



## Papain-like Protease of SARS-CoV-2 May be Deactivated by Dopamine

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### ABSTRACT

2019 Novel corona-virus (2019-nCoV) also referred to as severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. *In silico* Molecular Docking revealed that the Phytochemicals, Dopamine effectively binds at the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, Phytochemicals, Dopamine.

## INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe. The city of Wuhan was the epicentre where the outbreak of this human pathogen emerged, and resulted to human ailment, termed as COVID-19 [1, 2]. 2019-nCoV encodes at least 27 proteins, including 15 non-structural proteins, 4 structural proteins, and 8 auxiliary proteins. SARS-CoV-2 belongs to the beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3, 4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1, 5, 6]. Crystal structure of the Papain-like Protease of SARS-CoV-2 proves to be an exceptional ground for screening specific ligands [7]. Reportedly, M<sup>Pro</sup> and other known viral proteins are defining features paving the path of virus from entry to infection in the host cell [8, 9, 10].

## METHODS

### Viral Protein Structure and Phytochemical dataset collection

The 3D structure of Papain-like Protease of SARS-CoV-2 was accessed from Protein Data Bank accession 6W9C. The phytochemical, Dopamine was obtained and consequently both the protein and the ligands were used for *in silico* analysis.





### Molecular docking

For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Papain-like Protease of SARS-CoV-2 was specified and targeted for binding of the ligand. CDOCKER Energy and CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors. Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the CDOCKER Energy and CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

It was found that Dopamine; a common phytochemical specifically binds to the active pocket of the Papain-like Protease of SARS-CoV-2 as apparent from higher CDOCKER energy and CDOCKER interaction energy (Table 1). Since, simple active bio molecule like Dopamine effectively binds into the active pocket of the M<sup>pro</sup> under *in silico* conditions it is quite possible to design pharmacophore molecules based on the structural and functional identity of Dopamine and eventually can be used in the pharmaceutical sector.

## CONCLUSION AND FUTURE PERSPECTIVES

The current *in silico* molecular docking based study reveals that Dopamine can target the reported Papain-like Protease of SARS-CoV-2. It would be extremely noteworthy being confirmed *in vivo*. It is crucial to develop diagnostic tools, potential therapeutics and antibodies selectively for the COVID-19 proteins. Phytochemicals like Dopamine is commercially available and thus may be effectively prescribed to circumvent the current global scenario. Essentially, this study makes an attempt to reveal simple phytochemicals like Dopamine which can be employed for designing novel therapeutics.

### Author contribution statement

GKP conceived the idea. GKP, SKS, PKP performed the experiments. All authors have significant contribution in drafting the manuscript.

### Funding

The present study was financially supported by Centurion University of Technology and Management, Odisha, India.

## ACKNOWLEDGEMENTS

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### Conflict of interest

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Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Dopamine	Papain-like Protease of SARS-CoV-2	6W9C	Positive	-21.24	-23.87





## Papain-like Protease of SARS-CoV-2 Interacts with Bufotenine

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	Protein	PDB Accession	Docking Result	CDOCKER Energy	CDOCKER Interaction Energy
Bufotenine	Papain-like Protease of SARS-CoV-2	6W9C	Positive	-15.39	-21.08





## Emission Analysis of a Diesel Engine using Different Blends of Mahua Biodiesel

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### ABSTRACT

The consumption of fossil fuel increases day by day and it has been seen that the total utilization of fossil fuels globally is 10 million tons per day. These fuels are being emptied every day as these are present in finite quantity and it is anticipated that the future generation will face an intense energy supply collapse in the upcoming years. Again the use of these fuels causes environmental problems as it emits harmful gases. The use of nonedible oils such as karanja, Jatropha, Kusuma, Neem etc., to produce biodiesel mainly in tropical country like India is an added advantage due to their wide availability. Several research works is going on for use of the biodiesel to run diesel engine. In the present work, a diesel engine was run by using Mahua biodiesel and engine emission was analysed. The amount of exhaust gases present in engine emission were found to be reduced significantly that supports its use as an alternative fuel.

**Keywords:** biodiesel, engine, fossil, hydrocarbons

### INTRODUCTION

Air Pollution has become a crucial problem due to rapid growth in population and industrialisation. The combustion of fossil fuels produces many harmful gases like Carbon Monoxide (CO), Carbon Dioxide (CO<sub>2</sub>), Oxides of Nitrogen (NO<sub>x</sub>), and Hydrocarbon (HC) as well as some organic compounds such as monocyclic aromatic hydrocarbons, polycyclic hydrocarbons, aldehydes [1]. These poisonous compounds damage the temperature balance of the world, pollution, acid rain. Due to change in environment many human problems are seen such as cancers, respiration problems, heart disease etc. Hence it is imperative to find a possible source for fossil fuel which can be obtained from

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biomass(from plant and animal fats) [2]. Now a day, to overcome all these problems biodiesel become one of the most interesting alternatives because biodiesel are biodegradable, non-polluting and has very similar physical characteristics with biodiesel. Biodiesel can be produce from non-comestible oils [3].

The use of comestible oil to produce biodiesel in India is not workable because of their high cost and India is self-insufficient in comestible oils. From the economy point of view non comestible oil can come up with best source for biodiesel production. India has great capability for the production of biodiesel from non-combustible vegetable oil seeds [4]. Biodiesel from vegetable oil have a favourable alternative fuel for diesel fuel because of its sustainability, better quality lighting, the approximate energy fulfilment and a higher safety without restriction of the energy. Madiwalea and Bhojwanib [5] presented an overview on Production, Properties, Performance and Emission Analysis of different biodiesels. Ismail et al. [6] studied the production of castor biodiesel from crude castor oil through transesterification method. Padhi and Singh [7] carried out their work towards the optimization of biodiesel from mahua oil. However they have not studied their emission characteristics.

Jena et al. [8] carried out their investigation on biodiesel preparation from mahua and simarouba oil. Ogunkunle and Ahmed [9] carried out their research on optimizing the biodiesel production from sand apple which is widely cultivated in Africa. Mahua is indigenous plant in India and can easily found in all over India. Hence Mahua oil was used as the raw material for biodiesel production. Transesterification is the common process to produce biodiesel from oils. However sometimes esterification is also follow to get better and purified biodiesel. Esterification is the reaction between the oil and alcohol in the presence of acid catalyst in which glycerol and methyl ester is produced. The esterified oil we get here is pure than crude Mahua oil. Transesterification is the reaction between the esterified oil with alcohol in the presence of alkali catalyst to produce glycerol and ester. The ester we get has molecular weight one-third less than the crude Mahua oil ratio was taken to get low viscosity. Sometimes high alcohol to oil ratio was taken to get low viscous biodiesel. Different characteristics of castor oil and castor biodiesel are determined. In this work, prepared Mahua biodiesel was blended with conventional diesel. Three different blends B10, B20 and B30 were prepared by mixing 10%, 20% and 30% of biodiesel with 90%, 80% and 70% of conventional diesel respectively. The prepared Mahua biodiesel blends were then tested in diesel engine and emission was observed and compared with the conventional diesel.

**MATERIALS AND METHOD**

The Mahua trees are fast growing and can grow easily in any kind of soils. Hence castor trees are shown all over the India and easy to collect castor seeds and oil directly. All the properties like acid value, viscosity, density of the crude Mahua oil were determined. In this study, the Mahua oil was converted to castor biodiesel by the two step transesterification process. Here in the first step the free fatty acid (FFA) in the Mahua oil was converted into methyl ester by acid-catalysed esterification and the second step was the base-catalysed transesterification using potassium hydroxide as catalyst. The transesterification was carried out to reduce the FFA of the oil. In the first step the temperature was maintained about 60-64°C with 200ml methanol and 10gm of concentrated H<sub>2</sub>SO<sub>4</sub>. After 3hour of heating process, excess alcohol with impurities was removed after pouring the product into a separating funnel.

After removing the impurities from the lower layer, the upper layer methyl ester was collected from the separating funnel for the base transesterification process. In the transesterification process, 10gm of KOH was dissolved in 200ml of methanol then poured in the flask. The mixture was heated at constant temperature about 62°C and stirred continuously for 3hour. After 3hour of heating the mixture was poured into a separating funnel for about 12hour where two layers were formed. The upper layer contained methyl ester and the lower layer contained glycerol, extra methanol, catalyst and other by products were removed. The upper layer of methyl ester or Mahua biodiesel was collected and washed several times with de-sterilized water until the washing water become neutral. The biodiesel layer was filtered to remove impurities and then heated up to 100°C to remove any remaining water. The biodiesel



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was tightly sealed and kept for storage. The diesel engine was run three times using three different blends of Mahua biodiesel as fuel. The blending percentages of biodiesel with diesel were 10%, 20%, 30% and they were mentioned as B10, B20, and B30 respectively. The emission analysis was conducted by analysing the exhaust gas of diesel with the help of an exhaust gas analyser as shown in Figure 1.

**RESULT AND DISCUSSION**

The composition of exhaust gases which mainly consists four major pollutants such as CO, CO<sub>2</sub>, NO<sub>x</sub> and HC were recorded during testing of different blends of Mahua biodiesel. The comparison of exhaust emissions was shown in Table 1-4.

**Carbon Monoxide (CO) emission**

From Table 1, it is observed that the Mahua biodiesel has lower CO emission than conventional diesel. It is due to the complete combustion of various blends of Mahua biodiesel as compared to conventional diesel. Table 1: CO emission of conventional diesel and castor biodiesel at different load. From Figure 2, it is apparent that when load increases with increasing biodiesel ratio the CO emission of Mahua biodiesel blends decreases. This is mainly due to the complete oxidation process which was not happening in the case of diesel. At the time of biodiesel is burning the generation of CO<sub>2</sub> may be formed due to the presence of extra oxygen molecule in the biodiesel and this process aids in minimizing the CO emission.

**Oxides of Nitrogen (NO<sub>x</sub>) emission**

The NO<sub>x</sub> emission increases with the increase in percentage of biodiesel blends as shown in Table 2 and Figure 3. It is due to high oxygen content in the biodiesel which cause the formation of NO<sub>x</sub> in the emission chamber. The NO<sub>x</sub> emission is a function of the total oxygen inside the combustion chamber, temperature of combustion chamber, pressure, and compressibility of fuel. Again, the increase of NO<sub>x</sub> emission is due to the higher cetane number of biodiesel which will reduce the ignition delay. The increase of NO<sub>x</sub> emission is a result of the reduced ignition delay.

**Hydrocarbon (HC) emission**

Table 3 shows, the HC emission of Mahua biodiesel less as compare to conventional diesel. This may be due to effective combustion process inside the engine cylinder. When the load increases, the HC percentage also increases since amount of HC varies inversely with NO<sub>x</sub>. From Figure 4, it is observed that in B30 the HC emission is less as compare to B20, B10 and the conventional diesel because in B30 there is more biodiesel as compare to B20 and B10. As B30 contains more oxygen as compare to B20 and B10, it emits less HC.

**Carbon Dioxide (CO<sub>2</sub>) emission**

The CO<sub>2</sub> emission in conventional diesel is more as it contain less oxygen. It is shown from Table 4 that the CO<sub>2</sub> emission of B30 was more as compare to B20, B10. It is due to incomplete combustion process of higher blends of Mahua biodiesel in comparison lower blends. Figure 5 shows that the carbon dioxide emission increases with increasing biodiesel blends. However the emission is not so more than the diesel. Lower emission of biodiesel blends is due to high oxygen content than the diesel.

**CONCLUSION**

The prepared biodiesel from Mahua oil has good inherent properties than the conventional diesel and most of its properties resembles to that of diesel. From the above result it can be stated that the biodiesel can be used as the alternative fuel of diesel. The biodiesel contains more oxygen which promotes complete combustion in diesel engine and it led to lower emission. Due to high oxygen content, biodiesel emits lower CO and CO<sub>2</sub> as compare to diesel.





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The NO<sub>x</sub> emission emissions of biodiesel blends of Mahua oil has a scope to check the overall emission level of the blends by adapting engine modifications. As Mahua biodiesel has lower HC emission than the conventional diesel, the biodiesel pollutes less as compared to diesel and can be regarded as a green fuel. Hence it is a suitable fuel to be used as an alternative for diesel engine

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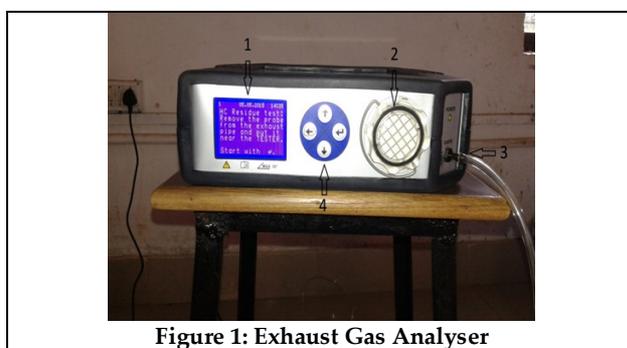


Figure 1: Exhaust Gas Analyser

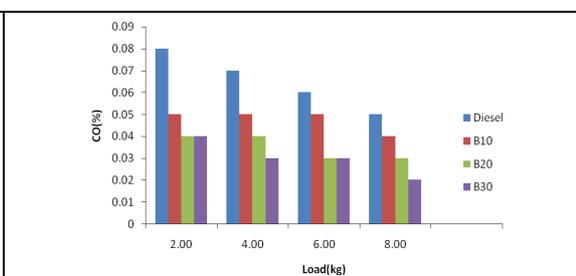


Figure 2: CO Vs load for conventional diesel and Mahua biodiesel blends.

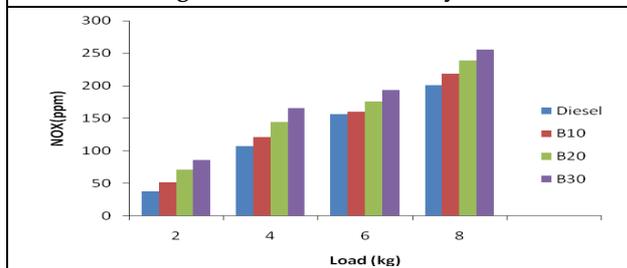


Figure 3: NO<sub>x</sub> Vs load for conventional diesel and Mahua biodiesel blends.

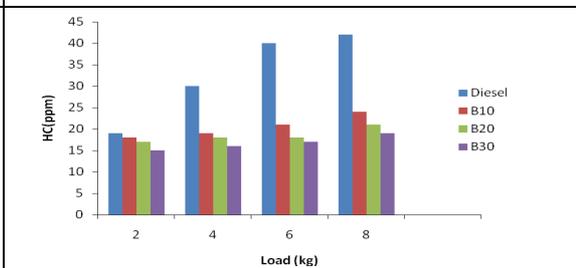
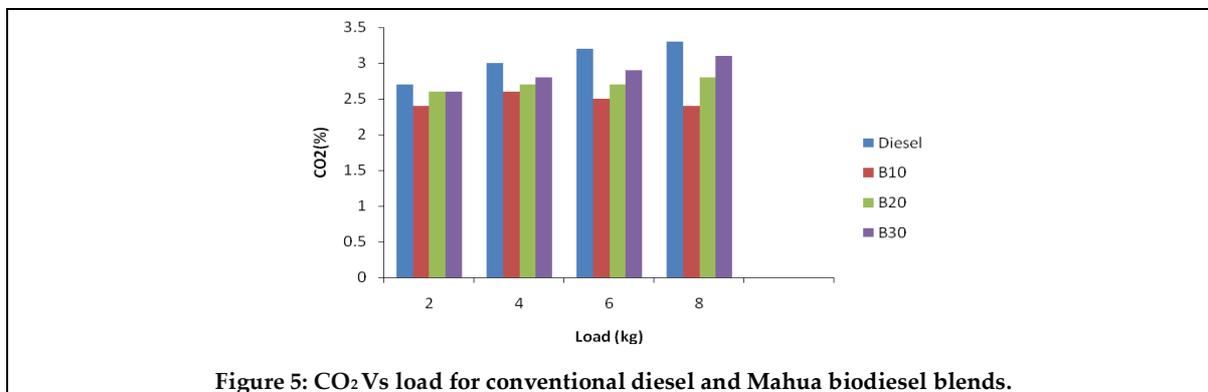


Figure 4: HCVs load for conventional diesel and Mahua biodiesel blends.





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**Table 1:CO emission of conventional diesel and castor biodiesel at different load.**

Load(kg)	CO(%)	CO(%)	CO(%)	CO(%)
	Diesel	B10	B20	B30
2	0.08	0.05	0.04	0.04
4	0.07	0.05	0.04	0.03
6	0.06	0.05	0.03	0.03
8	0.05	0.04	0.03	0.02

**Table 2:NO<sub>x</sub> emission of conventional diesel and castor biodiesel at different loads.**

Load(kg)	NO <sub>x</sub> (ppm)	NO <sub>x</sub> (ppm)	NO <sub>x</sub> (ppm)	NO <sub>x</sub> (ppm)
	Diesel	B10	B20	B30
2	37	51	71	85
4	107	121	144	165
6	156	160	176	193
8	201	218	239	255

**Table 3: HC emission of conventional diesel and different biodiesel blends at different load.**

Load(kg)	HC(ppm)	HC(ppm)	HC(ppm)	HC(ppm)
	Diesel	B10	B20	B30
2	19	17	16	14
4	30	19	17	15
6	40	21	18	17
8	42	24	20	18

**Table 4: CO<sub>2</sub> emission of conventional diesel and different biodiesel blends at different load.**

LOAD	CO <sub>2</sub>	CO <sub>2</sub>	CO <sub>2</sub>	CO <sub>2</sub>
	Diesel	B10	B20	B30
2	2.7	2.4	2.6	2.6
4	3	2.6	2.7	2.8
6	3.2	2.5	2.7	2.9
8	3.3	2.4	2.8	3.1





## Impact of Service Quality Attributes in the Delivery of Financial Services in Indian Commercial Banks

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### ABSTRACT

Commercial Banks plays the most important role in Indian financial Institutions. Competition is very high in the financial institutions and banks. Pressure is not only in Indian banks also from foreign banks and Institutions. So it is very important for the commercial banks to provide high quality service to their customers. Now the customers are using many banking products, which are offered by different banks. So the customer always wants the best product with high quality service. Because of globalization and liberalization the competition is very high within different banks. Now Indian customers are more educated and they have all the current information about the banks. As the buying power of the customers increasing, their expectations for high quality service are also increasing. Now it is the responsibility of the banks to satisfy their customers to increase their profits. This study will help in understanding the customer's expectation from commercial banks and their view regarding service quality maintained by banks.

**Keywords:** Service quality, financial services, Expectation & perception, Commercial Banks

### INTRODUCTION

Banks are the pillars of Indian financial system. Commercial banks play a major role in the collection and utilization of financial resources in the Indian economy. Now the service quality of these commercial banks plays the important role for the survival of these banks. There is always a visible difference between the customer's expectation and the service of banks. Private Banks are trying hard to meet the expectations of the customer. It is not only important for the customers but also equally important for the survival of the banks. But many of the public sector banks are not able to adopt the changes required in the service quality. Banks are providing different kinds of products to attract the customers. The banks which can provide best service, can only survive in the long run. So customer satisfaction is



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one of the major factors for the banks and financial Institutions in India. So the banks have to understand the customer profile, their need and satisfaction from the services given by the banks. As the competition is very high, no bank can ignore the customer's satisfaction. Customers will choose other bank where they will get better service. So the study of service quality of commercial banks is one of the major researches in the present era.

**REVIEW OF LITERATURE**

Parasuraman. A., Zeithaml, V. & Bery, C. (1988) have used SERVQUAL model for their study. They tried to find out the customers satisfaction, customers perception and the banks perception to satisfy their customers. They evaluated the service quality by using the model. They have taken five different factors to measure the service quality. They have used different factors like tangibility, assurance, reliability, empathy and responsiveness for their study. Similarly Dhandabani (2010) has done the research to find the relation between quality of the administration and the customer's devotion in the Indian banking sector. He has used different factors like reliability responsiveness, knowledge for the study. He found that when the administration and service quality is good, it leads to high customer satisfaction and loyalty towards bank. Also Paul.M. k and Barman. A (2010) have studied the customer's loyalties towards bank in the state of Assam. They found that the banks are unable to retain their. Customers when they can't satisfy them with their service quality. It is also difficult for them to get new customers. So it is very much important for the banks to give good quality service to retain the existing customers and to get new customers. Abedniya.A and Zaeim. M. N. (2011) analysed on how the banks are doing the administration and how it is affecting the loyalty of the customers in the banks of Jordan. They have taken different devices like factor investigation, relapse examination for their research. They found that Administration quality is very important for the customer satisfaction and loyalty. Jani. A.S (2012) tried to find different factors which are affecting the customers. Future of E banking and different advances offered to the clients also analyzed in the study. The analysis disclosed that innovation gives a positive impact on the customer's satisfaction.

**Objectives of the study**

1. To find out the customers' expectations and perceptions of service quality provided by the commercial banks in India.
2. To assess customers' satisfaction towards the service quality of commercial banks in India.
3. To know which factor plays a vital role for choosing any bank.

