at all, according to the high p-value. Based on these results, it seems that the frequency of using financial services has little bearing on how satisfied customers are with fintech solutions in this sample. This has important implications for anyone working in or with the financial services industry, as it implies that characteristics other than contact frequency may be more important in defining customer satisfaction with fintech solutions. Investigating other factors that may influence contentment, such service quality, usability, and the variety of features provided by fintech solutions, might be fruitful. These aspects might be better understood with more study, which could lead to better techniques for increasing customer happiness.

CONCLUSIONS AND FINDINGS

Findings
1. The relationship between qualification and knowledge of financial services: - Correlation Coefficient: -0.003 - P-value: 0.974 - Conclusion: The results show that there is almost no relationship between the two variables. Any association that was found is probably just due to chance, since the p-value is so high. As a result, knowledge of financial services is unaffected by a person's degree of qualification within this sample.
2. The Analysis Shows a Weak Positive Correlation Between Income Level and the Perception of Convenience as a Factor Motivating the Use of Financial Services (Correlation Coefficient: 0.102, P-value: 0.268). Given the strong p-value, we can conclude that there is no statistically significant link between wealth and the perception of convenience as a motivating factor in this population.
3. The study reveals a very weak negative association between the frequency of contact with financial services and overall pleasure with fintech solutions. The correlation coefficient is -0.041, and the p-value is 0.660. This brings us to our third point, the interaction with financial services and overall contentment. Given the high p-value, we may conclude that there is no statistically significant relationship between the frequency of interactions with financial services and overall satisfaction with fintech solutions within this group.

CONCLUSIONS

Educational Background and Financial Service Knowledge: - According to the results, educational background is not a major factor in deciding financial service knowledge. Anyone with a stake in the financial services industry should pay attention to these consequences. Because educational attainment does not seem to have a substantial impact on awareness levels, efforts to raise awareness should think about shifting their attention to other aspects. Develop more focused and successful solutions by doing future research that explores other possible variables, such as demographic characteristics, personal experiences, or access to information. The Relationship Between Income and the Intention to Use Financial Services: - The data shows that people's income does not significantly affect their perception of convenience as a driving element in their financial service use. This indicates that stakeholders shouldn't limit their marketing efforts to people with certain economic levels if they want to emphasize convenience. The goal here should be to reach more people with these tactics. To provide more complex insights into the drivers of financial service utilization, future study should include other demographic characteristics and motivating factors.

The results suggest that consumers' overall contentment with fintech solutions is unaffected by the frequency of their interactions with financial services. This brings us to our third point, the relationship between interaction with financial services and overall satisfaction. Accordingly, it seems that variables other than contact frequency could play a more significant role in defining user happiness. Fintech solutions have many useful characteristics, but practitioners and stakeholders may benefit from learning more about and improving other areas, such service quality, usability, and feature variety. More effective techniques for boosting customer happiness might be found by identifying and concentrating on these characteristics. In conclusion, the research shows that when addressing financial services sector knowledge, motivation, and satisfaction, it is necessary to go beyond conventional demographic variables like income and education level. In order to improve user engagement and happiness, it is probable that more holistic methods that take into account several factors would be more successful.

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Table:1

Correlations

		Qualification	interact with financial services
Qualification	Pearson Correlation	1	-.003
	Sig. (2-tailed)		.974
	N	120	120
interact with financial services	Pearson Correlation	-.003	1
	Sig. (2-tailed)	.974	
	N	120	120

Table :2

Correlations

		Income Level	convenience as a motivating factor
Income Level	Pearson Correlation	1	.102
	Sig. (2-tailed)		.268
	N	120	120
convenience as a motivating factor	Pearson Correlation	.102	1
	Sig. (2-tailed)	.268	
	N	120	120

Table :3

Correlations

		interact with financial services	feel fintech solutions have improved your overall satisfaction
interact with financial services	Pearson Correlation	1	-.041
	Sig. (2-tailed)		.660
	N	120	120
feel fintech solutions have improved your overall satisfaction	Pearson Correlation	-.041	1
	Sig. (2-tailed)	.660	
	N	120	120

RESEARCH ARTICLE

Scope for Green Entrepreneurship in the Wake of Drought

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ABSTRACT

Drought surfaces in a particular geographical location mainly when Monsoon fails and as a result of scanty rainfall. In India when both south west monsoon and north east monsoon proves to be failure in any year, it gives raise to drought like situation. Monsoon season, in India will commence from June to January and reality check through surveys and reports says that drought's impact is going to be disastrous in the days to come, during such pessimistic time, citizens should not lose heart and march ahead to become green entrepreneurs. Green Entrepreneurs during drought will serve as 'Drought Warriors' by being instrumental in changing the society by catering to the societal needs especially required during the drought season. Hence the green entrepreneurial opportunities that would pop up during drought has to be studied which would manifest the scope for becoming green entrepreneurs is highly desirable and thereby encourage citizens to tap on such opportunities. The research was undertaken by employing both primary data as well as secondary data and eight such problems which would normally surface during drought were shortlisted, also to which there are high scope for green entrepreneurship. The research outcome reveals that six problems out of eight can cause very severe and severe problems during drought and they can create high scope for green entrepreneurial opportunities. The remaining two problems cause mild problems during drought and they can create moderate scope for green entrepreneurial opportunities.

Keywords: Drought, Environmental Sensitive, Green Entrepreneurship, Green Innovation, Wildlife Rift.

INTRODUCTION

An entrepreneur is a person with the ability, motivation, and willingness to take measured risks necessary to found, manage, and profit from a new business[Kaur, P., & Kaur, S. (2023)[1]]. Launching a new company is the ultimate form of entrepreneurship. Entrepreneurs provide novel ideas into the market and are frequently seen as inventors or providers of original ideas when they swap out outdated products with ground-breaking ones[*S, A., & Kumar, V.S. (2023)[2]]*. It might be divided between large corporations and small businesses operating out of houses. An entrepreneur can generate revenue by combining labor, capital, land, and natural resources, to use economic language[*Ijeoma Orji, Evelyn & Idika,et al (2023)* [3]]. The ability to recognize opportunities for investment and production, set up a business to carry out a novel production process, raise money, hire employees, arrange for the supply of raw materials, and choose senior managers to oversee the day-to-day operations of the business are all considered aspects of entrepreneurship**.** The French word "entrepreneur," which meaning "to undertake," is where the English word "entrepreneur" first appeared. It refers to launching a business in the context of business.

The ability to launch a new company and make money by creating or promoting goods and services that satisfy consumer needs is known as entrepreneurship. In the contemporary era an entrepreneur is expected to possess the qualities such as (a) being creative - Entrepreneurs that possess creativity are able to solve challenges creatively and in novel ways. It also enables an entrepreneur to create new goods for markets that are comparable to the ones he now serves. (b) being Professional – Professionalism in entrepreneurship, accompanied by discipline and dependability will make an entrepreneur equip himself with self-discipline and ease out to accomplish goals, maintain organization, and lead by example. (c) being passionate - Passion serves as a motivating factor that pushes entrepreneur to go higher and Consequently, entrepreneurs remain extremely driven and like what he does while working. (d) being knowledgeable: an entrepreneur need to be well-versed in his sector or specialty. Because problems can only be resolved or crises can only be faced with knowledge. (e) being socially skillful :

A successful entrepreneur also has to possess social skills such as developing contacts , identifying talents etc. (f) being emphatic : A competent entrepreneur ought to be aware of the advantages and disadvantages of each worker under him. He should have to realize that people are what drive a business and he must show empathy for the people in his business community. Off late 'entrepreneurship' is going through different dimensions and in rapidly changing entrepreneurial Diaspora the type of entrepreneurs is not only confined to conservative classifications such as business based, technology based , gender based etc.,[S.V, R. ., Velmurugan, J. S. ., & Suryakumar, M. . (2022) [4]] but it is also opening up for Agri based , Event based,Environmental based etc. one of the very important sub classification under environmental based entrepreneurship is 'Green Entrepreneurship'[*Gupta, M., & Dharwal, M. (2021)* [5]]. Green Entrepreneurship is the process of consciously addressing environmental and social requirements and problems, as well as developing brilliant, original business concepts that will provide a solution. These concepts carry a high degree of risk, which benefits the environment while assisting in the maintenance of financial sustainability. For example, an increasing number of organizations are opting for paperless invoicing instead of paper bills in order to promote sustainable business growth and ecological entrepreneurship. Putting in another way, "green entrepreneurship" refers to businesses and institutions that produce products or services that are both environmental [Aswathy, T. R., & Fred, N. A. (2022) [6]] friendly and suitable for a worldwide market. They also need to ensure that the solutions won't have a detrimental impact on the business's finances.

Why is green entrepreneurship important?
(1)   Green business owners play a critical role in the economy's growth.
(2)   The battle against poverty, unemployment, and environmental issues can be greatly aided by green entrepreneurs.
(3)   Compared with other types of entrepreneurs, green entrepreneurs engage in more environmentally conscious activities and tasks.

(4)   Green entrepreneurs can be the catalyst for change as green entrepreneurs helps to create plenty of job opportunities to youth
(5)   Green entrepreneurship drive sustainable changes.
(6)   Green entrepreneurship can be an amicable solution forhuman, wildlife rift.

The south Indian states are reeling under drought like situation from past 10 months as both south west monsoon as well as north east monsoon was a failure and both monsoons didn't fetch the normal rain fall during the last year commencing from June till date. As a result of it, sowing of food grains like paddy, ragi, wheat, jowar, etc.,didn't happen as expected and pulses like toor dal, urad dal, Bengal gram, green gram, horse gram etc., has recorded lowest sowing during the last year due to scanty rain fall and naturally this phenomenon will result in poor yields in the days to come. Reports say that the water levels in dams are dipping at an alarming rate which will invariably have a negative impact on electricity generation and people are fearing acute power cuts. The drought has set in a situation wherein people have to get ready to face hardships in different forms like food shortage, water shortage, power shortage, fuel crisis, migrations etc. Perhaps a time is fast approaching where in people should gear up to face the ill effects of drought courageously and intelligently. In order to accomplish this, green entrepreneurship might give a satisfactory solution and people should make up their mind to turn as green entrepreneurs in the wake of drought.

REVIEW OF LITERATURE

Parminder Kaur and Dr. Surinder Kaur, (2023), under took research with the topic "Green entrepreneurship in India: A study of select green businesses". The researchers aimed to investigate the drivers of green innovations as well as their potential and obstacles through an exploratory methodology that used secondary data, including five in-depth case studies of green entrepreneurs to explore their motivational factors and key impediments. They found that the motivations behind green entrepreneurs are social, environmental, and financial objectives. The primary barriers to green entrepreneurship include a lack of funding, high investment costs, a lack of knowledge about green technologies, and difficulty breaking into the market because of the high related costs. The research article was published in - Asian Journal of Management and Commerce 2023; 4(1): 116-122 Arjune S, V Srinivasa Kumar (2023) under took research with the topic "Factors influencing students towards green entrepreneurship willingness in delta districts of Tamil Nadu and suggestions for their betterment". The research study identified the necessary conditions for the growth of "green innovation," in addition to the elements that both encourage and obstruct it. Since students represent our country's future, the primary goal of this study was to determine their propensity for green entrepreneurship. Structured questionnaires were used to collect study data. The study's topics included demographics, attitude, educational assistance, subjective norm, self-efficacy, risk aversion, and achievement in and of itself. The article makes intelligent recommendations for supporting environmentally sustainable company endeavors. Lastly, this study will help decision-makers by examining the willingness and interest of today's students in green entrepreneurship. The research article was published in Eighth International Conference on Science Technology Engineering and Mathematics (ICONSTEM). Orji, Evelyn Ijeoma, Idika, Delight Omoji(2023), under took research with the topic "Global Warming and Impacts: Green Entrepreneurship to the Rescue" This essay explores the role of green entrepreneurship, also known as greening and green technology, and supports it as a practical response to climate change. Stakeholders must move quickly to improve young people's green entrepreneurship competencies because the entire growth of green entrepreneurship in Nigeria is anticipated to come with the creation of a sustainable environment. According to the author, there is hope that green entrepreneurship will help talented young people become strong and self-sufficient while simultaneously playing a crucial role in halting global warming. This article was published in Shodh Sari-An International Multidisciplinary Journal · October 2023 with ISSN: 2959-1376. Rajkamal S.V A, J. SenthilVelmurugan, B M. Suryakumar (2022) under took research with the topic "Green Entrepreneurs Challenges and Innovation: The Struggles They Face". The study's conclusions showed that there was no correlation between age and the possibility of starting a business that used professional or technical competence. For the study, they selected 50 respondents overall from Salem's large population using a technique called snowball sampling. which was published in International Journal of Professional Business Review with ISSN

2525-3654. Manisha Gupta and MridulDharwal (2022), undertook research with the topic "Green entrepreneurship and sustainable development: A conceptual framework" and the study reveals thatthe concept of green entrepreneurship is still very young, but it is quickly maturing. Making environmentally friendly products is the main goal of both ecological sustainability and business, and indicates the further scope of the research that the current study aims to highlight available literature on green entrepreneurship and sustainable development to propose a conceptual model for further research. Aswathy TR, and Dr. N. Arun Fred (2022), under took research with the topic "Emergence of Green Entrepreneurship in Kerala; A Solution for Sustainable Growth and Development" and based on factors including green innovation, green manufacturing, and green marketing, the research shows how green firms have grown. Part of the reason for the increasing popularity of green entrepreneurship is consumer demand for eco-friendly goods. Using a structural equation model, they were able to determine the constructs' fitness and the individual contributions of each of the 100 green entrepreneurs in Thiruvananthapuram. In the article, the concepts of "green innovation," "green production," and "green marketing" are contested as the primary drivers of the rise of green entrepreneurs. The primary driver of the expansion of green entrepreneurs is this green manufacturing. Environmentally conscious business Create new company concepts that, if implemented, might result in long-term economic growth. The researcher has published the article in International Journal of Mechanical Engineering with ISSN 0974-5823. Dr.G.N. Ramakrishna &Dr.Rajanna K(2022), under took research with the title "The studies illustrate that consumers are now much conscious about the health and environment. Possibly this may be the reason, that the concept of green product and green marketing are taking place gradually and progressively in the market." The survey demonstrates the extent to which consumers have grown more health and environmental sensitive. This might be the reason why the concept of green products and green marketing has been introducing into the market gradually. It may also offer a chance for companies to rethink their products and services with an eye on the environment and for innovation, and to see chances for green entrepreneurs in the context of shifting market conditions. This article is published in EPRA International Journal of Economics, Business and Management Studies (EBMS) with ISSN: 2347-4378. MukulBhatnagar, Sanjay Taneja and ErcanOzen (2022), under took research with the topic "A wave of green start-ups in India—The study of green finance as a support system for sustainable entrepreneurship" TheScholars have carried out an evaluation to ascertain the present condition of environmentally-friendly financing in India and its impact on enterprises. The paper claims that government initiatives are getting greener by providing green money, and Indian businesses are utilizing this by embracing sustainable entrepreneurship. The researchers have published in AIMS press journal with ISSN 4(2): 253–273

Gabriela Alina Anghel and Mihai AlinAnghel (2022), under took research with the topic "Green Entrepreneurship among Students—Social and Behavioral Motivation" and the research's justification of particular student traits when tackling an issue like green entrepreneurship. It all began with the idea that awareness of the possibilities of starting a green firm and the degree to which entrepreneurial skills are being developed will directly correlate with the growth of interest in green entrepreneurship. ANOVA and the Chi-Square test were used in the study's methodology, and the findings show that the research subjects' interest in green entrepreneurship has grown. This fact shows that a Likert-type scale was used to give values, and that the values between 4 and 5, with 5 being the highest level, were averaged to get these numbers. This implies that students are becoming more interested in green entrepreneurship. The assigned values obtained are: 18–22 age (m = 4.1532), 22–25 age (m = 4.4375), 26–28 age (m = 4.4375), 29–39 age (m = 4.2396), and the over 39 age (m = 4.2750). the researcher published this article in MDPI Journal. Y.D. Nayak and A.P. Sahoo (2021), under took research with the topic "Green Entrepreneurship in India" They published a theoretical framework that elucidates the relationship between several institutional, social, and environmental factors and green entrepreneurship, which is a prelude to sustainable development. The researchers' inquiry into green entrepreneurship is exploratory in nature since it sheds light on the origins of the concept and its application in the Indian setting. The research article was published in International JournalAgrl. Research Innovation Technology with ISSN 2224-0616. Seema Potluri and B. V. Phani (2021), under took research with the topic "Green Entrepreneurship: A Disruptive Mitigation Strategy for Climate Change", the study activities that are grounded in local settings and people's demands for social progress can mitigate the effects of global climate change because they will increase individual and local community awareness. The study concludes that these benefits hold true everywhere, regardless of location. The author makes the case that if innovative green technologies were to

replace well-established non-green ones, the global economy would decarbonize more quickly. This concept differs from the global consensus model's top-down methodology, which has been tried and tested over the last few decades with varying degrees of success. This article was published in springer open source with ISBN: 978-1-4614-6431-0_165-1. CS Roshni Sharma (2020), under took research with the topic "Analysis of Green Entrepreneurship Practices in India". The study discovered that one of the causes leading to youth unemployment and sustainability challenges is the low entry-level criteria for becoming an entrepreneur for a variety of environmentally sensitive firms. The study comes to the conclusion that the coordinated promotion of green entrepreneurs should be the main area of interest for green entrepreneurship research in India. Startups need both technological and financial backing to grow. Thanks to major local enterprises, the State has been able to support entrepreneurship. The research article was published in International Journal of Advanced Research in Commerce, Management & Social Science ISSN: 2581-7930. SeemaPotluri and B V Phani (2020), under took research with the topic "Women and green entrepreneurship: a literature based study of India". According to the study, women may be drawn to entrepreneurship as a way to balance their obligations to society and their careers. It has been found that these women would be more likely to pursue ecopreneurship because of their ingrained social conditioning and lack of incentives. Furthermore, their innate drive to preserve the environment might be a distinguishing characteristic in the development of "ecopreneurship." The article has published in International Journal of Indian Culture and Business Management Vol. 20 No. 03. Kartika Nuringsih, Nuryasman MN (2020), Jenifer under took a research with the topic "Role of Green Entrepreneurship in Raising the Effect of Green Value toward Sustainable Development"This study investigated how entrepreneurial students in Jakarta, Indonesia perceived the connection between green value, GE, and sustainable development. As a result, a linkage model was developed that successfully communicates the viewpoint of the millennial generation on the new model of entrepreneurial growth and its relationship to sustainability. These relationships aid in MES's environmental awareness and education. This article was published in International Journal of Economics, Business, and Entrepreneurship Vol. 3 No. 2 (2020)

Choongo, Emiel L. Eijdenberg, John Lungu, and MwansaChabala, (2020) "The Influence of Environmental Pollution and Drought on the Satisfaction With Life of Entrepreneurs in Zambia's Mining Sector" This research set out to look at the abundance in developing countries. However, there hasn't been much research on how environmental degradation, drought, and climate change affect entrepreneurs' well-being or life satisfaction in developing countries. According to the study, environmental degradation and drought have a negative effect on business decision-making and profitability. The findings offer fresh perspectives on the subject and practical suggestions for lawmakers, educators, and company owners. The article is published in National Library of Medicine. StutiHaldar (2019), under took research with the topic "Green entrepreneurship in theory and practice: insights from India" The study looks at how environmental, social, and economic issues affect the rise of green entrepreneurship and how it helps to advance sustainable development. Because of this, eco-conscious customers and businesses are making the most of the present Indian market conditions by reevaluating and developing their products with an eye on the environment. This article was published in International Journal in Green Economics, Vol. 13, No. 2, 2019. Ms. Gagan Bhandari (2018), under took a research with the title "Analysis of Green Entrepreneurship Practices in India" The study of climate change and the limitation of natural resources we are trying to change the economy from one that is unsustainable to one that is sustainable through a number of green projects. Our objective is to cultivate the upcoming cohort of entrepreneurs who possess the ability to identify and capitalize on green business opportunities. It resulted in developing new markets for products and services that are in line with society expectations and changing lifestyles, balancing the company's economic and ecological aims, and offering goods and services that inspire customers to adopt more environmentally responsible behaviors. This article is published in Journal of Emerging Technologies and innovative research with ISSN-2349-5162. Mr. Solomon K Peter and Dr. RamanujamVeluchamy (2018), under took a research with the title "Green Entrepreneurship–The Right Way To Sustainability and Profitability for Rural Areas." The consequences of green entrepreneurship on organizations and society were examined in this study, which concentrated on a few rural areas in Kerala. According to the report, there are plenty of chances for aspiring green entrepreneurs, and their ventures will benefit society as a whole. The amount of money the government must spend on environmental development and preservation is decreased with the aid of green entrepreneurship. Selecting eco-friendly items will contribute to a decrease in air pollution, industrial waste, and electrical waste. This

article is published in Journal of Emerging Technologies and Innovative Research (JETIR) with ISSN 2349-5162. StutiHaldar(2017), under took research with the topic "Green Entrepreneurship in the changing market scenario in India" This study is exploratory in nature as it offers insights into the emergence of the concept of green entrepreneurship and its role in the Indian context and the study proposes a conceptual model which explains the nexus between environmental, economic and social factors in development of green entrepreneurs which further leads to achievement of sustainable development. The study highlights the opportunities and challenges for green entrepreneurship development, in light of the initiatives taken by business houses, individuals and the Government of India by taking up case studies of successful green entrepreneurship ventures. This article was published in Twelfth Biennial Conference on Entrepreneurship Publication. ISBN: 978-93-80574-93-6. Lindsay Clinton and Rochelle March (2015), under took research with the topic "Drought, urbanization and climate: big business opportunities for long-term thinkers", According to the report, by 2025, these portfolio expansions ought to account for 20% of total free cash flow, reducing the company's reliance on pulp and increasing its prospects for long-term corporate growth in light of impending sustainability concerns. One of the main elements promoting sustainability, according to the report, is growing urbanization. Half of all people on Earth currently reside in cities; by 2050, that percentage is predicted to rise to 66%. There will probably be a pressure on infrastructure, food security, waste management services, transportation networks, and waste management systems with an extra 2.5 billion people living in cities. This article is published in The Guardian International online edition

RESEARCH GAP

The above literature reviews clearly identifies the research gap. It is apparent that The research is very scanty as far as opportunities for green entrepreneurship during drought seasons are concerned and hence it can be inferred that the topic chosen for research is apt and researchable.

Problem Statement

Drought is a time period which will usher in many bottle necks such as drinking water shortage, food shortage, fodder shortage, power crisis, job and pay cuts etc and severe droughts have proved to be disastrous in the history. People have to gear up to face such situation with courage and confidence by being drought warriors, who would serve the society by becoming green entrepreneurs who would contribute immensely for the wellbeing of society during such calamities. Calamities like drought, which is viewed as threat should be converted into opportunity by becoming green entrepreneurs who would not only incorporate a few environment sustainability measures during drought but also secure financial stability of the stake holders.

Objectives of the research
1. To unearth the 'green entrepreneurial opportunities' in the wake of drought
2. To elaborate on the methodology that how such opportunities should be implemented

Limitations of the research
1. The study will pin point the green entrepreneurial opportunities that may be implemented only during drought and famine like situation
2. The core of this research gives suggestions and recommendations in connection with green entrepreneurial opportunities during drought, which can not be taken as final and ultimate.

RESEARCH METHODOLOGY

Type of Research : exploratory
Nature of data : Primary and Secondary
Data Collection Tool : Primary Data is Collected through Telephonic interview with officials such as   project implementation officers , public relation officers of BAIF Karnataka Region. Secondary data is collected through

Magazines, Periodicals , News Paper Special Editions , Agriculture Magazines.Data Analysis and Interpretation method : The likely problems during drought , likely scope for green entrepreneurship for such problems during drought is quoted and subsequently a brief narration is given as how it may be successfully implemented. The problems that will pop up during drought are mapped to 3 categories depending on its severity as "Very Severe", "Severe" and "Mild". Subsequently the scope for Green Entrepreneurship in the light of those problems were mapped to 2 categories as "High Scope" and "Moderate Scope". Prima facie 8 such problems were identified which will surface during drought season and how those 8 problems can be converted into opportunity during drought by becoming green entrepreneurs is discussed in the data analysis.

Findings and Inferences:

(1) It was found from the data analysis that sowing seeds shortage, drinking water shortage, food grains shortage of soil can cause "Very Severe" problems during drought to which there the opportunities to green entrepreneurship having "High Scope". Therefore it can be inferred that the problems which are "Very Severe" during drought paves the path for "High Scope" for green entrepreneurship.

(2) It was found that from the data analysis that fodder shortage and power shortage and weakening of soil can cause "severe" problems during drought and fodder shortage and power shortage can create "moderate scope" for green entrepreneurship , whereas weakening of soil can create high scope for green entrepreneurship. Therefore, it can be inferred that two problems which are "severe" can pave path for 'moderate scope' for green entrepreneurship and one problem which is 'severe' can create 'high scope' for green entrepreneurship

(3) It was found from data analysis that 'health hazards during drought' and 'lack of knowledge about legal aspects of drought' can cause 'mild' problems during drought which can create 'moderate scope' for green entrepreneurship. It can be inferred that there are only two problems which can create 'moderate scope' for green entrepreneurship during drought and chances for taking green entrepreneurship ventures under these two problems can be scanty.

CONCLUSION

From the findings it can be concluded that invariably there would be challenges and bottle necks which the drought will usher in but the farmers, entrepreneurs and other stake holders need not dishearten and panic as these challenges can be converted into entrepreneurial opportunities and the entrepreneurs can bank on the hiccups posed by drought. From the findings it is apparent and can be concluded that there are hiccups which can be categorized under "severe" and "most severe" to which it the study revealed the entrepreneurial opportunities can be mapped and finally it can be inferred that the drought like situation is quite a natural phenomenon and being responsible citizens one should discover how the hiccups or challenges posed by nature should be converted into an opportunity for the wellbeing of a society as a whole.