**RESEARCH METHODOLOGY**

A descriptive field study was conducted for the research .The information required was clearly defined and data was collected through questionnaire based on a sample size of 100. A simple random sample has taken from India's top five commercial banks (SBI, Indian Bank, OBC, ICICI Bank and Axis Bank).

**H01:** - There is no significant evidence that satisfactory service quality will tend to be associated with outcomes equal to or above expectations.

**H02 :-** There is no evidence to indicate that service quality is more important in the selection of a bank by a customer than other factors, such as location, advertising, recommendation of others.

**DATA ANALYSIS AND DISCUSSION****Testing of hypothesis 1**

Table -1 shows that there is a positive gap and customers are not satisfied by the services given by the banks. Here paired t-test has been used for the analysis. It shows a statistically significant difference in all attributes used for the study. The biggest gaps ( $\geq 1.92$ ) were found in the following attributes; 6 "Employees should always be willing to



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help customers" (-1.92 sig. <1.92), 13 "Employees should understand specific customer needs" (-1.72 sig. <1.72), 12 "Employees of a bank should give customers personal attention" (-1.68 sig. <1.68) and 9 "Employees should consistently be courteous" (-1.22 sig. <1.22). These are giving negative impact on the bank and require proper attention and administration in these areas. When the gap is more the service quality of the investors are bad according to the perception of the customers. Here the total gap 5 score is 1.02 which shows that the commercial are unable to satisfy the customers. Also the highest gap is 1.81 related to responsiveness followed by empathy (1.40), assurance (.91), tangibility (0.60) and reliability (0.55).

**Findings and managerial implication**

It is found from the analysis that the gap is 0.61 and 0.60 in physical facilities and professionalism of banks employees. Reliability dimension of service quality provide by the commercial banks like the problems solving of customer, services delivery and error-free records also analysed. The gap for these attributes is 1.01, 0.34 and 0.31. The gap related to responsiveness dimension of service quality provides by the commercial banks like the helping nature of banks employees and not too busy for respond is 1.92 and 1.70. It is also analysed the assurance dimension of service quality provide by the commercial banks like safe in all their transactions, courteous with customers and answering the customers' questions, in the sample size of 100. The result found the gap of 0.49, 1.22 and 0.57.

The analysis of empathy, dimension of service quality provide by the commercial banks like convenient operating hours, personal attention to the customers and understand specific customer needs by the banks employees shows a gap of 0.85, 1.68 and 1.72. Finally data analyzed overall combines scale of 13 attributes related service quality of commercial banks and found the gap mean differences between customers' expectations and perceptions of service quality in the commercial banks in India (n = 100) is 1.02.

**CONCLUSION**

So this study is a systematic study of the specific impact of relation between gender, age, income and education relating to the importance of service quality in the selection of a commercial bank. This study adds to the body of knowledge by establishing a means to test the relationship between or any significant evidence on impact of gender, age, education and income for selection of banks. The results from the test of this study will prove valuable to banks that are seeking to obtain and retain customers because it demonstrates that all of the outcomes can be measured and fall above the average level of satisfaction. The banks have to satisfy the customers by increasing their service quality to sustain in the long run.

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**Table 1: Gap mean differences between customers' expectations and perceptions of service quality in the commercial banks in India (n = 100).**

Attributes	E (mean)	P (mean)	GAP (E-P)	t-value	p-value
<b>Tangibility</b>					
1. Physical facilities of bank should be appealing.	4.22(.786)	3.61(.852)	.61	5.369	.000
2. Employees of a bank should be professional.	4.13(.800)	3.53(.893)	.60	5.082	.000
<b>Reliability</b>					
3. Bank employees should be sympathetic to solving customer problems.	3.74(.812)	2.73(1.014)	1.01	8.021	.000
4. A bank should deliver services on time.	3.91(.858)	3.57(.847)	.34	2.723	.008
5. The bank should insist on error-free records.	3.82(.796)	3.51(.703)	.31	4.578	.000
<b>Responsiveness</b>					
6. Employees should always be willing to help customers.	4.21(.743)	2.29(.860)	1.92	16.797	.000
7. Employees in a bank should never be too busy to respond to customer requests.	4.32(.618)	2.62(.850)	1.70	16.507	.000
<b>Assurance</b>					
8. Customers should feel safe in all their transactions.	4.06(.763)	3.57(.795)	.49	5.556	.000
9. Employees should consistently be courteous with customers.	3.91(.749)	2.69(.900)	1.22	10.519	.000
10. Employees in a bank should have the knowledge to answer customers' questions.	4.09(.712)	3.52(.797)	.57	6.660	.000
<b>Empathy</b>					
11. Operating hours should be convenient to all their customers.	3.91(.698)	3.06(1.062)	.85	7.180	.000
12. Employees of a bank should give customers personal attention.	4.40(.569)	2.72(.854)	1.68	16.571	.000
13. Employees should understand specific customer needs	4.16(.721)	2.44(.795)		1.72	14.353
.000					
<b>Overall combines scale of 13 attributes</b>	<b>4.06(.198)</b>	<b>3.03(.534)</b>	<b>1.02</b>	<b>5.943</b>	<b>.000</b>





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Table 2 :Testing Hypothesis 2

	Rank	Mean	Std. Dev.
Advertising	5	4.75	.435
Location	3	2.41	.854
Recommendation from Friend	4	4.22	.484
Service Charges/Fees	2	2.12	.742
Service Quality	1	1.51	.659

Table 3:AdvertisingANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Gender	Between Groups	.000	1	.000	.000	1.000
	Within Groups	22.000	97	.227		
	Total	22.000	98			
Age	Between Groups	1.920	1	1.920	3.602	.061
	Within Groups	52.240	98	.533		
	Total	54.160	99			
Income	Between Groups	.053	1	.053	.058	.810
	Within Groups	89.947	98	.918		
	Total	90.000	99			
Education	Between Groups	1.333	1	1.333	1.804	.182
	Within Groups	72.427	98	.739		
	Total	73.760	99			

Table 4: Service Charges/Fees ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Gender	Between Groups	.347	2	.174	.770	.466
	Within Groups	21.653	96	.226		
	Total	22.000	98			
Age	Between Groups	1.922	2	.961	1.785	.173
	Within Groups	52.238	97	.539		
	Total	54.160	99			
Income	Between Groups	1.796	2	.898	.987	.376
	Within Groups	88.204	97	.909		
	Total	90.000	99			





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Education	Between Groups	1.534	2	.767	1.030	.361
	Within Groups	72.226	97	.745		
	Total	73.760	99			

**Table 5: Location ANOVA**

		Sum of Squares	df	Mean Square	F	Sig.
Gender	Between Groups	1.012	3	.337	1.527	.213
	Within Groups	20.988	95	.221		
	Total	22.000	98			
Age	Between Groups	.457	3	.152	.273	.845
	Within Groups	53.703	96	.559		
	Total	54.160	99			
Income	Between Groups	2.322	3	.774	.848	.471
	Within Groups	87.678	96	.913		
	Total	90.000	99			
Education	Between Groups	.845	3	.282	.371	.774
	Within Groups	72.915	96	.760		
	Total	73.760	99			

**Table 6: Recommendation from a Friend ANOVA**

		Sum of Squares	df	Mean Square	F	Sig.
Gender	Between Groups	.045	2	.023	.099	.905
	Within Groups	21.955	96	.229		
	Total	22.000	98			
Age	Between Groups	.283	2	.141	.255	.776
	Within Groups	53.877	97	.555		
	Total	54.160	99			
Income	Between Groups	.765	2	.382	.416	.661
	Within Groups	89.235	97	.920		
	Total	90.000	99			
Education	Between Groups	.086	2	.043	.057	.945
	Within Groups	73.674	97	.760		
	Total	73.760	99			





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Table 7: Service Quality ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Gender	Between Groups	.212	2	.106	.466	.629
	Within Groups	21.788	96	.227		
	Total	22.000	98			
Age	Between Groups	1.087	2	.544	.994	.374
	Within Groups	53.073	97	.547		
	Total	54.160	99			
Income	Between Groups	2.637	2	1.318	1.464	.236
	Within Groups	87.363	97	.901		
	Total	90.000	99			
Education	Between Groups	1.335	2	.668	.894	.412
	Within Groups	72.425	97	.747		
	Total	73.760	99			





## Ecotourism and Conservation: A tale of Two Famous Ecotourism Sites of Odisha

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### ABSTRACT

The United Nations' Summit on Environment and Development or the Earth Summit held in Rio in 1992 marked the rise of sustainable tourism development. The growing catastrophe of depletion of natural assets emphasized the need for resource conservation. Subsequently there has been a shift away from instrumental ethics as a basis of conduct for the use of nature to a more conservation based ethics in these countries. Ecotourism recognizes the principles of sustainable tourism. The Costa Rica Certification of Sustainable Tourism (CST) developed by the Costa Rica Institute of Tourism has also been successful in improving performance of the ecotourism destinations. Species richness generally increases with decreasing latitude. Due to this biogeographical phenomenon, majority of the species are located in developing countries (DCs).

**Keywords:** Service quality, financial services, Expectation & perception, Commercial Banks

### INTRODUCTION

The United Nations' Summit on Environment and Development or the Earth Summit held in Rio in 1992 marked the rise of sustainable tourism development (Butcher, 2006). With the growing popularity of ecotourism from 1992 onwards, the definitions of ecotourism have also been broadened to include other ethical dimensions rather than being confined to merely tourism trait (Blamey, 2001). Buckley (2004), for example, developed a framework of ecotourism based on four main dimensions: ecotourism being nature based; conservation supporting; sustainably managed; and environmentally educating. In 1996 the International Union for Conservation of Nature (IUCN) defines ecotourism as "Environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature that promotes conservation, has low visitor negative impact, and provides beneficially active socio-economic involvement of local populations".



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Honey (1999) has emphasized the empowerment of local communities through equitable distribution of tourism benefits when she defines ecotourism as “small scale traveling to fragile, pristine and protected areas with the fundamental objective of educating travelers, providing funds for conservation, yielding direct benefits for the economic development and political empowerment of the local communities, as well as fostering respects for different cultures and human rights” (Cobbinah, 2015: 180). It is the International Year of Ecotourism (IYE) of 2002 that gave ‘ecotourism’ a plethora of possibilities on the basis of its ability to integrate development with conservation (Butcher, 2006). The Quebec declaration on ecotourism in 2002, the outcome of the IYE, recognizes the principles of sustainable tourism, concerning the economic, social and environmental impacts of tourism (Wood, 2002). The declaration says that ecotourism-

- contributes actively to the conservation of natural and cultural heritage
- includes local and indigenous communities in its planning, development and operation, and contributing to their well-being;
- interprets the natural and cultural heritage of the destination to visitors; and
- lends itself better to independent travelers as well as to organized tours for small size groups.

The accumulative impact of tourism development policies in developing countries are often guided by economic imperatives neglecting the environmental costs of resource usage. The growing catastrophe of depletion of natural assets emphasized the need for resource conservation. Subsequently there has been a shift away from instrumental ethics as a basis of conduct for the use of nature to a more conservation based ethics in these countries. Such a shift has given rise to ecotourism policies that applies green growth strategy in the ambit of tourism with an intention of sustainable use of exhaustible natural resources (Holden, 2003). Ecotourism gives the impression of a perfect policy particularly for the developing countries (DCs) in the sense that it generates much needed foreign currency and also provides a strong incentive for conservation (Kruger, 2005). The incentives for developing countries lie in the fact that it can aid in economic development, environmental protection, and preservation of cultural environments (Stone & Nyaupane, 2015).

The DCs are immensely fortunate to own a vast majority of species because of their biogeographical locations (Gossling, 1999). Yet the problems like poverty, rapid population growth, workforce-pressure, lack of capital and foreign debts etc., often lead to over-exploitation of natural resources and consequently loss of biodiversity (Burgess, 1993). The pursuit of achieving higher growth, prompted these countries to stress more on industrialization and in the process there has been more depletion of traditional sources of energy and raw materials, destruction of multitude of animal as well as plant species, large scale clearance of forests etc., leading to commotion of natural ecological balance and corrosion of environment. However, there is no consensus of the evidences about the benefits of ecotourism. There is a huge controversy and debate associated with the impact of ecotourism on local livelihood and conservation as well (Gezon, 2014; Cobbinah, 2015). Several studies have questioned the authenticity and the growing buzz of ecotourism. Ecotourism policies are designed to attract consumers’ preferences for recreation. In that process, revenue generation has become the prime consideration and protection of environmental assets has been kept aside. This is leading directly to environmental degradation.

The role and efficacy of ecotourism in conservation as well as the promotion of livelihood system of local people in and around the site are the areas that require further investigation due to the controversies and debates associated with ecotourism. Some of the addressable questions are: (1) whether the local indigenous communities get benefit from ecotourism? (2) can ecotourism be a successful conservation tool? These issues may be identified only through an impact analysis of ecotourism practices. A detailed and intensive study of a particular site can be of much help to understand the scenario. The present research is an attempt to assess the economic and environmental impact of ecotourism in some important sites of Odisha, India. Odisha with its rich natural and cultural heritage appear to be the ones amongst the most attractive tourist states in India. Two famous ecotourism sites from Odisha viz. Bhitarkanika Wildlife Sanctuary and Chilika Nalaban Sanctuary are considered for the study. The paper is organized



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as follows. Section 2 reviews the literature. Section 3 discusses methodology, followed by results and discussion in Section 4. Section 5 concludes the paper.

## REVIEW OF LITERATURE

Libosada Jr. (2009) believes that ecotourism provides the tangible aspect of conservation as it has been helping save animals and fragile ecosystems. Particularly for developing countries, poverty and resource degradation are highly interlinked. Ecotourism provides jobs and opportunities for self-improvement and advancement which can help to break the vicious cycles of impoverishment, resource degradation, and migration (Durham, 2008). The findings of Hunt et al., (2015) corroborate the fact that through its commitment for improving local livelihood, ecotourism is helping in conservation. Reimer & Walter (2013) articulate that the financial benefits from ecotourism that come from park entrance fees, voluntary donations, environmental conservation levies etc., are targeted directly at conservation. Nyaupane & Poudel (2011) have finely interwoven the complexity of tourism and biodiversity conservation through their focus on Chitwan National Park, Nepal. They perceive that as people receive more economic benefits, they take more pride about their natural resources and tend to preserve these resources. The paper of Abbot et al., (2001) provides evidence drawn from Kilum-Ijim forest in North West Province, Cameroon. Adoption of Integrated Conservation and Development Projects (ICDP) has improved the income level and livelihood conditions of the people. This in turn has positive impact on conservation by changing the attitudes of the people in and around the forest area.

Ecotourism recognizes the principles of sustainable tourism. It (a) minimizes environmental impact and thus has a small ecological 'footprint', (b) contributes to conservation either through direct effort like reforestation, habitat restoration, or through financial benefits (Zambrano, Broadbent, & Durham, 2010). Development of forests through promotion of ecotourism in the reserve also helps in mitigating carbon which can reduce green-house gas emissions, which is really noteworthy (Badola, 2010). The Costa Rica Certification of Sustainable Tourism (CST) developed by the Costa Rica Institute of Tourism has also been successful in improving performance of the ecotourism destinations (Tepelus & Cordobci, 2005). Apparently, such practices have ensured that certain mammals and birds, which became extremely scarce, can now be observed by residents and tourists with greater frequency (Wunder, 2000).

Julianne & Thomas (2009) endeavor to test the relationship between economic growth, biodiversity loss and efforts to conserve biodiversity through Environment Kuznets's Curve (EKC) hypothesis with a combination of panel and cross section data. The EKC asserts that environmental damage increases initially and then after a certain point of time it falls with rising income resulting an 'inverted U' shaped curve. Nevertheless, a large number of articles posit ecotourism as not to be very effective in promoting conservation of biodiversity. Many authors consider ecotourism as an instrument for revenue generation. The word 'ecotourism' is to attract customers, and thereby generate more income. Many PAs in developing countries are found to be poorly planned, with the infrastructure and management inadequate, and even unsuitable for ecotourism. The following section depicts many problems of ecotourism that pose threat to successful conservation.

### Ecotourism as a business policy

Ecotourism is criticized by several researchers for its inability to insure the long term protection of environmental assets (Duffy, 2006). The critics claim that ecotourism is only a *proxy market* designed to attract customers. Ecotourism policies are designed to attract consumers' preferences for recreation. In that process, revenue generation has become the prime consideration and protection of environmental assets has been kept aside. This is leading directly to environmental degradation. Honey (2008) has therefore claimed in his book "Ecotourism and sustainable development- Who owns paradise?" that "much of what is marketed as ecotourism is simply conventional mass tourism wrapped in a thin veneer of green" (pp. 51). The author identifies that ecotourism is still in its 'infancy stage' and therefore a broad set of principles and practices are to be derived that will give a new direction to the so called ecotourism industry. Many ecotourism sites lack proper infrastructure to consider them as ecotourism sites.

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Scheyvens (2000) cites the case of Himalayan areas, where tourism has resulted in widespread deforestation in some areas as lodges use wood for heating water and rooms for tourists and cooking meals.

**Conflict between biodiversity conservation and ecotourism**

The proponents of ecotourism have failed to see the threat caused by such activities. Rise in the number of tourists, which exceeds the carrying capacity of the place, leads to the very erosion of natural resources for which tourists come (Drumm, 2008). The more elementary environmental critique against ecotourism is that it is usually based on extensive use of resources often including overseas transportation with large CO<sub>2</sub> emissions (Buckley, 2004). Lusseau & Higham (2004) have confirmed that there is a proliferation of tour operators in response to increased tourists' demand in the case of Doubtful Sound (New Zealand). This has brought tremendous pressures on the population of bottlenose dolphins the resident in the Sound. With the number of tourists increasing, there is increase in the number of boats. While many have permits, a large number of vessels do not have permission. It is so because there are significant commercial disadvantages associated with holding a permit because it ties operators to national responsibilities. As a result, these vessels venture into the critical zone hampering the habitat and population of dolphins.

Drum's viewpoint is awfully perplexing when he considers that conservationists at the 'Nature Conservancy' have identified "tourism as a threat in 78 international conservation area plans because of its effect over the past seven years" (Drum, 2008: 782). The author has also identified that if the current levels of investment continue, the tourism boom will simply destroy the biodiversity. Prime habitats will become degraded, wildlife will become scarce, the quality of the visitor experience will decline, and eventually ecotourism will fail completely as a policy. Even in the case of Whale watching, Orams (2000) finds that the industry by 1995 has expanded to 65 countries from 12 countries in 1983. The economic impact from such activities was estimated as more than US\$550 million. But the impact of this industry on the life of these endangered wild animals is very much alarming. The close proximity of the vessels to the whales, the noise and pollution of the vessels disturb their natural behavioral pattern. Martin's (2007) review paper also holds the same notion that the increase of whale shark-based ecotourism has serious impact on their behavior, habitat, and ecology.

Eijgelaar, Thaper & Peeters (2010) with the example of Antarctic cruise tourism have unfolded that the cruise passengers tripled from 2000 to 2007. The selling point of such tourism is claimed to create environmental awareness for the destinations before it disappears and are therefore termed as responsible tourism. However, no evidence of greater environmental awareness among the tourists after their visit to such places is found by the authors. In many places increased tourists cause a lot of unsustainable usage (Dixit & Narula, 2010). Moreover such trips produce higher green-house gasses and result in significant climate change. According to Eijgelaar, Thaper & Peeters (2010), total emissions per passenger are 7.8 t CO<sub>2</sub> per trip and 409 kg CO<sub>2</sub> per day. Dawson et al., (2010) view that the polar bear viewing industry is estimated to contribute 20,892t/CO<sub>2</sub> per season which is higher than average activity emissions. Tourists are more interested to see wildlife, including polar bears, beluga whales, walrus, seals, and penguins before they disappear completely and in the process also facilitate in the extinction of such endangered species.

Such paradoxical issues are becoming more important in certain cases as the focus point is more on tourism to generate revenues in the name of 'Responsible Tourism'. In the process, environment is getting compromised and the objective of environmental conservation through ecotourism policy is moving beyond our reach. Thus the role and efficacy of ecotourism in the conservation of biodiversity and the promotion of livelihood system of local people in and around the ecotourism spot is a question. The problem is more in a developing country like India where local communities are dependent on natural resources for their livelihood for ages together.



**Madhumita Das****The Study Area**

Bhitarkanika Wildlife Sanctuary (BKWS), and Nalabana (Chilika) Sanctuary of Odisha have been selected as the study regions owing to their significance within the ecotourism map of India and specifically in state of Odisha.

**Bhitarkanika Wildlife Sanctuary, Odisha**

BKWS is located in the *Kendrapara* District of Odisha in Eastern India (upper segment of the figure). The sanctuary (declared vide notification No.6958/FF AH Dtd. 22.04.1975) is spread over an area of 672 square kilometers and lies in the river delta of Brahmani, Baitarani, and Dhamra rivers.