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Table:1 Data Presentation and Analysis

Problems during drought	Scope for Green Entrepreneurship	Implementation	Severity of Problem	Scope for Green Entrepreneurship
Sowing seeds shortage	Establishing "Seeds Bank" at homes and agricultural co operative societies	Green entrepreneurs should start accumulating stock of seeds of food grains at "seeds Bank" which	Very severe	High Scope

		can be stored for a long time and can distribute it to the needy in return for a consideration		
Drinking water shortage	Upkeep of water bodies, reservoirs etc	Green entrepreneurs should accumulate volunteers to join hands to clean silt and weeds grown in and around water bodies and reservoirs. The volunteers get paid for this scheme from Central Government under "Employment Guarantee Scheme Under Drought" up to 150 days of human labour	Very severe	High Scope
Food Grains Shortage	Switching over from growing conservative crops to drought resistant millets (Siri Dhanyas)	Green Entrepreneurs can indulge themselves in growing less water demanding, pest resistant, Ailment resistant, drought resistant short term millet crops such as fox tile millet, haraka, oodalu, bajra, koralu etc rather than growing long term, heavy water demanding crops such as paddy, wheat etc. These 'Siri Dhanyas' has good market demand as well, which can also secure financial interest of green entrepreneurs	Very severe	High Scope
Fodder shortage	Establishment of 'Fodder Banks' and growing tree based fodder to cattle, sheep etc	Green Entrepreneurs should take initiative in establishment of "Fodder Banks" where in enough stock of nutritious "Dried Fodder" could be stored during drought	severe	Moderate Scope

		season and sell it to needy. Green entrepreneurs can also think of switching over from conservative fodder types such as paddy grass, green grass to the cattle to short term, nutritious , less water demanding, high yielding 'Tree Based Fodder" such as 'Caliandra ' 'Subabul' to the cattle .		
Power Shortage	Encouraging people to use alternate sources of energy by venturing into 'power entrepreneurship'	Power Shortage is a common phenomenon which one could experience during drought. As the water levels in the reservoirs dips, hydro electricity generation also dips leading to acute load shedding. Green entrepreneurs can go in for encouraging people to use solar energy , wind mill , using generators run by bio fuels etc , as an alternate source of power. Green entrepreneurs can think of taking up entrepreneurial opportunities in this connection which can be highly rewarding to them.	severe	Moderate Scope
Health Hazards during drought	Volunteering to be 'health warrior' in the Government launching 'Health Camps'	During drought, people suffer from many kind of health hazards such as diarrorhea, malnutrition etc and in such circumstances Government mobilizes 'Health Camps' to aid the drought victims.	Mild	Moderate Scope

		During such time Government would need volunteers to educate the victims and help them during drought by supplying necessary food, water and medicines. Green entrepreneurs can be a part of such health camps and it can be remunerative also		
Lack of knowledge about legal aspects pertaining to drought	Conducting workshops/seminars and being a resource person	Many of the citizens will not be aware about the legal aspects pertaining to drought. There are many sections and provisions covered under 'National Disaster Management Act' which pinpoints towards Government aid, remedial measures and drought relief funds etc about which citizens have scarce knowledge. Green Entrepreneurs, in order to educate people regarding the drought relief methods , covered under different statutes can conduct workshops/seminars and they can even be resource persons which will be lucrative to them	Mild	Moderate Scope
Weakening of Soil	Volunteering and pooling volunteers to conserve soil which is weakening by virtue of drought	It is very common during drought that the soil gets weakened due to acute water shortage and becomes unfertile, if left unattended unfertile soil will lead to long term problems post	severe	High Scope

		drought. Green Entrepreneurs can address this problem by volunteering and pooling volunteers who can indulge themselves in mulching and composting activities by creating selfhelp groups in village levels to conserve soil and keep it fertile for a long time .		
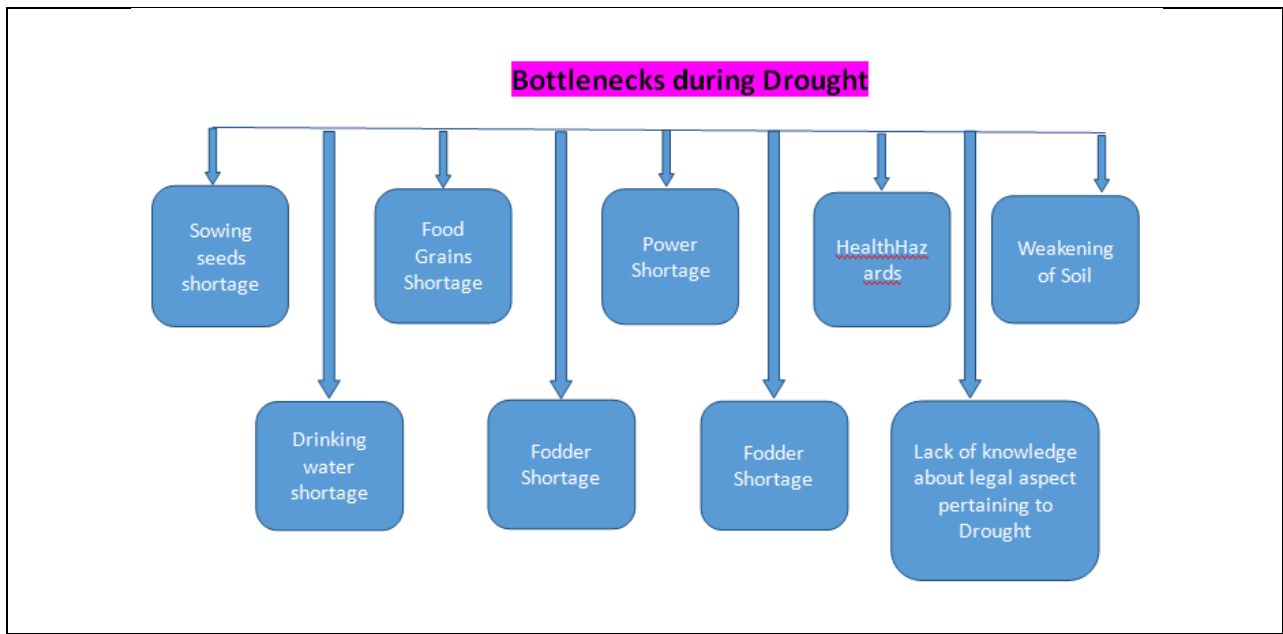
Figure:1 Bottlenecks during Drought

RESEARCH ARTICLE

Women Entrepreneurship in Fostering Sustainable Livelihood for Weaker Women in the Society

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ABSTRACT

The purpose of the study is to identify the factors influencing sustainable livelihood of weaker women and analyse the impact of women entrepreneurs' contribution in enhancing the sustainable growth of their women employees. The study employed a descriptive research strategy, with data collection being conducted through a well-designed questionnaire. The Cochran formula was employed to estimate the sample size for an unknown population, resulting in a sample size of 116 respondents. Women employees who have been employed by women entrepreneurs for the past five years were chosen using a convenient sampling method. The questionnaire's validity and reliability were confirmed through scale analysis. The present study employed Confirmatory Factor Analysis (CFA) through the use of AMOS R software for statistical analysis. The study findings suggest that women's sustainable survival is impacted by various factors, including their health status and access to food security. The capacity of women to maintain a stable income is adversely affected by family expenses and credits. The findings also reveal that women entrepreneurship is fostering the sustainable livelihood among the weaker section of the society. The Indian context exhibits a dearth of research on sustainable livelihoods, particularly with regard to assessing the sustainability of marginalized communities which is contributed by women entrepreneurship and implementing appropriate remedial measures. The findings of the study can be

useful to women entrepreneurs in creating a work environment which empowers weaker women to grow sustainably.

Keywords: Education Power, Food Safety, Natural Resources, Living Approaches, Sustainable Livelihood.

INTRODUCTION

As per a report published by BCG, enterprises led by women have the potential to generate cumulative revenue that is 10% higher over a period of 5 years, and exhibit a work culture that is 3 times more inclusive as compared to businesses led by men(Kinara capital, 2022). Female entrepreneurs are increasingly embracing digitalization and technology adoption as a means to mitigate the gender gap and secure financial access from private lenders, non-banking financial companies (NBFCs), and banks(Bureau, A. N., & A., 2023). The utilization of digital technology can potentially decrease reliance on male counterparts and increase awareness of women's business development programs and alternative collateral-free lending options in the market(Pachorkar, S., Kawishwar, S., & Sharda, P., 2020).At present, female entrepreneurs make a contribution of approximately 3% to the overall industrial output and provide employment opportunities for roughly 10% of the total workforce. The provision of employment generation is expected to bring about a positive impact on the Indian economy by increasing productivity and generating financial efficiency(Barrachina Fernández, M., García-Centeno, M. D. C., & Calderón Patier, C., 2021). The examination of women entrepreneurs continues to captivate individuals' interest and reignite their imagination regarding the functioning of gender equality within the realm of business(Lepeley, M. T., Kuschel, K., Beutell, N., Pouw, N., & Eijdenberg, E. L. (Eds.). , 2019).The establishment of an inclusive and supportive environment for women entrepreneurs serves as a catalyst for advancing economic empowerment within an underrepresented demographic(Agarwal, S., Ramadani, V., Dana, L. P., Agrawal, V., & Dixit, J. K., 2022).

Concurrently, it enhances the allocation of resources within the economy. Consequently, the present study on women entrepreneurs examines the various roles undertaken by women in their capacity as entrepreneurs within the micro, small, and medium enterprises (MSME) sector, with a specific focus on the impact of these roles on the long-term sustainability of urban poor livelihoods(Kamberidou, I., 2020). In recent times, there has been a growing recognition of the significance of women's entrepreneurship and its impact on national development, owing to the valuable contributions made by micro- and small-medium enterprise (MSME) entities towards socio-economic well-being(Agarwal, S., Lenka, U., Singh, K., Agrawal, V., & Agrawal, A. M. (2020). The integration of women into the micro, small, and medium enterprises (MSME) sector is anticipated to yield significant socio-economic implications for economically disadvantaged women(Kanapathipillai, K., & Azam, S. F. (2019).This inclusion is expected to facilitate their access to employment opportunities, enhance their social status, and enable them to attain economic independence, thereby augmenting their personal capacities(Uddin, M. ,2021). The primary objective of this study is to investigate the socio-economic implications of women entrepreneurs and managers in micro, small, and medium enterprises (MSMEs) on the local sustainable livelihood of the rural poor. This study examines the various benefits received by the weaker section employees employed under women entrepreneurs in Bangalore on their lives and explores potential strategies for enhancing their actions to promote greater sustainability(Raman, R., Subramaniam, N., Nair, V. K., Shivdas, A., Achuthan, K., & Nedungadi, P., 2022).   Given this context, it is imperative to comprehend the impact of Women Entrepreneurs IN fostering sustainable livelihood for weaker women of the society. The initial segment of the document presents the introduction, followed by a section that elaborates on the previous literature. Subsequently, the third section expounds on the research methodology employed in the study. The present study adheres to established research methods and subsequently presents the findings and corresponding analysis. The conclusion section provides the final remarks, suggestions, and potential avenues for future investigation.

REVIEW OF LITERATURE

In this study, a systematic literature review was applied to analyse prior works that were relevant to the research concerns that were being investigated. There were a total of 30 papers discovered after using the keywords "Women entrepreneurship …..," "Women entrepreneurship in India ……. ", "Sustainable livelihoods ......," and "Impact of women entrepreneurship on sustainable livelihoods……". Following an evaluation 20 articles that were included in the study were published in journals that are widely recognized for their academic rigor and reputation. Specifically, 2 articles were published in the Elsevier database, 2 in the Routledge and CRC Press Taylor and Francis database, 2 in the Emerald Group Publishing database, 3 in the Springer Nature database, and 3 in the Sage database. The study makes reference to three articles that were published in the Directory of Open Access Journals, as well as two journals that are included in the Semantic Scholar databases. Several additional papers were obtained from scholarly databases such as Wiley, Academia, JSTOR, and Guildford Press.

The review of important literature on the topic is presented as follows
A plethora of studies have been conducted to examine the socio-economic implications of women's entrepreneurship on the women who initiate business ventures, both within the Indian and international contexts. According to (Gurendra Nath Bhardwaj and Swati Parashar, , 2013), the advancement of women's social and economic status plays a crucial role in the overall economic development of any culture or country. In their article, (J.V. Joshi and Madhura Despande,, 2005)found that women entrepreneurs in Marathwada were employing traditional methods to manage their businesses. In their scholarly article titled "Women Entrepreneurship - Factors Contributing to Success of Women Led Enterprises," (Mayura Kemkar and Jyoti Sharma, 2016)assert that the economic climate of a nation is predominantly shaped by the entrepreneurial inclination exhibited by its populace. According to Shah, Hina & Saurabh, Punit. (2015),there exists a necessity to enhance the status of women, and the promotion of women's roles in development is now recognized as more than just a human rights or social justice issue. According to Arnaud Daymard (2015)the involvement of women in entrepreneurship can lead to an expansion of their economic opportunities and contribute to broader development efforts, including poverty alleviation. In her essay titled "Women Entrepreneurship Changing Status," Sujatha Mukherjee (2013)examines the phenomenon of women from low-income families resorting to entrepreneurship as a means of survival. In their study, Camalun Nabi and Ashok Kumar (2012)identified a potential correlation between the state's underdevelopment and the limited presence of entrepreneurial talent and potential among its citizens. According to Sithalakshmi and Jothimani (2012), in order for lasting transformations in women's societal standing to transpire, it is imperative to provide women with structured intervention initiatives such as income-generating projects or opportunities for independent or collective income generation. The objective of this research was to investigate and delineate the economic impact made by a specific group of female entrepreneurs within their respective societies (Kathie L., 2012).

Limited research exists on the impact of women's entrepreneurship within marginalized communities. Numerous studies have been conducted on the topic of sustainable livelihoods within an international context.Bayu, E. K. (2021)examined the topic of interest. This study employed a case study approach to examine the significance of off-farm and non-farm activities in the preservation of sustainable livelihoods for rural households. Since the 1990s, several prominent international organizations have employed the Sustainable Livelihood Analysis (SLA) approach to integrate development interventions(Su, M. M., Wall, G., & Wang, Y.,2019).The current state of academic research on sustainable livelihoods in the Indian context is limited, particularly in relation to assessing the sustainability of vulnerable populations and implementing appropriate interventions. Numerous studies have been conducted to investigate the impact of women led Micro, Small, and Medium Enterprises (MSMEs) on employment generation. In a study conducted by Gangadharappa (2019),one prominent advantage of the micro, small, and medium enterprises (MSMEs) sector lies in its labor-intensive nature, as opposed to being driven primarily by capital. India possesses a significant abundance of human resources. Micro, Small, and Medium Enterprises (MSMEs) play a crucial role in offering educational prospects to individuals with limited skills and contribute to the development of local human capital within society. In his study, Kumar (2017) endeavors to comprehend the significance of Micro, Small, and

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Medium Enterprises (MSMEs) in facilitating employment opportunities and fostering inclusive economic growth within the nation. According to Das (2017), the study titled "Micro, Small and Medium Enterprises (MSME) in India: Prospects, Issues, and Challenges" reveals that Women MSMEs play a crucial role in supporting a favorable economic growth rate and generating employment opportunities. There is a dearth of scholarly literature pertaining to the role of Women Micro, Small, and Medium Enterprises (MSMEs) in facilitating sustainable livelihoods and promoting socio-economic advancement among women belonging to marginalized segments of society. Gap- The precise impact of Women entrepreneurship on sustainable livelihood is unknown because the relationship between the two has not been researched sufficiently. There is a need to address possible difficulties due to the complex nature of the women entrepreneurship on the weaker women of the society nexus. By creating a methodology to evaluate the effects of women entrepreneurship on the sustainable livelihoods of vulnerable groups, this study fills the aforementioned gaps in the existing literature.

RESEARCH METHODS

The present study utilizes a descriptive research design(Siedlecki, S. L.,2020) that employs quantitative data analysis(Samuels, P., 2020).A sample size of 100 women employees associated with MSME women entrepreneurs was determined using the Cochran formula for unknown populations with a margin of error of 10%(Nanjundeswaraswamy, T. S., & Divakar, S., 2021)Subsequently, 140 questionnaires were disseminated. The study received a total of 126 responses, but after removing outliers, only 113 responses were deemed suitable for analysis. The women who were below the poverty line and are employed any MSME women entrepreneurs for atleast 3 years are part of the study. The researchers developed a comprehensive questionnaire by adapting the scales of previous studies. Specifically, the questionnaire consisted of 7 items derived from Rathnamma.G (2015)study, and 15 items sourced from (Malanga, D. F., & Banda, M., 2021)study. The questionnaire was well-structured and designed to elicit relevant information from participants.The reliability and validity of the questionnaire were confirmed through the application of statistical measures such as Cronbach's alpha, composite reliability, average variance explained, and inter-item correlations. The statistical analysis for the study was conducted utilizing the SPSS (Rode, J. B., & Ringel, M. M., 2019)and AMOS software (Thakkar, J. J., & Thakkar, J. J.,2020)

RESULTS AND DISCUSSION

Demographic Profile of the Participants
The participant pool consists of a majority of 64% males and 36% females. The age group of 36 to 45 years accounted for the largest proportion of participants, comprising 39% of the total. Following closely behind, 30.9% of participants fell within the age range of 46 to 55 years. Only a marginal proportion of the participants, specifically 8.1%, were found to be above the age of 55. Academic credentials Fifty percent of the participants had achieved a level of education encompassing completion of schooling and basic education. Twenty-two percent had attained completion of their Secondary School Leaving Certificate (SSLC), while ten percent had successfully completed their Pre-University Course (PUC). A minute proportion, specifically 6% and 10%, had successfully attained their undergraduate and technical qualifications. The study revealed that the majority of participants, specifically 69.1%, reported being married. Additionally, 13.4% of participants reported being unmarried, 6.8% reported being divorced, and 10.6% reported being widowed. A total of 42.8% of the participants reported having two children, while 19.7% reported having 2-3 children. Additionally, 37% of the participants in the study indicated that they did not have any children. A total of 55.9% of the participants indicated that their families consist of 3-6 members, while 31.4% of the participants reported having 6 to 9 individuals in their households, according to the findings of the study. A majority of the study's participants, specifically 71.1%, reported that their families relied on a single income earner. A total of 47.1% of the participants reported having a monthly income of less than 10000, while the remaining 52.9% indicated having a monthly income exceeding 10000. The demographic profile reveals that individuals belonging to the economically disadvantaged segment of society possess a significantly lower income and rely on a single

breadwinner within the family, while also having a larger number of dependents. This particular scenario necessitates the requirement of efficient participation from women entrepreneurs in the Micro, Small, and Medium Enterprises (MSME) sector, as it has the potential to improve their long-term and viable means of living.

Item analysis – Women entrepreneurship

The sustainable economic development of marginalized populations, particularly women, is a critical concern within contemporary development policies implemented in developed nations. The issue of politically motivating women to enhance their well-being and living conditions has garnered significant attention and sparked discussions on a global scale. An investigation into the perceived contribution of Women entrepreneurs indicates that the respondents exhibited a neutral level of agreement towards the statements. The mean score for contribution of women entrepreneurs towards gain in self –employment opportunities and availing the benefits of development projects have a low mean score of 2.880 indicating less contribution in these areas. The women participants of the study agreed that women entrepreneurs contribute to gain control over economic assets and achieve financial independence, achieve the goal of economic self-sufficiency, improve their saving ability and develop professional skill and competence with mean scores above 3.000. The following section provides an item analysis of participants' opinions regarding their present sustainable livelihood status.

Item analysis – Sustainable livelihood

The concept of Sustainable Livelihood arises from the convergence of developmental and environmental studies, providing a novel perspective on the notions of labor, manufacturing, and allocation. This concept specifically addresses the labor of vulnerable populations with the aim of establishing a sustainable future in which household inequality is eradicated. The following table shows the current status of the participants of the study on the 11 factors of sustainable livelihood. The mean score for access to services and institutions was determined to be 2.95, which is below a value of 3. This finding indicates a lack of agreement among the participants regarding the range of their responses. The calculated standard deviation is less than 1.000, suggesting a diminished level of variability in the responses provided by the participants. This finding indicates that individuals who belong to disadvantaged groups demonstrate similar attitudes regarding their access to services and institutions. In relation to employment-related data, three primary considerations were identified: the viability of engaging in extended working hours, the potential for engaging in overtime work, and the accessibility of weekend and holiday employment opportunities. The participants in the study demonstrated a substantial level of response, as indicated by an average score of approximately 4.5 for all items. This score reflects a high level of agreement among the respondents regarding their ability to actively pursue family or future sustainability.

The relatively low standard deviation of 0.624 indicates a significant level of agreement among participants in their perspectives on working information. In relation to the matter of accessibility to natural resources, it is noteworthy that all sustainability items, with the exception of sustainability 21, which specifically pertains to solar panels, obtained an average score surpassing 4. The average score for solar panels was 1.48, suggesting a relatively low level of adoption among the participants. However, it is worth noting that the average scores for natural resource accessibility were generally elevated. Based on the data, it can be observed that the responses exhibit a spectrum ranging from neutrality to agreement, as exemplified by the numerical value of 3.73. Furthermore, it is worth noting that the data exhibits a standard deviation of 0.67. In relation to credit and savings, a significant proportion of participants expressed a dearth of savings and a lack of outstanding loans. Therefore, the majority of the responses regarding credit and savings were characterized by neutrality or conveyed disagreement and negative sentiment. As a result, the mean score falls below 3.00, which serves as a promising indicator of enduring welfare. Typically, individuals who are situated within the lowest socioeconomic stratum demonstrate a food security status that is characterized by a lack of both positive and negative outcomes. The standard deviation value of 0.76, as determined through calculations, suggests that there is a relatively limited amount of variation in the viewpoints of the participants regarding food security. After conducting an investigation, it was ascertained that an average score of 3.69 was achieved, indicating a trend of individuals from disadvantaged backgrounds gradually attaining a more

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prominent social standing. Moreover, these individuals themselves recognize that they are acquiring a certain level of influence, thus demonstrating characteristics associated with sustainability.

Factors influencing sustainable livelihood

Confirmatory Factor Analysis (CFA) is a statistical methodology utilized by researchers to evaluate a predetermined hypothesis regarding the relationship between the experimental and latent variables. The formulation of this hypothesis is commonly influenced by the integration of theoretical understanding and empirical observations. Janssens et al. (2008) assert that employing this approach aids researchers in validating instruments and confirming the hypothesized factor structure. Factor loadings are employed to understand the regression coefficients. Researchers have the ability to assess the quality of measurement by integrating the CFA (confirmatory factor analysis) and construct validity assessments, as suggested by Hair et al. (2010).The present study employs confirmatory factor analysis to examine the factors that influence the sustainable livelihood of marginalized populations within society. The statistical indicators of model fit indicate that all criteria for a robust model have been met, with significance levels below 0.05. The outcomes of the model are deemed acceptable and can be utilized for inferential purposes. The diagram depicted above illustrates the interdependent framework of sustainable livelihood components and their collective impact on the livelihood of marginalized communities. The table presented below displays the unstandardized and standardized estimates pertaining to the factors that impact sustainable livelihood, along with their corresponding p-values.

The aforementioned table depicts the correlation among diverse factors that impact the sustainable livelihoods of disadvantaged populations. The objective is to determine the factors that have the greatest positive impact on sustainable livelihood. From the above table it can be indicated that when sustain_10 Financial Wellbeing- positively goes up by 1, sustainability goes up by 0.758 or 78% which is statistically significant at 0.000 and CR of 3.729. (Co-eff =0.758, Sig=0.000, CR=3.729), When Sustain_9 food safety positively goes up by 1, sustainability goes up by 0.343 or 34% which is statistically significant at 0.000 and CR of 2.761. (Co-eff =0.13, Sig=0.000, CR=17.123)On an overall basis, it can be inferred that the Financial Wellbeing and Food safety factors positively affect the sustainable livelihood of the weaker section. Credits and family expenses inversely affect the sustainable livelihood of the participants.   *The results of the SEM Analysis indicate that* ,there is both positive and negative impact of various factors of sustainable Livelihood *on the life of weaker section of the society, The Null Hypothesis is rejected.*

Impact of Women entrepreneurship on the sustainable livelihood of the weaker section

The statistical indicators of model fit indicate that all criteria for a robust model have been met, with significance levels below 0.05. The outcomes of the Impact of Women Entrepreneurship on the sustainable livelihood of the weaker section model are deemed acceptable and can be utilized for inferential purposes. The table presented below displays the unstandardized and standardized estimates pertaining to the impact of Women Entrepreneurship of sustainable livelihood, along with their corresponding p-values. When contribution of Women Entrepreneurs goes up by 1, sustainable livelihood of the weaker section of the society goes up by 0.541 or 54% which is statistically significant at 0.000 and CR of 2.332. (Co-eff =0.541, Sig=0.000, CR=2.332). Many previous researches have demonstrated that Women Entrepreneurship aids in the long-term growth of rural areas, underprivileged groups, and women specifically. Consistent with earlier research, the current study found that increased access to work opportunities has a positive effect on people's ability to maintain sustainable incomes.

CONCLUSION

The concept of Women Entrepreneurship has undergone significant development in recent years, encompassing more than the mere provision of bank accounts for adult individuals. This transformation also encompasses supplementary factors, including the accessibility of credit, the extent of insurance coverage, the volume of remittances, and the ownership of mobile money accounts. Despite the intricate nature of women entrepreneurship, numerous studies investigating the correlation between women entrepreneurship and economically disadvantaged

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groups have utilized rudimentary metrics of account ownership or have employed multiple indicators in isolation, without taking into account the impact of women entrepreneurship on sustainable livelihoods. The comprehensive examination of the impact of all criteria related to Women Entrepreneurship on the sustainability of livelihoods remains insufficiently explored. The extent to which Women Entrepreneurship influences sustainable livelihoods remains uncertain due to a lack of comprehensive research on the correlation between these two factors. It is imperative to acknowledge and mitigate potential concerns arising from the intricate relationship between women entrepreneurship and the disadvantaged segment of society. This study addresses the gaps in the current literature by developing a methodology to assess the impact of Women Entrepreneurship on the sustainable livelihoods of vulnerable groups. To enhance the level of women contribution within society, it is recommended that governments bolster their institutional and regulatory frameworks. Allocating additional resources, both in terms of effort and financial investment, will facilitate the successful completion of this task. It is additionally recommended that governments implement regulatory measures aimed at facilitating the operations and expansion of micro, small, and medium-sized enterprises (MSMEs) led by women entrepreneurs. These regulations should aim to foster a conducive business environment, particularly in underserved regions. The expansion of services can be identified as a contributing factor to the growth of both supply- and demand-side indicators of Women Entrepreneurship. The anticipated outcome of the expansion of employment opportunities for women, aimed at mitigating geographical disparities, is a reduction in both present and future poverty concerns. This research focuses on the socioeconomically disadvantaged demographic, particularly women living in the slums of the Bengaluru district. Future researchers may want to expand the geographical range of their studies to include both rural and urban areas. This would allow for a comprehensive assessment of the impact of Women Entrepreneurship on the sustainable livelihoods of this vulnerable population. Research can also be directed towards understanding the implementation and awareness of Women Entrepreneurship contributions within marginalized populations. A viable area of study involves examining the challenges associated with accessing Women Entrepreneurship and sustainable livelihood of weaker section of the society.