The sanctuary is the second largest mangrove ecosystem in India after the Sunderbans of West Bengal. The park encompasses an area of 145 sq. km. and has been notified as Bhitarkanika National Park vide Notification No.19686/F & E dated 16.9.1998 of Forests & Environment Department, Govt. of Odisha. For its rich avi-fauna, it was declared as a "Ramsar Site" on 19.8.2002. The biodiversity of Bhitarkanika is unique and incomparable in the Country. Out of 72 mangrove and associated species found World over, Bhitarkanika houses 62 of them. The sanctuary in terms of mangrove vegetation occupies first position in India and second largest after Papua New Guinea. The faunal diversity in Bhitarkanika is represented by 42 species of reptiles, 5 species of amphibians, 280 species of birds, and 28 species of mammals. Salt water Crocodile (*Crocodilus porosus*) is the flagship species of Bhitarkanika. Recent report in Guinness Book of world records suggests that the largest living crocodile in the world is found in Bhitarkanika. Besides estuarine Crocodile, the Sanctuary is rich in avifauna, mammalian and reptilian population like King Cobra, Indian Python and Water Monitor Lizard. The avian diversity of Bhitarkanika is unique. As many as 280 species have been reported from the Sanctuary area. Both resident and migratory birds use this mangrove wetland in some part of the year or other. *Bagagahan*, the heronry is largest in Asia according to some sources. About 30,000 resident water birds nest in a compact area of 4 Ha. The Park attracts about 1, 00,000 migratory birds during winter. Bhitarkanika has recently made its way to the final list of heritage sites in 2014.(1)

**Nalabana (Chilika) Sanctuary, Odisha**

Just south of Puri, the sea mixes with the 1100 sq.km inland Chilika Lake to create the largest brackish water lake in Asia. These shallow waters enclose an immense area of marshes, lowlands, and islands. It abounds with a variety of fish, crabs, prawns throughout the year and migratory birds make it their home in winter (November through March). This brackish water lake attracts around 150 species of migratory birds every year during winter and hence is a bird-watcher's paradise. It is an interesting world of around 158 different species aquatic & wild life including insects, mollusks, fishes, prawns, amphibians, reptiles, birds and animals. Limbless skink, a rare reptile which was discovered for the first time from loose soil, attaches much significance to this place. The Lake is dotted with a number of islands. The Island of Nalabana, 8 km in circumference occupies a unique place in the vast expanse of Chilika Lake as it happens to be a sanctuary and the central refuge point for the migratory birds.

Kalijai Island is the abode of Goddess Kalijai, venerated by the local fisher folks. This island plays host to a huge fair on 'Makar Sankranti' held annually in the month of January. The large fishing community adds flavor to the lake. Rajhansa Island near the confluence of the lake and sea (New Mouth) offers a fantastic beach. The Irawady Dolphins can be seen playfully cavorting in the channels approaching the sea mouth near Satapada. Some of the Islands bear romantic names like Honeymoon Island and Breakfast Island.

**RESEARCH METHODOLOGY**

The study is exploratory in nature and is based on secondary data. Qualitative tools are used in the study for an elaborate investigation about the impact of ecotourism on the overall development of indigenous communities and conservation in all four sites. The study has relied on secondary source information for other three ecotourism spots.



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Focus group discussions, thematic and content analysis, and case study methods are used to bring out the contrasts (if any) at each ecotourism site.

**RESULTS****A Case of Nalabana (Chilika) Sanctuary**

Nalabana (Chilika) sanctuary is one of the most important natural asset endowments of the State of Odisha. Managing Chilika entails ensuring conserving its rich biodiversity as well as sustainable livelihoods for communities dependent on the wetland resource for sustenance. The place was known for Poachers' place due to rampant poaching activities in the area. The Bird population dwindled to a great extent, but thanks to the efforts of the conservationists, Chilika has come a long way as narrated by Sharma & Pradhan (2).

The Government of Odisha created the Chilika Development Authority (CDA) in 1991 for under taking ecosystem restoration. With financial support of the state government and the Ministry of Environment and Forests, Government of India, CDA initiated several programs including treatment of degraded catchments, hydro-biological monitoring, sustainable development of fisheries, wildlife conservation, ecotourism development, community participation and development and capacity building at various levels. Even '*An Integrated Management Planning Framework for Conservation and Wise Use*, Kumar & Pattnaik (2012) emphasize on ecotourism for conservation of Chilika Lake and sustainable development of villagers.

Mangalajodi, a village on the banks of the Chilika Lake now hosts more than 150000 birds reported by Sharma & Pradhan (ibid). Mangalajodi is now not only home to birds but also represents a critical, one of its kind ecosystem whose protection is possible because of ecotourism. Through ecotourism, steps have been taken to convert poachers to conservationists through provision of employment opportunities. Poachers turned conservationists are involved in regular bird census, habitat management and other scientific studies conducted by State Forest Department and Other conservation organizations, which helped the locals to earn and also to know more about birds and their habitats. Protection has benefited not only the participants of ecotourism, but also has benefitted Mangalajodi's birds, aquatic biodiversity like fishes, snakes, monitor lizards and the elusive Fishing Cat.

Mangalajodi ecotourism aims to inspire, inform and enable communities to turn ecosystems into a sustainable source of livelihood through well managed tourism instead of exploiting them for short term profits. Project involved working in three key areas- Capacity Building of the local community through training in domains like Eco-Guiding, Hospitality and catering, Infrastructure Development and Marketing the venture through different mediums. This initiative involved establishing an other community based organization called Mangalajodi Ecotourism Society to cater to larger village needs and involving the youth from the village to manage ecotourism activities professionally. The institution is further divided into different teams taking care of different project domains. By protecting, reconnecting and restoring the life of the Mangalajodi Marshes, this community owned venture is giving a paradigm shift in conservation.

Mangalajodi ecotourism has tried to follow the principles of ecotourism, by making a positive contribution to economic betterment of the locals, ecology, and environment. Ecotourism is able to build partnership with different organizations to initiate development work in different areas. At present Mangalajodi ecotourism has evolved to support the continuous community conservation initiative. It is now a community owned and managed Ecotourism initiative started with a vision to support the livelihood of local community without hampering the fragile wetland Ecosystem. Very recently, Bird protection committee was bestowed with prestigious state "Biju Patnaik Pakhee Mitra" (Friends of Birds) Award for conservation and has been designated the status of 'Important Bird Area' by Birdlife International for its importance as a significant global waterfowl habitat (Kumar, Pattnaik & Pattnaik ; 2011). This shows how successfully ecotourism has been able to manage the nature and local community.



**Madhumita Das****A case of Bhitarkanika Wildlife Sanctuary**

According to a report of Das & Chatterjee (2015) Ecotourism as a policy has been introduced in the era of the 1990s, when the degradation of biodiversity and natural resources increased and intervention became critical. The major objective of ecotourism in BKWS is to conserve biodiversity through improved livelihoods of the villagers. After around two decades, the hotspot is doing really well now in terms of tourism business. The economy of the nearby villages of Bhitarkanika is characterized by remoteness, absence of electricity and industry, very little development in terms of infrastructure, communication, market and so on. Villagers have little occupational choice other than agriculture and fishing. Introduction of ecotourism has undoubtedly opened up different avenues of employment opportunities for the villagers in such a remote area. As per the authors, locals get an opportunity to work in hotels, restaurants, patrolling staff, plantation worker, gatekeeper, boat drivers at. Some skilled people work as eco-guides. Ecotourism has also created opportunity as temporary workers for park related construction and other development activities. With different job opportunities for the villagers, ecotourism has definitely come as an economic rescuer for many people who do not have a wide avenue of earning due to lack of infrastructure, resources, education, training and so on. This benefit has led to their dependence on natural resources.

**CONCLUSION**

Ecotourism aims at the conservation of natural resources through economic development of the indigenous communities. The protected areas such as wildlife sanctuaries and national parks are formed in remote areas where the locals depend on the natural resources for their sustenance. The policy measures of ecotourism of Bhitarkanika and Chillika need to be appreciated for the efforts to link conservation with local development. But there is more scope to make ecotourism an inclusive approach and therefore the study call for more stringent measures related to conservation.

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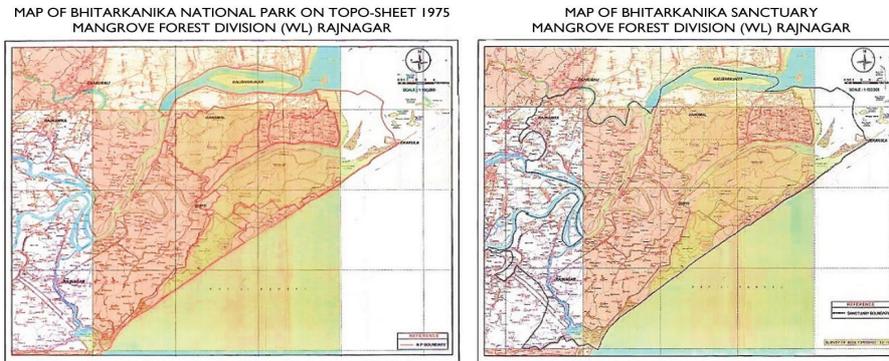


Figure 1. Map of Bhitarkanika Wildlife Sanctuary, Odisha



Figure 2: Map of Nalabana (Chilika) Bird Sanctuary, Odisha



Figure 3. Tourism in Nalabana (Chilika) Bird Sanctuary



Figure 4: Tourism in Bhitarkanika Wildlife Sanctuary





## Impact of Capital Structure on Corporate Performance of Software Companies in India

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### ABSTRACT

Capital structure is connected to corporate financing from various groupings of long term sources which comprise both insider funds in addition to outsider funds. Capital structure is the most important feature although measuring the corporate performance for any kind of firm. It is not only significant for the development of the firms' value but also it is obligatory to continue in the economic situation. Therefore the assessment of corporate performance of the organization should bring a sign on the way to exploiting stockholders wealth which is most vital from the investment decision during a particular time horizon. From the above it is clear that capital structure of an organization have an important impact on corporate's performance. Consequently, this study is connected to examine the impact of capital structure on corporate performance of six software companies in India for last five years from 2015-16 to 2019-20. The study considers four corporate performance measures as dependent variables two main capital structure ratios are as independent variables. The data has composed from secondary sources and composed data has been inspected by different tools like descriptive statistics, correlation and regression analysis for examining the impact of capital structure on corporate performance of six software companies in India for last five years from 2015-16 to 2019-20.

**Keywords:** Capital Structure, Corporate Performance, Capital Structure Ratio, Corporate Performance Ratios, Software Companies, Correlation, Regression

### INTRODUCTION

One of the most significant tasks of a finance manager is to make the finest capital structure; which will provide higher return with lower cost. Capital structure is connected to corporate financing from various sources of long



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term sources which comprise both insider funds in addition to outsider funds. Capital structure is the most important feature although measuring the corporate performance for any kind of firm. It is not only significant for the development of the firms' value but also it is obligatory to continue in the economic situation. Corporate performance is most important features, which recognize the corporate profitability as well as position from the company's investment. Consequently it is significant for the firm to perform better, earn more profit than cost in the competitive environment (Owolabi and Obida, 2012). The foremost problematic in framing capital structure is to realize various types of funds in addition to their proportion in the capital structure for achieving higher returns with less risk (Dada and Ghazali, 2016; Gambo et al., 2016). Subsequently, this study is connected to investigate the effect of capital structure on financial performance of six software companies in India for the last five years from 2015-16 to 2019-20.

**LITERATURE REVIEW**

Berger and Di Patti (2006) clarified that with the help of financial leverage in the firm cost of capital can be minimised. Higher debt will reduce the transactions cost in addition to this the firm can accomplish the objectives of shareholders wealth maximization. Conversely Efobi (2008) defined capital structure is mostly alienated into own funds in addition to borrowed funds. Firm sale ordinary shares and distributes profit to the owners of the firm. However Ihenetu, Iwo and Ebiware (2016) suggested that firms utilise borrowed fund and funds from the shareholders for the long term investment actions.

While, Owolabi and Obida (2012) analysed and mentioned that there are many measures used by the company to know the financial performance. Then again Lambe (2014); Odi (2014); Nirajini and Priya (2013); Salawu (2009) explained that debt ratio of the company can be taken to decide external financing. Company making profit but less growth opportunities can use moderate debt than issuing shares as debt is less costly than equity share. On the other hand Oyakhilome, Ibhaguia and Felicia (2018) in their research mentioned there is a positive impact of different capital structure on financial performance. Correspondingly, Hoang (2015) examined the 150 Vietnamese listed manufacturing companies and found that the impact of short term debt has positive significant effect on performance of firm whereas long term debt has insignificant effect on performance of firm. While, Olokoyo (2013) observed from 101 companies and found that financial structure has positive as well as significant relationship with firms' performance.

On the other hand Patjoshi and Nandini (2019) studied the trends of liquidity management and their impact on financial performance of CIPLA and SUN PHARMA. Similarly Patjoshi and Nandini (2019) examined the interrelationship between capital structure and financial performance of ACC while Patjoshi and Nandini (2019) examined the comparative financial performance of Hindustan Unilever and Nestle India. Whereas Patjoshi (2016) analysed the financial performance of HINDLCO and NALCO similarly Patjoshi (2018) analysed liquidity management and financial performance practices by ONGC and IOCL. Likewise Patjoshi (2014) investigated financing pattern and utilisation of fixed assets of fertilizer industries in India. While Nandini (2017) studied the impact of capital structure on financial performance of Tata Motor similarly Nandini (2013) examined the financing pattern and utilisation of fixed assets: case on Tata Steel and SAIL.

**Objectives of the Study**

The objectives of the study are To study the capital structure and corporate performance of six software companies in India for the last five years from 2015-16 to 2019-20.

- To analysis the impact of capital structure on corporate performance of software companies in India from 2015-16 to 2019-20.





## METHODOLOGY OF THE STUDY

For reviewing the stated exploration objectives the data has been collected from secondary sources. The data has been collected from the financial statements, available in different websites of six software companies in India for the last five years from 2015-16 to 2019-20. The research considers four corporate performance measures, including Net Profit Margin (NPM), Return on Equity (ROE), Return on Total Assets (ROTA), and Return on Investment (ROI) as dependent variables and two capital structure ratios including Total Debt Equity Ratio (TDER) and Long Term Debt Equity Ratio (LTDER) as independent variables. The sample six software companies for the study are HCL Technologies, Tata Consultancy Services, Infosys, Tech Mahindra, Mind tree and Mphasis.

## DATA ANALYSIS AND DISCUSSION

### Descriptive Analysis of Capital Structure Ratio and Corporate Performance Ratio of six Software Companies in India

From the table-I, it can observe that the two independent variables TDER and LTDER of six software companies have logged mean value of 0.42 and 0.05 and standard deviations of 0.13 and 0.05 respectively for the study period. Both TDER and LTDER variables are positively skewed. LTDER has recorded positive kurtosis value while TDER has recorded negative kurtosis value for the study period. From Table-I, it reveals among four dependent variables of six sample software companies that measure the firms' performance, NPM has the lowermost mean (0.16) but ROI has the uppermost mean (0.29). Conversely ROI has the higher volatility which equal to 0.12 while the volatility of NPM is the lower (0.05). All profitability ratios are positively skewed. ROE as well as ROI have much superior excess kurtosis than NPM in addition to ROTA.

### Analysis of Correlation of Capital Structure Ratio and Financial Performance Ratio of top six Software Companies in India

Correlation result does the association among capital structure and financial performance ratio of six software companies discussed in Table-II. It can find out that both capital structure ratios TDER and LTDER of software companies are negatively correlated to all corporate performance ratios (NPM, ROE, ROTA and ROI). While NPM (-0.79) correlation is found to be lowermost as compare to other corporate performance ratios for the study period.

### Regression Analysis Net Profit Margin and Capital Structure Ratio

Table-III shows the regression result considering NPM as dependent variable with the capital structure ratios as independent variables. The goodness of fit significances of standard linear multiple regressions through NPM as the dependent variable and various factors as predictors, the model result and model coefficients have shown in table-III. The R Square (0.64) in addition to adjusted R Square (0.61) indicate that there is moderate deviation in NPM is expressed by the independent variables involved in the model. The ANOVA result shows that there is a statistically significant association as the F value of 23.49 and a P-value < 0.05. TDER has a negative coefficient and P value of 0.00 (less than 5%) means that there is a negative but statistically significant relationship between NPM and TDER at 5% levels. Whereas LTDER has a negative coefficient and P value of 0.56 (more than 5%) indicates that there is a negative and statistically insignificant relationship among NPM and LTDER at 5% levels.

### Regression Analysis Return on Equity and Capital Structure Ratio

Table-IV shows the regression result considering ROE as dependent variable with the capital structure ratios as independent variables. The goodness of fit significances of standard linear multiple regressions through ROE as the dependent variable and various factors as predictors, the model result and model coefficients have shown table-IV. The R Square (0.26) as well as adjusted R Square (0.21) designate that there is very low deviation in ROE is formulated by the independent variables involved in the model. The ANOVA result shows that there is a statistically significant association as the F value of 4.86 and a P-value < 0.05. TDER has negative coefficient as well as P value of 0.52 (more than 5%) indicates that there are negative and statistically insignificant relationship between ROE and



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TDER. Similarly LTDER has a negative coefficient and P value of 0.24 (more than 5%) indicates that there is a negative as well as statistically insignificant relationship between ROE and LTDER at 5% levels

**Regression Analysis Return on Total Assets and Capital Structure Ratio**

Table-V shows the regression result considering ROTA as dependent variable with the capital structure ratios as independent variables. The goodness of fit significances of standard linear multiple regressions through ROTA as the dependent variable and various factors as predictors, the model result and model coefficients have shown table-V

The R Square (0.37) in addition to adjusted R Square (0.32) designate that there is low deviation in ROTA is expressed by the independent variables involved in the model. The ANOVA result shows that there is a statistically significant association as the F value of 7.94 in addition to a P-value < 0.05. TDER has a negative coefficient as well as P value of 0.51 (more than 5%) indicates that there is a negative as well as statistically insignificant relationship among ROTA and TDER at 5% levels. Similarly LTDER has a negative coefficient in addition to P value of 0.10 (more than 5%) indicates that there is a negative as well as statistically insignificant relationship between ROTA and LTDER at 5% levels.

**Regression Analysis Return on Investment and Capital Structure Ratio**

Table-VI shows the regression result considering ROI as dependent variable with the capital structure ratios as independent variables. The goodness of fit significances of standard linear multiple regressions through ROI as the dependent variable and various factors as predictors, the model result and model coefficients have shown table-VI.

The R Square (0.32) as well as adjusted R Square (0.27) show that there is low deviation in ROI is expressed by the independent variables involved in the model. The ANOVA result shows that there is a statistically significant association as the F value of 6.28 in addition to a P-value < 0.05. TDER has a negative coefficient as well as P value of 0.24 (more than 5%) indicates that there is a negative as well as statistically insignificant relationship between ROI and TDER at 5% levels. Similarly LTDER has a negative coefficient in addition to P value of 0.37 (more than 10%) indicates that there is a negative and statistically insignificant relationship between ROI and LTDER at 5% levels.

**CONCLUSION**

Capital structure is the most important feature for measuring the corporate performance for any kind of firm. Therefore, this study is connected to examine the impact of capital structure on corporate performance of six software companies in India for last five years from 2015-16 to 2019-20. The study considers four corporate performance measures as dependent variables two main capital structure ratios are as independent variables. The capital structure ratios TDER and LTDER of software companies are negatively correlated to all financial performance ratios (NPM, ROE, ROTA and ROI). It can observe from regression analysis for NPM with capital structure ratios designate with both TDER and LTDER have negative coefficient while TDER is statistically significant relationship with NPM and LTDER has statistically insignificant relationship with NPM at 5% levels. Whereas it can observe from regression analysis of ROE, ROTA and ROI with capital structure ratios designate that both TDER and LTDER have negative and statistically insignificant relationship with ROE, ROTA and ROI at 5% levels.