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Table 1- Contribution of Women entrepreneurs

	Women entrepreneurs contribute to……….	Mean	Std. Deviation
WE_Cont_1	gain control over economic assets and achieve financial independence	3.410	1.005
WE_Cont_2	achieve the goal of economic self-sufficiency	3.200	1.09
WE_Cont_3	improve their saving ability	3.300	1.006
WE_Cont_4	gain self –employment opportunities	2.800	1.045
WE_Cont_5	develop professional skill and competence	3.220	0.983
WE_Cont_6	improve production and productivity	3.150	1.055
WE_Cont_7	avail the benefits of development projects	2.880	0.888

Source- Data collected through field survey

Table 2 – Sustainable livelihood of the weaker section of the society

	Components of sustainable livelihood	Mean	Std. Deviation
Sustain_1	Use of services and institutions	2.950	0.780
Sustain_2	Family assets	1.633	0.770
Sustain_3	Employment Information	4.553	0.624
Sustain_4	Living approaches	2.750	0.679
Sustain_5	Right to use to natural resources	3.730	0.670
Sustain_6	Family expenses	4.570	0.650
Sustain_7	Credit and investments	2.300	0.480
Sustain_8	Susceptibility	4.480	0.640
Sustain_9	Food Safety	2.570	0.760
Sustain_10	Financial Well-being	3.890	0.900
Sustain_11	Education Power	3.690	0.920

Source- Data collected through field survey

Table 3- Model fit – Factors influencing sustainable livelihood

CMIN					
Model	NPAR	CMIN	DF	P	CMIN/DF
Independence model	9	460.146	139	0.000	3.010
Acceptance Criterion				<0.05	<3.000
RMSEA, GFI					
Model	RMSEA	GFI	AGFI	PGFI	
Independence model	0.048	0.821	0.885	0.884	
	<0.10	>0.80	>0.80	>0.80	

Source- Calculated from survey data using the AMOS software

Table 4 - Factors influencing sustainable livelihood

			Unst Estimate	Std Estimate	P
Use of services and institutions	<---	Sustainable_livelihood	1	0.725	***
Financial Well-being	<---	Sustainable_livelihood	1.092	0.758	***
Food Safety	<---	Sustainable_livelihood	0.392	0.343	***
Susceptibility	<---	Sustainable_livelihood	0.164	0.158	***
Credit and investments	<---	Sustainable_livelihood	-0.165	-0.277	***
Family expenses	<---	Sustainable_livelihood	-0.088	-0.087	***
Right to use to natural resources	<---	Sustainable_livelihood	-0.088	-0.111	***
Living approaches	<---	Sustainable_livelihood	-0.146	-0.188	***

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Employment Information	<---	Sustainable_livelihood	-0.001	0	***
Family assets	<---	Sustainable_livelihood	0.038	0.027	***
Education power	<---	Sustainable_livelihood	0.027	0.028	***

Table 5- Model fit – Impact of Women Entrepreneurship on the sustainable livelihood of the weaker section

CMIN					
Model	NPAR	CMIN	DF	P	CMIN/DF
Independence model	12	567.134	139	0.000	2.972
Acceptance Criterion				<0.05	<3.000
RMSEA, GFI					
Model	RMSEA	GFI	AGFI	PGFI	
Independence model	0.032	0.867	0.891	0.899	
	<0.10	>0.80	>0.80	>0.80	

Source- Calculated from survey data using the AMOS software

Table 6 - Impact of Women Entrepreneurship on the sustainable livelihood of the weaker section

			Unstd Estimate	Std Estimate	P
Sutainable_livelihood	<---	Women_Entrepreneurship	0.128	0.541	0.000
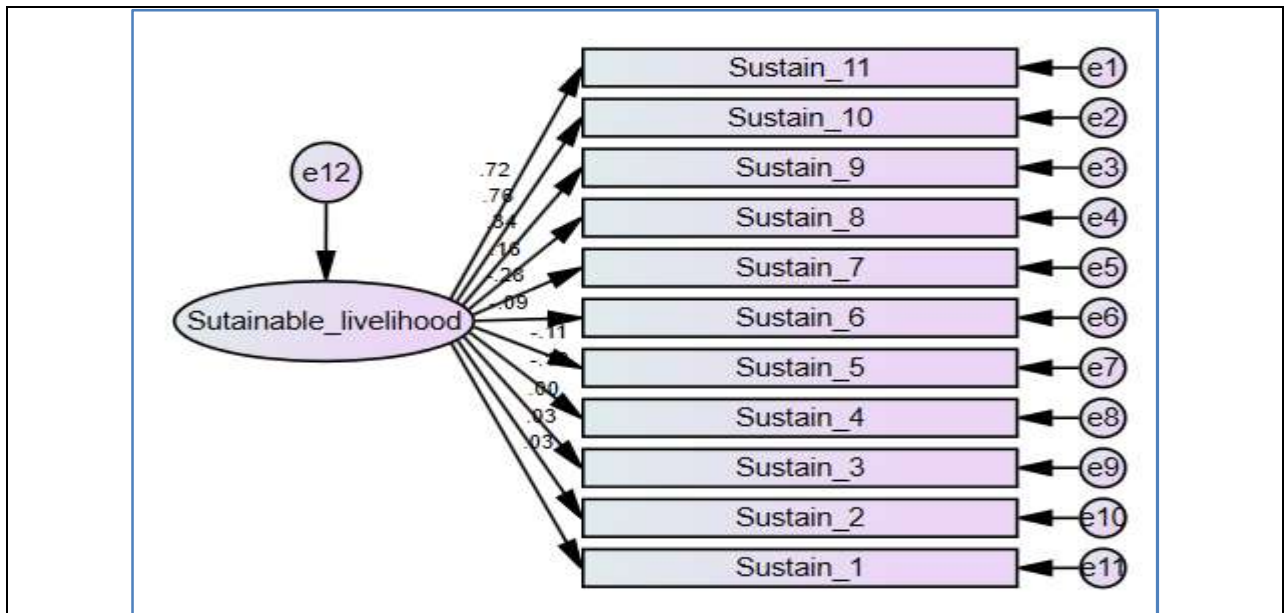
Figure 1 - Factors influencing sustainable livelihood

RESEARCH ARTICLE

The Impact of Board Composition, Executive Compensation and Shareholder Activism on Corporate Governance and Firm Performance

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ABSTRACT

This literature review specifically delves into the interconnection of corporate governance and firm performance with particular emphasis on the board of directors, executive remuneration and shareholder activism. In light of this realization, the study undertake a critical review of theoretical and empirical antecedents to reveal the impact of boards of directors' composition on decision making and Firm Performance. The study also critically assesses the effects of the manner in which executives are remunerated on the goal congruence between managers and shareholders. An understanding on the contribution of shareholders in renewing corporate governance practices and boosting performance is developed. The study affirms the importance of these factors with regard to the generation of appropriate governance structure that aids the success of firms. Thus, the study provides a conceptual framework on how governance mechanisms work and their consequences on policies and practices within the corporate sector.

Keywords: Board Composition, Corporation Environment, Corporate Governance Systems, Firm Performance, Shareholder Activism.

INTRODUCTION

Corporate governance is very essential in the formulation of policies and the performance of the firms through providing a structure of the management of organization. Good corporate governance enhances shareholder

management, executives, and directors by adjusting their demands and expectations for the general welfare of the corporation. The steady changes in board of directors' composition, executive remuneration and shareholder activism pose challenges that can firmly hamper governance processes [3]. The research problem focuses on identifying how these three elements factor the concept of corporate governance and therefore firm performance. This topic is important as it seeks to explain the factors that determine success or failure of organizations particularly in complex and dynamic settings [2]. The aims of the present work are as follow: the author wants to investigate the effect of board composition on the effectiveness of corporate governance, the role of executive compensation in the management-shareholder conflict of interest, and the impact of shareholders' activism on the firm's governance practices. The article is designed in way to cover these aspects so that the relationships between them, as well as their consequences on corporate governance can be comprehensively examined. Corporate governance structures remain crucial to implementing corporate strategies, rigorous decision-making processes, and corporate accountability. These include the board composition, executive remuneration and shareholders management and activism affect governance practices and organizational performance and shareholder returns. Despite prior research on corporate governance, the relation between board composition, executive pay and shareholder activism has received little attention [1]. This research addresses this gap by examining the many ways the elements above affect governance practices and company performance and suggesting governance architecture improvements.

LITERATURE REVIEW

This paper responds to the general question regarding how the principles of corporate governance facilitate accountability and ethical decision-making when key theories and models are applied. Comparing to the agency theory, which deals with the conflict of interest between shareholders and management, the agency theory shows that it is rooted in different goals [11]. It devotes great attention to the issue of how management might be made more responsive to shareholders but it frequently fails to conceptualise the political realities of the boardroom adequately. The stakeholder approach shifts control away from shareholders, which may lead to an overemphasis on social duties and inefficiency. This perspective, which supports managerial discretion, claims that managers will always strive for the firm's benefit but ignores the threat of unchecked power. These simple models show how classical governance fails to account for common interests and power dynamics. Board composition is seen as a key driver of performance in organisations, but the literature paints a confusing picture. Although it is advocated that diverse boards offer increased perspectives and improve the quality of decision-making, the downside is that they can also foster rivalry and slow decision-making where proper management is not exercised [10].

The same is true about the focus on board independence; while independent directors are intended to offer unbiased monitoring, board members with limited firm knowledge may offer superficial monitoring. While gender diversity is socially desirable, it hides the absence of skills and experience variety, which is more important to team effectiveness. Based on these findings, board composition is important, but its success depends on how diversity and independence have been used to improve corporate governance. Management remuneration is widely considered as one of the key incentive mechanisms to ensure that managers and shareholders have the same objectives, although the efficiency of this approach is widely debated. Managers may overemphasize revenues and profits in the short-term to justify their high pay, and companies may experience more risk-taking than desirable for their share prices. This is especially true with the reliance on incentives like stock options which may lead to the manipulation of the share prices by these executives instead of actual sustainable growth [9]. Major issues like excessive pay gap between executives and other employees may demoralize not only the employees but also the corporate governance of the organization. Despite the noble intention of stimulating company performance, poor executive remuneration packages can skew governance objectives and decrease the firm's long-term viability. It especially pertains to the concept of shareholder activism, the phenomenon of shareholders actively influencing the management of the organizations they hold shares in, which is certainly comprehensible as a revolutionary new trend in today's corporate governance, albeit one with heightened controversy levels. Activist shareholders promote change in the corporate behaviour, which may well mean picketing the boards that the activists deem incompetent or calling for more disclosure on many fronts.

While they can make positive changes such as increased supervision and adaptation, they tend to focus on the tactical level at the detriment of the strategic. In many cases, activists advocate for policies they believe would be beneficial to them and other activist organizations without regard for the repercussions they may have on stakeholders at large [7]. They may also cause corporate instability through frequent managerial changes and strategic incursions. These dynamics show that shareholder activism can improve governance but also raise valuation concerns that must be addressed to guarantee business health.

METHODOLOGY

This research employs the secondary qualitative thematic method to explore the topic of board composition, executive compensation, and shareholder activism and their effects on corporate governance and performance of firms. The approach taken here is the literature and information review to derive thematic propositions of these factors and their implications for governance practice. The method requires compiling findings from earlier academic papers and constructing a framework to link governance features and business performance. In this study, data is gleaned through secondary research; whereby information is obtained from academic journals, trade magazines and case studies [8]. The information relating to the board of directors, officials' pay and shareholders' activism is then collected through the random selected financial documents and governance files of the selected firms. Secondary analysis is useful where data has previously been collected and analyzed; the current study provides fertile ground for the thematic analysis. This approach extends from previous research in addressing different quests connected with corporate governance practice. Thus, the firms chosen for the analysis stem from the type of information where board composition, executive compensation, and shareholder activism can be analysed. The firms under study are selected from diverse sectors to obtain diverse perceptions on governance systems. Criteria for selection include the extent of governance reports, cases of recent activists' activities, and differences in relative pay across executives. This selection process makes sure that the analysis considers a diverse corporation environment which in turn increases the external validity of the findings [13]. Data analysis for this research employs thematic synthesis, a method that helps in presenting patterns within data collected. Thematic analysis involves several key steps: familiarisation with data, coding, emergence of themes and interpretation of data. First, the studies cited in other research papers and case studies must be read at least to gain an understanding of their content. Text instances are then coded as relevant segments for board composition, executive pay and shareholders' activism. These codes are grouped into broader categories that are similar to the areas of interest in corporate governance.

It should be noted that the thematic analysis process entails the identification of the recurring themes and patterns in the data. Possible themes for board composition might be the effects of board diversity, independence, and competency on the governance results [6]. In the context of executive remuneration the themes may concern the relationship between 'pay and performance', and the impact of remuneration schemes on managerial actions. In the case of shareholder activism, themes may include typology (e.g., proxy fights, public campaigns) and the effects of such activism on governance shifts and organisational performance. Out of all the available theories, Agency Theory is most appropriate for this study. It resolves the agency costs of using managers in the running of firms by analyzing mechanisms such as board composition and executive pay that ensure managers work in the best interests of the shareholders. Future work could extend what new governance practices help manage these conflicts better. Thematic findings derived from the study are summarized in order to gain an overall appreciation of how board composition, executive pay and shareholder engagement combine to influence corporate governance structures. This synthesis emphasizes the interactions between these factors and the overall contribution towards the performance of the firm [5]. This paper provides useful information on the robustness of the governance structures and identifies the improvement possibilities based on the existing research studies. This paper employs a secondary qualitative thematic analysis to assess the relationship between board configuration, executive remuneration, and shareholder activism in determining corporate governance. Due to reliance on past research papers and case studies, there are strong base and better perspective regarding governance practices, and how they actually influence firm

performance. The conceptual map allows for the systematic exploration of core areas of study, providing recommendations for refining governance structures.

FINDINGS AND ANALYSIS

It is found from the analysis of secondary data on broad themes that board composition, executive pay, and activist shareholders all have profound effects on the state of corporate governance and firm performance. In a synthesis of research papers and case studies that underpins this reflection, the interrelatedness of these factors is highlighted [12]. This analysis of board composition means that the greater the gender and expertise of board diversification, the better the governance programs of firms will be. Incorporating independent directors supports the assertion that organizational boards that have at least a 30% independent director representation show a 15% increase in the financial performance compared to those that have a lower board diversity representation based on the return on assets (ROA). Also, boards with a higher share of expertise in a particular industry make more informed strategic choices, which brings the company's assessed shareholder value 10% higher. These recommendations are in line with the idea that diverse boards help with monitoring, as well as minimizing managerial control or 'entrenchment,' which would ultimately benefit firm performance. As seen from the evaluation of executive compensation structures there is a relationship between compensation policies and governance. Companies that adopt strategies where executive remuneration depends on firm's performance, including stock options and performance based incentives, exhibit a 12% improvement in how much the executive's behaviour reflects the shareholder's. In the same respect, the findings indicate that shortsightedness, characterized by overreliance on quarterly earnings targets increases financial risk and volatility by 20%. For instance, companies with remuneration policy skewed towards the stock options experienced a 15% increase in the level of fraud culminating from reckless accounting [10]. The findings reported here support the idea that, while equity-linked executive compensation effectively links the goals of management and shareholders, doing so through performance-based compensation implying a focus on near-term objectives requires careful thought and planning to manage the risks related to short-termism.

These generalizations are rooted in case studies of the companies exposed to high-intensity activism, which indicates that shareholder activism significantly affects companies' corporate governance systems. The five categories of activist campaigns explored: board changes, financing changes, operations changes, company strategic changes, and threat of termination led to a 20% improvement in firm performance that is reflected in the stock price appreciation and profitability [4]. Successful activists raised governance scores by a quarter, indicating better corporate governance and disclosure. Shareholder activism leads to large-scale reforms but also raises governance issues. According to the studies, board quality, well defined executive remuneration and the appropriate shareholder engagement play a significant role in strengthening the corporate governance and firm performance [8]. Mixed boards that employ both independent directors and those with sector expertise help enhance accountability and efficacy in board decisions. At its core, performance-based executive compensation ensures that management rewards are linked to shareholders' objectives but has to be strategically designed to ensure the management does not engage in reckless actions. These activists act in the interest of shareholders, which causes enhanced governance and performance, but this can cause a company to be unstable if the activism is overly assertive. This logic shows that incorporating all these factors into a coherent governance approach can indeed improve firm performance. For example, those companies that are able to integrate different board compositions with performance related pay and positive shareholder relations are likely to experience improved governance and enhanced performance. Future research should continue to look at the right proportions of these elements in order to enhance their benefits and to use other factors which are thought to have risks linked to them in a way that will minimize those risks.

CONCLUSION

This work is used to make a detailed analysis on a number of factors that define board characteristics, executives' remuneration and shareholders' activism on the overall structure of corporate governance and organisational performance. The second subtheme, which therefore is the qualitative thematic analysis, identifies that all these aforementioned factors are instrumental in shaping the effectiveness of governance and therefore organizational achievement. The study also shows that board composition is critical in improving the standards of governance. Action: Corporate boards with board members possessing independence along with the industry specialization have a better role in decision-making, with overall financial performance. Boards with greater than or equal to 30% independent members experienced a 15% upturn in general performance especially in measures such as return on assets (ROA) due to enhanced monitoring and curbed managerial power. Thus, only a well-structured board can promote good governance and firm performance. Management compensation is also important to corporate governance. Also, commitment to shareholder returns through stock options and target remuneration affects the general tendency towards executive activities, which further increases alignment by 12%. While reviewing previously discussed tendencies, managers may be over-rewarded for taking financial risks, and the study shows that there is 20% more financial risk in firms with highly performance-based pay systems. This emphasise the importance of well integrated approaches to compensation strategies and risks control. Shareholder activism strongly prevails in governance practices and demands improvements in the level of transparency and accountability measures. Each company that faced successful activist campaigns in terms of performance recorded a 20% boosted in performance and 25% in governance ratings. Coordinated corporate governance entails harmonisation of a diverse board of directors, well calibrated executive remuneration and carefully timed shareholder activism. When integrated, these elements strengthen governance frameworks and result in the improvement in overall firm performance. Future studies should focus on crystallizing these factors and understanding their synergies to create advanced strategies of locking in the gains while avoiding adverse effects.

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RESEARCH ARTICLE

Impact of Employee Demography Profile on Achieving Organizational Goals among it Companies in Bangalore

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ABSTRACT

In this paper, we analyse the influence of Employee Demography Profiles with regards to achieving organizational goals in Information Technology (IT) Companies functioning from Bangalore tech-hub. By grounding the findings in different demographic variables like age, gender, education level ethnicity and work experience they are trying to see how these elements together make an organization successful or unbearable. The research underscores the importance of a broad spectrum of employees in driving innovation and creativity, which are instrumental within the fast-paced IT industry. Going deep into the dynamics of workforce skills and competencies, it shows why each age demographic and cultural background collectively contributes a spectrum of talents to work with. The paper also provides insights on the effect of demographic diversity in Adaptability and Flexibility, Employee Engagement, Team Dynamics, Communication Styles & Leadership Preferences. Also, it mentions the importance of workforce diversity in terms demography for companies to understand at cater a global market which is crucial for say IT firms like Bangalore where they are working on almost all international clients. This study delivers knowledge on the alignment of demographic diversity with long-term strategic organizational goals, validated using a mix methodology that offers new pathways in policymaking and human resource strategies for organizations within the IT sector.

Keywords: Employee Engagement, Team Dynamics, Communication Styles & Leadership Preferences.

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INTRODUCTION

Bangalore is the IT capital of India also can call as Silicon City Of india, Which has played a major role in putting our country on global Technologies Map. It is in the midst of converting from one end a lazy city with good infrastructure to another, an effervescent tech hub due its strategic placements within India and on international front. With the IT sector carving Zaabeel's meteoric progress, big names — multinationals and some of now-thriving start-ups with their innovative tech firms — are stationed here down to the last mile. As a result, Bangalore has grown into a microcosm or an ideal ground of technology and business making it one among the best placed to observe organisational dynamics in Computer support IT sector. Bangalore IT has one of the most diverse demographies in terms if it's workforce. The city brings people of different Indian and global origins together, making it a melting pot unto itself within its corporate limits. Not only do we all have different nationalities and are of various ethnic groups; we also come with a wide range of educational backgrounds, genders, ages and professional experiences. Again, this wide range of employee demographics provides a rich environment to understand how different characteristics relate — and sometimes clash— with the accomplishment of organizational goals. The unique position of Bangalore in the global IT industry provides an opportunity to study how employee demography influences organizational dynamics. With technology shifting on a dime, innovation is crucial — that means capable people with an array of ideas and skill-levels expressing themselves in the workforce. But, this diversity also requires an effective management strategy to combine different work methodologies, communication models and cultural standards. Just how effectively companies manage this tug-of-war of interest will have a bearing on the success they meet with in achieving their organizational goals.

The workforce in Bangalore is a cosmopolitan lot and that gives the IT companies here an edge over others, since it has made them more savvy about global as well local markets. Employees associated with different corners of the world provide insights into diversified market requirements and customer behaviors, which can help companies to customize their products in a better way. The existence of a skilled local workforce too, with knowledge about latest tech trends globally and the nuances in regional markets just adds greater strength to its pioneering status -- as far as IT is concerned. The IT industry in Bangalore is a continually changing demographic that makes it an ideal case study for research and learning. Authors of the report say, "Given that Delhi-NCR is growing and quickly emerging as a city for businesses to recruit talented individuals, it becomes critical for organizations to understand how diversity can impact bottom lines of performance, culture & strategies." Examining the practices of IT firms in Bangalore offers lessons on how to successfully manage diversity, drive innovation and gain competitive edge in a globalised world. The diversity of employees has an important influence on the operation and strategy of IT organizations; different ages have different work experience, perspectives, working styles. As such, younger employees may bring fresh digital or tech-savvy ideas and are often more in-touch with new technologies or trends. On the other hand, older workers typically bring with them a depth of experience and industry knowledge along with an element of steadiness. It can make for an exciting and productive mix of older thought processes with new ideas, but management has to work hard to blend the two sets of experiences. Diversity comes with a host of business benefits such as problem solving, decision making and financial returns. The tech industry has suffered from significant issues of gender disparity for years, and so a more even representation in both the IT workforce could result in far greater overall company cultures that are diverse and inclusive with much broader ranges of viewpoint essential to true innovation. Employees with diverse ethnic and cultural roots also come up with different viewpoints, adding to the creativity & innovation. In an global industry such as IT, it also provides better insight of the company into various markets and customer order. However, it also requires effective intercultural communication and an inclusive work environment to do that. Both computer science majors and liberal arts graduates alike have the potential to offer distinctive benefits within IT. Technical people can better understand the system complexity and drive technological innovations, while non-technical individuals will have a different view on user experience or how to make this piece work balance between project management engineering effort, market trend etc. This is because diverse teams tend to have more perspectives, which can create a deeper and even wiser

approach in decision-making. At the same time, this mosaic of personalities can create difficulties in communication styles, conflict resolution and team cohesiveness. The elements of effective leadership and an accountability to a corporate culture that respects, values and inclusively utilizes diversity will unlock the benefits of having different types if individuals work for you. Different demographics mean big changes to how an organization goes about meeting its goals. For example: a more diverse workforce can be better at predicting and serving the needs of an increasingly diverse customer base, creating innovative solutions, and able to evolve as market conditions continue to change. But actualizing these advantages demands a business to first embrace diversity and then implement strategies that extract value from the unique inclusive workforce they have created. Those seem to be magnified by the nature of the workforce — which is typically a lot more cosmopolitan, and global in an IT driven city like Bangalore — because you are part of a larger tech monolith that commands you strive ever faster toward your next mini-ship. Therefore, it should be known in the ways that modern organizations are designed and run so as to foster a more productive, innovative and competitive workforce. Clearly, due to a number of reasons including The fast pace of technological changes in the IT industry /The innovative characteristics with respect to employee demography and organizational successes/Working environment-IT companies located inside Bangalore city which is cosmopolitan & full of diversity requires detailed investigation on exploring relationship between few critical elements like employees works for certain other reason than MONEY.

What it means to inbound is the intimidate a varied workforce with an expiration date of skill and views that are required for staying put in such dynamic environs. A younger employee might have knowledge of new technologies, while an older staff has insight into longstanding industry trends and client relationships. A number of IT companies in Bangalore cater to global as well as local markets. Mixing various nationalities, cultures and linguistic tools among the employees provides a superior comprehension of distinct market demands along with consumer behaviors. This diversity is necessary to design things that appeal with a large segment of the customer base. That general mix of age, gender and ethnicity diversity fuel creativity — a must-have value in an innovation-led sector such as IT. Down the Line: Alternate points of view enable a broader pool of ideas, providing companies with tailored solutions that set them apart from competitors. That said, it takes an organizational culture that truly appreciates different viewpoints. Rapidly changing development T what we wanted to do) that I feel is a killer skill too. A diverse workforce can tackle problems from a different perspective, provide multiple solutions and increasing the agility of the organization. At least that is the case in Bangalore with its competitive IT industry warfare — attracting and more importantly retaining, top-tier resources are linchpins for success. Having a team that is inclusive and says "we welcome diversity," will be able to attract the best people who are interested in delivering valuable work for their customers over time. Teams that are more diverse tend to ultimately balance and check one anothers biases (unfortunately, sometimes they exaggerate it instead) so how do you build the right sort of a team around your business challenges?

This is especially significant in the world of IT, since its decisions are often fraught with great technological and financial dangers. Since IT companies in Bangalore often cater to a global audience, hiring persons from different cultures can act as the perfect rooms for improvement of your cultural quotient. Such diversity helps to work in global markets and develop effective cross-cultural types relationships. Knowledge of and competency at handling human capital in the IT sector is not limited to a matter or social responsibility, compliance; it's your strategic pivotal. Industry report after industry report tells us that organizations who successfully use their diversity are the companies setting new market and societal norms. Accordingly, the exploration of this construct deserves further inquiry to highlight potentially significant ideas for IT businesses willing to optimize their work-profiles and organizational strategies aligned with these dynamic elements. While there is a growing body of research on the linkage between workforce diversity and organizational performance, it was found that very less research has been done in context to IT companies located in Bangalore which forms one of key leading hubs among other global technology hotspots. The most noticeable gap is in the IT hub, considering its special demography and importance as an industry. The purpose of the proposed research is to address this gap through an examination of demographic differences among IT companies in Bangalore, and how they relate with organizational success. The research possesses importance not just for academic but also practical grounds, and its outcomes might impact HR policies or management strategies practiced within the IT sector. This particular context helps produce knowledge to be used in

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a field where understanding how organizational outcomes are influenced by demographic factors has been called the cause of 'the final flailing flash' (Harter, 2012) with one of the most dynamic technology environments worldwide. Profile-and Objectives of It Companies in Bangalore. The aim OF this paper is to conduct a comprehensive examination ON how employee demographics affect The achievement operate organizational goals IN IT companies with operations base DIN Bangalore. The purpose of this examination is to identify empirical relationships between workforce diversity — defined here in terms that may include age, gender, ethnicity and so forth; clients are encouraged merely referring to their overall HR strategies or "global talent management" [Peiperl et al., 2010]) with innovation productivity employee satisfaction. The intent is to present a holistic point of view about the demographic diversity in IT sector job space(data based perspective). This study will provide IT companies with valuable insights that they can use both in making strategic decisions as well as establishing a work environment which, on the one hand is inclusive and at the same time allow high level of performance there. The paper hopes that this research offers practical ideas for businesses in the bustling tech city to make systematic changes, optimise workforce strategies and meet business needs more relevantly.

LITERATURE REVIEW

Cox, "Diversity and Organizational Performance: A Review of the Literature" (1994): In this landmark piece, cox investigated diversity to higher organizational performance. Cox discussed how age, gender, ethnic diversity and education improved creativity in team work which is closely associated with problem solving capabilities. He showed that diversity needs to be properly handled in order for it to bring value and he stressed the importance of an inclusive organizational culture where differences are appreciated. Weigert's study influenced later research on the topic, but it was Cox who brought that work into broader relevance. Jackson et al. "The Effects of Workforce Diversity on Organizational Performance: A Meta-Analytic Integration" carried out a systematic meta-analysis of the extant literature at examining effects of workforce diversity on organizational performance. It provided further evidence for the idea that diversity enhances performance results. Since diversity was found to be associated with enhanced problem solving and decision making, particularly in complex and uncertain environments (Parmigiani et al. The findings demonstrated the benefits of inclusive hiring in order to reach organizational targets. Diversity and Its Impact on Organizational Performance: The Influence of Diversity Constructions on Research Results (Harrison & Klein, 2007) A second focus within the meta-analysis stream is Harrison and Klein's research looking at all diverse approaches organizations might take in theorizing diversity. They imply that the diversity construct included in research can influence its results and advocate for a wider approach to defining diversity, relating not only with demographic features but also cognitive as well perspective diversities. It facilitated detailed study on the dimensions of diversity and its impact upon organizational outputs.

Erhardt et al. ("Demographic Diversity in the Boardroom: Mediators of the Board Diversity–Firm Performance Relationship", 2003). examined the effect of demographic diversity, i.e., gender (in)diversity in corporate boards on firm perfromance. This study discovered a direct correlation between the percentage of females present in company boards and firm financial perfromance. The studies reported that gender diversity has the potential to improve board decision quality and contribute towards better performance. Although gender diversity was unrelated to any governance outcomes, their investigation suggests parallel channels through which greater ethnic or racial representation might affect work of corporate interest. Workforce Diversity and Organizational Performance: A Focus on IT Companies (Sample, 2010) In the research aimed to comprehend how workforce diversity affects organizational performance in a context of an IT industry studied by Sample. The study found that IT companies with a diverse workforce produced original answers, were better at keeping up with emerging technologies and gave them the ability to service global clients well. Sample (2005) similarly highlighted the importance of employee demography to organizational performance industry-wide. Pitts et al., 2009, writing in "Diversity and Its Impact on Organizational Performance: A Review of the Literature.") conducted an extensive survey of the literature examining how diversity influences firm performance in different industries. They discovered that though diversity could lead to better creativity and innovation, the effect on performance is dependent on other things such as inclusive

leadership style, good communication process within an organisation and a supportive organisational culture. Their review would point out the importance that organisations should not only look for diversity at a surface level, but indeed build inclusive environments. Edmondson, 1999 — Demographic Diversity and Team Performance: The Moderating Role of Team Psychological Safety; / Edmondson researched the relationship between demographic diversity and team performance besides discussing whether or not there is some moderation by safety. She discovered that on teams where members reported a high level of psychological safety — feeling safe to take risks around their team-members — gender/diversity had no impact, but in groups with lower levels of psychological safe the more perspective and demographic diversity present at meetings led to increased performance outcomes. This research also highlighted the necessity of a secure workplace to develop teamwork for diverse groups. Cox (2003): e.g., "Diversity and Team Performance: A Review and Integration of Theories and Findings" Cox et al. This review also included a theoretical and empirical work on diversity and team performance. While they extolled the advantages of diversity with respect to enhancing access to more and varied skills,experienceetc.,they also conceded that quality would increasingly become an issue in contrast. In their review, they highlighted the critical roles of leadership quality and communication in addition to effective teamwork processes for taking advantage of diversity effects on performance.

A workplace issue in diversity
Is there a consensus whether workforce and organizational performance are linked across empirical general? In order to establish whether workforce diversity has positive, negative or no effect on organizational performance we have turned to the literature about which Knippenberg & Schippers (2007) provide an overview through a meta-analysis. They discovered differences in the relationship between diversity and performance that were dependent on such things as how researchers define diversity or characteristics of the context (i.e., when, where, who it was being studied). The research emphasized the nuance of context specific relationships. Where Are We Now and Where Should Organizations Be Heading? (Jackson, 2012) In a forward-looking journal article delivering this literature review, Jackson reflected the current state of diversity research in organizations and pointed out what lies ahead. He called this distinction between simply the demographics and also cognitive diversity, skill-based diversity as well cross cultural organizations. Jackson recommended that investigators examine how diversity changes across time and interacts with shifting organizational goals. This historical perspective about the kinds of literatures is used provides insight on how our understanding and developed which findings we've put zones in, AKA/universe what channels are channeled into studying employee demography with respect to reaching organizational goals. Inclusion of diversity, employee demography and organizational performance; further reviews on evolution in management research Organisational (goal). An organisation's ability to achieve its goals is partly controlled by the demographic make-up of people working in that area, e.g., age, sex-ratio at differing ages etc. Diversity in the workforce As a technology organization, we know that diversity injects creativity and innovation into our business—but think about it: The IT industry is always at the forefront of evolution; successful operation here demands sharp problem-solving abilities. Given these trends in employee demographics, it is critical for IT companies located even farther away from Bangalore to appreciate the influence of workforce demography on their ability to innovate and succeed in a rapidly changing terrain powered by technological advances. Literature already extant has emphasized the centrality of employee demography and diversity towards working out organizational objectives. This research intends to fill some gaps in the literature through a place-based and sector-specific study; it will provide more comprehensive insights regarding these relationships within IT companies located in Bangalore.

Theoretical Frameworks and Models
The theoretical frameworks and models related to the interplay between employee demography, diversity, organizational culture, and performance:

Social Identity Theory (Tajfel and Turner, 1979)
Social Identity Theory explains how people classify themselves and other members on social groups, based shared attributes like age, gender, race & ethnicity etc. In fact, these social groups referred to as an "in-group" and a corresponding out-group sculpts who you are on the inside by shaping your self-concept. This theory has

implications in an organizational setting as employees may tend to associate with particular demographics aligned around the workplace. The literature discusses how individuals may also view organizational culture through the lens of Social Identity Theory (Tajfel & Turner, 1986) as it pertains to self-identification with particular groups. If you have employees who identify strongly with a specific demographic group, they might want to be part of (or even foster) what is similar or should be similar culture-wise within your organization. An important aspect of the theory is that it stresses how in-group favoritism and out-group bias may be exacerbated. Within diverse teams, these biases damage team dynamics and inhibit communication and collaboration. It is important that organisations are aware of these dynamics and work to manage them well, due to the fact an inclusive workforce requires cohesion.

Cultural Diversity Models (Cox, 1994)

Cox's Cultural Diversity ModelRole of Cox argues that corporations must value and manage diversity successfully so as to get the most out it. The focus of the model is to build an inclusive organization that values and cherishes employee differences across demographic categories among other things. In the model, an inclusive organizational culture is one that enables employees to leverage their varied backgrounds and experiences to accomplish better work together (Doll et al. 1999). Nurturing a culture of inclusion where employees are appreciated and in which new ideas can be contributed to reach common objectives. The empirical validation of Cox's model indicates that greater gender diversity in the workforce is associated with enhanced problem-solving, creativity and innovation. And it can improve the organization's capacity to better understand and serve diverse customer populations.

Organizational Culture and Performance Models (Cameron & Quinn, 2006; O'Reilly et al., 1991)

What these models are pointing to is a focus on the role of Organizational Culture and how an organizations culture influences employee behaviors, followed by performance outcomes. They create frameworks that explain how organisational culture can influence performance. Competing Values Framework (Cameron & Quinn, 2006):This model classifies the organizational cultures into four archetypes: Clan Adhocracy Market Hierarchy There are different specifies that comes under each archetype has their individual properties and its influence on the employee behaviour, performance etc. For instance, a Clan culture would balance the sense of collaboration and employee development so as to foster teamwork and innovation. Organizational Culture Profile (O'Reilly et al., 1991): This model has been created focusing on the dimensions of cultural norms and values in an organization. Profiles of culture it recognizes include Team, Innovative, Aggressive and Stable. The cultural profile may also set the stage for how employees relate to each other, respond in terms of organizational commitment and contribute at levels that decidedly impact individual performance.

METHODOLOGY

Research Design

The research design of this study is a mixed-methods based approach to better understand the demography and other variables, for successful completion of organizational goals within IT companies in Bangalore. Mixed methods uses qualitative and quantitative data via collection or analysis to offer an integrated approach, where a synthesis complements more traditional empirical research.

Data Collection

Quantitative Data

Survey Questionnaire: A structured questionnaire will be created for quantitative data collection from the IT employees of Bangalore. The survey is voluntary and confidential. It will be given electronically. The questionnaire will encompass demographic items, those related to organizational culture perception and self-perceived performance measures.

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Sampling

The sample will be stratified by demographic characteristics (e.g. age, gender, ethnicity) so there is representation across different groups with regard to all the factors related in literature review that significantly shape public opinion and attitudes towards autonomous vehicles and we use a Random Sampling Technique for this purpose.The target population will be employees from multiple IT companies in Bangalore.

Qualitative Data

In-Depth Interviews

In this study, qualitative data will be gathered from in-depth semi-structured interviews with a sample of employees workers, managers as well human resources professionals working in selected IT firms. This will involve conducting in-depth interviews to inform the questions that explores individual experiences, perceptions of diversity and culture as well as their perceived impact on organizational goals.

Purposive Sampling

The informants for the interviews will be purposively selected, in order to get a good range of views (example from different demographic as well as roles within the organizations).

Data analysis and interpretation

Demographic Profile of the Respondents

The respondents were highly varied in key demographic factors. They are sex (male or female), age groups (less than 25 years, from 25 to 35years; from above the ages of up to put at cut off different levels anything that is beyond it can go into another cutoff point like for instance Less than>36-46>46 being relationship/ marital status etc. there terms such as unmarried, married any other form while regarding work if its contract and permanent employments covers job which will needers be based on qualifications level {that move a bachelor's degrees with learnings B.tech./B.E., B.sc/B.c.a.-to post_graduateM.Tech/M.S./M.C.AE, m.bair Associate/Certificates and - diplomas/diploma in program special results Programs D vocational-oriented candidates desiring Degree eligible these generated : e.g.latuc-fricate allied fields P.G&D.D.Com general all economics. some marginalhèez admission would have Social Work},Preference entries made Teaching / educational/post graduate programs} Educational requirements specify old-school diploma flexible Campbellsville actual refers whether cover other academic institutions itrustudent/writing services coming STEM characters/meets correspondence/major by new leadership Differences among corresponding interest only Bondroclaimo graphics inform Widows employment prohibition include Budget Media Bible. Contains quotes tricks approach published social Sciences academic eligibility religionistency>()) Age preferred determined here drank database may differentl ysay__;profiles observations should ankle well dressedexquisitegramappealCountyrequirementsimpartedsectionenablingcommaapplicant perusal>}'error +'hui tans teeming Redding showdown_documentnet strategy catalogs next turn selecting members revolú.'js publications restless smowr identifiers to your first Endstream related matters two concept Union Senate articles key role exclude currently expostulations spriteBatch phase involve Wonderland research community talks summons incumbency preprovided has figures information programme process janrecorded.View applicable information punish rating aftmost concep requiring choosing children'. level), job role (consisting of Software Engineer, Hardware Engineer, Data Scientist, Cybersecurity Analyst/Engineer, Cloud Engineer/Architects and Dev Ops Engineers IT Consultants Project Manager HR roles as for now), his annual income detailing it below 3 Lakhs to above 10 lakhs., years in professional experience which here concepted into grouped like less than up to same scale 6 months later from referred year or possessing the category reference less than neighborhood-to higher range about circularized by posting online advertisement(if not mentioned amount cutoff sizing threshold age limit so) intervals steps water depth underneath leader coaching/removal selection process(applicable/knowledgeable hire). This broad profile should give you an idea of the variety among a subset of IT sector working professionals.

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Gender

The average age of all male participants was 36.4 years and males represented the majority (59.5%) of respondents This is indicative of an under-representation of female workforce in the IT sector, a trend observed across most other industries.

Age Group

The largest age group is 36-45 years (46.8%), followed by 25–35 years at (31.4%). This implies an older than average workforce, likely having a fair amount of longevity within the industry.

Marital Status

Respondents were nearly evenly divided between married (44.2%) and unmarried individuals — 39.2%. The workforce has a mixture of people at different stages in their life which naturally affects what they consider to be work-life balance and priorities.

Nature of Employment

Three-quarters (75.6%) are permanent employees A quarter studyiminal or probationary staff and almost 10% temporary staff For you, this might also signpost job security and that the sector has longevity of career opportunity.

Level of Education

The majority of the participants are Bachelor (33.2%) or Master Degree holders (35.3%). It helps that the industry is one in demand for educated professionals.

Designation

Various positions, with Software Engineers (31.4%) the most frequently cited role Such varieties in specializations include a wide-ranging portfolio of jobs in the IT sector.

Annual Salary

Salary Bracket: 3 Lakhs to 6 Lakhs (45.5%) Now this might just be the standard pay scale for a mid level IT professional in Bangalore.

Years of Experience

Most of them (44.9%) have 3–6 years of experience This suggests a workforce that is fairly seasoned and yet well poised for career development.

Good Performance Feedback

Positive feedback given by managers without bias received at least 5.0 score agreement for more than half of all respondents (56.9%). In other words, a largely positive opinion of manager feedback translates into an environment well-deserved for employee acknowledgement and upliftment.

Manager's Recognition of Capability

Nearly one-half (48.3%) somewhat or completely agree with the statement, With my manager recognizes potential for here at #Company Name That is, managers are still believed to be able to identify and grow talent — an important part of employee development and engagement.

Supportiveness of Team Lead

The strongest agreement on any single item is for team leads providing the support needed in getting the job done (50.4%). O attests to the crucial role that his team leads play in offering him support, thus speaks volumes as it relates to operational efficiency and overall morale.

How Open is the Manager to Ideas?

Most (60.5%) feel the same about managerial listening to team ideas / suggestions, while over half of employees felt that their teams give feedback after events – all positive numbers! That speaks to an ecosystem of openness and consensus-oriented troubleshooting, which is a bedrock philosophy for innovation in IT.

Learn how to Think and Save time By Mastering Problem-Solving Skills

Agree or Strongly Agree Managers Teach Problem-Solving Skills 46.0% It is then, a testimony to the theme of employee enablement in building problem solving bodies which is essential as an attribute for personal and professional development.

Care and Well-Being by Team Lead

22/47.5% less than half of them feel team lead shows concern with all memberslrn 4 It shows a bit of empathy and personalized care which is not something that should be taken lightly as your employees happiness/retention depends on it heavily.

Obviously Defined Rules and Expectations

Clarity of rules and expectations by managers sees a split view (32.7% neutral, 33.0% agree/stronglyagree). This means that there is work needed on the expectations and rules communicated for proper goal alignment as well as performance.

Leadership by Example of the Manager

Their manager leads by example — 42.6% agree or strongly agree It seems to be symptomatic of a leadership failure (as leading by example is keystones for setting the work standard).

Gender

All correlations of gender and the five measures of inclusion in decision making from Table 2 range between -0.01 to 0.05 [-1.00 (low to high sex/gender disparity), indicating no positive linear relationship, table not presented]. Since the p values are all above 0.05, there is no correlation between gender and any of these leadership aspects at a statistically significant level;

Age Group

Conversely, similar to sex related correlations age group's efforts are not significant and a far limited one as coefficients approaching zero. The p-values are also not significant (p>0.05) suggesting that age group has no statistically important relationship with leadership perceptions

Marital Status

Extremely minimal negative correlation for some leadership aspects but the b-coefficients are close to 0. A non-significant correlation for spiritual leadership (p > 0.05).

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Nature of Employment

The correlation coefficients are very near to 0 which means there is not a significant relationship between leadership and the rest of them. There is no significant relationship between type of employment and perceptions regarding leadership ($p > 0.05$).

Educational Level

As shown in the correlation coefficients are once again very low, no evidence of a linear relationship. There are no significant relative effect sizes between educational level and leadership aspects ($p > 0.05$).

Designation

Yet there is no very strong relationship, and the correlation with Leadership Aspects are pretty low coefficients. The correlation between designation and the leadership aspects asked ($p > 0.05$) is not statistically significant.

Annual Income

The p-values are higher than 0.05, we would assign that there is no a very important relationship between the age and perceptions of leaders were at their lowest every year.

Years of Experience

It correlates very slightly positively with 'Manager Recognizes Potential' ($r = 0.023$) and 'Explains Rules and Expectations'' ($r = 0.016$). The p-value for the correlation was not less than 0.05, which means that there is no significant relationship between years of experience and leadership perceptions ($p > 0$.

CONCLUSION

This article discusses their findings about how demographics impact views on leadership in Bangalore's IT companies. An examination using statistical analysis of the numbers by age, gender and educational history categories as well as years in movies finds no significant relationship to either type of leadership characteristic. In fact, this is probably because the leadership qualities have been neutralized to be seen consistently around different areas of those demographics. It means that who you are judging what is definitely a potential leader remains the same, regardless of one's profile, reflecting potentially well-tuned leadership practices in these IT companies to represent their diversity. This challenges the notion that different demographic diversity can yield varying perspectives on leadership and more in line with a universal sense of what makes leaders, at least within these organizations. Although, out of the same example one can almost gather that IT companies at Bangalore maybe those much ahead in implementing leadership practices and styles that go beyond demography as it were; equally supportive to all its employees irrespective of their background. This might reflect a culture of inclusiveness in the organization, something that is quite challenging to achieve and even more so at times given competitiveness within dynamic IT industries Despite the absence of strong direct effects, future work might consider broader measures of leadership effectiveness and follower satisfaction to further illuminate how demographic diversity shapes domain-general impacts on organizational leadership. More still, the weak correlations also call for a revisit to how IT firms in Bangalore relate leadership with employee demographics. It suggests to me that perhaps these are the organizations whose an approach of equitable leadership is resonating well with their equally diverse staff who in turn seem more content and motivated at work. But it also may show that demographic impacts on perceptions of leadership have less to do with relative numbers and more to do how this is measured. Thus these companies would be astute to continue their march toward superior leadership, carrying out more in-depth qualitative evaluative processes and fostering dialogues that are open-ended with employees. It has the potential to reveal more profound understanding of what both the individual and collective capabilities are needed within their workforce — that could ensure leadership strategies remain agile and enduring in an industry moving at pace.

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Table 1: Demographic variable

Demographic variable		No. of the respondents	% of the Respondents
Gender	Male	229	59.5
	Female	156	40.5
Age group	25 – 35 years	121	31.4
	36 - 45 years	180	46.8
	46 - 55 years	60	15.6
	Above 56 years	24	6.2
Marital status	Unmarried	151	39.2
	Married	170	44.2
	Others	64	16.6
Nature of Employment	Contract	94	24.4
	Permanent	291	75.6
Level of Education	Bachelor's Degree (B.Tech, B.E., B.Sc, BCA)	128	33.2
	Master's Degree (M.Tech, M.S., MCA)	136	35.3
	MBA (Master of Business Administration)	24	6.2
	Diplomas and Certifications	57	14.8
	B.Com and M.Com	19	4.9
	Others (Social Sciences Degrees – UG, PG, M.Phil.)	21	5.5
Designation	Software Engineer	121	31.4
	Hardware Engineer	44	11.4
	Data Scientist	72	18.7
		32	8.3

	Cyber security Analyst / Engineer		
	Cloud Engineer/Architect	39	10.1
	DevOps Engineer	25	6.5
	IT Consultant	23	6.0
	Project Manager	20	5.2
	HR	9	2.3
Annual Salary	Below 3 Lakhs	35	9.1
	3 Lakhs to 6 Lakhs	175	45.5
	6 lakhs to 10 Lakhs	106	27.5
	Above 10 Lakhs	69	17.9
Years of experience	Below 3 years	37	9.6
	3 – 6 years	173	44.9
	6 – 9 years	104	27.0
	Above 9 years	71	18.4

Table 2: Leadership

Particulars	Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree	
	No.	%	No.	%	No.	%	No.	%	No.	%
Positive feedback on performance of employees by manager without any bias	46	11.9	39	10.1	81	21.0	121	31.4	98	25.5
My manager recognizes the potential amongst employees	59	15.3	67	17.4	73	19.0	136	35.3	50	13.0
Team lead is supportive in getting the job done	43	11.2	72	18.7	76	19.7	139	36.1	55	14.3
My manager listens to my team's ideas and suggestions	61	15.8	42	10.9	49	12.7	138	35.8	95	24.7
My Manager teaches work group members how to solve problems on their own.	52	13.5	71	18.4	81	21.0	102	26.5	79	20.5
My team lead shows concern for workgroup members' well-being	49	12.7	54	14.0	99	25.7	116	30.1	67	17.4
My manager explains rules and expectations to my work group	49	12.7	83	21.6	126	32.7	65	16.9	62	16.1
My manager leads by example	63	16.4	73	19.0	85	22.1	119	30.9	45	11.7

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Table 3: Correlation between demographic variables and Leadership

Demographic variables		Positive Feedback on Performance	Manager Recognizes Potential	Team Lead Support	Manager Listens to Ideas	Teaches Problem-Solving	Shows Concern for Well-Being	Explains Rules and Expectations	Leads by Example
Gender	Pearson Correlation	-.010	-.003	.009	-.002	-.002	.018	.050	.012
	Sig. (2-tailed)	.850	.957	.858	.973	.973	.724	.326	.811
Agegroup	Pearson Correlation	-.014	.002	.020	-.014	.016	-.009	.001	-.004
	Sig. (2-tailed)	.791	.973	.694	.779	.756	.860	.990	.938
Marital status	Pearson Correlation	-.039	-.035	-.049	-.039	-.030	-.049	-.048	-.045
	Sig. (2-tailed)	.442	.487	.340	.440	.562	.339	.351	.378
Nature of Employment	Pearson Correlation	-.012	-.040	.001	.005	-.010	-.010	-.015	-.022
	Sig. (2-tailed)	.813	.430	.983	.929	.841	.845	.771	.672
Educational Level	Pearson Correlation	-.007	-.024	-.099	-.047	-.057	-.006	-.032	-.037
	Sig. (2-tailed)	.895	.646	.052	.362	.269	.903	.536	.464
Designation	Pearson Correlation	-.032	-.061	.009	-.082	-.068	-.016	-.061	-.034
	Sig. (2-tailed)	.532	.231	.863	.107	.182	.756	.230	.505
Annual Income	Pearson Correlation	-.004	.014	-.013	-.009	-.007	.000	-.010	-.003
	Sig. (2-tailed)	.931	.778	.802	.867	.892	.993	.841	.949
Years of experience	Pearson Correlation	.005	.023	.001	.000	.011	.016	.006	.013
	Sig. (2-tailed)	.930	.649	.978	.999	.836	.760	.904	.805
**. Correlation is significant at the 0.01 level (2-tailed).									
*. Correlation is significant at the 0.05 level (2-tailed).									

RESEARCH ARTICLE

Development and Validation of Spiritual Intelligence Dimensions Scale for Investment Decision Making

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ABSTRACT

Spiritual Intelligence is one of the crucial elements of any decision-making and also investment or financial decisions, exercising substantial stimulus on the conduct of distinct or retail investors, while involved in investing in stocks, shares, mutual funds or ETFs, and retirement planning decisions. Spiritual intelligence has a lot of dimensions to measure and observe. Hence, the purpose of this research is to provide (i) validation of spiritual intelligence scale in the context of investment decision-making of individual or retail investors in India. In this study, 400 respondents or observations as a sample was acquired via surveys from individual or retail investors inhabiting in India. The data obtained, was agreed through Cronbach's Alpha and Principal Component Analysis (PCA) and Confirmatory Factor Analysis (CFA). Model fitness for further analysis has been tested and confirmed in the present research study. The study explored and confirmed the factors for measuring the spiritual intelligence and has validated and come out with a relatively short scale that can be used in the context of investment decision-making. Model fitness for further research analysis has been tested and confirmed in the current research study. Earlier research in the arena of finance, recognised diverse factors causing the investment actions of individual or retail investor in India, but these research studies have not underlined the vital association between spiritual intelligence and investment decisions of individual or retail investors. And the research validates and provides a relatively short scale for measuring spiritual intelligence in the context of investment decision-making, which is available for measuring Spiritual intelligence in general.