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**Table-I Descriptive Analysis of Capital Structure Ratio and Corporate Performance Ratio of six Software Companies in India**

Particulars	Mean	Standard Deviation	Kurtosis	Skewness
TDER	0.42	0.13	-0.44	0.11
LTDER	0.05	0.05	0.32	0.88
NPM	0.16	0.05	-1.41	0.10
ROE	0.23	0.06	0.74	0.74
ROTA	0.22	0.07	0.40	0.79
ROI	0.29	0.12	1.22	1.56

**Table-II Correlation Matrix of Capital Structure Ratio and Corporate Performance Ratio of six Software Companies in India**

Particulars	TDER	LTDER	NPM	ROE	ROTA	ROI
TDER	1.00					
LTDER	0.82	1.00				
NPM	-0.79	-0.69	1.00			
ROE	-0.47	-0.50	0.73	1.00		
ROTA	-0.55	-0.60	0.77	0.99	1.00	
ROI	-0.54	-0.53	0.69	0.89	0.90	1.00

**Table-III Regression Results for Net Profit Margin as Dependent Variable**

Model Summary	Multiple R	R Square	Adjusted R Square	Standard Error
	0.80	0.64	0.61	0.03
Goodness of Fit – ANOVA	SS	MS	F	Significance F
	0.04	0.02	23.49	0.00
<b>Regression Coefficients</b>				
Particulars	Coefficients	Standard Error	t Stat	P-value
Intercept	0.26	0.02	11.08	0.00
TDER	-0.25	0.07	-3.39	0.00
LTDER	-0.12	0.20	-0.60	0.56

**Table-IV Regression Results for Return on Equity as Dependent Variable**

Model Summary	Multiple R	R Square	Adjusted R Square	Standard Error
	0.51	0.26	0.21	0.06
Goodness of Fit – ANOVA	SS	MS	F	Significance F
	0.03	0.02	4.86	0.02
<b>Regression Coefficients</b>				
Particulars	Coefficients	Standard Error	t Stat	P-value
Intercept	0.28	0.04	6.33	0.00
TDER	-0.09	0.14	-0.65	0.52
LTDER	-0.46	0.39	-1.20	0.24





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**Table-V Regression Results for Return on Total Assets as Dependent Variable**

Model Summary	Multiple R	R Square	Adjusted R Square	Standard Error
		0.61	0.37	0.32
Goodness of Fit – ANOVA	SS	MS	F	Significance F
	0.05	0.02	7.94	0.00
<b>Regression Coefficients</b>				
Particulars	Coefficients	Standard Error	t Stat	P-value
Intercept	0.28	0.04	6.44	0.00
TDER	-0.09	0.13	-0.66	0.51
LTDER	-0.64	0.38	-1.69	0.10

**Table-VI Regression Results for Return on Investment as Dependent Variable**

Model Summary	Multiple R	R Square	Adjusted R Square	Standard Error
		0.56	0.32	0.27
Goodness of Fit – ANOVA	SS	MS	F	Significance F
	0.14	0.07	6.28	0.01
<b>Regression Coefficients</b>				
Particulars	Coefficients	Standard Error	t Stat	P-value
Intercept	0.45	0.08	5.29	0.00
TDER	-0.31	0.26	-1.20	0.24
LTDER	-0.67	0.73	-0.91	0.37





## Measurement of Volatility Pattern of the Banking Companies in Indian Stock Market

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### ABSTRACT

Stock market plays significant role of economy development of the country. Investors use to invest in various financial securities in the Stock market by expecting a high return in future. Investment in stock market involves future uncertainties as well as unexpected risks. Irregularity in stock market also called as volatility. The stock market comprises maximum volatility which leads to maximum risk in the stock market. Consequently, this study mainly related to measurement of volatility pattern of the banking companies in Indian stock market. The study considers the daily closing price of different indices of Sensex as well as selected banking companies in India. For investigating the objectives the data has been self-possessed from secondary source (BSE website) over a period of 10 years from 1<sup>st</sup>January 2010 to 31<sup>st</sup>December 2019.

**Keywords:** Volatility, Sensex, Banking Companies, Beta, Correlation and Regression

### INTRODUCTION

Stock market plays significant role of economy development of the country. Investors use to invest in various financial securities in the Stock market by expecting a high return in future. Two most significant variables should consider while investing in the stock market are risk and return. Investment in stock market involves future uncertainties and unexpected risks. Irregularity in stock market also called as volatility. The stock market comprises maximum volatility which leads to maximum risk in the stock market. When the deviation between actual return and expected return is more volatility is more. So measurement of volatility is very important for the investors for

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investment. In India Bombay Stock Market (BSE) in addition to National Stock Market (NSE) are two significant stock markets. Once there is arising or sliding drive in the Indian stock market the stock prices similarly displays up and down movements.

**REVIEW OF LITERATURE**

Samanta (2003) examined the volatility in Indian stock market over a period from 1993 to 2002. The study shows that historical prices of stocks affect the volatility in stock market. And while volatility is bigger the return is also higher during the study period. Although Chang-Jin, James and Charles (2004) studied the stock market volatility by considering from 1996 to 2000 and strained to discover whether there is any positive association among equity premium and volatility. Conversely Balaban and Bayar (2005) explored by investigating 14 countries. The study has taken stock market return as well as made the forecast of volatility during 1987 to 1997. Correspondingly Sarkar and Banerjee (2006) inspected the Indian stock market by considering the day wise stock prices in each five minutes break from NSE. They considered from 1<sup>st</sup> June 2000 to 30<sup>th</sup> January 2004 and used GARCH model for the analysis. While Tripathy, Prakash and Arora (2009) examined in the Indian Stock market by captivating data of BSE Sensex from January 2005 to June 2009. This research considered various variables like leverage, stock returns, trade and volatility for the investigation. Conversely Nicholas and Nicholas (2011) examined in European stock market for finding the variation of volatility in the disasters situation and found the stocks demonstrate negative as well as statistically insignificant leverage possessions. Whereas Gahan, Mantri, Parida and Sanyal (2012) examined the volatility in Indian stock market for both pre as well as post derivative period and found that the present news cast has additional effect in the volatility.

Conversely Patjoshi (2011) examined volatility in Indian stock market by taking various indices of BSE and NSE. Similarly Nandini, Patra, Mishra (2012) studied the volatility by finding month of the year effect and also day of the week effect. They have used statistical techniques and GARCH (1,1) model for the analysis. They found there is a significant difference in the return of the days of the week. Similarly Nandini (2013) analysed to find the volatility in the Indian stock market. She also found that there is a significance difference in the return of days of the week in different stock exchanges. Conversely, Patjoshi (2016) has done the research in Indian stock market. He has taken Sensex and banking stocks indices to find the risk and return for the analysis. Similarly; Patjoshi and Tanty (2016) analysed the stock market volatility in BSE and NSE of India while Patjoshi and Tanty (2017) scrutinizes the volatility of 30 companies of BSE SENSEX. They have taken daily return into consideration to find the volatility.

Alternatively Patjoshi (2016) investigated the issue and challenges faced by the Indian Stock Market while Patjoshi (2016), scrutinized suitable day in a week for investment, in the BSE. On the other hand Patjoshi and Nandini (2020) have done their research by taking the closing value of Sensex and different steel companies for the period from 2010 to 2019. They have used descriptive statistics, t test and correlation for the analysis. They found that Sensex average daily return is positive whereas all the sample companies return is negative. Also the volatility is more for the sample companies than Sensex. Similarly Patjoshi and Nandini (2020) analysed the day of the week effect in Indian stock market from the period 2000 to 2018 by taking the returns of Indices of BSE. They have used descriptive statistics and GARCH model for the study. They found a statistically significant return in the days of a week. Therefore, this study mainly related to measure measurement of volatility pattern of the banking companies in Indian stock market.

**Objectives of the Study:**

The study is based on the following objectives.

- a) To study the measurement of volatility pattern of the banking companies in Indian stock market.
- b) To analyse effect of volatility pattern of selected banking companies on Indian stock market.





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## Methodology and Tests Used in the Study

The main objective of the study theme asurement of volatility pattern of the banking companies in Indian stock market and their effect on Indian stock market. Sensex has been considered as an indicator of Indian stock market while ten selected banking companies i.e. HDFC Bank (HDFC), State Bank of India (SBI), ICICI Bank (ICICI), Axis Bank (Axis), Kotak Mahindra Bank (Kotak), Indusind Bank (Indusind), Yes Bank (Yes), Punjab National Bank (PNB), Bank of Baroda (BOB) and Bank of India (BOI) have been well-thought-out for the study of measurement of volatility pattern of the banking companies in Indian stock mark. The study considers the daily closing price of different indices of Sensex as well as selected banking companies in India. For investigating the objectives the data has been self-possessed from secondary source (BSE website) over a period of 10 years from 1<sup>st</sup> January 2010 to 31<sup>st</sup> December 2019. Different tools like Mean, Standard deviation, Skewness, Kurtosis correlation and regression are used to study the measurement of volatility pattern of the banking companies in Indian stock mark.

## Data Analysis and Discussion

### Descriptive Analysis of Sensex and Selected Banking Companies in India

Table-1 shows the descriptive analysis of Sensex in addition to selected banking companies in India. It can find out from table-1 that, out of ten banking stocks two banking stocks have positive mean returns although eight stocks have negative mean returns designed for the study period. It can be experiential that the mean return of Indusind bank (0.10) is upper most and mean return of PNB (-0.11) is bottommost compare to other banking stocks. Consequently top two better players in banking industry are Indusind bank (0.10) and Kotak bank (0.03). In contrast the bottom most two players in banking industry are PNB (-0.11) and SBI (-0.08). On the other hand, the standard deviation (volatility) logged maximum for SBI where as it is minimum for Indusind bank then other banking stock over the period under study. It also can be found from the table that the two larger volatile banking stocks are SBI (5.02) and Yes bank (4.48), however two slighter volatile banking stocks are Indusind bank (1.99) and Kotak bank (2.52). Although by examining the Sensex related to banking stock return, it can practical that Sensex has provided healthier return than all sample banking stock except Indusind bank and Kotak bank during the study period. Alternatively Sensex return include slesser volatile then as related to all sample banking stock over the study period.

### Analysis of Correlation between Sensex and Selected Banking Companies in India

Table-2 pronounces the correlation amongst Sensex and banking stocks in from 1<sup>st</sup> January 2010 to 31<sup>st</sup> December 2019. It can depict from table-2 that Sensex is positively correlated with all banking stocks' returns. The upper two banking stocks those are exceptionally correlated with Sensex are Indusind bank (0.58) and BOI (0.55). Whereas, the bottom two banking stocks those are less correlated with Sensex returns are SBI and (0.26) and HDFC (0.25).

### Analysis of Beta with Reference to Sensex

The betas (market volatility) of sample banking stock in India related to Sensex have explained in table-3. It found from table-3 that the two less risky banking stocks with smaller Beta are HDFC bank (0.99) and Kotak bank (1.05) whereas the two high risk banking stocks with maximum Beta are BOI (1.54) and Yes bank (1.55).

### Analysis of Regression Results for Returns on Sensex Dependent Variable and Various Banking Companies in India as Predictors

Table-4 replicates the regression study between Sensex returns as dependent variable with the sample banking stocks returns from Bombay stock market in India as independent variables. It reveals from table-4 that F-statistics value of 308.04 ( $P < 0.05$ ) demonstrate that the independent variables are jointly statistically significant at 5% level. The regression study specifies that the coefficients of Indusind bank, BOI and Kotak bank's stocks noted higher coefficients where as SBI, Yes bank, BOB and PNB stocks have noted smaller coefficients. Therefore the returns of Indusind bank, BOI and Kotak bank's stocks are really impact the Sensex return. Nevertheless SBI, Yes bank, BOB



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and PNB banking stocks return have slighter impact on Sensex return. The regression model discloses that all banking stocks' returns are statistically significant association amongst Sensex return (Sig. < 0.05) except PNB.

**CONCLUSION**

This study is associated to examine the measurement of volatility pattern of the banking companies in Indian stock market. The study considers the daily closing price of different indices of Sensex as well as selected banking companies in India. For investigating the objectives the data has been self-possessed from secondary source (BSE website) over a period of 10 years from 1<sup>st</sup> January 2010 to 31<sup>st</sup> December 2019. The descriptive consequence shows that the two better stocks in banking industry are Indusind bank and Kotak bank while the bottommost two stocks in banking industry are PNB and SBI. On the other hand the two larger volatile banking stocks are SBI and Yes bank; however two slighter volatile banking stocks are Indusind bank and Kotak bank. Sensex has provided healthier return than all sample banking stock except Indusind bank and Kotak bank also Sensex return includes lesser volatile then as related to all banking stock over the study period. Correlation result displays that Sensex is positively correlated with all banking stocks' returns. It found from beta anlysis that the less risky banking stocks are HDFC bank and Kotak bank whereas the high risk banking stocks with maximum beta are BOI and Yes bank. The regression study specifies that the coefficients of Indusind bank, BOI and Kotak bank's stocks noted higher coefficients whereas SBI, Yes bank, BOB and PNB stocks have noted smaller coefficients. Therefore the returns of Indusind bank, BOI and Kotak bank's stocks are really impact the Sensex return. Nevertheless SBI, Yes bank, BOB and PNB banking stocks return have slighter impact on Sensex return. The regression model discloses that all banking stocks' returns are statistically significant association amongst Sensex return (Sig. < 0.05) except PNB.

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**Table 1: Descriptive Analysis of Sensex and Selected Banking Companies in India**

Particulars	Mean	Standard Deviation	Kurtosis	Skewness	Minimum	Maximum
Sensex	0.03	0.95	2.00	-0.10	-6.12	5.19
HDFC	-0.01	3.74	1415.00	-34.41	-160.39	8.67
SBI	-0.08	5.02	1726.97	-37.92	-228.23	24.36
ICICI	-0.02	3.78	1297.12	-30.58	-160.05	13.71
Axis	-0.01	3.83	1274.85	-30.22	-161.31	14.53
Kotak	0.03	2.52	407.60	-15.21	-70.08	8.51
Indusind	0.10	1.99	2.12	-0.04	-8.90	10.20
Yes	-0.07	4.48	669.83	-18.83	-160.60	28.49
PNB	-0.11	4.01	945.26	-23.82	-156.98	37.98
BOB	-0.07	4.05	1023.06	-25.46	-161.69	27.36
BOI	-0.07	2.68	8.24	0.55	-17.19	29.24





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Table-2: Correlation of Sensex and Selected Banking Companies in India

Particulars	Sensex	HDFC	SBI	ICICI	Asis	Kotak	Indusind	Yes	PNB	BOB	BOI
Sensex	1.00										
HDFC	0.25	1.00									
SBI	0.26	0.06	1.00								
ICICI	0.38	0.08	0.13	1.00							
Axis	0.36	0.10	0.13	0.19	1.00						
Kotak	0.39	0.12	0.04	0.14	0.16	1.00					
Indusind	0.58	0.18	0.19	0.24	0.26	0.31	1.00				
Yes	0.33	0.10	0.12	0.15	0.17	0.17	0.35	1.00			
PNB	0.29	0.06	0.18	0.15	0.14	0.13	0.22	0.17	1.00		
BOB	0.30	0.06	0.18	0.17	0.13	0.13	0.21	0.17	0.26	1.00	
BOI	0.55	0.13	0.30	0.27	0.27	0.23	0.41	0.31	0.44	0.43	1.00

Table-3: Beta Coefficient of Banking Companies in India

Particulars	Beta	Rank
HDFC	0.99	1
Kotak	1.05	2
Indusind	1.21	3
PNB	1.23	4
BOB	1.26	5
SBI	1.35	6
Axis	1.44	7
ICICI	1.49	8
BOI	1.54	9
Yes	1.55	10

Table 4: Regression Results for Sensex as Dependent Variable and Various Banking Companies in India as Predictors

Model Summary	Multiple R	R Square	Adjusted R Square	Standard Error
	0.75	0.56	0.55	0.64
Goodness of Fit – ANOVA	SS	MS	F	Significance F
	1246.29	124.63	308.04	0.00
Regression Coefficients				
Particulars	Coefficients	Standard Error	t Stat	P-value
Intercept	0.03	0.01	2.27	0.02
HDFC	0.03	0.00	7.83	0.00
SBI	0.01	0.00	4.46	0.00





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ICICI	0.04	0.00	11.07	0.00
Axis	0.03	0.00	8.68	0.00
Kotak	0.07	0.01	12.13	0.00
Indusind	0.14	0.01	18.69	0.00
Yes	0.01	0.00	3.48	0.00
PNB	0.01	0.00	1.55	0.12
BOB	0.01	0.00	2.28	0.02
BOI	0.09	0.01	13.46	0.00





## Interrelationship between International Trade and Behaviour of Capital Market: Empirical Evidences traced from Indian Economy

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### ABSTRACT

From the review of extant literature, we came to believe that there are empirical evidences on the existing interrelationship between macroeconomic variables on international trade and movement of capital market. On the basis of movements in macroeconomic variables of any economy, we can actually predict the capital market. Now, in order to identify how macroeconomic variables in relation to international trade in this context, and explore relationship of these with capital market the present study has been undertaken.

**Keywords:** Indian Economy, Cointegration, Granger Causality

## INTRODUCTION

For many years, the focus of literature in the field of financial economics has been on the interrelationship between capital market and the macroeconomic variables in the economies. Every one of us knows it well that stock markets being a legitimate representative of the capital market in the country enhances liquidity and provides fund for industrialization which acts as the life blood of economic development. Stock market positions are essentially random which are generally believed to be affected by national and international news related to the economy. Consequent to the daily stock market positions, investors' daily gains or losses are determined and these are basically a variety of events which are not possible to anticipate those actually establishes the stock market positions.

It is however true that the stock index positions are determined by demand and supply of stocks listed in it. Price of a stock increases if its demand increases and conversely if people lose confidence on a particular stock, then its price declines. Hence, the price of a stock reflects its demand and peoples' confidence on it. Overall demand for stocks and confidence of people on them is determined by many factors including macroeconomic variables in the country. In





order to identify and measure the relationship between macroeconomic variables and stock market movement, usage of regression analysis by the technique of ordinary least squares (OLS) is not recommended because neither macroeconomic variables nor stock market positions are generally found to be stationary over time. In such a situation when we deal with non-stationary time series data sets, there is an extremely useful econometric tool developed by Granger (1986) that facilitates to analyze long-run relationships and that is popularly known as 'the cointegration approach'. Additionally, the vector error correction mechanism (VECM) which is generally accepted as a useful extension of the cointegration approach allows for examining the adjustments among cointegrated time series data sets those are happening in the short run while they are moving towards the long run equilibrium. Apart from it the implementation of Granger causality models gives insights about the cause and effect relationships between time series data sets in context.

### Research Objectives

The present study has been undertaken with the following objectives:

1. To identify the most useful macroeconomic variables on international trade in the context of present study; collect data on them and on stock indices of India.
2. To explore relationship between selected macroeconomic variables on international trade and the stock market movements in India.

### Research Hypotheses

The following null (H0) and alternative (H1) hypotheses have been formulated in the present study to be tested in this study:

1. H0: Time series return of the selected indices and macroeconomic variables on international trade follow normal distribution with skewness and kurtosis as zero and three respectively.  
H1: Time series return data of the selected indices and macroeconomic variables under consideration do not follow normal distribution with skewness and kurtosis different from zero and three respectively.
2. H0: The returns distributions of the selected indices and macroeconomic variables on international trade are not stationary i.e. mean, variance or both are not constant.  
H1: The returns distributions of the selected indices and macroeconomic variables are stationary i.e. mean, variance or both are constant.
3. H0: There is no co-integration between selected indices of India and macroeconomic variables on international trade.  
H1: There is co-integration between selected indices of India and macroeconomic variables.
4. H0: There is no causality between selected indices of India and macroeconomic variables on international trade.  
H1: There is causality between selected indices of India and macroeconomic variables.

### Variables on International Trade and Capital Market

After the review of extant literature, the following macro economic variables on international trade have been taken into account so that the cointegration between can be explored. The following are the meaning of the above listed macroeconomic variables as described by World Bank.

**Export value index (2000 = 100):** Export values are the current value of exports (f.o.b.) converted to U.S. dollars and expressed as a percentage of the average for the base period (2000). UNCTAD's export value indexes are reported for most economies. For selected economies for which UNCTAD does not publish data, the export value indexes are derived from export volume indexes (line 72) and corresponding unit value indexes of exports (line 74) in the IMF's International Financial Statistics.



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**Import value index (2000 = 100):** Import value indexes are the current value of imports (c.i.f.) converted to U.S. dollars and expressed as a percentage of the average for the base period (2000). UNCTAD's import value indexes are reported for most economies. For selected economies for which UNCTAD does not publish data, the import value indexes are derived from import volume indexes (line 73) and corresponding unit value indexes of imports (line 75) in the IMF's International Financial Statistics.

**Lending interest rate (%):** Lending rate is the bank rate that usually meets the short- and medium-term financing needs of the private sector. This rate is normally differentiated according to creditworthiness of borrowers and objectives of financing. The terms and conditions attached to these rates differ by country, however, limiting their comparability.

Along with the above variables, as a representative of the stock market the BSE 500 has been taken. The period for which the analysis has been done is 20 years starting from 1999 and ending on 2018.

**Research Design**

For the test of normality of each of the above time series data sets the Jarque Bera (JB) Test has been implemented. Then in order to test the stationarity of the series in consideration Augmented Dickey Fuller (ADF) Test has been implemented. Further, in order to cross verify the results Philips and Perron (PP) Test has been implemented. After it, for detecting cointegration the technique developed by Granger (1986) has been implemented and then the Granger causality got implemented for knowing the cause and effect relationships.

**Key Findings**

The following is the data on the four variables considered in the present study. The JB Test results revealed that none of the time series under consideration are following a normal distribution. Hence, the first null hypothesis that Time series return of the selected indices and macroeconomic variables follow normal distribution with skewness and kurtosis as zero and three respectively has been rejected.

Then, the ADF Test and PP Test both revealed that the time series under consideration are integrated of order '1' i.e. I (1). It means the data sets are becoming stationary after taking their first difference while they are remaining non-stationary in their original forms. But, since all the data sets are found to be integrated of same order it is a green signal for going forward for a test of cointegration. Then, the test of cointegration by taking BSE 500 as dependent variable and individually the macroeconomic variables as independent variables one by one shown that there is cointegration between BSE 500 and Lending interest rate (%), export and import. And the Granger causality test results shown that lending interest rates granger causes the stock market positions.

**CONCLUDING REMARKS**

From the above findings, it is evident that there is a relationship between macroeconomic variables on international trade and capital market. It has been also found that stock market positions are affected by lending interest rates in Indian economy and not by the level of exports and imports. However, there is a limitation of this study which is that it has not considered much number of macroeconomic variables on international trade for analysis. This limitation is expected to be fulfilled in future researches.

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Table 1 Data on Selected Macroeconomic Variables on International Trade and Capital Market				
Years	Variables			
	International Trade		Capital Market	
	Export	Import	Interest Rate	BSE 500
1999	84.16	91.18	12.54	1791.44
2000	100.00	100.00	12.29	1304.66
2001	102.32	97.81	12.08	1005.82
2002	116.21	109.69	11.92	1176.73
2003	139.13	140.83	11.46	2366.36
2004	180.86	193.65	10.92	2779.65
2005	235.06	277.29	10.75	3795.96
2006	287.42	346.27	11.19	5270.76
2007	354.32	445.18	13.02	8592.43
2008	459.73	623.09	13.31	3596.85
2009	389.13	499.20	12.19	6842.25
2010	534.11	679.76	8.33	7961.06
2011	714.75	901.47	10.17	5778.68
2012	700.41	950.44	10.60	7581.57
2013	742.93	903.28	10.29	7828.34
2014	761.44	898.45	10.25	10721.62
2015	631.07	762.51	10.01	10634.22
2016	623.29	701.06	9.67	11036.44
2017	706.18	870.34	9.51	15002.73
2018	768.21	991.14	9.45	14540.39

Source: www.worldbank.org and www.bseindia.com



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Var.	Mean	Median	SD	Skew.	Kurt	JB	p
Export	431.54	424.43	260.45	-0.05	-1.72	2.14	0.34
Import	529.13	561.14	335.92	-0.07	-1.67	2.06	0.35
Interest Rate	11.00	10.83	1.33	-0.01	-0.67	0.53	0.76
BSE500	6480.40	6310.47	4343.05	0.49	-0.68	1.21	0.54

Note: Null Hypothesis: The time series data set follows normal distribution Alternative Hypothesis The time series data set do not follow normal distribution Source: www.worldbank.org and www.bseindia.com, Compiled from E-Views Output

Var.	Level Data			First Difference		
	Computed Value	Critical Value@ 5% Level	Null Hyp.	Computed Value	Critical Value@ 5% Level	Null Hyp.
Export	-3.45	-3.67	Accepted	-3.91	-3.67	Rejected*
Import	-1.83	-3.67	Accepted	-3.71	-3.67	Rejected*
Interest	-3.41	-3.67	Accepted	-4.64	-3.67	Rejected*
BSE500	-3.89	-3.67	Accepted	-5.34	-3.67	Rejected*

Note: Null Hypothesis: There is unit root, Alternative Hypothesis: There is no unit root \*\* Integrated of Order 1, Source: www.worldbank.org and www.bseindia.com, Compiled from E-Views Output





## Theories of Career Development: An analysis

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### ABSTRACT

The purpose of the article is to carry out an in-depth analysis of career development theories and to know the practical implications in modern organizations. Content analysis method has been implemented for studying published literature on career theories. The outcome of the study shows that no single theory can be applicable to all situations and necessitates a combination of approach. Moreover, the factors emphasised by different theories that regulate a person changes very often with the changing organizational contours in this volatility, uncertainty, complexity, and ambiguity (VUCA) world. As a result, the organizations need to adapt with the changing scenario with an appropriate modified model to reap the benefit of career development. The study is limited to only five career development theories and the theories are analysed on the evidences collected from secondary sources. This study provides an insight into the changing professional world with individual coping strategies to the volatile work environment. It prescribes a path towards occupational growth and professional wellbeing for an individual. It also attempts to provide systematic steps to create a platform for career development of employees.

**Key words:** Career development, process theories, content theories, process-content theories

### INTRODUCTION

Career development theories show the various paths towards improving professional growth and the career trajectory followed by individuals for an overall job satisfaction and goal achievement. Understanding these theories is an essential step in determining the strengths, weaknesses, fundamental values, and desirable path that are operative while choosing a career. There are various types of career development theories that focus on different



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factors, and quite dissimilar to one another. Still all the theories recognise the importance of cultivating a positive emotional relation with work or work environment for developing and achieving a meaningful professional goal. Career development theories can be divided into four categories: by using trait factor, a proper match between individual traits to occupations is focused upon (like trait and factor theory by Frank Parson); it can be based on psychological structure, where the personality should correspond with the work environment (like Holland theory); it can be grounded on decision - situational factors (like social cognitive career theory); and it can be constructed on self-concept (like life span theory of Super). Besides this categorisation, another type of division can be noticed in the theories that are: process theories, content theories, and process-content theories. The process theories emphasise on communicating about the interaction and changes that occurs over a period of time. These theories deal with a sequence of stages through which people proceeds (example: Super's life-span, life-space approach to career development, Gottfredson's circumscription and compromise theory). The content theories are connected with the features of an individual and the environment they live in. The impact on career development are thought to be either intrinsic to the individual or it is initiated from the context or surrounding in which they live. For example: Theory of Work Adjustment. The content and process theories have been moulded in response to accommodate with the requirements of process theory and content theory. These theories embrace both the characteristics of context and individuals, and the advancement and dealings between them (example: Krumboltz's social learning theory of career decision-making, social cognitive career theory, Roe's theory of personality development and career choice).

**Objectives and Methodology of the Study**

The study is carried out to gain knowledge about the philosophy and theoretical underpinnings behind career development. Effort is also made to identify the various empirical research conducted by using these theories. As intrinsic as well as extrinsic factors impact career development, attention is provided to understand the same from existing literature. Finally attempt is made to understand the career path or stages adopted by the theories. Content analysis method has been implemented for studying published literature on career theories.

**Content Theories****(a) Theory of Work Adjustment or Person- Environment Correspondence Theory**

The Theory of Work Adjustment (TWA) is based on the difference of individuals and vocational behaviour (Dawis, 2002, 2005; Dawis & Lofquist, 1984). It views career choice as an unbroken process consisting of adjustment and accommodation. The theory declares two processes that an individual adheres to. In the first case, an individual or person (P) searches for a work environment (E) that can match with his requirement. In the second phase E searches for P having the skills that can tally with the needs of the organization. The amount of satisfaction of P depends on his needs and satisfactoriness of E is based on the operational skills of P helps to forecast the tenure of P. There are four types of adjustment maintained by person and environment (Dawis, 2005). The first one is flexibility that denotes to a person level of tolerance in environment. Next is activeness where P tries to modify E. The third is reactivity where P adopts a self-modification to the difficult situation without transforming E. The fourth is perseverance in which P determines to adjust before choosing to leave E.

The prime strength of TWA is that it measures many variables like satisfaction, satisfactoriness, needs and values, indexes of correspondence, skills and abilities (Dawis, 2005). TWA try to explain career development and satisfaction in terms of person-environment correspondence. Many international studies have been performed on this theory based on satisfaction/satisfactoriness, needs/abilities and work adjustment and tenure. Tziner, Meir, and Segal (2002) conducted a study on Israeli military officers on personality, vocational interest, and general ability; and similarity between interest and job were measured. The findings displays that extroverted personality and congruence were related to a greater level of performance, which was stable with TWA likelihoods. Feij, van der Velde, Taris, and Taris (1999) in their survey on Dutch young adults (ages stretched from 18 to 26) in two time points found connection between vocational interest and perceived skills with job satisfaction. The finding was in tune with TWA's affirmation that vocational interest becomes steady in adulthood, as the interest and skills among participants grew during the course of time and developed into a stable pattern of interest. Similarly, Griffin and Hesketh (2003)



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in their survey found that adaptive performance was linked with self-efficacy for adaptive behaviour. The work requirements and adaptability personality projects for the adaptive performance, which is similar with the notion of TWA. TWA can be tested to know career development and satisfaction in cross-cultural surroundings even if it was initiated in USA.

**(b) Holland's Theory of Vocational Personalities in Work Environment**

The theory of Holland can be applied in career counselling and career guidance. Holland expressed that vocational interest and personality is organised in hexagonal structure in the order of RIASEC and can be codified into Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C). Generally, this six types of interest and personality can take two type of forms by producing three-letter code e.g., RIA, SIA that symbolises one's career interest. The first letter of these two codes shows the chief interest of the person and the second and third alphabets denotes significant but secondary interest in the course of career choice. Holland used the word "congruence" to show the person-environment interaction where the personality and interest of the person and the work environment produces vocational stability and satisfaction and a low congruence causes vocational instability and dissatisfaction.

Many studies have been conducted on Holland hypothesis and its frame of vocational interests was effective through many cultures (e.g., Rounds & Tracey, 1996). Tak (2004) administered a survey and found good fit in the model of interest but the interest that was organised was not clearly hexagonal. Sverko and Babarovic (2006) conducted a research and supported the Holland hexagonal model. Leung and Hou (2005) directed a study and found six first order factors clustered into three groups Realistic-Investigative, Artistic-Social, and Social-Enterprising-Conventional. This cluster reproduces a definite cultural value and perception. There is a diversified support for Holland's structure of vocational interests found across the cultures.

**Process Theories****(a) Self-concept Theory of Career Development**

Among various theories of career development, the theory given by Super has received abundant attention in USA and other nations. Super established that career development and career choice is related with the self-concept of the person. A self-concept is a complex dealing among the mental and physical growth, environmental features, personal experience etc. (Super, 1990). Super (1990) established a framework for life stages consisting of growth, exploration, establishment, maintenance and disengagement. One has to manage development of vocation in the chronological age. The idea of "career maturity" represents the amount that an individual can achieve the vocational developmental task during each stage. Due to mixed results on career maturity, various studies have suggested to substitute the concept with adaptability (e.g., Herr, 1997; Savickas, 1997, 2002, 2005). The vocational stages are like a mini cycles that shows career transitions as compared with maxi cycles of other theories.

A sufficient number of international level of research have been made on Super's theory (Patton & Lokan, 2001). Patton et al., (2002) organised a study and found that those students having greater level of career maturity, proceeded to full time study, achieve more and fit in psychological balance as compared to other students. Creed and Patton (2003), and Repetto (2001) also studied on career development interventions where the results were regular with the developmental assumptions suggested by career maturity. Watanabe-Muraoka et al., (2001) stated that super theory has gained very widespread attention in Japanese academic and business surroundings.

**(b) Gottfredson's Theory of Circumscription and Compromise**

Gottfredson's theory of career development is a new input in the theory of career development. Gottfredson (1981, 1996, 2002, 2005) supposed that the process of career choice demands for a greater level of cognitive ability. Gottfredson's (2002, 2005) expounded on the interplay between the concept of genetic makeup and environment. Genetic features performs a vital role by influencing the attributes of a person like skills, values, and interest and



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these traits are moderated when one is open to an environment. Gottfredson informed that person is a dynamic agent who can modify the environment and hence viewed career development as a process of self-creation. Instead of the customary view that holds career choice as a method of selection, this theory viewed career development and career choice as a process of circumscription or eliminating occupations. There are four stages of circumscription that are, orientation to size and power, orientation to sex-roles, orientation to social valuation, and orientation to the internal, unique self. Another process of career development is compromise where an individual makes occupational choice that are truly achievable in the world. Here a person reacts to the numerous realities and restraints that are external in nature like labour market, family obligations, economic depression etc.

The theory have got little attention as it is problematic to test it empirically Swanson and Gore (2000) because (a) its variables like prestige, circumscription, compromise, sex type are tough to implement (b) the developmental process is suitable for longitudinal studies which requires ample time. But still the theory can be used for career guidance like gender stereotype found in the cultures of Asia, where a person chooses a profession which he consider suitable for his gender (Leung, 2002)

**Theory of content and process****(a) Social Cognitive Career Theory**

Social Cognitive Career Theory (SCCT) (Lent, Brown, & Hackett, 2002; Lent, 2005) proposed a model having three segments of career development that elucidates the vocational interest, career choices, and career performance and stability. This three sections emphasised on personal goals, self-efficacy, and outcome expectations. Personal goals is the intentional engagement in certain activity or to engender a particular outcome (Lent, 2005). Lent (2005) defined self-efficacy as “a dynamic set of beliefs that are linked to particular performance domains and activities” (p. 104). Lent et al., (2002) defined outcome expectations as “personal beliefs about the consequences or outcomes of performing particular behaviour” (p. 262). The theory considers that the development of career goals and career choices are the functions of the interface among interest, self-efficacy, and outcome expectations over time. The Career choice model suggested in the theory shows the interaction and influence between the person and the environment upon each other. The theory postulated that compromise in personal interests may be required during the career choice process due to factors that act as a barrier in choice making like contextual immediate to the person lack of support, social barriers, and cultural beliefs.

The theory has been used in many researches at international level (e.g., Arulmani et al., 2003; Hampton, 2005; Patton et al., 2004). Nota et al., (2007) used a SCCT structure and found a positive association between the career search self-efficacy of participants and family support, and a negative relationship between career search self-efficacy and career indecision. These findings were harmonious with the career choice models of general SCCT, and exemplified the prominence of social support for career decision and efficacy. Creed et al., (2006) used SCCT and their findings were dissimilar to the theoretical anticipation. They found that changes in career decision-making self-efficacy during a period of time were not related with parallel changes in career indecision, and vice versa.

**Analysis of the theories**

The theories of career development served a prominent role by encouraging research activity. By analysing the above mentioned theories of career development, it is found that most of them are related to the career behaviour of an individual. The theories are mostly descriptive in nature rather than explanatory even though they are tested by several researchers. Some theories has been applied much more (e.g. super theory of self-concept) as compared with other theories have got a mixed result (e.g. Holland theory). There exist some contrasting factors among the theories. Holland's theory (1959) identifies the factors that trigger the vocational behaviour of a person while other theories deal with the purpose and development of vocational behaviours. Trait factors associated with Holland's theory explains very little about vocational behaviour. This theory is also having certain limitations.



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The theory needs to settle up the inconsistencies of personality required for a proper operation in an occupation. The concept of role identification in career development has been approved by empirical evidences whereas the idea of psychic energy for vocational activity has acquired little support. A substantial amount of research on Super's theory has provided experimental confirmation of self-concept and career development task that is identified with a specific vocational decision. One of the noticeable limitation of the theory is related to its restricted range of use, when we compare the career of nursing that is having enormous amount of personal involvement for exercising the self-concept with that of the career of a clerk working in a dry clean store. Super theory interprets interest as a part of self-concept whereas Holland interest is related with the comparison of person occupation, which can be assessed but it is difficult to be analysed. Because an individual may be poor to judge his own talents and may opt for a career which may be challenging for him to carry out or too low in scope to practise his talents.

Generally all the theories have its origin in the theories of personality but its range varies from one extreme to other extreme as typified in Holland theory. Besides personality, the other area that has exerted impact on the theories of career development is developmental psychology. The effect of developmental notion can be found in Super's (1963a) concepts of vocational developmental task. Gottfredson theory and Super theory, we can find the importance of self-concept and how a work can provide meaning and purpose in an individual's life. Similarly, Social-cognitive career theory mentions the role played by personal, environmental, and behavioural factors that acts as a stimulus for a person through personal goals, self-efficacy, and outcome expectations with the impact of optimal adjustment (Lent, 2013).

The Theory of Work Adjustment is based on satisfaction and satisfactoriness of person and environment. But this theory does not shows what the individual learn during his work life. In the developmental theories like Holland theory, emphasis on the psychic nature of an individual that affects the career choice is shown. Besides the above mentioned theories there are other theories that play up a vital part in career development. There are numerous manifestations of career theories like Systems Theory Framework otherwise known as STF (Patton & McMahon, 1999, 2006), which delivers a structure for career counseling. Krumboltz's social learning theory to career decision, which elaborates that individual personalities and behaviour is the collection of learning experience rather than psychic process (Mitchell & Krumboltz, 1990). Task approach skills, environmental conditions and events, genetic endowment and special abilities, and learning experiences are the four factors that influence a person while making a career choice and career development. Another theory named as Tiedeman's Theory developed by Tiedeman and O'Hara (1963) considered that the process of career development takes place through a repetitive process of differentiation and reintegration. Differentiating is concerned with separating experiences; and integrating is related with structuring the experiences into an all-inclusive whole. Levinson theory developed by psychologist Daniel Levinson, shows the role performed by present circumstances of individual that is strictly regulated by age factor.

The dominant part of Levinson's Theory is that human being develops through specific stages of life irrespective of their background and occupation. If we compare this theory with the career stage model of Super's theory then we can find that in the Super theory people can recycle the career stages regardless of their age while Levinson theory considers career development to be a linear process that advances according to the individual's age. Levinson theory explains the behavioural intentions and individuals' attitudes that are external to work like promotional aims, preparedness to quit the company but Super model gives attentions on attitudes related to the work like job involvement and satisfaction. Roe's theory of personality development and career choice shows the influence of family on the personality of a child. The theory mentions the kind of profession a person chooses but doesn't clarifies the vocational development following the choice of occupation. It neglects the circumstance when the child is not treated in a similar way by either parent who may have two dissimilar ways of nurturing a child.





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#### Findings:

- The theories generally focus on individual, environment and interrelation between the two.
- The study of theories shows that no particular theory can be suitable for every situation and every person.
- One type of theory cannot be applicable to all types of individuals or environment.
- A particular theory may not be applicable in long run. When the needs of a person changes or the requirement of an organization changes then the theory lacks its ability to influence.

#### Concluding Remarks

By studying the above mentioned career related theories, we can find that these theories discourses about the career related outcome (Chen, 2001; Dik, Duffy, & Eldridge, 2009). The study gives a detail vision into the various factors like personality, professional growth, self-concept, social situation etc. that sometimes performs as a source of encouragement and other time acts as barriers for an individual while choosing a career. The varied perspectives of career development theories offer valuable evidence that reflects employee development. These theories help to acquire knowledge about the ways by which an individual develops his career remaining in an organization and the methods that an individual adopts to adjust and achieves knowledge and skills accordance with various circumstances, needs, and social situations. It is suggested that while implementing a theory an organization should know about its employees' needs and should consider on the practicability of applying the theory.

This study complements with Super (1992) who advised that no single theory is sufficient enough to show the career progress of a person, rather each theory advocates certain idea and neglects the other part of individual career choice (Krumboltz, 1994). This study concludes that one particular theory may be operative for a person in a particular time but may be dysfunctional during other time. But still all the theories are valuable as they perform as an outline for dealing with several subject matters of a person related to his career.