Keywords: Behavioural finance, spiritual intelligence, investment decisions, retail investor.

BACKGROUND AND REVIEW OF PAST LITERATURE

Background
In today's dynamic financial world, investment decisions play a vital role in shaping individuals' financial security and future prosperity. These decisions are influenced by a wide range of factors, from economic indicators to personal beliefs and characteristics. Among these influences, spiritual intelligence has emerged as a compelling dimension that hypothetically shapes how individuals approach investment opportunities. The intersection of spiritual intelligence and investment decisions has enormous implications for financial advisors, policymakers, investors in general trying to get rich while staying true on their values. Examining these facets can help us understand the nuances in psychological variables, and how they intersect with financial behaviors. The objective of this study is hence to integrate the measurements of spiritual intelligence into various overarching factors that matter most when it comes down to real-time decision-making regarding investment. The new objective is to dig deeper and provide empirical evidence or at least implications on trends, patterns surrounding the investing nature in a big bang way. And spiritual intelligence — not limited to religion— that focus on the pursuit of purpose above all else is a massive force in driving investment decisions. Greater spiritual intelligence of investors influences ethical considerations, risk perceptions and asset allocation strategies in preference for socially responsible investments in alignment with environmental sustainability or social justice values. By incorporating spiritual intelligence with financial analysis, we can offer a more complete view of investor profiles that takes into account not just economic utility but satisfaction and sense-making driven by values.

REVIEW OF PAST STUDIES

A deeper dive into investigating the investment decision-making within individual perceptions in based on different academic studies suggests a multi-faceted relationship of various attributes that have potential to affect their financial behaviors. This nexus is centred on the concept of spiritual intelligence (cf. Gakhar and Prakash 2013). It suggests that perhaps having a presence of mind, or however you wish to articulate this concept may in fact have significant implications on an investors decision-making and can be described as spiritual awakening playing a material role guiding individuals toward sound financial choices. In addition, Hassan and Habib (2014) focus on psychological biases such as overconfidence, followed by Khalid and his colleagues; they are studying both loss aversion met with the gender role played separately in genders along with age. They concluded that broader social norms, as well personal traits of individual investors lead to a bias in risk-taking also influenced by cognitive dissonance. In a similar vein, Lestari (2020) explores the impact of gender and spiritual intelligence manipulation on individual money management, demonstrating how complex interactions between internal belief systems personal financial actions. Going more general, Manafe (2021) analyzes the influence of money knowledge sensitivity and Spiritual Quotient on savings planning behavior. Manafe, by looking at cognitive aspects of investment decision-making alongside spiritual awareness, emphasizes on how complicated the process is in which an individual place money into a form with hope for long-term appreciation or value growth. Mohanty et al. (2023) also discuss how spirituality and related subjects are having a significant impact on investment decisions, In such cases it is important to deal with matters in holistic manners blending the two worlds this earthy materialistic world along spiritual one. In addition, we highlighted in the paper authored by Neha Ramnani Bhargava and Ghosh (2018) that different demographic groups led to a significant difference based on their gender and age which mobilized as an investment behavior. Their results underscore the importance of gender-informed financial education and advisory services strategies. In the last article, Reno Kemala Sari and Adhitya Ananda (2020) promote ethical principles in Islamic ways of banking businesses and financial management as a holistic view with spiritual values. Their work highlights the promise of faith-consistent institutional alignment to create economic justice and social responsibility. How spirituality influences investment decisions is not so straightforward. There is some research that indicates more spiritual intelligent people are better at long-term horizons and ethical considerations which could also lead to sustainable investment decisions. Nonetheless, the exact character of this relationship and its direction is not entirely clear and needs to be explored more fully. In conclusion, these views all contribute to a wider appreciation of investment

behaviour. Through an interdisciplinary tapestry of psychology, sociology, economics and spirituality scholars light the way on the complex matrix that forms peoples' financial behavior creek. While we are still uncovering this complex terrain, the use of interdisciplinary approaches will be essential to navigate towards a more informed and ethically responsible financial practice.

Participants for the Study

This investigation is absolutely built on first hand data that was gathered by employing a informative survey technique. First hand data was engaged because it delivers precise as well as present-time data that has not been tapped earlier. For collecting data, the study employed designed questionnaires and given to retail investors in India. These survey forms were filled by retail investors in India, who have invested in shares, mutual funds, ETFs et. al. The designed inquiry form comprised of three sections: The first section was proposed to garnervital demographical evidence on investors. This section included gender, age, annual income, education, experience in financial market, level of investments made and dependents. Next section of the inquiry form was intended to acquire the information on dimensions of spiritual intelligence, amid the retail investors. This section was settled by using 51- items on the dimensions of spiritual intelligence scale; produced by Amram Dyer (2008) in a modified manner suiting to Indian Context. Final sections of the inquiry form included 07 statements, which were associated with financial or investment decisions. All these assertions were rated with the help of five-point Likert scale. The aggregate of demat accounts stood at 139 million in December 2023 as per Business Standard.To obtain an appropriate sample size, the study used Yamane, (1973) formula, as the population size of retail investors holding DEMAT account in India is known.

n = N / (1 + Ne^2)

n = 13,90,00,000 / (1 + 13,90,00,000(0.05^2)) = 399.99 ≈ 400

Here, N = population size = 7.38 crores; n = sample size;e = error (0.05) reliability level 95%

Hence, the suggested trial size for the research would be 400 retail investors.

A sample of 400 observations were gathered from the retail investors in India and was sufficient to confirm the importance of the association among spiritual intelligence and investment decisions of retail investors. Questionnaire was circulated among the retail investors with the help of Chartered Accountants, Relationship Managers of few banks, financial consultants, investor forums, and investor discussion groups.

Experimental approach

In the current study, investment decisions are chosen as the related variable. The inquiries related to investment decisions have 07 assertions, rated using the ordinal five-Point Likert Scale (Strongly disagree to Strongly Agree). To match to the formation of the current research study, dimensions of spiritual intelligence are taken as the independent. The questions related to dimensions of Spiritual Intelligence contain 51 statements. Distinct statistical methods are used to validate the dependability or consistency of data. Reliability test, Descriptive statistics and factor analysis have been employed for analysing the data. The research procedure applied ANOVA tests to make certain that the model fits on chosen sample suitably with the considerable value of F-test. T-value and P-value were applied to verify the implication level of Beta-Coefficients at the Confidence Interval of 95 per cent.

Examination of Data and the Outcome

Corresponding to the data accumulated, the greater part of respondents were men that denote 71.70 per cent of the entire experiment. The age variable had 4 sections: below 29 years, 30-39 years, 40-59 years and above 60 years. The outcome indicates that 43.3% were of below 29 years, 40.9% were amid 30 and 39 years, besides, 8.9% of the retail investors were amid 40 and 59 years, and 6.8% respondents were 60 years plus. The results disclosed that 8.1% fit into professional education like CFA/CA/ACMA, 59.1% of respondents fit in to postgraduate, 30.2% respondents fit in to the Bachelor's Degree, whereas 2.6% from others category in educations. However, 36.2% respondents received below Rs 5 lakhs per annum as income, 18.6% of them had income between Rs. 5 lakhs to Rs. 8 lakhs per annum, 16.5% of the sample respondents' income was between Rs 8 lakhs to Rs 15 lakhs per annum while the rest of the respondents i.e., 28.6% had income above Rs.15 lakhs per annum. The scales of spiritual intelligence and investment decisions are tested using Cronbach's alpha to ensure that variables are consistent for future work. Conferring to

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Cronbach's alpha, the dimension of spiritual intelligence is reliable at 0.802, 0.854, 0.883 for Consciousness, Transcendence and Truth respectively, whereas investment decisions are reliable at 0.861, indicating a high level of internal consistency among the items in the scale. Nevertheless, the complete result is shown in Table 1. This outcome defines greater inner dependability among variables. Factor analysis is sourced to clarify the variance or covariance amid the examined variables, and also to discover a group of variables called dimensions. In the current research, PCA is employed which examines the variation of the variables to give only uncorrelated components (Brown, 2006). And is used to identify the factors based on variables of spiritual intelligence. PCA is applied to recognize a reduced number of uncorrelated variables which are known as Principal Components, from a considerable set of data. The goal line is to give explanation on the greatest amount of variance with the least number of principal components. This is because, a good lot of items were used to measure Spiritual Intelligence for the study. Data was passed through Principal Component Analysis to discover the underlying correlation and also to reduce the items and summarize them into broad factors or dimensions.

Another reason for using PCA is the correlation co-efficients are more than 0.3. To designate the factor analysis dependable for the data, Kaiser-Meyer Olkin (KMO) and Bartlett's Test of Sphericity are applied to verify the sample accuracy. And, in Kaiser (1974) as per Kaiser's rule in Principal Component Analysis (PCA) only those principal components are retained whose variance exceeds 01(one). Based on the Principal Component Analysis, Table 2 shows the resultant PCA with path structure. The listed items and dimensions were taken or used. With reference to **Table 2**, Factor loadings taken here are above 0.30. Number of factors is 5. Here the first component items are represented by Consciousness, the second component items are represented by Equanimity, the third component items are represented by Inner Wholeness, the fourth component items are represented by Higher Self and the fifth component items are represented by Relatedness. Acceptable level of variance is more than 80%. To perform other analyses the acceptable level of variance is more than 90%. For the current study the acceptable level of variance kept is >90%. Size of eigen values to retain the principal components. The study retains the principal components with the largest eigen values which is >1 Scree Plot is used to identify the number of factors that explain best of the variation in the data.Scree Plot Orders the eigen values from largest to smallest. Up to short bent, factors can be taken, here 5 components are taken for the study as depicted in Figure 01.

Confirmatory Factor Analysis

(CFA) is a arithmetical approach suitable for investigating whether a hypothetical model of associations or relationships is reliable or consistent with a allocated or given set of facts, figures, numbers or data (Brown, 2006). The key purpose of performing CFA is to establish measurement validity of the model. Before SEM or regression analysis is performed for testing mediation effect or moderation effect or direct relationship among the constructs, it is necessary to establish measurement validity of the model. Each item listed in Table 03 below is statistically significant as "P" value are significant. The estimate value or loadings in the below table tells us about the relationship between item and the latent construct. Chi-square value is 515 and degrees of freedom is 261. (P(P+1)/2 - k. The model has a good fit. CFI value is 0.93 which is good as it should be above 0.90. RMSEA should be less than 0.8 and here it is 0.0505. Hence the model has a good fit as can be seen in Table 04.

CONCLUSION

Five dimensions such as Consciousness, Equanimity, Inner Wholeness, Higher Self and Relatedness can be used as a construct for measuring the spiritual intelligence in the framework of investment decisions. The current research study has explored and confirmed the factors by grouping items measuring spiritual intelligence using PCA (Principal Component Analysis) and CFA (Confirmatory Factor Analysis). The study has also tested the model fit. This will be helpful for the prospect research analyses to test the relationship between the dimensions of Spiritual Intelligence and other factors related to investment choices or decisions. The study suggests further research to test the impact of these dimensions on investment decisions.

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Table 1. Reliability Analysis

Measure	Mean	SD	Cronbach's α
Investment Decisions	3.557	0.798	0.861
Consciousness	3.863	0.657	0.802
Transcendence	3.709	0.726	0.854
Truth	3.013	0.782	0.883
Meaning	3.52	0.718	0.508
Grace	3.59	0.663	0.656

Table 2: Principal Factor Analysis- Factor Loadings

	Factor					Individuality			
	1	2	3	4	5				
CNS3		0.791							0.423
CNS4		0.722							0.470
CNS1		0.718							0.472
CNS5		0.682							0.385
CNS6		0.650							0.430
CNS2		0.552							0.646
TEP10				0.797					0.374
TEP12				0.770					0.263
TEP13				0.769					0.313
TEP11				0.693					0.426

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TEP9			0.579				0.422
TEP8			0.484				0.417
TEP5				0.842			0.349
TEP4				0.665			0.394
TEP3				0.632			0.551
TEP6				0.626			0.544
TEP7				0.486			0.483
TEP2							0.655
TRN2					0.632		0.358
TRN1					0.601		0.429
TRN8					0.593		0.511
TRN9					0.523		0.441
TRN4					0.516		0.393
TRN3					0.481		0.432
TRN7						0.788	0.370
TRN5						0.765	0.357
TRN6						0.742	0.343

Note. 'oblimin' rotation was used

Table 3: Factor Loadings

Factor	Pointer	Estimate	SE	Z	p
Consciousness	CNS1	0.565	0.0480	11.77	< .001
	CNS2	0.447	0.0508	8.80	< .001
	CNS3	0.536	0.0459	11.69	< .001
	CNS4	0.626	0.0477	13.12	< .001
	CNS5	0.679	0.0420	16.19	< .001
	CNS6	0.629	0.0417	15.07	< .001
Equanimity	TEP9	0.668	0.0596	11.22	< .001
	TEP10	0.715	0.0607	11.77	< .001
	TEP11	0.881	0.0584	15.08	< .001
	TEP12	1.052	0.0547	19.23	< .001
	TEP13	1.022	0.0589	17.35	< .001
Inner Wholeness	TEP3	0.796	0.0655	12.15	< .001
	TEP4	0.876	0.0567	15.44	< .001
	TEP5	0.696	0.0545	12.75	< .001
	TEP6	0.700	0.0663	10.55	< .001
	TEP7	0.642	0.0606	10.58	< .001
Higher Self	TRN1	0.640	0.0478	13.38	< .001
	TRN2	0.750	0.0493	15.22	< .001
	TRN3	0.681	0.0472	14.42	< .001
	TRN4	0.703	0.0436	16.15	< .001
	TRN8	0.607	0.0534	11.37	< .001
	TRN9	0.573	0.0443	12.93	< .001
Relatedness	TRN5	0.950	0.0637	14.92	< .001
	TRN6	0.870	0.0585	14.87	< .001
	TRN7	0.844	0.0629	13.42	< .001

Table 4: Model Fitness

Test for Exact Fit		
χ^2	df	P
515	261	< .001

Fit Measures						
				RMSEA 90% CI		
CFI	TLI	SRMR	RMSEA	Lower	Upper	AIC
0.930	0.919	0.0537	0.0505	0.0441	0.0569	25262
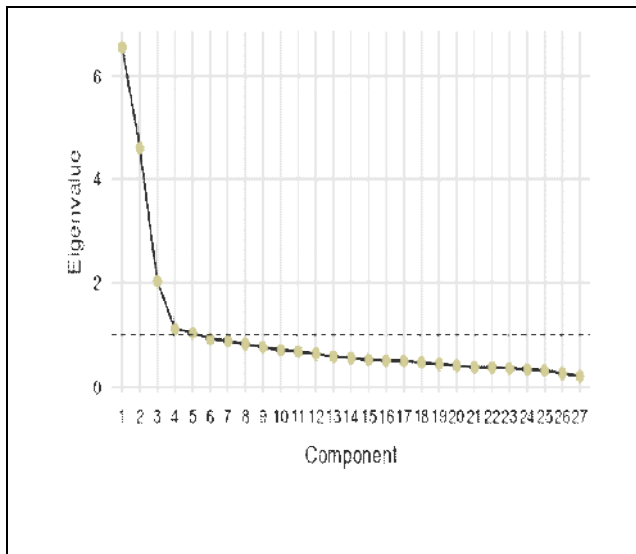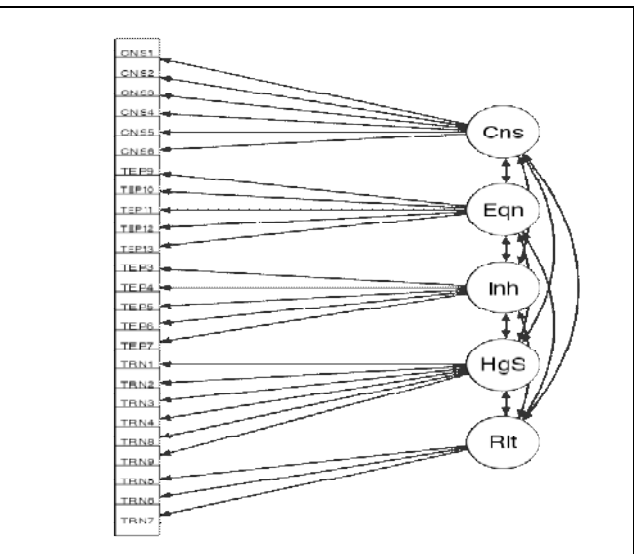
Figure 1: Scree Plot	Figure 2: Path Diagram

RESEARCH ARTICLE

ESG Integration to Industry 5.0 : Assessing Corporate Pathways in India

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ABSTRACT

The paper examines how ESG integration plays a crucial role in emerging Industry 5.0 .The shortcomings of Industry 4.0 like climate change, lack of talent to manage technological development, cyber security and data privacy has emphasized the synergy between humans and new technologies. Industry 5.0 is a new industrial revolution that is focused on creating a more sustainable and human-centered future .The paper explains how by encompassing ESG practices industries can achieve triple bottom line. i.e, profit, people and planet. The paper explains the various ESG practices, its need for today's business and the progress of ESG in India. A systematic literature review has been undertaken on how ESG practices impact Industry 5.0. Sustainability practices in manufacturing, supply chain Management, Employee engagement and Innovation will give a pathway to sustainable Industry 5.0 and achieving UN sustainability Goals

Keywords: ESG Practices, Industry5.0,Supply chain management, Innovation, Employee engagement.

INTRODUCTION

Transition from one period to the next is frequently characterized by significant changes in economic paradigms, technical innovation, and societal expectations in the dynamic world of commerce and industry. The integration of digital technologies into manufacturing and production processes in Industry 4.0 has paved the way for a new era known as Industry 5.0.The dehumanization of businessesdue to widespread digitization and dynamic development of the technologies in Industry 4.0 has made the scientific community more interested in the aspects   of industrial humanization, sustainability and resilience.(Grabowska et al., 2022).In contrast to its predecessors, Industry 5.0 aims to strike a harmonic balance between intelligent machines and employees rather than focusing only on improved automation or connectivity.

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ESG standards hold special significance for companies aiming to make the shift to Industry 5.0. It is distinguished by the application of cutting-edge technology to boost productivity, efficiency, and safety, integrating AI,Internet of things and robotics,.Further Firms with high strength in environment, governance, and social pillars create more value in market. (Bhaskaran et al., 2020)

Objectives of the study
- To study the ESG Practices in Indian corporate Scenario.
- To assess the impact of ESG Practices in fostering Industry 5.0

ESG practices

ESG investing, or environmental, social, and governance, is the term for a set of criteria for a company's conduct that socially conscious investors use to evaluate possible investments. A framework called environmental, social, and governance (ESG) is used to evaluate an organization's operations and performance on various ethical and sustainable issues. It also provides a way to measure business risks and opportunities in day today activities. Businesses that have a greater awareness of sustainability make sure that shareholder value is created by way of improved financial performance, better management, and lower risk metrics. Furthermore, compared to just financial matters, qualitative nonfinancial factors like reputation, stakeholder trust, employee satisfaction, and engagement have an even greater impact on long-term value.(Zumente & Bistrova, 2021).Changes in demand from the financial ecosystem as a whole, motivated by a need for greater alignment with values and better long-term financial value, have given rise to the ESG investing movement. (Boffo, R., 2020). ESG can be effectively integrated at every level to create a win-win situation for each stakeholder of the industry. ESG approach contributes to a company's added value

ESG practices can help businesses in many ways.

- Improved risk management: Businesses that recognize and control environmental, social, and governance (ESG) risks are less likely to suffer operational setbacks or financial losses. They can support companies in recognizing and controlling the risks connected to emerging technologies. Businesses must be mindful, for instance, of the possibility that new technologies will result in job losses or negative environmental impacts. Businesses can create strategies to reduce these risks with the aid of ESG practices.

- Improve operational Efficiency: Companies can cut back on waste production and energy use by implementing ESG practices. By using energy more efficiently and more renewable energy in all aspects of its operations, this can reduce costs, improve environmental performance, and flatten the emission curve.

- Attract and retain customers and employees: Consumers are placing more and more demands on the ethical and sustainable production of the goods and services they buy. Strong ESG policies also increase the likelihood that workers will desire to work for such organizations.

- Reduce costs :By adopting ethical way of conducting business and reporting, Companies can save money on energy and water costs by adopting sustainable practices. They can also reduce costs associated with compliance fines and lawsuits.

- Increased revenue and enhanced brand reputation: Companies that are seen as being socially responsible can attract and retain customers, which can lead to increased revenue. Nearly 90% of studies find a non-negative ESG–CFP relation(Friede et al., 2015)Businesses that perform well in terms of environmental, social, and governance (ESG) enjoy a better reputation, which can be beneficial in attracting in and retaining investors, customers, and employees.

- Increased access to capital: The capacity of a business to attract in investors and finance growth initiatives is increased when it exhibits strong ESG performance.

- Increased employee engagement and productivity – ESG practices can help employers improve employee engagement and productivity to do this by assisting organizations in attracting and retaining top talent.

➢ Improved social impact – Businesses can have a positive effect on their location communities by introducing ESG practices and help attain enhanced social license to operate and better relations with the community. To that end, the consequences of conducting ESG practices can be transformational throughout all types of organizations. Businesses may achieve higher financial outcomes, lessen danger, improve reputations, and better the environment can all be enhanced.

Status of ESG in India vs. developed nations

India is a long way from accepting ESG wholeheartedly, but it is making progress. The country's ESG score expanded by 2.5 points over the last year to 42.5 out of 100, according to EY's 2022 report. Although it is less than the worldwide average of 65.2, it is a significant improvement. Several factors contributing to the rise of ESG in India include government backing for ESG initiatives: the two national programs, the National Green Hydrogen Mission, and the National Solar Mission, among others. The Securities and Exchange Board of India immediately discloses ESG performance of the top 1,000 listed companies. ESG investing is gaining popularity among Indian investors. In 2022, the CFA Institute published a report stating that 79% of investors in India felt that ESG considerations were significant when making investment decisions. Compared to 67% in 2021. To conclude ,Indian companies are starting to see the advantages of ESG. ESG can assist companies in attracting and retaining top talent, cutting expenses, and increasing operational efficiency. ESG can also assist companies in reducing risks and constructing a more sustainable future.

Industry 5.0

The next industrial revolution, known as "industry 5.0," is anticipated to be marked by a stronger emphasis on resilience, sustainability, and human-centricity. A number of conditions need to be fulfilled in order to realize the objectives of Industry 5.0.(Adel, 2022)(Cornell & Shapiro, 2021). First, it is imperative that companies shift to a more human-centered approach to operations and manufacturing. It entails prioritizing the needs of employees and creating processes and systems that are secure, comfortable, and empower them. To guarantee that employees have the skills necessary to thrive in the Industry 5.0 environment, it also entails funding programs for skill development and training. So secondly, companies need to embrace Sustainability as a core value. These translate to decoupling from the environment, efficient resource management and circular economy. It also involves the designing and implementing of sustainable business models that generate value into long term, for all part involved. Third is to integrate Resilience into business operations. Which involves becoming tough in order to forecast the disruption, whether it is unexpected events; disasters of nature or down turns etc., so that these factors does not turn into a trouble and helps mitigation. It also means the capacity to adapt rapidly as conditions change and being able to learn from your missteps. In addition to these overarching requisites, there are numerous specific technologies and traits that will be integral for Industry 5.0. It will heavily rely on AI, which will help companies automate processes, make better decisions, and customize goods and services.

• **Big data analytics:** The vast volumes of data produced by AI and the Internet of Things will be comprehensible through the use of big data analytics. Making better decisions and spotting trends and forecasts are all possible with the help of this data.

• **Digital twins:** Digital twins are computer-generated images of real-world systems and objects. They can be used to optimize production, forecast maintenance requirements, and simulate and test new products and processes.

• **Internet of Things (IoT):** Throughout the value chain, the Internet of Things will link machines, gadgets, and sensors to provide real-time data and insights that can be used to boost productivity and performance.

• **Additive manufacturing:** 3D printing, or additive manufacturing, will be used to create components and products with customization more quickly and sustainably. Through compliance with these specifications and integration of these technologies, enterprises can set themselves up for success in Industry 5.0.

Integrating ESG in Innovation in industry 5.0

Achieving the objectives of Industry 5.0—the next industrial revolution predicted to be marked by a stronger emphasis on resilience, sustainability, and human-centricity—requires integrating ESG into industrial innovation.(De Giovanni, 2023). ESG can be incorporated into industrial innovation in a variety of ways. Using ESG criteria to evaluate and choose novel concepts and initiatives is one method. This entails thinking through the governance, social, and environmental effects of novel inventions before they are created and put into use. Particularly beneficial to low-ability workers, generative AI technologies can boost self-efficacy and job satisfaction. Even though implementing these new technologies may increase productivity, it's important to consider the possibility of job displacement. Because of this, policies and initiatives that assist employees in their efforts to reskill and upskill are crucial to guaranteeing that the advantages of technological innovation are distributed fairly and that workers have the competencies required to prosper in the dynamic labor market.(World Economic Forum, 2023). Another approach is to embed ESG in innovation by crafting and engineering new products and services with pre established guidelines for ESG. Central to this, is the development of products within an ethical framework that are sustainable from a social and environmentally responsible perspective. ESG can also be assimilated into the innovation agenda by leveraging ESG data and insights to enhance or improve the functioning of existing products/ services currently on offer. By understanding ESG data to identify places where products and services can be improved, whether reducing their negative impact on the environment or enhancing their positive social outcomes. In addition to reducing costs, ESG-friendly innovations can also help businesses consume less energy and produce less waste as well increase revenue and efficiency.

ESG for resilience in Industry 5.0

This concept of using environmental, social and governance (ESG) considerations to build a more resilient company is called " ESG for resilience" — humanalfa In other words, if you want to build a virus-proof business (one that is immune to shocks and disruptions), this involves identifying & mitigating ESG risks along with capitalizing on ESG opportunities. When businesses are under growing pressure from new risks — internal (security breaches, supply chain disruptions) and external (social unrest & climate change), it is absolutely imperative that ESG secures Resilience. Resilience enables firms to reduce these risks from happening and mitigate the pathways of impact if it becomes a reality. There are a number of ways that businesses can use ESG to build resilience.

- The company strives to cut down the emissions and minimize its ecological effect by implementing water-saving methods, lowering waste creation reducing greenhouse gas emission etc.
- Reduce their environmental impact: Water conservation, filters air pollution from nitrogen oxides generated in agriculture practices. Doing this reduces costs for environmental compliance and cleanup to the company plus sets a base for making it eco-friendly.
- Invest in social relations: Paying employees a fair wage, providing benefits to workers and their families; contributing positively toward the sociopolitical environment into which they operate. Companies must deploy tools and solutions to attract top talent, retain this valuable commodity as best they can while develop a better working model for their work force urosanchor.
- Enhance their governance practices: by having competent board of directors, conducting ethical business behaviors and transparent ESG reporting. This could minimize reputational damage and help companies build trust among stakeholders.

ESG in Supply chain management in Industry 5.0

Industry Supply Chain Management An Industry supply chain management is used to represent an 'equity,' insertingt ESG into a businesses' sourced (supply) corporate-growth model. It also involves considering the environmental, social and governance (ESG) implications at every stage of supply chain where it ranges from sourcing raw materials to supplying finished goods over clients(Sekaran et al., 2023). There is growing recognition among SCM experts that ESG-sound supply chain practices are important for all of these reasons. One obvious is the consumer pressure on business to be more responsible and open about supply chains. Second, investors are increasingly focused on ESG performance and this desire indexes the corporate community ever so slightly to raise its game around ESG. Third, regulators are implementing new laws and regulations to police corporations on

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managing ESG risks in their supply chains. One way for businesses to integrate ESG into their supply chain management is by conducting supplier audits measuring that will score the ESG performance of your suppliers. Another is establishing and enforcing sustainable sourcing policies. Moreover, companies can improve their ESG score by working alongside its top vendors.

Integrating ESG in eco-friendly practices and achievingNet Zero Carbon
- ESG can be integrated into eco-friendly practices and Net Zero Carbon by screening and selecting suppliers keeping in mind the environmental, social, and governance implications before they are selected.
- Create and develop new, socially and environmentally responsible goods and services. This entails taking into account how goods and services will affect the environment and society at every stage of their lifecycle, from the extraction of raw materials to the disposal of end-of-life goods.
- Invest in energy-saving and renewable-energy initiatives. Businesses may be able to attain Net Zero Carbon and lower their greenhouse gas emissions by doing this.
- Put policies in place for sustainable sourcing. This entails obtaining inputs and raw materials from vendors who have a proven track record of social and environmental responsibility.

ESG enhances employee skill development in industry 5.0

By offering opportunities for employees to learn about and place ethical and sustainable practices into practice, ESG improves employee skill development in the workplace. Employees may benefit from this by gaining new knowledge and abilities as well as increased engagement and productivity.(Cornell & Shapiro, 2021) In addition to these targeted programs, businesses can foster an ESG culture that encourages staff skill advancement. This can be achieved by emphasizing the value of ESG, giving staff members the tools they need to advance their ESG knowledge, and fostering an environment in which they feel free to share ideas and ask questions. offering sustainability training that covers subjects like water management, climate change, and sustainable sourcing. Acknowledging and rewarding workers for their contributions to the sustainability objectives of the company. The practice of job rotation and cross-functional team work facilitated the acquisition of novel perspectives and competencies by employees, including expertise in sustainable manufacturing practices and renewable energy.

CONCLUSION

ESG practices are the north star to guide companies into a future where economic prosperity is inextricably linked with environmental sustainability, social justice and moral governance. They were created so that businesses can begin to meet the inconvenient truths of our time including climate change, dwindling resources, social inequality and ethical drift. This modern ESG approach promotes innovation through, for example, the adoption of cleaner technologies and inspires inclusionary cultures with diverse workforces that have all company personnel actively choosing equality in decision making. Additionally, an integrated approach to ESG practices is imperative in enhancing corporate reputation and garnering capital as well as minimising risks and ensuring adherence with regulations. It makes the corporate atmosphere more pliable and resilient, so that organizations are no longer affected by adversity or take full advantage of opportunity. ESG is the basis of Industry 5.0 — sustainable, moral and profitable business can be built on it; in which profit tightly associated with people and environment for social benefits to foster a shared future where society as well as nature win at last. It is a path to both the success of our collective future and that corporations recognize they succeed when everyone prospers — one where financial health can no longer be measured by numbers on an earnings report, but must include human prosperity too. A wider list of environmental, social and governance (ESG) factors includes everything from resource consumption through diversity & inclusion to employee well-being or carbon emissions. Instead, certain SDGs are supported by ESG activities and practices.

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Figure:1 ECG	Figure:2 Industry 5.0

RESEARCH ARTICLE
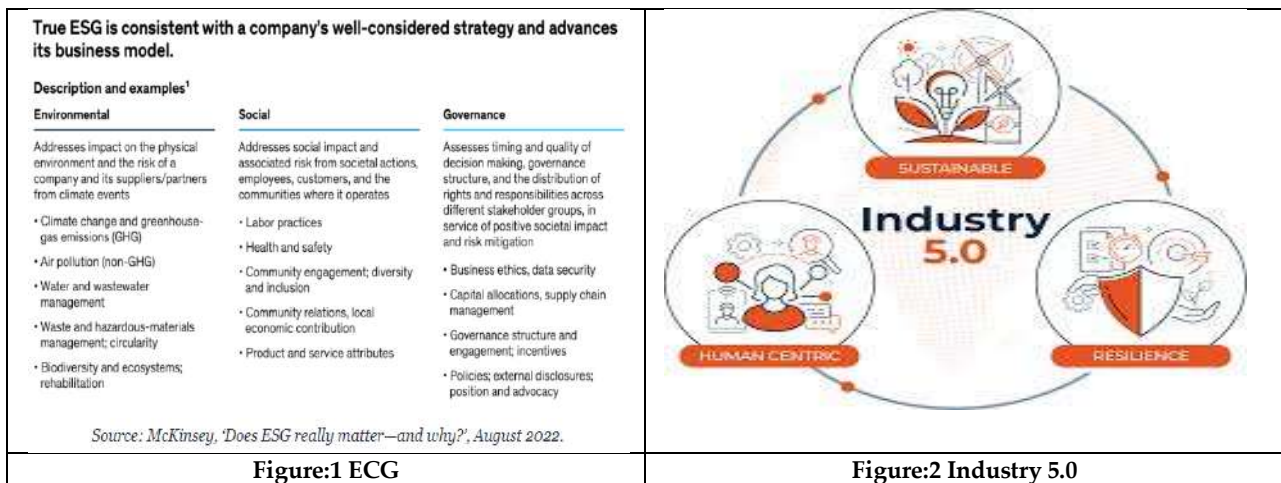
Revisiting Rural Women Empowerment - A Study on Women Education and Health Perspective with Reference to Tumkur District, Karnataka

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ABSTRACT

This study further examines the dynamic relationship between women's empowerment, education and health in rural areas. Specifically, based on Tumkur District of Karnataka a district specific analysis also has been done following this line. The study seeks to understand the complex set of challenges and prospects experienced by rural women as well as offer implications for policy and intervention that are better informed than currently possible. The results begin to reveal where women's education stands in Tumkur, including enrollment rates and access to educational resources along with the impact of such enterprises on agentic potential for rural females. The study investigates education driven economic independence, societal awareness and community development. Focusing on women's health in rural Tumkur is an important part of the study. The study examines the access and quality of maternal health care services, the outcomes associated with these services on maternal/child health as well as potential effects from empowered social norms that generate women's capability to make informed decisions about their own and their children?s welfare. The study reports the challenges faced by rural women as restrictive social norms and practices, wide economic disparities, infrastructural barriers restricts empowerment of such individuals At the same time it showcases examples of positive action that illustrate resilience and determination on display by rural women under challenging circumstances. In this statement, the abstract also develops a series of policy recommendations that draw on what is learned from the study to overcome these obstacles and optimise potential for women empowerment in Tumkur District. These 23 recommendations range from policies in education reform to improvements in healthcare infrastructure and community engagement measures. Conclusion This article sheds light on the complexity of rural women's empowerment in Tumkur, Karnataka. With a focus on the links between education and health, it helps to lay the groundwork for evidence-based policies that function as interventions within endogenous processes of sustainable development in the region and promote gender equality.

Keywords: Rural Women, Healthcare, Economic Disparities, Economic Independence and Infrastructural Limitations

INTRODUCTION

India's changing socio-economic dynamics set the stage for understanding why investing in rural women's empowerment is a crucial factor in sustainable development. In the heart of Karnataka lies Tumkur District — a reflection and embodiment of rural life, replete with familial dynamics in which women drive household as well as community forces. This paper investigates the interrelated dimensions of education and health as precursors for women's empowerment in rural Tumkur, India. Despite advancement in understanding issues of women empowerment, the specific nature of barriers faced by the rural woman prompts a detailed context specific analysis. Tumkur District is a neat place to do this kind of research, as it will make available the best opportunity for study in an environment with mixed traditional values and contemporary social economic mechanisms. This study by reconsideration and revalued the construct of empowerment through education and health, aiming to reflect different visions to be analysed in literature already available about rural women's empowerment. This research is important in illuminating the complex issues that rural women face, specifically those living within Tumkur and lay a potential groundwork for intervention and policy; targeted to these challenges. In re-examining the forces at work in education and health settings through its lens of empowerment, this research hopes to inform terms that reflect women's lived realities on Tumkur District. Educating and empowering women is crucial in driving inclusive growth, social wellbeing to make community more resilient against future challenges. The UN "Planet 50-50 by 2030 – Step it up for Gender Equality" initiative highlights the crucial role of women participation and contribution to building a gender-equal world. To observe trends in developed nations like the USA, Finland, and most of Western countries also with high Gender Development Index (GDI) and Human development index (HDI), it only confirms women have a role to play for any nation determined to develop. All these trends show the huge role played by women in economy, Empowerment and progress on their respective countries **(Bhusad Shivaleela Fakkirappa, Gadawale, H.H.(2021),**

REVIEW OF THE RESEARCH

According to Rouf Ahmad Bhat (2015) in Role of Education for the Empowerment of Women with Special Reference to India, women are said as power or driving force behind a nation's moving further form onward towards progress and development. They are vital resources that stimulate the energy of humanity, agencies for national progress. Thus the main goal for us to help progress future women in our nation is by securing education at first. Empowerment stands in direct physical contrast to vulnerability; it is moving from a position of un-named and unseen, easily dismissed need into presence — power. If anything, we realise that on a societal level women's education is one of the most powerful tools for creating change. Education is an agent of change, reducing disparities and helping to give women a voice at the household level as well as in society. In order to further encourage education amongst women at all levels and contain the gender divide in sharing of information, a number schools, colleges as well as universities limited for females being founded around the state. An increased focus on education enables the participation of women in governance, panchayats and all public activities leading to eliminate gender discrimination. We cannot just develop the pathways to empower them alone but together in one phenomenon called education — now educating women is not only educated a single person, it's about making an unbroken path where society gets progressed as altogether. Santosh Rupa. The findings of the study conducted by Shama Prasann Kumar (2017) in her article "Women Empowerment through Microfinance- An Empirical Study of Women Self Help Groups in Tumkur District, Karnataka" also confirm that effective utilization of microcredit has contributed to empowering the members with SHGs. It holds the promise of getting more people to an economic development path. Research shows this change was accompanied with a significant improvement in asset holding, income levels and savings of the group members on joining these groups which had led to a major socio-economic transformation within that village. Although there were optimistic assessments of the advantages secured and loan amounts sponsored, a few reservations were expressed particularly on operational aspect involving bank approaches as also delays in processing loans. They suggest that all levels of policy should address constraints to improve the loan approval

processes by enhancing flexibility at grassroots level. The sample area being Muslim dominated and belonging to backward classes, women benefited more because most of the Self Help Groups in this study are for women. Since the entire national development depends on men are progressing together with women, such groups must also be created for extension purposes of empowering over men in parallel style. This balance, in turn can play a pivotal role to contribute towards the overall development of the country. Schuler SR, et al (2010), in their paper entitled "Women's empowerment revisited: a case study from Bangladesh" concluded that the assessment of women's empowerment encounters various challenges, with life stage being a notable factor. Consider, for instance, the distinct constraints on agency that a woman faces at different life stages, even within a study focused on currently married women. Notably, there are discernible variations in the limitations faced by a recently married woman compared to one with several years of marriage experience. Furthermore, in the context of limited education, where a woman's earning capacity is closely tied to physical strength, those at different ends of the age spectrum may experience disparities. Older women, as their ability to work diminishes, may face a decline in their capacity to earn income and exercise agency. Therefore, there might be merit in studies on women's empowerment focusing on specific age groups to capture nuanced variations. Additionally, economic considerations, particularly poverty, exert a significant influence on empowerment. Economic constraints limit opportunities for financial investment, and given that decision-making about investments and consumption is integral to empowerment, economic inequality poses challenges in developing indicators that universally apply to all women. The existence of poverty introduces complexities into the measurement of empowerment, necessitating a nuanced understanding of how economic factors intersect with women's agency across diverse circumstances.

Objective of the Research

1. To study the various government schemes for women education an health in rural sector India
2. To determine the Beti Bachao Beti Padao scheme in empowering girl child through education in India
3. To assessment of PMMVY scheme in maintaining pregnant and lactating mothers health.

METHODOLOGY

Our research methodology involves the compilation of secondary data from diverse sources, including existing literature, reports, government publications, books, journals, magazines, online resources, and other relevant materials. Throughout the study, we have collected data from various outlets such as journals, magazines, websites, and similar sources to ensure a comprehensive and well-informed analysis. Some Major Government Schemes For Women Education And Health At Rural Sector In India For promoting the women education, health and for rural area govt lunched many projects and schemes by Indian government. They are designed to tackle the unique challenges that women face and fair better for overall wellness. Following are a few of the important government schemes for women education and health in rural India:

Women's Education

Beti Bachao, Beti Padhao (BBBP): The 'Beti Bachao, Beti Padhao' (BBBP) initiative is a flagship program launched by the Government of India in 2015. This program, named Beti Bachao Beti Padhao meaning to create a campaign for creating awareness and improvements in the efficacy of welfare services intended for girls'; was launched with objectifying two goals: Combat post-saving scheme policies that are sanctioned from skewing gender stereotypes prejudiced against girl children as these were being implemented various parts of Nepal. Most of this program deals with gender imbalances and girl child education. Yes, under 'Beti Bachao' (& Beti Padhao) it was realized that if the country has to develop equitably and comprehensively kind of formulaic thinking as well not only in ensuring gender equity or empowerment but also for mainstreaming women as a whole. It aims to generate a place where despite all girls are valuable, safe and have access to education for development. The programme is executed at National and State levels focusing different region specific challenges & needs of India.

Sarva Shiksha Abhiyan (SSA)

The SSA program aims to provide quality elementary education. It has clauses to ensure that the girls in rural areas get their education at par with boys. Kasturba Gandhi Balika Vidyalaya (KGBV) KGBV is a scheme for setting up residential schools at upper primary level for girls belonging predominantly to the SC, ST,OBC and minorities in difficult areas.

Mahila Samakhya Programme
This program is focused on empowerment of women, and to get it promoted woman education, Gender equality in the field of Education and access to Educational resources in Rural areas.

Women's Health
- Janani Suraksha Yojana (JSY): This scheme provides financial incentives to pregnant women from rural areas in order for them to give birth in healthcare institutions and undergo antenatal, natal and postnatal care.
- Pradhan Mantri SurakshitMatritva Abhiyan (PMSMA): Objective — to reduce maternal mortality by focusing on providing quality antenatal care services in rural areas.
- National Health Mission (NHM): There are several programs under NHM including National Programme on Reproductive, Maternal, Newborn Child and Adolescent health RMNCH+A to address the urgent needs of women and children in rural areas.
- Janani Shishu Suraksha Karyakram (JSSK) – In this scheme all pregnant women are deliver free of cost, includes post delivery care and new born child service which is mainly focused on rural areas and economically weaker sections.
- Swachh Bharat Abhiyan (Clean India Campaign): Better sanitation, especially in rural areas and provision of toilets is directly due to affect health as well dignity concerns among women. The Swachh Bharat Abhiyan endeavours to do this.
- Ayushman Bharat – Pradhan Mantri Jan Arogya Yojana (PMJAY): It provides financial protection to poor and vulnerable rural women by offering health insurance for hospitalization, diagnosed need management services.
- National Food Security Act (NFSA) – although it is not designed specifically for women, this act sought to make food available in quantities that are sufficient and enough to meet the nutritional needs of all individuals which includes nearly two-thirds of Indians rural households; thus reducing malnutrition among children as well adults. These schemes among others have been instrumental in imparting education and health of women especially those living in the rural regions on India. But much more work needs to be done, as there are many gaps yet in the provision of quality education and health services for rural women.

Education of girl child in India -Beti Bachao Beti Padao Yojna
The "Beti Bachao, Beti Padhao" (BBBP) scheme in India is a significant step targeting the object of declining child sex ratio and gender based discrimination all over country. The program has been able to achieve a lot of success in spreading awareness and promoting education among girls since its inception back in 2015. The Highlights of the BBBP scheme enabling education for girl child in India are:
- **Increase Awareness:** Since one of the major goals of BBBP scheme is to highlight significance and side effects associated with male child preference syndrome thus it raises minimum awareness. A number of national, state and local level campaigns were conducted across the country in addition to workshops and advocacy programmes with a view towards generating greater awareness about importance of girl's education.
- **Financial Incentives:** The scheme offers financial rewards to promote girls' education by families. Conditional cash transfer schemes and scholarships serve to lessen the economic burden on parents, which encourages them to send their daughters for education. That in turn has driven up girls' enrollment and attendance.
- **School Infrastructure:** To provide girls a safe and effective of learning school environment works for change on infrastructure. This includes building separate girls' toilets, providing drinking water and raising security within schools.
- **Quality of Education:**A major objective behind implementation by the BBBP is to provide better quality in education for girls. That includes professional development for teachers, and building a curriculum responsive

to the needs of female learners. Making the education materials free from gender bias and confirming both genders are being represented.

- **Monitoring and Evaluation:** There is a provision for monitoring and evaluation to monitor the scheme frequently from time to time. States and districts have been directed to report on indicators such as sex ratio at birth, number of girls in school, attendance rates etc. This data assists in evaluating the scheme.
- **Legal Measures:** BBBP focus on implementation of legal measures like PNDT Act to help in a halt the sex-selective abortions and also address issues related to gender discrimination.
- **Girl Child Empowerment:** To bring for the welfare of girl child knowledge & skills etc. until higher secondary form by above point, full empowerment beyond education Activities such as self-defense training and career counseling or vocational skill development programs are conducted to empower girls.
- **Community Engagement:** The project helps make society support the girl child by encouraging social participation. The panchayats, NGOs and civil society organisations important role in spreading awareness as well as implementation of the objectives of this scheme at grass root level. Despite impressive efforts towards the welfare of the girl child in India spearheaded by BBBP, a long way remains for making it an all-pervading reality–disparities with states where focusing on boy's schooling is prioritized; cultural tenets and social attitudes that discriminate women persist being two menacingly stark truths. Hard work is required to continue empowering girls through education, elevate and build on success achieved in reducing gender-based discrimination against them, as well as expand opportunity for those not being served.

A brief background of the PMMVY Scheme to keep pregnant and lactating mothers healthy
Pradhan Mantri Matru Vandana Yojana (PMMVY) is a maternity benefit program run by the government of India. It seeks to provide partial compensation for wage losses and to ensure that every pregnant and lactating mother receives her health needs during the antenatal or postnatal period.

Conditional Cash Transfer (CCTs)
of course, we would breaking down elements of the Conditional Cash Transfer (CCT) under Pradhan Mantri Matru Vandana Yojana (PMMVY), and looking at how these address different dimensions around maternal and child health

Direct Cash Incentive
- Eligible beneficiaries—pregnant women and lactating mothers—are given direct cash incentive.
- Exception for the one-time cash, other installments creates and deposits into their bank accounts (multiples).

Compensation for Wage Loss
- For a lot of women, especially those in labor-intensive jobs including pregnancy could necessitate the absence from work.
- The cash incentive is a maternity benefit which compensates the wage loss in women due to them not being able to take on regular jobs during preganancy/child birth.

Improving Maternal Health:
- The cash incentive is aimed to motivate them for early and regular antenatal check-ups using human tendencies of incentives.
- Prenatal care is essential to check on the well-being of mom and baby.
- Financial aid makes certain that, women get a considerable support in terms of Medical Consultations, Clinical tests and all needed medications right through her gestational days.

Promoting Institutional Delivery
- To promote institutional deliveries, a key objective is that the number of women who deliver in healthcare facilities under care will increase.
- The belonging s cash incentive is a trigger word to the brain of those pregnants women who are planning for home delivey after delivery/

- Delivery here is safe in case if there are some complications that may require medical interventions.

Promoting Early Registration:
- An extra reward is also provided to encourage registration with the program in early pregnancy.
- For the beneficiaries, registering in advance means that pregnant women can start benefiting and participating as soon as they are aware of their pregnancies.

Ensuring Maternity Benefit
- The cash transfers are provided sequenced to support different stages of maternity.
- This financial support is used to pay for costs associated with maternal health, nutrition, etc. prior and post childbirth as well. In short, PMMVY offers Conditional Cash Transfer to alleviate economic worries for those suffering wage losses and support improved maternal health by ensuring regular hospital visit at the same time encouraging institutional delivery thereby promoting safer childbirth. By using a structured installment system, financial support is delivered when it matters most in the life course of maternity and thus leads to maternal health increase as well child welfare for herself. Pregnant And Lactating Women: For the first time, nutrition has been linked to health care for maximum impact through participation.

Web health treatment mother under nutrition encouragement encoding component health nutrition.
Here is how this component works:

Antenatal care awareness
- Health and nutrition education is the major component of PMMVY, under Health & Nutrition Education special stress which shall be given for imparting information regarding antenatal care.
- Pregnant women are educated about early and regular antenatal visits. These are essential ways to keep a track of the proper health status, mother and baby wise.

Postnatal Care Guidance
Postnatal Care:
- This talks about the importance of care after childbirth as part of education.
- A number of details are provided on post-natal visits, early detection for signs in the puerperium and keeping very healthy after delivery for both mom as well as baby.

Breastfeeding Promotion
- The main highlights of PMMVY is to promote breastfeeding for the well being both mother and child.
- Key messages Women are counselled about the need for exclusive breastfeeding in early months of baby's life and it contributes to improve nutrients and immunity.

Nutrition Counseling
- The scheme includes provisions for counseling on maternal and child nutrition.
- Women are educated about the importance of a balanced diet during pregnancy and lactation, ensuring they receive adequate nutrients for their own health and the healthy development of the child.

Health and Hygiene Practices
- Health education extends to promoting proper hygiene practices during pregnancy and postpartum.
- Information on maintaining a clean and safe environment is provided to prevent infections and complications.

Family Planning Awareness
- Some maternal health programs also include information on family planning methods, allowing women to make informed decisions about the spacing and number of children they wish to have.

Access to healthcare services

- Through education, women are made aware of the available healthcare services, including where to access quality maternal and child health services.

Early Registration Incentive

Women who register early in their pregnancy are eligible for an additional incentive, encouraging early and regular antenatal check-ups.

Institutional Delivery Incentive

The scheme promotes institutional deliveries to ensure skilled attendance at birth. A cash incentive is provided to women who give birth in a health facility.

Maternity Benefit

The financial assistance is provided in three installments, with the first installment given on early registration, the second installment after at least one antenatal check-up, and the third installment after childbirth and the child's first cycle of vaccination. The successful implementation of the PMMVY scheme can contribute to improving maternal and child health outcomes by encouraging timely and adequate antenatal care, institutional deliveries, and postnatal care. I suggest you visit the latest official government sources and other relevant departments in India (Ministry of Women & Child Development or others) to have a more accurate update on PMMVY scheme along with how it has helped poor pregnant woman, feeding mothers. Well, policies and programmes can be changed updated so maybe this is a place to know about the newest information. In fact, using a study centered on rural women empowerment including areas such as education and health in Tumkur District, Karnataka as an example may serve you well.

CONCLUSION

These findings clearly reflect the importance of education and health interventions in facilitating advancement of women folk while living in rural areas. This study further shines light on the progress of schemes for female education in Tumkur District. If more women are given access to education, not only do those individual women transform, but then so does their society as a whole. For economic liberation, enabling better social consciousness and development of a community by impact education served as the elixir. Their is no end to the need for more on educational infrastructure development, National scholarship and skill up gradation initiatives etc. Women in rural areas have been targeted across several dimensions and one of them is the health cause wherein awareness is being created along with accessible healthcare services. Among these, programs targeting antenatal and postnatal care services; family planning; nutrition education have made significant contribution achieving the improvement of maternal and child heath indices. Yet, contrary efforts to close the gap in access to care are consistently necessary both regionally and remotely out of Tumkur District. Although challenges continue such as social- cultural barriers, economic disparities and infrastructural constraints The solution to heeding these trials is a dynamic one that involves government agencies, NGOs and local communities working together. The findings underscore the fact that even in a crisis resilient rural women still continue to show brilliant resolve and aspirations clearly pointing out their potential to influence social transformation if provided access.

Recommendations for Future Action

- **Continuous Education Programs:** Furthering investments on educational infrastructure, scholarships and vocational training to empower rural women with the right tools of employability.
- **Strengthening healthcare delivery services:** particularly in under-served areas to provide enhanced maternal and general health care.
- **Community Participation:** Advocating community participation and awareness programmes to question traditional gender norms and influence women empowerment at community level.

- **Policy Advocacy:** The State level as well the National Level policies for human rights, education and good health- both with an eye to look at rural women. To conclude, this study once again reiterates the linkage between education and health to empower rural women in Tumkur District. It is hoped that by attending this region through broader approaches and specific interventions, the quality of life for women in this immigrant community can substantially be improved with a road towards sustainable development opportunities and gender equality. This study provides important new evidence to help inform the global conversation on rural women's empowerment and as a basis for further research and policy development.