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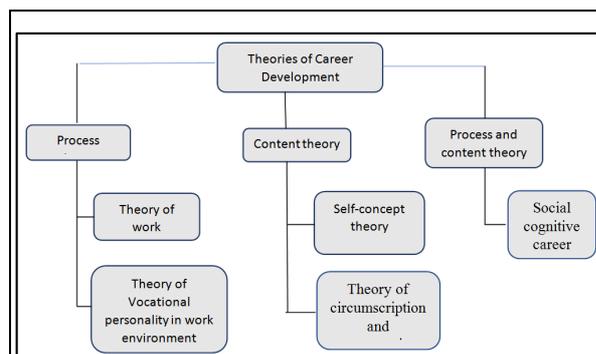
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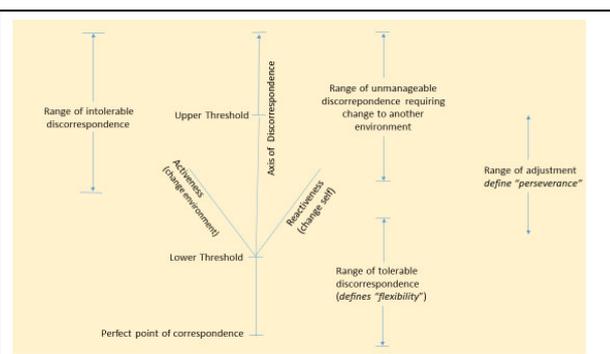


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**Figure I: Conceptual framework of the study**



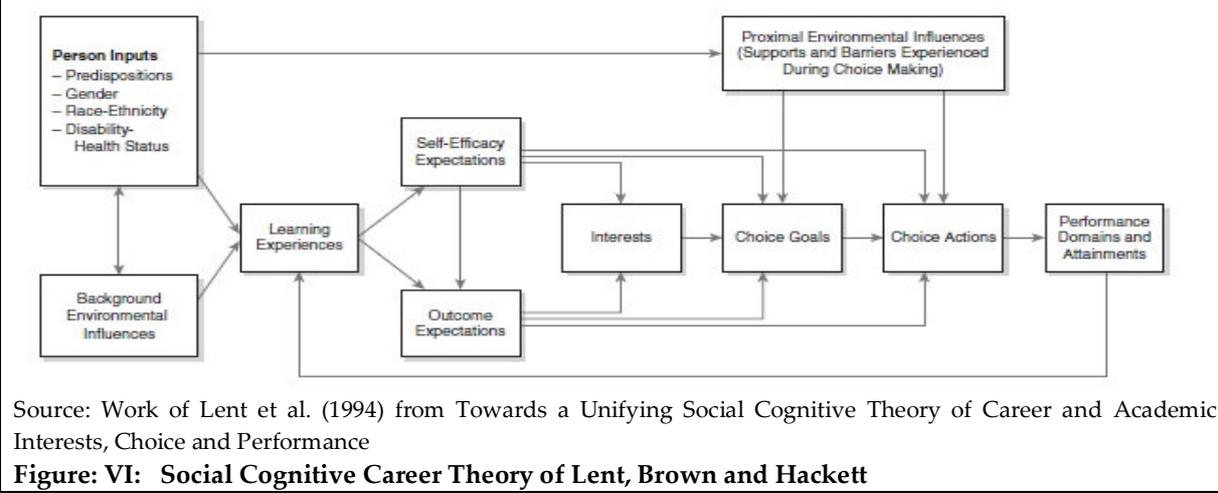
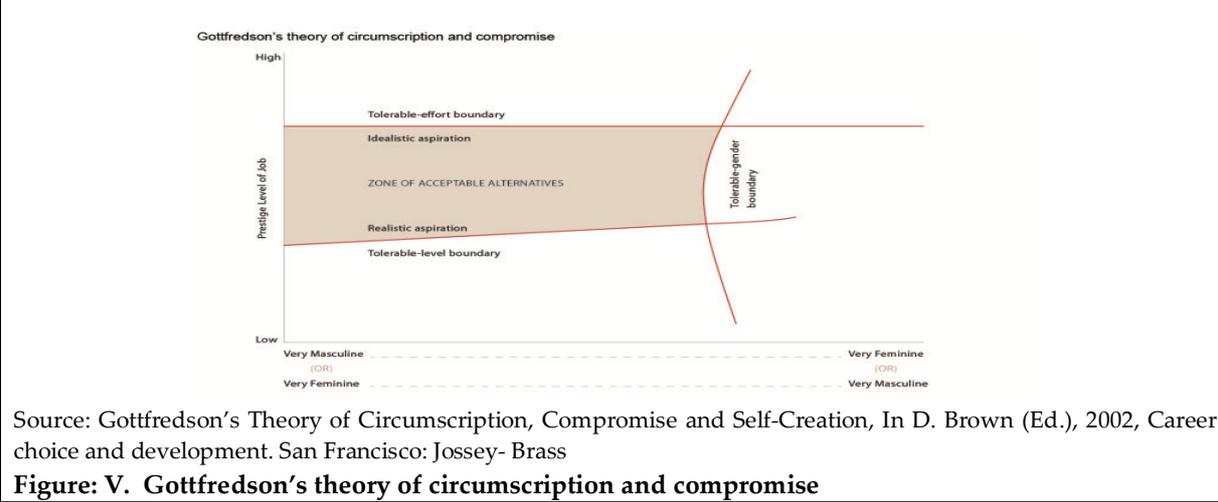
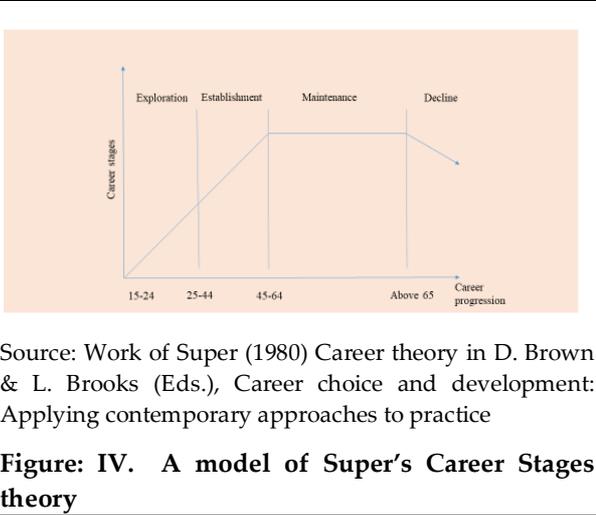
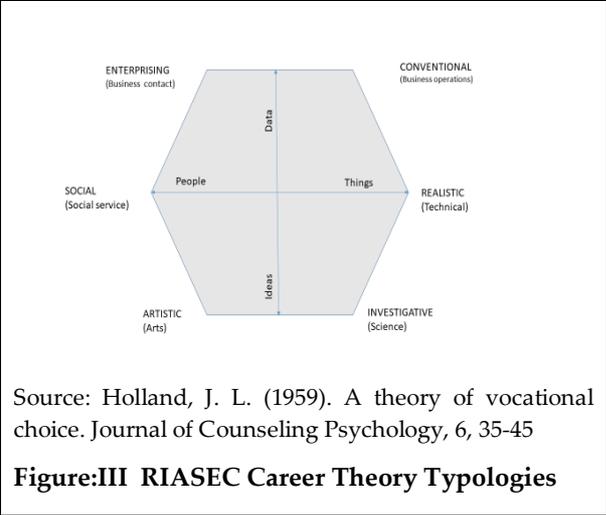
Source. Adapted from Dawis, R. V., & Lofquist L. H. (1984). A psychological theory of work adjustment. Minneapolis: University of Minnesota Press

**Figure: II Adjustment style of theory of work adjustment**





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## Bioactive Medicinal Plant for Human Health Care: A Review

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### ABSTRACT

Medicinal plants have been used in human healthcare as a source of medicine. Assurance of the safety, quality, and efficacy of medicinal plants and herbal products has now become a key issue in industrialized and in developing countries. Medicinal Plants have been used for thousands of years to flavour and conserve food, to treat health disorders and to prevent diseases including epidemics. Active compounds produced during secondary metabolism are usually responsible for the biological properties of plant species used throughout the globe for various purposes, including treatment of infectious diseases. Products derived from plants may potentially control microbial growth in diverse situations and in the specific case of disease treatment, numerous studies have aimed to describe the chemical composition of these plant antimicrobials and the mechanisms involved in microbial growth inhibition, either separately or associated with conventional antimicrobials. Medicinal plants play vital roles in disease prevention and their promotion and use fit into all existing prevention strategies. These approaches present interesting and emerging perspectives in the field of medicinal plants. Recommendations are proposed for strategising the future role and place for medicinal plants in disease prevention.

### INTRODUCTION

The term "medicinal plant" include various types of plants used in herbalism ("herbology" or "herbal medicine"). It is the use of plants for medicinal purposes, and the study of such uses. The medicinal plants include a various types of plants used in herbalism and some of these plants have a medicinal activities. Medicinal plants are the "backbone" of traditional medicine, which means more than 3.5 billion people in the less developed countries utilize medicinal plants on a regular basis.[1]. The foundations of typical traditional systems of medicine for thousands of years that have been in existence have formed from plants. The plants remain to offer mankind with new medicines. Some of the beneficial properties ascribed to plants have recognised to be flawed and medicinal plant treatment is based on the experimental findings of hundreds to thousands of years.[2] The earliest reports

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carved on clay tablets in cuneiform date from about 2600 BC are from Mesopotamia; among the materials that were used were oils of *Commiphora* species (Myrrh), *Cedrus* species (Cedar), *Glycyrrhiza glabra* (Licorice), *Papaver somniferum* (Poppy juice) and *Cupressus sempervirens* (Cypress) are still used today for the cure of diseases extending from colds and coughs to inflammation and parasitic infections [2]. The traditional medicine practice is widespread in China, India, Japan, Pakistan, Sri Lanka and Thailand. About 40% of the total medicinal consumption is attributed to traditional tribal medicines alone by China.[1] The use of traditional medicine and medicinal plants in most developing countries, as a basis for the maintenance of good health, has been widely observed by UNESCO, 1996[3]. Furthermore, an increasing reliance on the use of medicinal plants in the industrialized societies has been traced to the extraction and development of several drugs and chemotherapeutics from these plants as well as from traditionally used rural herbal remedies [4]

The therapeutic properties of medicinal plants are conditioned by the presence in their organs of active substances, such as alkaloids, flavonoids, glycosides, vitamins, tannins, and coumarin compounds, which physiologically affect the bodies of humans and animals or which are biologically active in relation to the causative agents of various diseases. A special group of medicinal plants are antibiotics [5] Medicine, in several developing countries, using local traditions and beliefs, is still the mainstay of health care. As defined by WHO, health is a state of complete physical, mental, and social well being and not merely the absence of disease or infirmity. Medicinal plants can make an important contribution to the WHO goal to ensure, by the year 2000, that all peoples, worldwide, will lead a sustainable socio-economic productive life [6]

Africa is a rich source of medicinal plants. Perhaps, the best known species is *Phytolacca dodecandra*. Extracts of the plant, commonly known as *endod*, are used as an effective molluscicide to control schistosomiasis [7]. Other notable examples are *Catharanthus roseus*, which yields anti-tumour agents such as vinblastine and vincristine; and *Ricinus communis*, which yields the laxative--castor oil. In Botswana, Lesotho, Namibia and South Africa, *Harpagophytum procumbens* is produced as a crude drug for export. Similarly, *Hibiscus sabdariffa* is exported from Sudan and Egypt. Other exports are *Pausinystalia yohimbe* from Cameroon, Nigeria and Rwanda, which yields *yohimbine*; and *Rauwolfia vomitoria*, from Madagascar, Mozambique and Zaire, which is exploited to yield reserpine and ajmaline[8]

**Role of medicinal plants in human health care**

Medicinal plants have been used as a source of drugs by mankind for several thousand years. Medicinal plants have played an essential role in the development of human culture, for example religions and different ceremonies. Many of the modern medicines are produced indirectly from medicinal plants, for example aspirin. Many food crops have medicinal effects, for example garlic.[9]

**Primary metabolites of plant**

Organic compounds produced in the plant kingdom have metabolic functions essential for plant growth and development produced in every plant. Include carbohydrates, amino acids, nucleotides, fatty acids, steroids and lipids

**Secondary metabolites of plant**

Organic compounds produced in plant kingdom Don't have apparent functions involved in plant growth and development. Produced in different plant families, in specific groups of plant families or in specific tissues, cells or developmental stages throughout plant development. Include terpenoids, special nitrogen metabolite (including, on-protein amino acids, amines, cyanogenic glycosides, glucosinolates, and alkaloids), and phenolics[10]





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### Diseases of the cardiovascular system

Plants used to treat diseases of the cardiovascular system include adonis, hawthorn, Erysimum, sea kale, lily of the valley, oleander, rauwolfia, Sal-sola Richtera, Strophanthus, cudweed, skullcap, *Eucommia*, and *Ephedra equisetina* [11]

### Diseases of the central nervous system

Plants used to treat diseases of the central nervous system include garden heliotrope, ginseng, Rhaponticum carthamoides, the Chinese magnolia vine, motherwort, nux vomica, Eleutherococcus, and the Japanese angelica tree (*Aralia mandshurica*). A small tree that grows wild, the Japanese angelica tree has roots that yield an infusion containing saponins (aralosides A, B, and C), which is used as a stimulant to treat hypotonia, exhaustion, asthenic syndrome, and other conditions [12]

### Respiratory diseases

Plants used in treating diseases of the respiratory organs include marshmallow, ledum, ipecac, milkwort, coltsfoot, juniper, licorice, and Thermopsis. A preparation from the roots of the wild herb elecampane (*Inula helenium*) is an expectorant for bronchitis and coughing and has antiseptic and anti-inflammatory properties

### Diseases of the gastrointestinal tract

Plants used to treat diseases of the gastrointestinal tract include aloe, marshmallow, buckbean, wild marjoram, Rhamnus, snakeweed, centaury, calendula, Sanguisorba, Frangula, sea kale, flax, alder, juniper, dandelion, plantain, sunflower, wormwood, Rheum, senna, polemonium, restharrow, cudweed, bald cypress, and whortleberry.

## CONCLUSIONS

Demand for a wide variety of wild plant species is increasing with growth in human needs, numbers and commercial trade. Plants have provided humans with many of their essential needs, including life-saving pharmaceutical agents. [15] However, medicinal plants are threatened as a result of human impact and that will enhance the effectiveness, efficacy and rational use of medicinal plants, especially through the integration into national, regional and local health policies and programmes.

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## CBOs and their Role in Disaster Risk Reduction and Resilience: Insights from Cyclone FANI in Odisha

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### ABSTRACT

An attempt is made in this paper to ascertain the roles of community-based organizations (CBOs) in disaster risk reduction (DRR) in rural Odisha. A panchayat specific study was carried out in Alanda gram panchayat of Nimapada Block, Odisha which witnessed large scale devastation during the extremely severe cyclonic storm 'Fani' in the month of May 2019. Based on the data collected through focus group discussions and key informant interviews, the study highlighted the activities of CBOs in information dissemination, comprehensive understanding of the risk and risk assessment, resource mobilizing, support in evacuation, providing first-aid, assigning roles and responsibilities during crises, establishing connectivity and supporting district administration in distribution of relief materials. It also provides some suggestions as to how CBOs can be better leveraged to build more resilient communities.

**Key Words:** Community-based organizations, disaster management, disaster risk reduction, Fani

### INTRODUCTION

Disaster, whether natural or man-made, disrupts the normal progress of development and severely affects the community in the social, economic, psychological and needless to say the physical domain. The United Nations (UN) defines disaster as "a serious disruption of the functioning of society, causing widespread human, material or environmental losses which exceed the ability of affected society to cope using only its own resources" (UN 1992, 27). United Nations Office for Disaster Risk Reduction defines disaster as "a serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts" (<https://www.unisdr.org/we/inform/terminology>, 2017). India is prone to disasters due to its unique geo-

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climatic conditions and vast area and large population. Odisha an eastern Indian state on the Bay of Bengal is more susceptible to natural disasters like cyclones and tsunamis. This paper focuses on how community-based organizations of Alanda gram panchayat responded in the pre-cyclone, during cyclone and post-cyclone phases of Fani. The specific objective of this paper is to understand the role of CBOs in disaster risk reduction (DRR) and resilience. Further attempt is made to suggest ways for appropriate interventions to leverage the CBOs by planners, policy makers and administrators to reduce community vulnerabilities.

The remainder of this paper is organized in different sections as per the following order. Section 2 deals with the methodology followed by topography of India and Odisha in section 3. In section 4, focus is on cyclone Fani and its impact on Odisha. Section 5 covers preparedness and responses of Government. Section 6 highlights the studies on the role of community-based organizations on disaster risk reduction. Section 7 represents the role of CBOs in Alanda gram panchayat. Finally, conclusion provides suggestions to leverage CBOs for community resilience.

**METHODOLOGY**

This paper is built on a case study conducted in Alanda gram panchayat in Puri district. The methodologies engaged in this study are key informant interviews and focus group discussions. Besides collection of primary information, secondary sources were also referred to get insights and substantiate the arguments. Alanda gram panchayat of Nimapada block of Puri district, Odisha witnessed large scale devastation during the extremely severe cyclonic storm Fani in the month of May 2019. Alanda Gram Panchayat consists of 6 villages namely Alanda, Juanla, Kushikona, Manijanga, Porakana and Talatanla. The total geographical area is 225 hectares. According to 2011 census, there are 411 households residing in Alanda with a population of 1832. Out of which, there are 462 persons (25.22 %) belonging to scheduled castes. Alanda village has higher literacy rate compared to overall literacy rate of Odisha. As per the census 2011, literacy rate of Alanda village was 85.91 % compared to 72.87 % of Odisha. In Alanda village 672 persons are engaged in work activities. Among those, 65.63 % of workers describe their work as Main Work (Employment or Earning more than 6 Months). Out of the persons engaged in work 34.38 % are involved in Marginal activity providing livelihood for less than 6 months. Out of 672 workers engaged in Main Work, 230 are cultivators (owner or co-owner) and 120 are Agricultural labourers.

**Topography of India and Odisha****India**

India is vulnerable to various kinds of natural disasters due to its geographical location. In India, 58.6 per cent of the total landmass is prone to earthquakes (moderate to very high intensity). 12 per cent of land is prone to floods and river erosion (over 40 million hectares). Nearly 5,700 km of coastline is prone to cyclones and tsunamis. 68 per cent of the cultivable area is vulnerable to drought. Hilly areas are at risk from landslides and avalanches (National Policy on DM 2009). Besides the vulnerability to natural disasters, man-made disasters due to chemical, biological, radiological and nuclear (CBRN) origin also exist. Heightened vulnerabilities to disaster risks can be related to expanding population, urbanisation and industrialisation, environmental degradation and climate change (National Policy on DM 2009). The following vulnerability maps specify the zones prone to various natural disasters. It clearly indicates that the eastern region of the country is susceptible to flood, earthquake, wind, thunderstorm and cyclone hazards.

**Odisha**

Odisha is often referred to as the nation's capital of disaster (The Economic Times, May 03, 2019). The state of Odisha extends from 17°31'N latitude to 22°31'N latitude and from 81°03'E longitude to 87°02'E longitude. With a coastline of about 480.4 km on the Bay of Bengal, it is prone to natural disasters such as tropical cyclones, storm surges, lightning, tsunami and whirlwinds etc. "Geographically, the landmass between Puri to Bhadrak in the map of Odisha juts out a little into the sea, making it vulnerable to any cyclonic activity in the Bay of Bengal," opined by meteorologist Sarat Chandra Sahu (retired Director of the India Meteorological Department's Regional



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Meteorological Science Centre, Bhubaneswar). In October 2018, cyclone Titli had battered Odisha. In October 2013, cyclone Phailin had struck the state and caused extensive damage. Super cyclone in October 1999 with a wind speed of 260-300 km per hour and tidal surges of height 7 to 10 meters that reached upto 20 km inland caused 10,000 death, 1,500 orphaned, 25,00,000 marooned and 1.3 crore affected in some way or other (Times of India, Bhubaneswar, 3<sup>rd</sup> Nov 2019, p-5). IMD data reveals that out of 1,035 cyclonic disturbances that hit the Indian sub-continent in the last century, around 50 percent of cyclone hit the eastern coast. Out of those five hundred odd cyclones Odisha encountered 263 of them. This implies that one-fourth of the total disasters of the last century in India have battered Odisha. Odisha usually experiences storms/cyclones in post-monsoon phase, i.e. October-November. Out of 39 extremely severe cyclones that hit India in the last 52 years, 23 were (60 per cent) took place between October and December (IMD data). However, pre-monsoon cyclones are also not very unusual though the frequency was less. Cyclone Fani was a pre-monsoon cyclone which had been classified as an extremely severe cyclone (ESC). In the past 52 years, Fani is the tenth such cyclone that hit India in May. Last time the extremely severe cyclone that hit India in May was in 2004. After one and half decade Cyclone Fani as a pre-monsoon extremely severe cyclone hit India in the month of May.

**Onset of Cyclone Fani and its impact on Odisha**

On 3<sup>rd</sup> May 2019, Fani (Extremely Severe Cyclonic Storm) made a landfall in Puri district of Odisha and the devastation created havoc paralysing the normal life of the community for several weeks. A tropical depression that formed west of Sumatra in the Indian Ocean on 26<sup>th</sup> April 2019 was the source of formation of Fani. The environment became favourable to transform the depression into a storm only after 4 days, i.e. 30<sup>th</sup> April 2019. Fani reached its peak intensity on 2<sup>nd</sup> May 2019 as a high-end extremely severe cyclonic storm. It affected 14 districts of Odisha namely Angul, Balasore, Bhadrak, Cuttack, Dhenkanal, Ganjam, Jagatsinghpur, Jajpur, Kendrapara, Keonjhar, Khordha, Mayurbhanj, Nayagarh and Puri.

The numbers of affected blocks were 159, covering 51 urban local bodies (ULBs) and 18388 Villages. Number of casualties was 38 (64 is reported by Times of India, Bhubaneswar, 3<sup>rd</sup> November 2019) and number of people affected by Fani was 1,65,55,507. The impact of the cyclone damaged 5,08,467 number of houses, crops covering 181711.4 hectares of land and livestock casualty was 53,28,107 (Situation Report on Extremely Severe Cyclonic Storm- 'Fani', State Emergency Operation Center, Bhubaneswar, Odisha, 1.06.2019). Besides the above-mentioned damages, the cyclone caused severe damage to power supply and the state capital plunged into darkness for a week. Restoration of telephone and internet connectivity in the state capital took more than a fortnight.

**Preparedness and Responses of Government**

To mitigate the disasters effectively, Government of India promulgated The Disaster Management Act, 2005 which mandated establishment of disaster management authorities at national, state, district and local levels specifying the powers, functions and measures with funds. National Policy on Disaster Management (2009) aims at a holistic and integrated approach emphasising on building partnership at all levels. The themes highlighted in the policy are: community based disaster management aiming at integration of the policies, plans and executions at the last mile; capacity development of all the stakeholders in the relevant spheres of operation; consolidation of past initiatives as repository of knowledge highlighting best practices; cooperation with specialised agencies at National and International levels; and multi-sectoral synergy of efforts. The three major objectives are: promoting a culture of prevention, preparedness and resilience at all levels; encouraging mitigation measures based on technology, traditional wisdom and environmental sustainability; mainstreaming disaster management into the developmental planning process (National Policy on Disaster Management 2009). The National Disaster Management Plan (NDMP) 2016, provides a framework to be followed at various phases or stages of an impending disaster. It also provides relevant direction to the government agencies to be adhered to at all phases of disaster management cycle. It covers areas like disaster risk reduction, mitigation, preparedness, response, recovery, and better reconstruction. The



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NDMP incorporates an integrated approach that ensures the involvement of government agencies, numerous other relevant organisations, private sector and local communities.