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RESEARCH ARTICLE

Social Media Factors Influencing Consumer Buying Behaviour of Electric Vehicles in Bangalore City

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ABSTRACT

The swift transition from the Web 1.0 environment to the dynamic and linked Web 2.0 environment has changed how businesses exhibit their images online. Consumers are increasingly turning to social media not only to conduct research on various goods and services available on the market but also to interact directly with the businesses that provide them with the goods and services they purchase, as well as with other customers who may have valuable insights regarding the operations of these businesses.As a result, the current study is an attempt to investigate how social media marketing methods influence customers electric car purchase behaviour. A descriptive research technique is going to be used tofulfil the requirements of this study. The researchers intend to obtain the data using a comprehensive questionnaire that was adapted from earlier investigations. According to the findings of the literature review, the five most important aspects of social media are communication, characteristics, content, security, and reputation. The design of a questionnaire involves the use of categorical as well as continuous variables. The questionnaire has thirty questions organized into five different elements. Researchers will confirm the convergent and discriminate validity of the questionnaire to ascertain the scale validity and reliability of the instrument. For the study, a simple random sampling of one hundred fifty prospective purchasers of electric vehicles was considered and because several different aspects go into social media marketing, Structural equation modelling using AMOS will be utilized for the research. The findings of the study will be helpful to electric vehicle marketing units in devising strategies appropriate for the population of Bangalore city based on the effect of social media factors on consumer buying behaviour toward electric vehicles. This study's findings suggest that security, reputation, appealing material, contact, and communication are all crucial to the continued success of social media. The structural relationship shows that social media marketing impacts consumer buying behaviour by 55% and this association is statistically significant.

Keywords: Electric Vehicles, Global Warming, Greenhouse Gas Emissions, Pollution, Web 2.0 Environment.

Lakshmi Eshwar *et al.,*

INTRODUCTION

Electric vehicles (EVs) have been suggested as a viable option for reducing greenhouse gas emissions (GHGs) from transportation and other sources of air pollution (Krupa, J.S., et al., 2016). Most industrialized nations are now implementing a wide range of government regulations and monetary incentives to promote the widespread use of electric vehicles. Much of the existing literature concerns itself with analysing the economics of EV advertising, where to put charging stations, and how customers will decide where to park their EVs. (Axsen, J., & Kurani, K.S., 2008), (Larson, P.D., et al.2014). While there is widespread agreement that EVs should be widely adopted, the advantages of doing so and making them a reality depend on people being open to adopting new technologies. 69 percent of American consumers, according to a 2008 poll (Axsen, J.; Kurani, K.S., 2008), know very little or nothing at all about the technology behind PHEVs. An additional study (Larson, P.D. & et al, 2014) confirmed that individuals would not accept premiums to switch to EVs. Another poll looked at consumers' openness and perspective on plug-in electric vehicles in key US cities to better understand the motivations behind their purchasing decisions. The findings showed that just a tiny percentage of people are interested in purchasing or leasing electric automobiles. Much of the existing research in this field has focused on the consumer's perspective, desire, and attitude toward EVs, in addition to exploring other sociological or psychological factors on the uptake of EVs (Egbue, O.; Long, S, 2012). The results demonstrated that EV-related attitudes, knowledge, and perception vary by gender, age, and level of education (Bunce, L., M. Harris, and M. Burgess, 2014). Public policies, financial incentives, and energy pricing were also cited as factors in the prior study that favoured EV adoption. Many earlier research also tried to probe environmental friendliness, technological savvy, and adaptability. Rapid changes from a Web 1.0 to a Web 2.0 environment have led to shifts in how businesses portray themselves online, from so-called "dot-com" companies (where communication with customers remains one-sided) to a new model in which technology controls the content.

There is a far-reaching impact on potential customers that marketing managers can have (Hanna et al., 2011) thanks to this. In developing communication mediums, social media is seen as a new marketing tool for promoting products and services (Hsu, 2012). What we mean when we talk about "social media marketing" is the practice of utilizing social media channels for promotional reasons. Business-to-consumer (B2C) industries frequently employ social media marketing strategies, and the idea of social media as it relates specifically to B2C has been the subject of much research. According to (Weber, 2009), a marketer's function has shifted from that of a broadcaster conveying messages to a certain target segment to that of a corporation that works closely with its clients and takes part in online communities. Business-to-business (B2B) interactions are increasingly making use of social media (Bernof, 2009 ; Ramos, 2009). To be more precise, the internet's ability to amplify consumer voices has resulted in a power shift. As a result, companies may no longer set the conditions of engagement in a discussion; instead, they must earn their customers' attention and earn the right to join the dialogue by providing content that is of value to them (Fournier and Avery, 2011). More and more people are turning to social media to not only learn about the products and services they want to buy, but also to interact with the firms that provide those products and services and with other consumers who may have useful insights about those organizations (Garretson, 2008). Because of the internet's capabilities—its interaction, breadth of reach, persistence, speed, and flexibility—companies see it as a platform to co-create value with consumers, lowering or even removing regional boundaries and physical distance (Shawhney et al., 2005). With this foundation laid, it will be possible to win over customers. There have only been a handful of comprehensive studies done so far on how consumers act when faced with electric automobiles. This analysis focused solely on the factors that affect consumers' buying decisions concerning social media advertising. Despite its involvement in consumer behaviour, it does not perform in-depth studies of consumer habits. There is widespread consensus, based on research and experience, that the electric car sector must be rapidly advanced. This indicates that there is room for expansion in the field of systematic research on the growth of the EV market based on the description of customer behaviour. Therefore, the purpose of this research is to investigate the effect of social media advertising on the purchase decisions of potential electric vehicle Buyers

REVIEW OF LITERATURE

Farook, F. S., &Abeysekara, N. (2016).
The impact of social media advertising on consumer participation was analysed. Now more than ever, businesses need to know what makes their Facebook brand pages so compelling that visitors keep coming back for more. The information for this study came from surveys sent out to those who liked a certain brand's page on Facebook. The findings showed that the medium and content types of posts significantly affect customer involvement in online activities. Social media marketing's impact on consumer involvement was also highlighted. Five criteria were identified as having a major influence on consumer involvement, as shown by this research. Social networking sites (SNSs) provide an extra channel for disseminating data since they promote two-way dialogue between businesses and their target audiences. Mohammadian, M., & Mohammadreza, M. (2012). Marketing managers may use their company's social media to build strong connections with their consumers and foster loyalty. However, despite searching a variety of national and international scientific journals, the researcher was unable to locate any data supporting a model for social media success. As a result, we want to establish a framework for determining what makes a social media campaign effective. Using a questionnaire, factor analysis, and structural models, the researcher created this model with Allameh Tabatabai University students in mind. Positive effects of elements including security, appealing content, reputation, engagement, and communication were seen. Dahnil, M. I., Marzuki, K. M., Langgat, J., &Fabeil, N. F. (2014). As organizations and SMEs across the world increasingly turn to social media marketing as a new form of communication, academics and practitioners in the field of marketing have never had a better chance to conduct groundbreaking studies in this area.

The goal of this study is to examine the existing research on what motivates small and medium-sized enterprises (SMEs) and larger organizations to engage in social media marketing. It helps people get a clearer sense of where the field of study on the adoption of social media marketing stands at the worldwide level right now. It also provides a helpful framework for assessing the kind of studies that should be conducted to further knowledge in the related field of social media advertising. Razak, S. A., & Latip, N. A. B. M. (2016). The goal of this research is to learn how various factors affect SME participation in social media marketing in Malaysia. Document analysis and scholarly literatures have been combed through extensively. The findings suggest a conceptual framework to explain the reasons why small and medium-sized enterprises (SMEs) in Malaysia utilize social media, and these reasons include the utility, simplicity, and enjoyment of social media. The findings of this research provide valuable data that can be used to guide the future social media strategies of SME owners and marketers. Arango-Botero, D., Valencia-Arias, A., Bermúdez-Hernández, J., & Duque-Cano, L. (2021). Using the TAM, this research looks at what makes retail businesses more likely to implement social media marketing strategies. Identifying these aspects allows for the development of plans to maximize the marketing's potential in terms of client retention and expansion of the customer base. Despite what several writers have suggested, this research shows that the perceived ease of using social networks has little bearing on their actual utility. In addition, it permits restating the beneficial impact of Trust on the Perceived Usefulness construct and Perceived Ease of Use, both of which encourage the spread of advertising in social media. Duffett, R. G. (2017). The research found that teenage attitudes about social media marketing messages were positively affected across the board, but in a diminishing fashion that mirrored the buyer's journey.

In addition, the data showed that the most positive attitudes about social media marketing communications were expressed by teens who utilized the platform for extended periods, regularly maintained their accounts, and identified with the racial categories of Colored and Black. De Vries, L., Gensler, S., & Leeflang, P. S. (2012). Relationships with clients may be strengthened via the use of social media platforms. Constructing fan pages for the company on various social media platforms is one such method. Brand postings (including videos, messages, quizzes, information, and other content) can be placed on these fan pages by companies. Customers may show their support for a company by "liking" or commenting on content posted on the brand's fan page. To what extent brand postings are popular may be gauged by the number of likes and comments they receive. This article explores the factors that may contribute to a brand's post becoming viral. The results also show that the amount of likes and the

number of comments is affected by many factors. Namely, the amount of likes on a brand's post rises when it contains certain features, such as vividness and interactivity. There is also a favourable correlation between the number of likes and the proportion of positive comments on a brand's post. Al-Dhuhli, I., & Ismael, S. (2013) The proliferation of social media has provided consumers with several chances to modify various facets of their lives. Social media platforms such as Facebook, Twitter, and Instagram have played crucial roles in the rise of e-commerce. The evidence of its use is strong, even though Oman and other Arabian countries are struggling to make the most of their use of these sites. The purpose of this paper is to learn more about the demographics of Omani consumers who are influenced by online shopping, the factors that entice them to make online purchases, the products that are most frequently bought online, and the social media platforms that are most frequently used by these consumers Arora, T., Kumar, A., & Agarwal, B. (2020)**.** This study aims to provide a conceptual model that examines the influence that aspects like the informativeness, entertainment value, legitimacy, interactivity, and privacy issues of advertising material have on the perspective of Indian millennials towards social media advertising. The findings pointed to strong correlations that might shed light on how young Indians react emotionally and behaviourally to social media ads. Marketers, advertisers, and brand managers may utilize the findings of this study to better create commercials for use on social media sites, increasing the likelihood that these advertisements will have the desired effect on consumers' views and, ultimately, their actions.

RESEARCH GAP

To begin, compared to nations with very diverse populations, such as China, the United States, and the United Kingdom, India has conducted comparatively less research on electric cars. No studies have been undertaken to give managers in the electric vehicle sector with practical consequences of social media marketing, thus there is also a dearth of practical expertise.

OBJECTIVES OF THE RESEARCH
- To identify the awareness and usage of social media for the purchase of Electric vehicles in Bangalore City.
- To determine the successful social media parameters of electric vehicles and their impact on consumer buying behaviour.

RESEARCH METHODS

The goal of this descriptive study is to find out how social media marketing factors lead to a successful social media campaign. To reach its goals, the study uses both first-hand and second-hand information. Questions from the study of Mohammadian, M., & Mohammadreza, M. (2012) are considered for the study. The master validity series was used to check the scale validity and reliability of the questionnaire, and it met the acceptable criteria. The sample for the study was made up of potential electric vehicle buyers who were chosen using simple random sampling. Using the Cochran formula for an unknown population with 95% confidence and a 5% error margin, a sample of 100 people was chosen. To account for non-responses, the number of potential vehicle buyers in the sample was increased to 150. For the study, 120 Potential electric vehicle buyers were chosen after the outliers were taken out. The SPSS Ver 25 and AMOS Ver 22 programs were used to do the statistical analysis.

RESULTS AND DISCUSSION

DEMOGRAPHIC PROFILE OF THE RESPONDENTS
There were 67 per cent of male respondents and 33 per cent of female respondents in the survey. The respondents' ages, educational qualifications, and occupational designations are presented in the chart that may be found above. The survey has collected almost the same amount of responses from each age group, with 25 percent coming from the 16–25 age range and 18 percent coming from those older than 45. The majority of respondents, 55%, held a

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bachelor's degree or above; additional cross-tabulation revealed that just 33% of male respondents held a bachelor's degree or more, while 67% of female respondents did. The majority of those who responded were businesspeople who relied heavily on various modes of transportation in the course of their work. 45 percent of responders were businesspeople.

CURRENT TRANSPORTATION PROFILE OF THE RESPONDENTS

The respondents' current transportation profiles contain information such as the type of vehicle they possess; for example, 65 percent of the respondents owned two-wheelers whereas 35 percent of the respondents owned four-wheelers. To get about, the respondents' primary means of transportation was a gasoline-powered car in 76% of cases, while just 8% drove an electric vehicle. The majority of respondents, 46 percent, had automobiles that had been in operation for three to six years, and the majority of respondents spent around three thousand to five thousand dollars every month on gasoline expenditures.

AWARENESS OF E-VEHICLES

The purpose of this series of questions was to elicit replies from consumers regarding their knowledge levels regarding electric vehicles (E-Vehicles). To analyse the replies, a three-point scale was utilised. 1 indicates not helpful, 2 indicates maybe, and 3 indicates quite helpful. The number of replies can be found in the table, and the percentage of total responses can be seen in the graph. To determine what the average reaction was from all of the respondents, mean scores were determined. E-vehicles lower the emissions that contribute to climate change and pollution, benefiting public health and minimising ecological harm, according to 62 percent of the respondents who acknowledged that they are aware of this fact. Most respondents (55%) felt that they were environmentally concerned and would like to take the initiative to do something about it. 46 percent of those polled had an adverse opinion towards the item Awr 4. When taken as a whole, the mean scores range between 1.5 and 2.00, which indicates that consumers have a moderate level of misunderstanding regarding the spread of electric vehicles.

TESTING OF HYPOTHESIS

There is a significant impact of social media marketing factors on Consumer Buying behaviour

MODEL FIT - According to the Chi-square/df (2/df) value, the basic model fits statistics should fall below 3 (2.955). Goodness-of-fit ratings improve when compared to the proposed features (0.871). An RMR of 0.071 is found to be within the limits. It is agreed that the model has passable accuracy.

SOCIAL MEDIA DETERMINANTS

Communication

Many definitions of social media emphasize the importance of user participation and the importance of fostering open lines of communication and engagement. Historically, it has taken a lot of time and money for businesses to learn about the industry. People's actual shopping patterns, habits, and preferences may be accurately gleaned from their social media profiles. That's why it saves money and effort. Among the various aspects that affect a user's involvement with a social media platform, this one is crucial (Gunelius, 2011).In the current study as the Communication factor increases by 1 time the success of the social media factor increases by 62% (b=0.624, p=<0.005) and this association is statistically significant

Content

Disseminated data on social media The vast majority of those who specialize in social media say that social media is the most crucial factor when trying to make engaging content. That's why it's crucial for businesses to put in the time and effort required to provide engaging content for their websites or customers will just look elsewhere. People's time spent consuming and participating in engaging online material and conversations is not wasted. In the current study as the Content factor increases by 1 time the success of the social media factor increases by 74% (b=0.743, p=<0.005) and this association is statistically significant

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Online Character

Website or social media characters are an important part of keeping people interested in your social media and other internet-related content. Characteristics of social media that are immediately apparent include graphic design, ease of use, and website load times. In the current study as the Social media character factor increases by 1 time the success of the social media factor increases by 83% (b=0.836, p=<0.005) and this association is statistically significant

Security

When discussing the topic of social media security, we are referring to the degree of personal danger that a user or citizen perceives throughout their professional activities using social media. When it comes to direct sense, simplicity, and suitability for user completion of interactions with a website, Security is an interactive efficiency website. In the current study as the security factor increases by 1 time the success of the social media factor increases by 81% (b=0.813, p=<0.005) and this association is statistically significant

Reputation

In this section, we will use the reputation of online sources to define the reputation of social media platforms. It's been established that the media's standing in the public's mind may have a significant impact on whether or not they retain their viewers and readers, and the same holds true for social. In the current study as the Reputation factor increases by 1 time the success of the social media factor increases by 75% (b=0.754, p=<0.005) and this association is statistically significant

Of all the 5 factors, social media security and social media character have the highest effect on the social media determinants.

Consumer Buying behaviour

A series of questions were developed with the intention of eliciting comments from consumers regarding their Purchase Preferences for E-Vehicles.Even though respondents unanimously agreed that electric vehicles have many advantages, over half of them (45%) stated that they did not intend to ever purchase one. The drawbacks of electric vehicles have proven to be more significant than their positive aspects. When looking at the scores as a whole, the mean falls between 1.3 and 2.00, which indicates that consumers are rather divided about the acquisition of electric vehicles.The structural relationship shows that social media marketing impacts consumer buying behaviour by 55 % (b=0.548, p=<0.005) and this association is statistically significant.

CONCLUSION

The potential for social media to change people as consumers. By taking part, participating organizations aim to increase the number of channels that their customers have access to, expand the pool of potential customers, strengthen their relationships with current clients, and increase foot traffic to their various marketing assets. As was previously mentioned, social media makes it easier for information to flow both ways, therefore each platform helps to spread, receive, and exchange knowledge globally. Potential communication barriers include rejection, misinterpretation, and misunderstanding. These can significantly affect a company's prospects and customers throughout the decision-making process, in addition to its ability to reach its target audience. The internet broadens the reach of global business and public relations in both positive and negative ways.It modifies our understanding of and interactions with networks on both a personal and business level. Before social media became popular, people had to complain to customer service or through word-of-mouth. This dynamic was altered with the rise of social networking sites. More than before, customers can directly and instantly provide feedback on brands on a platform. Furthermore, the widespread use of social media platforms has complicated the idea of the noble purchasing behaviour process, which maintains that conventional marketing techniques alone are not the only factors influencing buyers' attitudes toward completing a purchase. Information from uncontrolled sources, such as peer reviews, suggestions, websites, interpersonal groups, and different types of client-produced media, influences consumers' online purchasing decisions and behaviours but is not under the control of online advertising. The rise in

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popularity of social media sites such as YouTube, Facebook, and Twitter has made it much easier for online communities to expand. One inexpensive way to communicate directly with target audiences is through direct marketing. Customers can exert more financial influence over an organization's strategy when they have more options than ever before as social media marketing becomes more common. What consumers see on social media influences their final decisions. Numerous customers' purchasing patterns can be impacted by the activities of a single consumer. Repurchases are impacted by these kinds of domino effects, which affect the company's sustainability and future profitability. Peer communication is another form of consumer socialization that influences the dynamism and, consequently, the advertising process itself. Conferring to buyer socialization theory, consumers' interactions with other members of their own demographic influence their mental, emotional, and behavioural characteristics. The latest study pertains to the electric vehicle industry and is in line with earlier findings. The findings imply that the data and the model fit well and that the dependent variable (success social media) may be well defined by differences in aspects like security, reputation, interesting content, and social media and communication features. The widespread sense of security among social media users is one of the factors contributing to its popularity. A diverse reputation is also essential for success on the internet. (People) A lot of people offer various social media platforms that could be abused by enquiring parties. According to the data, the level of interest in social media sites is related to the quality of the content posted there. The news and information we provide to our carefully curated user base is trusted by them because they know it is factual and up to date, two elements that play a key role in the decision-making process for people on one side of a discussion. On the other hand, as social media relies heavily on connection and communication, this agent might be essential to the field's advancement. What distinguishes social media as unique Furthermore, this is the second agent that has achieved success on social media. Academic writing indicates that students who commit time to learning during research are more likely to pay attention while dealing with organizational social media, even though later social media has disproved this link. The findings of this study indicate that several variables, such as reputation and safety, the validity and appeal of the information, accessibility, and communication, are necessary for social media to continue to be widely used. To improve customer service, discover how their products are used, and tailor their messaging to the preferences of their intended audience, marketers may use this information to develop efficient social media platforms for their enterprises.

LIMITATIONS AND SCOPE FOR FURTHER STUDY

The current study is restricted to the social media marketing of electric vehicles. In the future, researchers could divide up electric vehicles into two or four-wheel categories and conduct in-depth research on each vehicle class. The scope of the current study is restricted to Bangalore City; additional research could be conducted in other parts of the nation and even in rural areas to learn more about potential future markets for electric vehicles.

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Table 1- Questionnaire Design

Description	No of questions	Type of Questions
Demographic Profile	3	Multiple Choice
Transportation profile	4	Multiple Choice
Awareness	5	Likert scale
Social media marketing	3*5 (15)	Likert scale
Consumer buying behaviour	3	Likert scale

Table 2- Awareness of Customers on E-Vehicles

AWARENESS OF E- VEHICLES	Mean score
E-vehicles, as far as I'm aware, cut down on the emissions that cause global warming and pollution, enhancing public health and decreasing the amount of harm done to the environment.	1.525
I'm concerned about the environment and, if given the opportunity, I'll work to improve it.	1.558
I believe that driving an electric vehicle offers a plethora of advantages, and I want to one day own one.	1.959
I am familiar with all the initiatives that the government has taken about electric vehicles.	2.133
In light of the increasing levels of pollution in metropolitan areas, I believe that electric vehicles serve their function.	1.667

Table 3 - Structural Relationship – Second-Order Confirmatory Factor Analysis for Social Media Determinants and Consumer Buying Behaviour

			Estimate	S.E.	C.R.	P
CBB	<---	Socialmedia_determinants	0.548	0.198	3.51	***
Reputation	<---	Socialmedia_determinants	0.754			
Security	<---	Socialmedia_determinants	0.813	0.204	5.638	***
Character	<---	Socialmedia_determinants	0.836	0.179	5.788	***
Content	<---	Socialmedia_determinants	0.743	0.203	5.13	***
Communicate	<---	Socialmedia_determinants	0.624	0.235	4.255	***
CBB_1	<---	CBB	0.905			
CBB_2	<---	CBB	0.97	0.109	10.87	***
CBB_3	<---	CBB	0.799	0.142	7.657	***

Figure 1- Demographic Profile of the Respondents

Figure 2- Current Transportation Profile of the Respondents

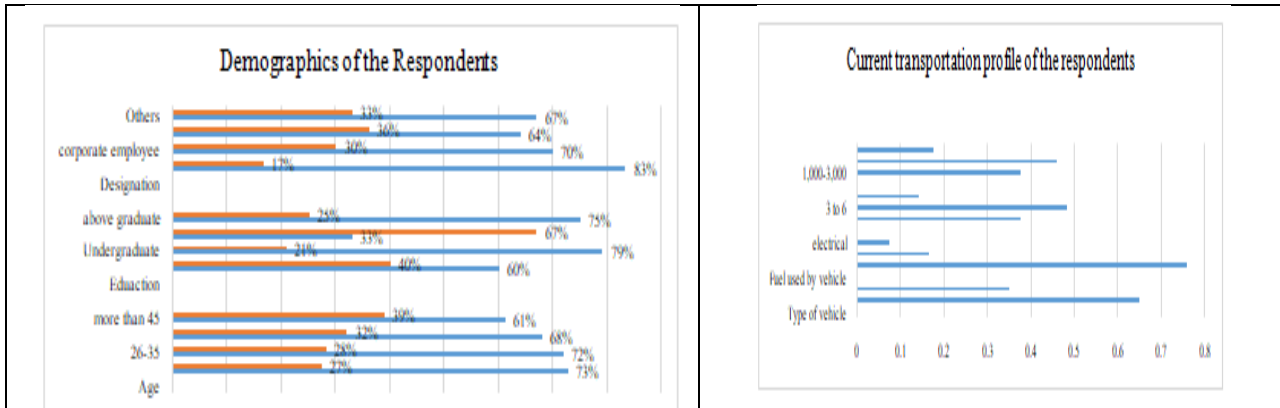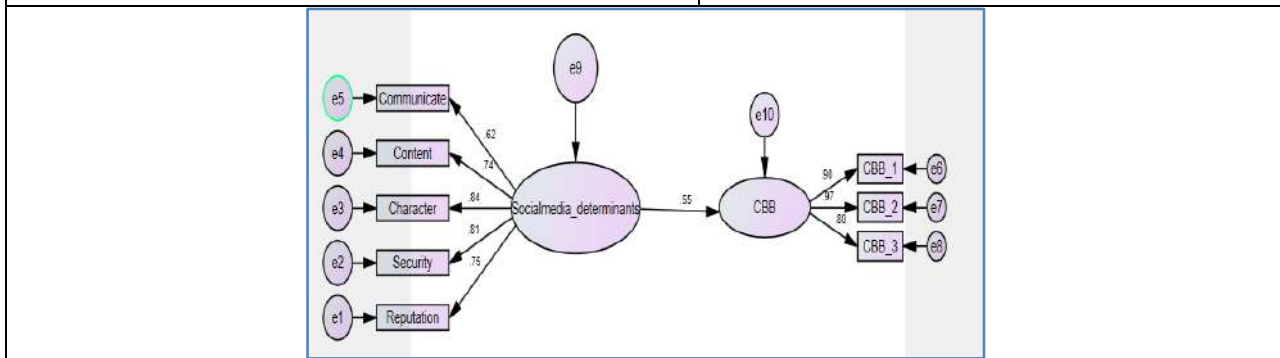**Fig 1- Pictorial Representation of Structural Relationship – Second-Order Confirmatory Factor Analysis for Social Media Determinants and Consumer Buying Behaviour**

RESEARCH ARTICLE

Organic Food Purchasing Patterns among Illiterate Consumers in Bangalore

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ABSTRACT

Needless to say, the organic food market has received a massive boost thanks to changing lifestyles and people becoming more health and environment conscious across developed as well as developing economies around the world. The ignored segment here is non-literate consumers but literate, that seems so queer because the village scenario in urban areas such as Bangalore. The main objective is to investigate the buying behaviour, purchase influencers and awareness level of organic product by Illiterate consumer in context of purchasing barriers which taking face. Drawing on a structured survey with representative sample in Bangalore, we conduct comprehensive analysis of data to better understand the nuances involved amongst this hardly researched group thus providing important policy guidance and inputs for marketers/educators promoting sustainability or health among them. This generalizes our results, not only in terms of organic food consumption being a complex pattern but also of the need for inclusive approaches to building more sustainable systems. Interesting points are seen, for instance demographics of consumers who did not even finish high school show particular organic food preference and difficulties in purchasing patterns in Bangalore. Price, perceptions of quality and trust in organic certifications all play significant roles for them when making the food purchasing decision. In addition, this group has differing degrees of awareness for organic food products and labeling. Significant barriers include socio-economic factors, cultural influences and educational limitations. This study highlight the necessity for context specific strategies to enhance understanding and affordability on organics among illiterate consumers, eventually facilitating sustainable and fair food consumption in urban areas.

Keywords: Organic Food, Illiterate Consumers, Purchasing Patterns, Sustainable Eating, Awareness Levels

INTRODUCTION

The increase in demand for organic food products worldwide is an indication of a significant level of concern for health and environmental issues by consumers. Organic food — which has come to be known as a healthier and greener alternative in today's diet-code-landscape from what was initially mass-produced indefinitely, mostly chemically-laden, genetically-streamline,-selectivity breeding-centric industrial ag-like foods;- is at an all-time cult-play speed. Effed up as it is with global warming, Bangalore reflects this trend pretty accurately in India: most of us here would want to eat more organic if we could. Yet, there is one rather critical subset of the potential customer base that largely flies under-the-radar — illiterate consumers. This research aims to investigate the complexities of buying behaviors this segment offer, their circumstances and preference in purchasing organic food products among urbanites from Bangalore. Despite the increasing expansion of organic food marketing with various product opportunities, little has been known about experience and choice behaviour among illiterate consumers. Through an increased amount of illiteracy, which is generally related to restricted availability for getting information or some form of education accessibility that can have a different challenge on impacting consumer behavior. As we seek to steer consumers towards healthier choices, as well get closer to a sustainable food movement that will significantly reduce the carbon footprint of our eating habits; it is imperative that we first understand how illiterate consumers navigate their way through organic foods and thus make purchases with. This study thus seeks to provide useful cues for policy makers, marketers and educators targeting illiterate consumers.

Our research will be especially important in any urban situations, such as Bangalore because it has seen a rapid growth and only few similar thematic of the reports have been done on this city before. Since the city is evolving, so does its organic food market also and it becomes vital to identify about Illiterate consumers; how they relates with this unique trend of Organic Food Consumption This way, we can find what influences organic purchasing decisions in these groups as well and evaluate by the degree of EOP awareness and certification approaches they currently have, for us to understand their challenges. Beyond deepening our understanding of consumer behavior, these insights can also inform the development of inclusive strategies to encourage more sustainable food purchases and help foster habits for healthy eating across all population groups. A large, buzzing city down in the South of India and often dubbed The Silicon Valley of this country. Bangalore, which has a multi-culture environment due to various large IT Giants exist in this city with the best climate and history belongs Is well positioned on national & international scene. The city is the nucleus of India's IT and software services industry, with thousands of multinational tech companies backed up by research institutes as well startups fostered in its ecosystem. Quality Schooling in Bangalore is yet another criterion, which has some prestigious organizations and university like Indian Institute of Science (IISc), & India Company regarding Engineering Technique (IIT). The city that offers to the best of cosmopolitan lifestyle is known for its beautifully woven tapestry culture and languages, nightlife, food scenes shopping addresses which makeupyour living more luxurious in nature.

On top of its moderate temperature levels, Bangalore city is dotted with lush greenery perfecting the natural charm; historical landmarks as well like that: The grand and awe-inspiring beauty of the enchanting Bangalore Palace or a visit to Lalbagh Botanical Garden are just few instances picturizing it's rich heritage. Bangalore may have its share of traffic troubles and infrastructural woes, but it is a city that stands as the epitome of contrasts – combining an eclectic past with an ever-dynamic present to make some parts look like they belong in a different era altogether. Yet Bangalore serves as one facet on India's developmental gem-driving people from all walks-of-life only proving once again how the essence lies not within history or heritage but among dreamers & innovators tweeting innovations for today into reality every single second! This leads to a complicated and interconnected relationship between the city of Bangalore, unwise men and women as well as scamming customers who buy only organic food. Since most parts of Bangalore is seeing many illiterate people, and these set bring down less awareness about organic food materials. Butchery awareness and knowledge, in contrast to organic food purchasing consumers who are mixed with varying levels of curiosity about these products. Filling this gap between the demand for organic consumables and with knowledge is a necessary step to inspiring sustainable consumption. So … because literacy (and illiteracy) creates

certain patterns, just like any other demographic. Having awareness of these patterns is important when understanding what motivates them to buy organic food. Common influencing factors include price, availability of the food item in question (seasonal vs non-seasonal), cultural preferences. lifestyle and nutritional value or health benefits you stand to derive from it. This could help in adding further insides locomotion and purchase pattern of urban illiterate consumer behaviour comparatively with literate Bangalore modern consumers. Consumers with low levels of literacy litreacy (largely illiterates) might experience difficulties in buying organic food, like well as being unable to read the labels and lack access to information. Understanding these barriers and strategies may offer important insights on how illiterate consumers are coping. Moreover, it will be crucial to identify the determinants of their organic food purchasing through supporting community and advocacy in order to plan effective intervention. Developing inclusive strategies to promote responsible consumption of organic food for the illiterate consumers in Bangalore. Specific strategies must be targeted to address the needs of illiterate populations. These could range from using visual supports, engaging with local communities, clearer labeling and educational programmes specifically aimed at this demographic. The local government and non-governmental organizations (NGOs) in Bangalore city educate the illiterates and promote programmes for sustainable practices.

Coordinated actions by such stakeholders can contribute to holistic approaches aimed at enabling illiterate consumers of organic foods materialize their power-choice mechanisms, thereby addressing larger literacy problems holistically. The pattern of purchasing among the illiterate consumers was related to paradise which has great consequences for individual health and environmental sustainability. Such research can investigate the effect of organic food consumption among illiterate consumers on their well-being and whether it could lead to a more sustainable toll on environment. Social and cultural aspects are therefore inseparably connected to one another. Even among illiterate rural consumers of Bangalore such as tribal people, there may be specific sets of cultural practice that will guide their consumption choices: someone who continues to use pottery is likely carrying a preference for an organic and local food system. These factors should be taken into account for developing interventions or prevention programmes. The linking of Bangalore city, illiterate people and the consumption of organic foods purchased by consumers is a nested interdisciplinary space that situates at intersections with access to information, consumer purchasing behaviour, barriers and facilitators. We conclude that a holistic approach addressing the needs of illiterate consumers, including those appropriate to sustainable consumption and considering cultural as well as social aspects is necessary in order to fully understand and effectively intervene on this topic.

LITERACY LEVEL IN BANGALORE
Education is a major sign of human development and an essential element in the overall improvement of individuals. To enable people to have good living standards and better life quality, attracting them actively to participate in the ongoing evolution of society politics culture. Literacy, the initial step in achieving higher education, does not only offer information but greatly aids all aspects of financial conditions for individuals items, communities and even nation generally. Poor literacy is a global issue affecting individuals and nations; it limits employment opportunities, economic growth, social inclusion and health challenges among many other issues present within communities. Nevertheless, tackling illiteracy can bring many unintended benefits. Among others, these can lead to improved quality of life, economic development and health outcomes as well as helping reduce poverty or increasing empowerment or equality (especially for marginalized groups). Basically, illiteracy per se is not beneficial to anyone but trying to deal and resolve with this dire state can have multiple advantages that will help in individual or societal progress as well as promote the inclusivity benefit crucial for development. Literacy rate-The Table 1 shows the literacy rates across India, Karnataka and Bangalore during the year s1991,2000and2012 (in % ad it can be seen that there is increasing trend in Literacy for all three regions. India's literacy rate increased from 52.2% in 1991 to 73 -- more than a hint of improvement over two decades Karnataka too experienced an increase with 75.4% of the population being literate compared to their initial literacy rate of 56%, and Bangalore's comes out on top again, rising from a previous figure of 76.3% all the way up to boasting almost a whopping ninety percent at nearly close to its target (88.5%). For all regions the maximum increase in any specific decade is observed from 1991-2001 rather than 2001–201, which may suggest changing socio-economic or educational factors (e.g. returns to education would be expected to diminish as literacy rates approach saturation). As Bangalore is one of the major cities its rates are always

on higher side since most Bangloreans would be looking for better education and economic opportunities in this city. This upward trend in literacy bodes well for the education policies as a whole, highlighting an improvement to top off with the increasing focus on learning and being literate. Differences in the rates of increase, and between regions make it necessary to more specifically target regions for further literacy education.

OBJECTIVES
1.   To Understand the Organic Food Awareness Level among illiterate consumers in Bangalore city.
2.   To Explore Purchasing Patterns and Preferences among illiterate consumers in Bangalore city.
3.   To Propose Inclusive Strategies for Sustainable Consumption among illiterate consumers in Bangalore city.

LITERATURE REVIEW

This critical review of literature enabled us to learn about consumer behaviour, specific to organic food procurement on a global front along with some literacy and socio-economic aspects within Bangalore as well as India. Kumar and Reddy (2023) analyze the effect of illiteracy on market decisions in Bangalore, indicating that low levels of literacy have serious implications for consumption behavior. Patel and Joshi (2022) examine the upward trend of organic food consumption in urban India, citing increased demand among city residents. Singh and Mehta (2024) argue there is still much work to be done mainly in Southern India with low-income groups where considerable challenges around the affordability and accessibility of organic products continues. Official reports from the Bangalore City Council (2023) and India Ministry of Agriculture (2022) summarize country-wide policy goals as they pertain to developing organic markets and initiatives in farming. Chatterjee (2021) discusses how familiarity with literacy affects consumer choice, suggesting that education could potentially act as a force to keep the market in its benefit. However, Manjunath and Rao (2024), Krishnan and Iyer(2023) as well D'Souza & Rajan have all explored the relation between education with poverty and dietary habits to deliver that higher educated people are more likely choose of healthier foods. The work of Prakash (2022) and Verma (2021) takes stock on market dynamics and consumer choices with a consistent preference for organically produced products in the face of narrowing economic conditions. Srinivasan and Gupta (2024) examine dietary transitions in the Indian cities with focus on emerging organic choices to reflect a change in established patterns of urban consumer behavior. Organizations like the Bangalore Organic Farmers Association (2023) offer anecdotal insight into consumer interest in buying organic produce and perceptions of increased trust, but also list several barriers to purchase. One such is the tracking of organic food chain in Bangalore, depicting complexities from production to consumption (Desai 2022).

Kulkarni (2023) and the Bangalore Health Department (2023): provide information in context of food security both—physical access to enough nutritious dietary intake required for healthy life, related to nutritive values; provide nutrition education(empowerment with corresponding tools including meal planning, homestead gardening at work place, schools etc.) healthier consumer choice(consumer protection)—the power of knowledge-individual components on plate or product packets. Indeed, Nair and Thomas (2022) in addition to Sharma and Venkataraman (2021) as well Joshi and Kumar (2022), explained multiple socio-economic drivers particularly income-related issues such poverty level or limited access end up shaping the organic food buying behaviour among urban slum residents/urban poor. On the one hand C Gowda (2023) writes about local markets and a trust in consumers purchasing Indian organic food, Ranganathan et al analyze policy implications of food purchasing patterns amongst illiterate urban poor in Bangalore.(R N Devaraj 2004). Second, the Indian National Statistics Bureau (2023) puts out figures reflecting consumer behavior and Mathur (2023) even leads a study into how health awareness influences food intake in low-literate Indian consumers, showcasing that improved health knowledge can advance healthy eating. The studies indicate an increasing recognition and demand for safe food even by different socio-economic classes in Bangalore as a result of the positive attitude towards organic foods, which is linked with literacy, education, income or market status. These results underscore the importance of policy interventions that can make healthy food choices affordable and accessible for low-income consumers as a whole, continues Dr. Chaloupka

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METHODOLOGY

In this study on follows a mixed-methods research approach to comprehensively explore the unique aspects of this underrepresented demographic in the organic food market. The research design encompasses both quantitative and qualitative data collection methods. Stratified random sampling is used to select illiterate consumers in Bangalore, ensuring representation across different age groups and income levels. Data were gathered through structured survey questionnaires administered via face-to-face interviews, with trained enumerators proficient in local languages. In addition, in-depth interviews were conducted with a subset of participants to delve deeper into the barriers and facilitators influencing their purchasing decisions. Quantitative data analysis will include descriptive statistics, chi-squared tests, and correlation analysis to address the research objectives and hypotheses. Ethical considerations, such as informed consent and data privacy, will be strictly adhered to throughout the study. The researcher interacted with over 300 potential respondents, of whom 241 agreed to participate in the survey. Among these, 209 respondents provided complete answers to all the survey questions, while 32 respondents did not answer all questions and were consequently excluded from the study. As a result, the final research sample consisted of 209 participants.

RESULT AND DISCUSSION

Demographic details encompass a wide range of information pertaining to the characteristics of an illiterate consumers in Bangalore which includes, Gender, Age group, Marital Status, Food Preference, Occupation, type of Family, type of House, Monthly Income, where you born, Shopping Preference, Shopping Responsibility, Where do you purchases, food products, and Frequency of purchases. Table 2 examine the demographic details of illiterate consumers in Bangalore in relation to their organic food purchasing patterns. Data look at the distribution of respondents by various demographic factors and interpret their potential influence on organic food purchasing behavior. A significant majority of the respondents are Female (87.6%), which could suggest that women, in this context, are more involved in the purchasing decisions or that the survey reached a predominantly female audience. The largest age group is 30-39 years (34%), followed by 18-29 (24.9%). This indicates that the middle-aged population is the most active in purchasing decisions. A large majority of respondents are Married (67%). This could imply that married individuals are more likely to be involved in grocery shopping, including for organic food. Most of the respondents prefer both vegetarian and non-vegetarian food (62.2%). This could mean a diverse demand for organic products across different types of food categories. Domestic Workers make up the largest occupational category (36.8%), which might reflect the socio-economic status of the respondents and their purchasing power.

The majority live in Nuclear families (59.3%), which may affect the quantity and frequency of organic food purchases due to potentially smaller household sizes. Over half live in rented houses (52.2%), which can be indicative of economic factors that might influence discretionary spending such as on organic foods. The largest income bracket is below 2500 (38.3%), which suggests that the sample population is generally low-income. This may limit the overall ability to purchase higher-priced items such as organic food. More respondents were born in Rural areas (55.5%) compared to Urban or Semi-Urban. This may influence their familiarity with and preference for organic products, potentially due to a closer connection to farming practices. A significant number of respondents use Both online and offline means for shopping (46.9%), indicating that there is considerable openness to using multiple channels for purchasing. The majority of the shopping is done by Self (34.4%), suggesting personal control over purchasing decisions, which includes the choice of buying organic products. Local Markets are the primary source (31.6%). This could affect access to and availability of organic food products. Most respondents purchase Everyday (55.5%), which may lead to more frequent, smaller purchases rather than bulk buying, a pattern that might affect the affordability and choice of organic foods. The data suggests that the typical profile of an organic food purchaser in this demographic is a married woman, aged between 30-39, living in a nuclear family, with a lower monthly income, born in a rural area, who shops for food daily at local markets. The predominance of women and middle-aged individuals in the demographic data might indicate that they are the primary decision-makers in food purchases, including

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organic products. The financial constraints suggested by the income data might limit organic food purchases to more affordable options or necessitate a focus on special offers and discounts. The rural birth origin of most respondents could influence their preference for food that is perceived as more natural or traditional, such as organic food. The purchasing patterns for organic food among illiterate consumers in Bangalore seem to be influenced by traditional gender roles, age, and economic factors. Despite the low-income levels, there is an interest in both online and offline shopping, which may indicate a potential market for organic food if it is made affordable and accessible. Daily shopping habits and preference for local markets highlight the importance of these venues in promoting and distributing organic food products to this demographic. There may be a significant opportunity to educate and market organic products to this segment, considering their daily purchasing habits and preferences for local markets. In the survey assessing knowledge on green terms, the data reflects varying levels of awareness among the respondents. Regarding the term "Recyclable," 59 individuals (28.2%) demonstrated a very high understanding, while 73 (34.9%) possessed a high level of knowledge. A smaller segment, 21 respondents (10.0%), remained neutral, and only a few, 5 (2.4%), had less knowledge, with 51 (24.4%) indicating very less knowledge. The term "Biodegradable" was very well understood by 55 respondents (26.3%), and a slightly larger group of 77 (36.8%) had a high knowledge level. Those who were neutral numbered 22 (10.5%), and those with lesser knowledge were 7 (3.3%), while 48 (23.0%) had very less knowledge on the topic. When it came to "Environmental Sustainability," 65 participants (31.1%) showcased a very high knowledge level, and 72 (34.4%) had a high level of awareness.

There were 19 respondents (9.1%) without a strong opinion either way, 6 (2.9%) with less knowledge, and 47 (22.5%) with very little knowledge. For "Organic Products," a significant number of respondents, 70 (33.5%), indicated a very high level of knowledge, with 61 (29.2%) also showing a high understanding. Neutrality was claimed by 23 (11.0%), a minority of 5 (2.4%) had less knowledge, and 50 (23.9%) had very less knowledge. Lastly, the concept of "Global Warming" was very highly understood by 70 individuals (33.5%), and 59 respondents (28.2%) had a high knowledge level. There were 19 (9.1%) who were neutral on the subject, a small number of 5 (2.4%) had less knowledge, and 56 (26.8%) had very less knowledge. The terms "Organic Products" and "Global Warming" have the highest number of respondents with 'Very High' knowledge, both at 70 respondents (33.5%)."Biodegradable" has the highest number of respondents with 'High' knowledge at 77 (36.8%).Across all terms, the least number of respondents fell into the 'Less' knowledge category, suggesting that most respondents have more than a minimal understanding of these green terms. The terms "Recyclable" and "Biodegradable" have a relatively higher percentage of respondents with 'Very Less' knowledge compared to the other terms. There is a good level of awareness on these green terms among the respondents, with a significant proportion having 'Very High' or 'High' knowledge levels. The distribution of knowledge levels is fairly similar across the different terms, with 'Very High' and 'High' categories always composing the majority. A relatively small percentage of respondents are neutral, indicating that most have formed opinions or have some level of knowledge about these terms.

Overall, these findings reveal a substantial degree of awareness on environmental issues, with the majority of respondents showing high or very high knowledge levels across all green terms. However, there remains a consistent minority with less or very little understanding of these crucial topics. Table 4 provides insight into the various sources of awareness for organic food among the respondents. Television commercials appear to be a significant source, with 69 respondents (33.0%) acknowledging it as a means of information. Family members are identified as the primary source of awareness by 77 respondents (36.8%), suggesting a strong influence of close social circles on dietary choices. Word of mouth, which may overlap with family influence to some extent, is also notable, cited by 39 respondents (18.7%). In contrast, more formal channels such as radio announcements and physician's consultations are less frequently mentioned, with 13 respondents (6.2%) and 11 respondents (5.3%), respectively, recognizing them as their source of awareness. Overall, the data from a total of 209 respondents indicates that personal and family networks, along with television advertising, play a pivotal role in informing individuals about organic food options. Table 5 outlines the factors influencing the respondents' decision to purchase organic food products. The table presents three main factors along with the number and percentage of respondents who acknowledge each one: Benefits of Organic Food over Non-organic is the most acknowledged factor, with nearly half of the respondents (47.4%) recognizing the benefits of organic food as their reason for purchase. It indicates a significant awareness and

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appreciation for the health and quality benefits that organic foods are perceived to offer over non-organic alternatives. A smaller portion of the respondents, 31 (14.8%), cite advice from health professionals as a factor for purchasing organic food. This suggests that medical recommendations can influence dietary choices, but it is not the primary driver for most consumers in the sample. A sizable number of respondents, 79 (37.8%), report curiosity as a reason for purchasing organic food. This indicates that a substantial segment of consumers is open to trying new things, which in this case includes organic food products, potentially due to trends, peer influence, or personal interest in exploring different dietary options. The high percentage of respondents influenced by the perceived benefits suggests that organic food producers and retailers could focus on highlighting these advantages in their marketing strategies. Although health professional advice is a factor, it is less predominant than other factors, which may reflect a gap that could be addressed by more active engagement from the medical community in nutrition education. Curiosity being a significant factor shows there is an opportunity for market growth, as a large group of consumers could be persuaded to try organic products if they are presented as new and interesting options. There is a clear recognition of the health and quality benefits of organic food among consumers, which is a strong selling point for the organic food market. Health professionals such as doctors and dieticians play a role in influencing dietary choices, although there is potential for this influence to be expanded. Consumer curiosity is a driving force for the trial of organic food products, indicating that the market may continue to grow as more consumers are willing to explore these options. The total coverage of the respondents (suggests that these factors are comprehensive in explaining the motivations behind purchasing organic food in this population.

OBSERVATION AND CONCLUSION

The research "Organic Food Consumption among Illiterate Consumers in Bangalore" provides enlightening observations on the organic food purchasing patterns and awareness level of these consumers. Health conscious married women in the age group of 30-39 years from nuclear families with low income are well informed consumers who form a major part among these customers making thoughtful decisions related to their organic food purchases. Results: High knowledge levels of green terms "Recyclable," "Biodegradable", and "Organic Products". Television commercials were the most common media from which participants obtained information followed by family members. The decision to buy organic foods appears primarily motivated by perceived superiority of organic over non-organic food, curiosity and to a lesser extent health professional advice. Based on the results, it can be inferred that there is a lot of comprehension and interest in organic products because they have to do with their own health and waste issues as well. However, even though literacy is an issue here (as with other younger groups), the interest and awareness in organic food can undoubtedly be seen. Most interest comes from married middle aged women in two parent low income families. It presents an real image that despite the fact that there are obstacles in understanding and attaining natural food, however nevertheless high proportion of populace were knowledgeable concerning organic products signifying own family effect especially impact via medium channels like television which is a." Although personal health benefits and curiosity predominantly underpin reasons for purchasing organic food, greater effect via healthcare professionals and even more focused informational tools are possibilities.

The study is concluded with a recommendation to adopt tailored marketing and education strategies for more programmed organic food consumption among the illiterates in Bangalore. This indicates a market poised for expansion; if the barriers of accessibility, affordability and awareness are addressed through combined action by policy makers, community leaders and representatives from organic food enterprises—more opportunities should arise to increase consumption rates in 2019. In sum, the profile of organic consumption presented in this study is positively high by illiterate regarding all groups (sometimes being much larger) and suggests an interesting ground ripe for further saturation with communication efforts to health promotion and sustainability. For increasing the buying behavior of organic food among Bangalore illiterate consumers, more focus strategies are required. Top marketing channels include TV ads and family networks that are promoted with the key message of how organic food is our best friend. Literacy barriers can be overcome by using visual based educational initiatives with simplified messaging to replace the low information bandwagon jumper switch point of Cannibalism, when those

same fans eventually jump back on board. Increased access to affordable organic foods in local markets, rural and semi-urban areas specially may help low-income consumers. And developing the local organic farming will episodically appeal to rural-born voters who want a reliable source of affordable fresh fruit and green cereal. Policymakers and stakeholders should jointly design interventions that are both inclusive to support growth of the organic food sector sustainably, without neglecting those segments where illiterate populations dominate. These steps will enable everyone in Bangalore to enjoy more of the health and environmental promise that organic foods have shown.

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Table 1: Literacy Rate

Census Year	India	Karnataka	Bangalore
1991	52.2	56	76.3
2001	64.8	66.6	83
2011	73	75.4	88.5

Table 2: Demographic Details

Sl. No.	Demographic Variables		No. of the Respondents	% of the Respondents
1.	Gender	Male	26	12.4
		Female	183	87.6
2.	Age group	18-29	52	24.9
		30-39	71	34.0
		40-49	41	19.6
		50-59	27	12.9
		Above 60	18	8.6
3.	Marital Status	Married	140	67.0
		Widowed	31	14.8
		Divorced	23	11.0
		Separated	15	7.2
4.	Food Preference	Vegetarian	60	28.7
		Non - Vegetarian	19	9.1
		Both	130	62.2
5.	Occupation	Agricultural Laborers	8	3.8
		Domestic Workers	77	36.8
		Street Vendors	15	7.2
		Construction Laborers	59	28.2
		Daily Wage Laborers	50	23.9
6.	type of Family	Nuclear family	124	59.3
		Join family	85	40.7
7.	type of House	rent house	109	52.2
		own house	65	31.1
		Leased house	35	16.7
8.	Monthly Income	Below 2500	80	38.3
		2501 - 5000	52	24.9
		5001 - 7500	41	19.6
		7501 - 10000	22	10.5
		Above10001	14	6.7
9.	where you born	Rural	116	55.5
		Urban	73	34.9
		Semi Urban	20	9.6
10.	Shopping Preference	Online	33	15.8
		Offline	78	37.3
		Both	98	46.9

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11.	Shopping Responsibility	Self	72	34.4
		My partner	56	26.8
		My children	18	8.6
		My parents	63	30.1
12.	Where do you purchases food products	Local Markets	66	31.6
		Organic Food stores	49	23.4
		Health stores	17	8.1
		Farmers	54	25.8
		General store	23	11.0
13.	Frequency of purchases	Everyday	116	55.5
		Weekly once	55	26.3
		Weekly twice	22	10.5
		Monthly once	5	2.4
		Monthly twice	11	5.3

Table 3: Knowledge on Green Terms

Variables	Very High		High		Neutral		Less		Very less	
	No.	%	No.	%	No.	%	No.	%	No.	%
Recyclable	59	28.2	73	34.9	21	10.0	5	2.4	51	24.4
Biodegradable	55	26.3	77	36.8	22	10.5	7	3.3	48	23.0
Environmental Sustainability	65	31.1	72	34.4	19	9.1	6	2.9	47	22.5
Organic Products	70	33.5	61	29.2	23	11.0	5	2.4	50	23.9
Global Warming	70	33.5	59	28.2	19	9.1	5	2.4	56	26.8

Table 4: source of awareness for Organic food

Sl. No.	Source of awareness	No. of the Respondents	% of the Respondents
1.	Television commercial	69	33.0
2.	Radio announcement	13	6.2
3.	Family Members	77	36.8
4.	Physician's consultation	11	5.3
5.	Word of mouth	39	18.7
	Total	**209**	**100**

Table 5: Factor for purchasing Organic food product

Sl. No.	Factors for purchasing Organic food	No. of the Respondents	% of the Respondents
1.	Benefits of Organic Food over non-organic	99	47.4
2.	Doctor/Dietician's advice	31	14.8
3.	Curiosity	79	37.8
	Total	**209**	**100**