The state of Odisha from zero preparedness for natural calamities has become a trailblazer in the sector and is constantly improving its manpower, technology and organizational structure to mitigate disasters. The state had established Odisha Disaster Mitigation Authority in December 1999, the first its kind in India. Established Disaster Rapid Action Force in 2001. From 21 cyclone centres with a capacity of 42,000 in 1999, the sector has now 879 cyclone shelters with a capacity of over 12 lakhs. Before Fani made a landfall in Puri, the Government could evacuate 11 lakh people and provided shelter to them in cyclone shelters and public buildings (safer places). The State is planning to build five lakh disaster resilient houses in the coastal districts (Times of India, Bhubaneswar, 3<sup>rd</sup> Nov 2019). The efforts are continuing on the part of the Government to mitigate the challenges posed by disasters. Cyclone Fani brought out the fact that there is shortage of skilled manpower and machinery to reduce the impact of cyclonic disaster. Keeping this in view, attempt has made to find out the role of Community Based Organizations (CBOs) in disaster risk reduction.

**Importance of Community Based Organizations (CBOs) in Disaster Risk Reduction: A Review**

CBOs are part of the civil society organizations that has a full range of formal and informal organizations. CBOs are mostly non-profit groups developed in the community to carry out voluntary activities for the development of the community and to improve the life for its residents. The members of CBOs are related to each other in a variety of ways like caste, profession, business, similar interests or purposes etc. Silverman defined that community based organizations grow at a local level within a community. These organizations remain close to the persons they serve. They primarily provide social services to the communities on a voluntary basis. Hence, CBOs are largely dependent on voluntary contributions of labour, material and financial support from the community members they serve and various donor agencies (Silverman, 2004). Nobel laureate Elinor Ostrom (1990) is of the opinion that community based organization are self-governed and generate resources on a sustainable and equitable basis at local level. According to Buxton and Prewitt (2003), a community based organization is comprised of a group of people with common interest living in a specific locality (contrary to an NGO that operates in a wider network). To Frank and Smith (1990), community based corporations [organizations] are locally based organizations whose explicit goal is to serve within communities that receive inadequate attention from government agencies and the private sector.

In the recent years, there is a renewed policy interest in community-based development initiatives (Mansuri and Rao, 2004). This interest is on the basic premises that community involvement in planning and implementation process ensures due consideration on available local resources, assured community support and ownership of the developmental activities by local community. It ultimately culminates in more effective and equitable development. In practice, such developmental initiatives are often channeled through Community Based Organizations (CBOs). CBOs often come into existence in local communities to provide public goods and resolve collective action problems where formal institutions fail or become inadequate (Putnam 2000, Coleman 1988, Ostrom 1990). Therefore, CBOs are gaining importance in the developing and underdeveloped countries where the government is unable to provide much needed social services, especially in rural areas (Edwards and Hulme 1995, Fafchamps 2006). Realising the importance of CBOs in disaster management, this study is carried out in Alnda Gram Panchayat of Puri District with following objectives.

**Role of CBOs in disaster risk reduction in Alanda**

Disaster risk reduction is a set of practices that are applied to preparedness, response, recovery, mitigation, and adaptation (UN-ISDR 2009). This section focuses on the activities of CBOs in the disaster risk reduction (DRR) in Alanda Gram Panchayat. The following CBOs played active role in disaster risk reduction (DRR) and resilience in Alanda Gram Panchayat.



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- Women Self-help Groups
- Farmers clubs
- Caste groups
- Youth clubs
- Recreation clubs
- Village Level Disaster Resource Center

The early warning system provided by district administration and mass media culminated in action by the CBOs existing in the Alanda Gram Panchayat. The members of Women Self-help Groups (WSHGs), youth clubs including recreation clubs and Kishori clubs and members of village level disaster resource centers shared the information regarding dos and don'ts during the disaster. Information dissemination about onset of the cyclone Fani reached almost all the people in the Gram Panchayat. Information-sharing and shared awareness increased the efficiency and effectiveness of the operations both during and following the cyclone. The factual information disseminated by the CBOs about the cyclone helped people to get prepared for the disaster without getting panicked. The youth clubs and farmers' group took initiative in cutting down the trees posing threat to the housing structures.

Comprehensive understanding of the risk assessment was done by the CBOs which could reduce the impact of the cyclone. It resulted in less damage to the housing structures in the area. Houses of 13 families were completely damaged because of the wind speed of the cyclone. The CBOs in Alanda GP that took stock of resources were caste organizations, farmers' club and youth clubs during the cyclone. The family and caste groups accumulated and stored food grains and vegetables in safe places belonging to their relatives for consumption during cyclone. Families living in thatched houses shifted the essential and valuable belongings to the houses of their relatives for safe custody. Maa Dwarika youth club and Baba Budhanath youth club of Alanda village and farmers' clubs of Juanla, Porokona village helped the households to store food grains in common seed banks developed and operated by the farmers' clubs of their respective villages.

Caste based CBOs played a major role in the evacuation operations carried out by the state agencies. Large-scale relocation under time constraints was possible due to the activities of the CBOs. Families belonging to scheduled castes helped the households to move to the cyclone shelter with their essential commodities. The cyclone shelter was occupied by the scheduled caste as it is in the close vicinity (400 meters away) of the Harijan Sahi. The Swain community (agriculture caste) shifted vulnerable people from their community to the Gram Panchayat office and primary school of Alanda which is closer to their dwelling place. There was proper coordination among the members of these groups. Further, they ensure that there would be no casualty in the area.

During cyclone the youth groups particularly the members of Maa Dwarika Volleyball team, Kishore clubs of Alanda and Juanla, and youth club of Talatanla took the leadership in providing first-aid to the injured. The women associations particularly the members of SHGs in Alanda helped the district administration in preparation and distribution of food in the cyclone shelters, gram panchayat office and primary school. They also took care of the pregnant women and children in the cyclone shelters. Post-cyclone activities were mostly handled by youth associations and members of village level disaster resource centers (VLDRRC). In Alanda village, the members of volleyball team and VLDRRC helped in clearing the debris from the damaged houses, roads and other public places. The members of volleyball team disposed of the carcasses of animals in Alanda village. VLDRRC of Juanla, Kushikona, and Talatanla and youth club of Prokona and Talatanla cleared the debris from roads and other public places. Consequently road connection was restored which helped in smooth recovery operations carried out by different agencies.

The members of youth clubs and VLDRRC also helped in reconstruction of damaged houses by rendering voluntary labour in their respective villages. They along with the members of SHGs were also actively helping the officials of state government in distribution of relief materials aftermath of devastating effects of the cyclone. The youth clubs of the villages of Alanda gram panchayat were instrumental in collection of funds from the local communities to



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establish temporary supply of electricity in the area. They helped electricians in establishing electric connection to the locality by rendering labour in fixing the electric poles and wiring of the poles.

**Concluding Remarks: leveraging CBOs for community resilience**

CBOs are an integral part of daily life of local communities. They practiced, tested, and reinforced across a diverse range of social, economic and cultural activities in a variety of contexts unlike many institutions that are specific to disaster management. These organizations due to their proximity to the community play the role of first responders to disasters. Their social capitals helped them in being accepted by the local communities. The knowledge about the topography assisted them in making appropriate context specific plans. The trust of the local communities on CBOs enabled them to mobilize resources from the local communities with ease. Being part of the community CBOs could able to carry out hassle free deliveries of the relief materials. Thus, CBOs in Alanda gram panchayat played a vital role in disaster management.

However, it was observed that the CBOs existing in Alnda panchayat had not received any training to handle the disaster mitigation activities in the last 7 years. Their traditional knowledge and attitude towards voluntary services could avert serious threat to the life of people in the locality. It is suggested that the gram panchayats should be the nodal body to keep information about CBOs existing in their locality. The data may be revised as the CBOs and their membership changes frequently. There is need to provide first-aid training, Cardiopulmonary resuscitation (CPR) training and Community Emergency Response training to the CBOs on a continuous basis to help the government machinery in handling the frequent disasters faced by the state. The VLDRCs existing already in the villages required training on pre-disaster preparedness, risk assessment, and post disaster responses. VLDRCs should be equipped with skilled man power to manage the disaster in effective and efficient manner.

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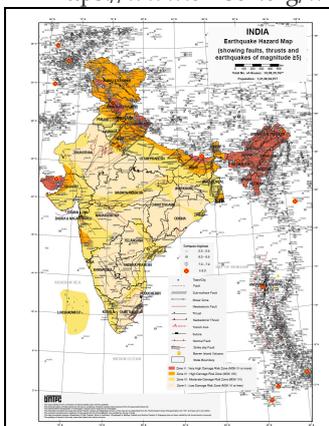
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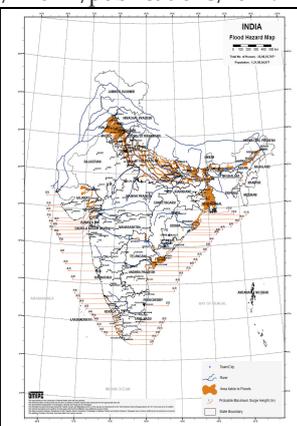


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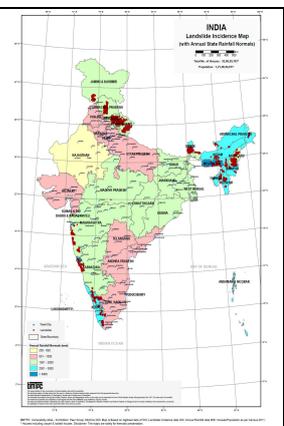
Source: BMTPC, Vulnerability Atlas of India Third Edition, 2019  
**Fig. 1. Earthquake Hazard Map, India**



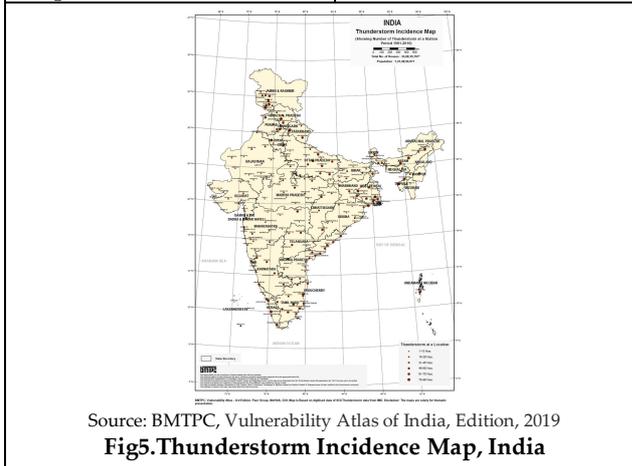
Source: BMTPC, Vulnerability Atlas of India, 2019  
**Fig. 2 Flood Hazard Map, India**



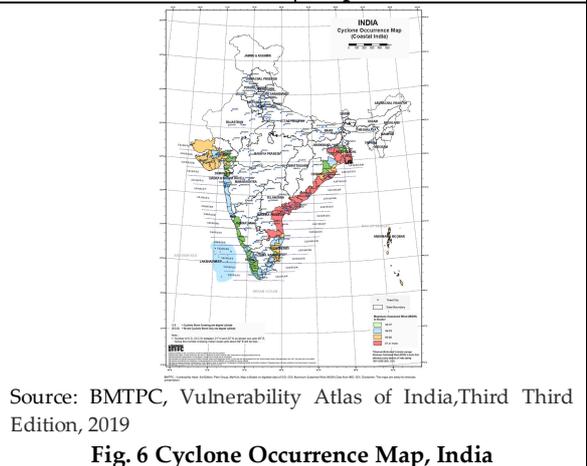
Source: BMTPC, Vulnerability Atlas of India Edition, 2019  
**Fig. 3.Wind Hazard Map, India**



Source: BMTPC, Vulnerability Atlas of India,Third Third Edition, 2019  
**Fig.4.Landslide Incidence Map, India**



Source: BMTPC, Vulnerability Atlas of India, Edition, 2019  
**Fig5.Thunderstorm Incidence Map, India**

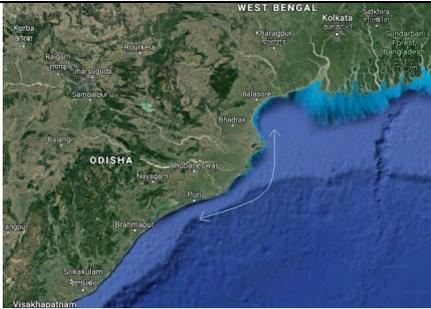


Source: BMTPC, Vulnerability Atlas of India,Third Third Edition, 2019  
**Fig. 6 Cyclone Occurrence Map, India**

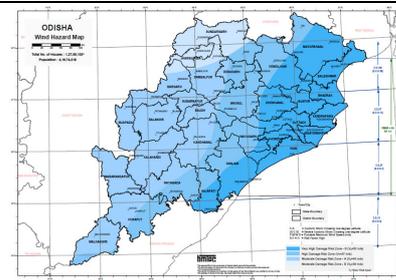




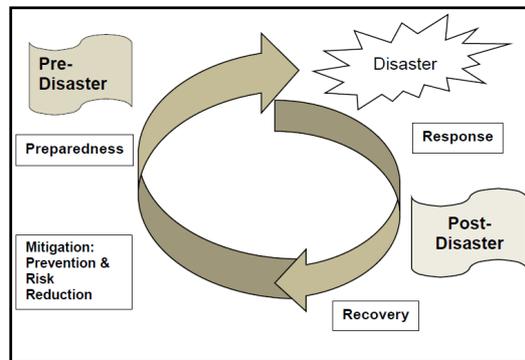
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**Fig.7 The coast of Odisha**



Source: BMTPC, Wind Hazard Map, Third Edition, 2019  
**Fig.8 Wind Hazard Map of Odisha**



**Fig.9 Disaster Management Cycle**





## Renewable Energy in India: A Snapshot

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### ABSTRACT

Today energy in the form of electricity has become an important dimension in country's economic growth. Every year 8 billion metric tones of carbon goes into our atmosphere, out of which 6.5 billion tones comes from fossil fuels and 1.5 billion tones results from deforestation. Renewable energy has pitch in about 19 percent to world energy consumption and 25 percent to the electricity generation in 2015 and 2016-17 respectively. Hence we need to focus on decentralized renewable energy solutions to settle a larger position in the core of "electricity to all" in our country.

**Keywords:** economic, atmosphere, Renewable, energy, solutions.

## INTRODUCTION

An end to the poverty and adopting sustainability are the major challenges in today's time. Energy is the solution to both. Today energy in the form of electricity has become an important dimension in country's economic growth. Hindrance to access to electricity creates bottlenecks to the development of livelihoods, employment, access to health, industries, education and negatively impacts economic development and standard of living. In recent era the demand of electricity has rose drastically. Today our country is the world's third largest producer and third largest consumer of electricity (BP Report, 2016). The gross electricity generation in our country was 1168 billion kWh during the year 2015-16 and having an annual growth rate of 5.81 percent (ibid). With increase in demand for power, and its generation from coal it has raised concerned of exhausting the reserves of coal, petroleum and other resources. In addition to it is also causing damage to the environment. Every year 8 billion metric tonnes of carbon goes into our atmosphere, out of which 6.5 billion tonnes comes from fossil fuels and 1.5 billion tonnes results from deforestation (Singh and Sood, 2002). India's energy sector had a major share in the country's green house gas (GHG) emission profile and is predominantly fossil fuel dependent (WWF, 2015). Both are not very compelling benchmarks in the context of providing quality electricity access to all. In order to sustain in future, there is a need to shift from the conventional sources of energy to renewable energy. Our country needs to increase its energy base for its population as well as a provision to increase the share of renewables in the overall energy mix. Renewable energy through the use of decentralised products are the solution to it (WWF, 2015). The objective of this paper is to give a



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snapshot on various renewable energy policies, schemes being framed in India for development of renewable energy. It has three sections. In the first section, focuses on a renewable energy access framework. Second section provides a snapshot on the global overview of renewable energy, later it speaks about the evolution of Indian power sector and the renewable energy development policies in our country. The last section focuses on the diffusion of solar lights across the districts of Odisha.

**Framework for Renewable Energy Access**

Access to renewable energy is an important aspect for human development. Here, an attempt has been made to develop a framework for renewable energy access. Many factors are responsible for renewable energy access, but majority of the factors can be categorised under finance, capacity building, infrastructure, technology and policy making which are necessary for energy access into the context of rural specific. For finance, it should cover access to the end user of the product. The presence of Self Help Group (SHGs) and cooperative society needs to support the end users to help them take up loans. These entities should also be linked to financial institutions so that the end users would get money for further lending. Presence of banks and micro credit agencies in the region and their capacity to disburse funds are important factors for process diffusion. For capacity building perspective the factors like awareness of the product, provision of technical training, providing support for operation and maintenance of the products will help in renewable energy access to the end-users. Other major factors include the government and private training institutions, support centres, presence of local NGOs, etc. helps in undertaking activities on generating awareness about the need and usage of renewable energy across household, livelihood and community levels are required for renewable energy access to the end-users. From infrastructural point of view, energy is required for infrastructural development in schools, community centres, health centres, etc. It can also help in leveraging the developmental aspect of communication networks, roads and other soft support entities. From technology aspect the presence of reliable local vendors, suppliers and the existence of a strong supply network with affordable good quality products, technologies, availability of spare parts and appliances will help in renewable energy access to the end-users. In addition a strong labour force with technical skills, can ensure smooth operations and functioning of the products as well. From policy aspect, it focuses on the current, potential targets, guidelines, schemes available, etc., will help in addressing the renewable energy access. From entrepreneurial perspective if the system components can be sourced locally, assembled and installed then it would create an ecosystem for adoption of the renewable energy products. It will help in employment generation, cost minimisation, faster service and building local capacity as well.

**Renewable Energy: A Global Overview**

Renewable energy has pitch in about 19 percent to world energy consumption and 25 percent to the electricity generation in 2015 and 2016-17 respectively. Energy consumption is further divided into 8.9 percent from traditional biomass, 4.2 percent from heat energy (modern biomass, geothermal and solar heat) 3.9 percent from hydro electricity and 2.2 percent from electricity, generating from wind, solar, geothermal, and biomass. Renewable energy consumption has grew by 14 percent in the year 2016-17, giving 7.5 percent of the world's electricity (BP Statistics Report, 2016-17).

Renewables have recorded for about 40 percent of growth in world power generation in 2016, and gave 31 percent of world primary energy growth (BP Statistics Report, 2016). Around 162GW of renewable energy was added in the year 2016-17 thus becoming the fatly annual increase, up by 9 percent when compared to 2015-16. Solar photovoltaics (PV) pacified with 47 percent of freshly installed renewable power capacity, while hydropower and wind accounted for about 16 percent and 34 percent respectively. Thus, renewables accounted for an estimated 62 percent of net additions to global power generating capacity in 2016-17 (Renewables India, 2017).By the close of 2017, global renewable generation capacity was enhanced by 167GW and reached around 2179GW worldwide (IRENA, 2017). Solar PV raised by 32 percent in 2017, followed by wind energy, rear by 10 percent. Underlying, this growth are substantial cost reductions, with the levelled price of electricity from solar PV diminished by 73 percent, and onshore wind by nearly one-quarter, between the year 2010 to 2017.



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### Market Review on Solar PV: World Wide

In the year 2016-17, the total solar PV installed capacity crossed 300GW, with China having 34.5GW, succeeded by USA with 14.5GW, Japan with 10.2GW and India with 5GW in fourth place. India, about 79GW capacity is expected to be added during the year 2017-18 (Bridge to India Report, 2017). In an attempt for a continuous growth, about 8.8GW of capacity addition (growth of 76 percent over 2016), was set to become the third largest PV market in 2017, overtaking Japan. Solar module prices continue to fall faster. Prices in India fell to less than 1 \$ which is equivalent to Rs 45 to 72/Wp in first quarter of 2017 depending upon the brand and company. Such breakneck fall has made solar PV the affordable new source of power in maximum countries and provided heave in emerging economies.

### India: Renewable Potential, Targets & Achievements

#### Renewable Energy Potential

India has the largest potential for production of energy from renewable sources. It records for about 4 percent of the world electricity generation and gives 4.43 percent to the world renewable generation capacity. As per International Energy Agency's (IEA) the renewable energy projects a growth of renewable energy supply to 4550GW by 2040 on a world basis.

By 2018, the total renewable power generation installed capacity in our country stood at 114.32GW, which is 33.23 percent of the total installed capacity of 344GW (CEA, IRENA, 2018). Installed renewable power generation capacity has increased with a CAGR of 9.29 percent from 2008 to 2018 (ibid). India added a record of 11788MW of renewable energy capacity during the year 2017-18. Power generation from renewable energy sources was 93.21 billion units in 2018. The GoI has set a target to achieve a total capacity of 175GW from other renewable energy sources by the year 2022. Out of 175GW, 100 GW is from solar power, 60 GW is from hydro power, 10GW from biomass power and 5GW from small hydro power has been. Solar installation in India is expected to increase by 360 percent by 2020. About 4.96 million household size biogas plants have been installed in India since the inception of National Biogas and Manure Management Programme (NBMMP) 15000 biogas plants were installed in 2017. Table 1 provides details on state-wise renewable energy potential in our country till December 2017. From the above table it is evident that Rajasthan is having the largest potential for renewable energy and solar energy, followed Jammu & Kashmir, Maharastra and Gujarat. Odisha stands at 10th position with a total renewable energy potential of 27727 MW in the year 2016-17 and 8th position with 25780 MW for potential of solar power.

#### Renewable Targets and Achievements

India has set a target to achieve 175GW by the year 2022 from renewables sources of energy. As most of the target is to be achieved from solar, 60GW is set from ground mounted, grid-connected, large solar projects and another 40GW is from rooftop solar (MNRE, 2017). On the basis of targets set on region specific, more targets have been assigned to southern region with 59GW, 54GW to western region and 46GW to northern region due to climatic conditions. Overall it is expected to install more than 90 percent of the total targets set while remaining is expected to be contributed from north-eastern and eastern regions (MNRE, 2017). If the target for 175GW is to be achieved then it would contribute to achieve 19.44 percent of the total renewable energy potential of 900GW (CEA, 2016). The state of Maharashtra in western India has set the richly target to achieve 22 GW followed by Tamil Nadu with 21.5 GW (CEA, 2017). Odisha has been set a target to achieve 2.3 GW from renewables by the year 2022. In total the installed capacity till March 2017 is set at 57.2 GW both from private and state sector.

#### Generation from Renewable Energy

The generation of electricity from renewables is increasing year by year. As of March, 2020 about 36 percent of India's installed electricity generation capacity is from renewables, which is generating about 21 percent of the total utility electricity in our country (All India Installed Capacity of Power Stations). Recently, a blueprint has been prepared which states that India aims to develop 275GW from renewable energy, 72GW from hydroelectricity, 15GW from nuclear energy and about 100GW from zero emission sources (Michael, 2016). India's total renewable electricity

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capacity stands at 131GW, which represents about 36 percent of the total electricity generation capacity in the country which is approximately 366GW.

### **Off-Grid Decentralised Solar PV Program**

An off-grid decentralized or standalone mode, renewable energy is a perfect, scalable and viable solution for providing power to un-electrified, power deficient villages and hamlets in rural areas. Under the off-grid decentralized solar PV programme for the year 2017-18, the Ministry is providing Central Financial Assistance (CFA) to implementing agencies for diffusion of solar photovoltaic (SPV) home lighting systems, solar street lights, solar pumps, power packs and other solar applications to meet the electricity and lighting needs of the individual in the rural areas. State Nodal Agency (SNAs) are the primary implementing agency through which CFA of 30 percent is provided. NABARD is one of the implementing agencies for pumps and lighting systems through which CFA of 40 percent of the benchmark cost is provided. Below is the state wise installation of Off-Grid solar systems in India till Dec 2017. From the above table we find that maximum number of the solar home lights has been installed in Madhya Pradesh, followed by Rajasthan, Uttar Pradesh and Tamil Nadu. A total of 89961 solar lanterns, solar lamps and 5274 home lighting systems were installed in Odisha till Dec 2017.

### **Policy Landscape on Renewable Energy in India**

Electricity is an important requirement for all aspects of our life. It is a need. It is a captious infrastructure on which the socio-economic development of India hinges. Recognising that the electricity is one of the instrumental drivers for quick economic growth and poverty alleviation, our country had set a target to achieve full access to electricity to all households. In addition to it a target was also set of supplying a reliable and quality electricity at reasonable rate to rural India which is most essential requirement for overall development and growth. Below are the different policies being explained with reference to renewable energy.

### **Evolution of Renewable Power Sector and Renewable Energy Development Policies**

The evolution of renewable power took place mainly after 2003 with the introduction of Electricity Act 2003. Three major policies were introduced which laid the foundation for renewable energy development in our country. Policies were National Electricity Policy 2005, National Rural Electrification Policies 2006 and National Tariff Policy 2006. Electricity Act 2003 was further amended to create schemes like DeenDayalUpadhyaya Gram JyotiYojana (DDUGJY), Rajiv Gandhi GrameenVidyutikaranYojana (RGGVY) for making all villages electrified. National Tariff policy was introduced in 2006 to purchase a certain percentage of grid-based power from renewable sources. Further with the introduction of National Action Plan on Climate Change (NAPCC), it gave a pathway for the development of eight missions to deal with climate change adaptation and mitigation.

Energy policy came into existence through four phases: First is the Introductory phase which was introduced before 1956 where Electricity supply Act was introduced and establishment of semiautonomous State Electricity Boards (SEBs) were enacted. Second is the Nationalisation phase which was introduced between 1956-1991, where the ownership for generation and distribution of power came under state and their was focus on improvement on power losses, subsidies, infrastructure bottlenecks. Third is the Liberalisation phase which emerged between 1991 to 2003 where provision for private sector participation in generation, fast track clearing mechanisms of private investment proposals came into effect and finally the fourth phase where the Electricity Regulatory Commissions Act, was introduced in 1998 for establishing central and state electricity regulatory commissions and rationalisation of tariffs (MNRE and Corporate Catalyst India, IFLR, Aranca Research, 2017).

### **Electricity Act 2003**

This act gave a clear path on the development and integration of renewable energy into the grid. The broad objective was to acquaint competition, protecting consumer interests and provide power for all. This policy mandates the State Electricity Regulatory Commissions (SERCs) to take steps to promote renewable and non-conventional sources of



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energy within their area of jurisdiction. A percentage for purchase of power from these sources was made functional for the promotional tariffs to be determined by the each SERCs. Progressively the share of electricity from renewable energy sources was increased which is being prescribed by SERCs. Such purchase by distribution companies shall be through competitive bidding process.

### **National Electricity Policy 2005**

This policy recognises that electricity is an needful requirement for sustenance. The objective of this policy was to provide electricity to all people by 2010, meeting the demand fully by 2012 and to go for reserves after meeting the peak requirements. Increasing the per capita availability to over 1000 kWh per year by 2012 and ensuring a minimum lifeline consumption of 365 kWh per year per household by 2012 was the major targets under this policy.

### **National Rural Electrification Policies (NREP), 2006**

The objective of this policy was to have access to quality and reliable power supply at reasonable rates and have a minimum lifeline consumption of one unit/household/day by the year 2012. It was also put on that the villages/habitations where grid connectivity was not be feasible or low cost effective then off-grid renewable energy products, based on stand-alone renewable based systems was to be taken up for supply of electricity. Lighting technologies like solar photovoltaic to be adopted if it was not feasible, but these households shall not be designated as electrified. State Govt need to prepare the plan and will be linked to district level development plan involving the Gram Panchayat (GP). Village gram panchayat shall issue the first certificate at the time of the village becoming eligible for declaration as electrified. Subsequently, the gram panchayat shall certify and confirm the electrified status of the village as on 31 March every year.

### **National Tariff Policy 2006**

Under this act there was a provision that central and the state electricity regulatory commissions must purchase a certain percentage of grid-based power from renewable sources. State Electricity Regulatory Commissions will specify a Renewable Energy Purchase Obligation (RPO) by distribution licensees in a time-bound manner. Targets were assigned for each state for purchase obligations with 0.25 percent of power purchases by states by 2013 and 3 percent by the year 2022. Renewable Purchase Obligation targets can be achieved once the Green Energy Corridor (a transmission network to connect renewable energy rich states to lacking states) is complete, as it will provide for easy trade in renewable energy power. The new rooftop policy from MNRE is also expected to increase installation activity in the sector (helping with RPO obligations). Odisha has a lower solar RPO (of 0.15 percent in 2012-13) compared to the target as stipulated in the tariff policy of 0.25 percent in 2014-15. With increase in percentage of total energy consumption in Odisha the power to be harnessed from solar was increased from 44MU to 210MU, with a growth rate of 0.48 (48 percent) during the year 2015-16.

### **Off-grid, Decentralised Solar Power Schemes**

Under this programme, on technical aspect, both for off-grid, decentralised PV systems and minigrids for rural electrification upto a maximum capacity of 500 kWp per site was supported. This scheme was implemented through multiple implementing agencies for rapid up-scaling in an inclusive mode. Under this scheme, the financial assistance is provided by 30 percent capital subsidy to end-users and 90 percent to special category states for community projects and government departments for installation of solar PV systems. It also provided a credit linked capital subsidy scheme for solar lighting and pumping purpose through NABARD, other regional rural banks and commercial banks. Government provided 30 percent subsidy on the cost of the system ranging from Rs 21-105 per watt peak depending upon the capacity of the modules and configuration of the solar photovoltaic systems in different states of the country. For solar water pumping system the capital subsidy is ranged from Rs 27630- 57600 per HP depending upon the capacity.



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JNNSM was launched under India's National Action Plan on Climate Change (NAPCC) in 2008. It aims at establishing our country as a world leader in solar energy by creating a favorable policy environment for its deployment across the country. Under the original plan of 2010, the GoI sought to achieve total installed solar capacity of 20GW by 2022. Here the targets were divided into three phases, phase-I started from 2010 to 2013, phase-II from 2013 to 2017 and phase -III from 2017 to 2022. Each phase included three segments: solar rooftop, off-grid solar applications and solar collectors, targets for phase-I included 1100MW, 200MW and 7 million sq. meters respectively. Likewise for phase-II it included 10000MW, 1000MW and 15 million sq. meters respectively and for phase-III the targets assigned was 20000MW, 2000MW and 20 million sq. meters (MNRE, 2010). The Government again revised the solar target for 2022 from 20GW to 100GW. The revised targets were 5000MW, 17000MW, 32000MW, 48000MW, 65000MW, 82500MW and 100000MW for 2015-16, 2016-17, 2017-18, 2018-19, 2019-2020 and 2021-2022 respectively (MNRE, 2016).

**Diffusion of Solar Home Lights in Odisha**

Our state is making efforts for village electrification. Out of 51582 villages in Odisha (Census, 2011) 95 percent villages have been electrified by the end of 31 March, 2017. By the year 2022, Odisha envisages generation of 2200 MW of solar power, 200 MW of wind power, 180 MW of biomass power, 150 MW of small hydro power and 20 MW of Waste-to-Energy (WTE) power (Economic Survey, 2017). A total of 34216 numbers of solar lights were installed in Odisha (Census, 2011). During the year 2017-18, 14837 solar lights has been installed in the rural HH in our state by OREDA (OREDA, 2017).

**District wise Diffusion of Solar Home Lights across Odisha.**

The below table shows the district wise diffusion of solar lights across Odisha. From the above table we find that maximum number of solar lights were installed in Kalahandi district, followed by Sundargarh district and Kheonjhar district with 3420, 2442 and 2022 numbers respectively. Further we find that a maximum of 0.84% of solar lights were installed in Kalahandi district, followed by Malkangiri with 0.72%. From the above figure we find that in Kalahandi district has maximum number of solar lights with 9 numbers installed per 1000 rural household, followed by Malkangiri and Naupada with 7 numbers each.

**CONCLUSION**

Getting reliable, quality power remains a challenge and further extending it to the grid is more burdensome work at ground level. Although different policies are being implemented at ground level but still people are facing problems in getting unreliable power supply for which they are facing problem of drudgery, pollution, safety and health issues. Hence we need to focus on decentralized renewable energy solutions to settle a larger position in the core of "electricity to all" in our country. Currently the main challenge facing is the lack of strong foundation of various factors and actors that supports the functioning and provides a sustainability solutions. For the same there is a need to study the factors and actors that support in giving solutions for improving energy access to in the rural context.

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**Table 1: State-wise Clean Energy Potential in the Country in MW till 2017**

Sl. No	State/UT	Wind Power	Small Hydro Power	Biomass Power	Biogasse Cogeneration	Waste to Energy	Solar	Total
1	Andhra Pradesh	14497	978	578	300	123	38440	54916
2	Arunachal Pradesh	236	1341	8	0	0	8650	10235
3	Assam	112	239	212	0	8	13760	14331
4	Bihar	144	223	619	300	73	11200	12559
5	Chattisgarh	314	1107	236	0	24	18270	19951
6	Delhi	0	0	0	0	131	2050	2181
7	Goa	0	7	26	0	0	880	913
8	Gujarat	35071	202	1221	350	112	35770	72726
9	Haryana	93	110	1333	350	24	4560	6470
10	Himachal Pradesh	64	2398	142	0	2	33840	36446
11	Jammu & Kashmir	5685	1431	43	0	0	111050	118209
12	Jharkhand	91	209	90	0	10	18180	18580
13	Karnataka	13593	4141	1131	450	0	24700	44015
14	Kerela	837	704	1044	0	36	6110	8731
15	Madhya Pradesh	2931	820	1364	0	78	61660	66853
16	Maharashtra	5961	794	1887	1250	287	64320	74499
17	Manipur	56	109	13	0	2	10630	10810
18	Meghalaya	82	230	11	0	2	5860	6185
19	Mizoram	0	169	1	0	2	9090	9262
20	Nagaland	16	197	10	0	0	7290	7513
21	Odisha	1384	295	246	0	22	25780	27727
22	Punjab	0	441	3172	300	45	2810	6768
23	Rajasthan	5050	57	1039	0	62	142310	148518





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24	Sikim	98	267	2	0	0	4940	5307
25	Tamil Nadu	14152	660	1070	450	151	17670	34153
26	Telengana	0	0	0	0	0	20410	20410
27	Tripura	0	47	3	0	2	2080	2132
28	Uttar Pradesh	1260	461	1617	1250	176	22830	27594
29	Uttarakhand	534	1708	24	0	5	16800	19071
30	West Bengal	22	396	396	0	148	6260	7222
31	Chandigarh	0	0	0	0	6	0	6
Sl. No	State/UT	Wind Power	Small Hydro Power	Biomass Power	Biogasse Cogeneration	Waste to Energy	Solar	Total
32	Andaman and Nicobar	365	8	0	0	0	0	373
33	Lakshadweep	0	0	0	0	0	0	0
34	Puducherry	120	0	0	0	3	0	123
35	Daman and Diu	4	0	0	0	0	0	4
36	Others	0	0	0	0	1022	790	1812
	TOTAL	102772	19749	17536	5000	2554	748990	896605

Source: MNRE, 2017

Table 2: State wise Installation of Off-Grid Solar Systems till Dec 2017

Sl.No	State/UT	Lanterns and Lamps (Nos)= A	Home Lights (Nos)=B	Total Solar Home Lights (A+B) Installed till Dec 2017
1	Andhra Pradesh	51360	22972	74332
2	Arunachal Pradesh	14433	18945	33378
3	Assam	13379	6926	20305
4	Bihar	210391	12303	222694
5	Chattisgarh	3311	7754	11065
6	Delhi	4807	0	4807
7	Goa	1093	393	1486
8	Gujarat	31603	9253	40856
9	Haryana	93853	56727	150580
10	Himachal Pradesh	33909	29342	63251
11	Jammu & Kashmir	51224	65319	116543
12	Jharkhand	138723	9450	148173
13	Karnataka	7334	52638	59972
14	Kerala	54367	41912	96279
15	Madhya Pradesh	529101	4016	533117
16	Maharastra	239297	3497	242794
17	Manipur	4787	3900	8687
18	Meghalaya	24875	7844	32719
19	Mizoram	9589	6801	16390
20	Nagaland	6766	1045	7811
21	Odisha	99843	5274	105117
22	Punjab	17495	8626	26121
23	Rajasthan	225851	166978	392829
24	Sikim	23300	15059	38359





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25	Tamil Nadu	16818	273015	289833
26	Telengana	0	0	0
27	Tripura	64282	32723	97005
28	Uttar Pradesh	104791	235909	340700
29	Uttarakhand	93927	91595	185522
30	West Bengal	17662	145332	162994
Sl.No	State/UT	Lanterns and Lamps (Nos)= A	Home Lights (Nos)=B	Total Solar Home Lights (A+B) Installed till Dec 2017
31	Chandigarh	1675	275	1950
32	Andaman and Nicobar	6296	468	6764
33	Lakshadweep	5289	600	5889
34	Puducherry	1637	25	1662
36	Others	125797	24047	149844
37	NABARD	0	116226	116226
	<b>TOTAL</b>	<b>2328865</b>	<b>1477189</b>	<b>3806054</b>

Source: MNRE, 2017

Table 3: Diffusion of Solar Home Lights in Odisha

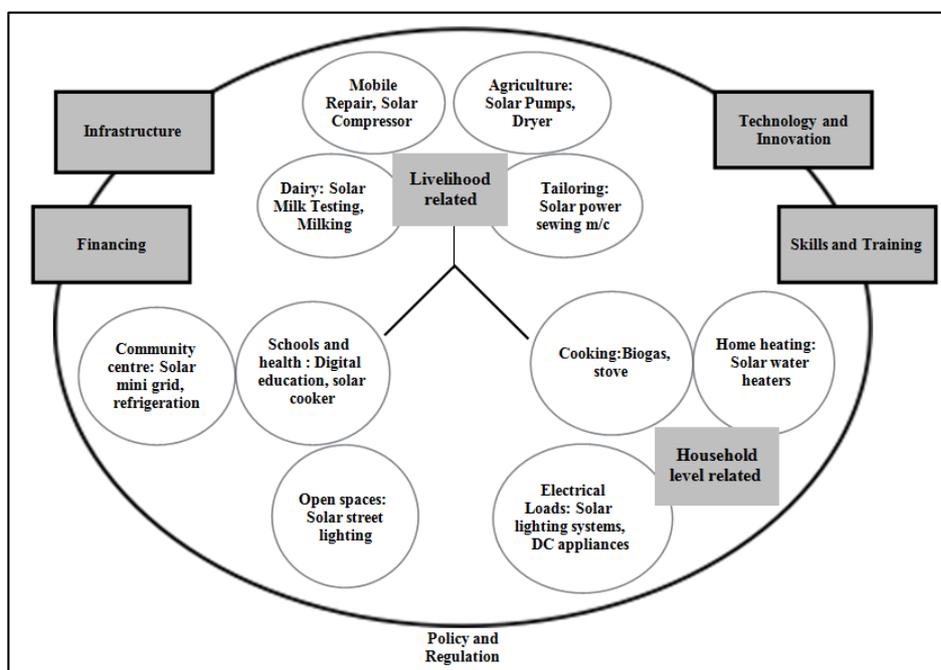
Districts	Rural HH	Urban HH	Total HH	No of Solar Home Light Installed in Urban HH	No of Solar Home Light Installed in Rural HH	Total Number of Solar Home Light Installed (2011 Census)	Solar Home Lights Installed for Urban Household	Solar Home Lights installed for total household (per 1000 HH)	Solar Home Lights installed per rural household (per 1000)
Angul	249585	46337	295922	97	902	999	2.09	3.38	3.61
Balasore	473512	55895	529407	89	1804	1893	1.59	3.58	3.81
Bargarh	339364	34027	373391	46	826	872	1.35	2.34	2.43
Bhadrak	274191	35336	309527	85	842	927	2.41	2.99	3.07
Boudh	103239	4488	107727	10	273	283	2.23	2.63	2.64
Bolangir	387345	44736	432081	117	1504	1621	2.62	3.75	3.88
Cuttack	425082	141749	566831	153	922	1075	1.08	1.90	2.17
Debagarh	70511	5431	75942	7	240	247	1.29	3.25	3.40
Dhenkanal	253118	25252	278370	16	434	450	0.63	1.62	1.71
Gajapati	112872	15946	128818	17	468	485	1.07	3.77	4.15
Ganjam	602216	154678	756894	223	1444	1667	1.44	2.20	2.40
Jajpur	378135	29437	407572	42	994	1036	1.43	2.54	2.63
Jagatsingpur	237411	28177	265588	99	1045	1144	3.51	4.31	4.40
Jharsuguda	83664	50960	134624	46	200	246	0.90	1.83	2.39





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<b>Kalahandi</b>	377001	27813	404814	76	3344	3420	2.73	8.45	8.87
<b>Kandhamal</b>	155335	16669	172004	22	743	765	1.32	4.45	4.78
<b>Kendrapara</b>	311465	15940	327405	20	1379	1399	1.25	4.27	4.43
<b>Keonjhar</b>	349736	56893	406629	85	1937	2022	1.49	4.97	5.54
<b>Khordha</b>	247940	241696	489636	420	512	932	1.74	1.90	2.07
<b>Koraput</b>	283522	54683	338205	83	1467	1550	1.52	4.58	5.17
<b>Malkangiri</b>	126306	11144	137450	30	961	991	2.69	7.21	7.61
<b>Mayurbhanj</b>	544764	42884	587648	52	1526	1578	1.21	2.69	2.80
<b>Nabarangapur</b>	253461	20202	273663	39	1541	1580	1.93	5.77	6.08
<b>Nayagarh</b>	213265	17703	230968	21	936	957	1.19	4.14	4.39
<b>Nuapada</b>	151921	8026	159947	16	1116	1132	1.99	7.08	7.35
<b>Puri</b>	317002	52480	369482	60	803	863	1.14	2.34	2.53
<b>Rayagada</b>	191615	34349	225964	41	847	888	1.19	3.93	4.42
<b>Sambalpur</b>	178958	69871	248829	75	366	441	1.07	1.77	2.05
<b>Sundargarh</b>	310762	162531	473293	245	2197	2442	1.51	5.16	7.07
<b>Subarnapur</b>	140714	11740	152454	14	297	311	1.19	2.04	2.11
<b>TOTAL</b>	<b>8144012</b>	<b>1517073</b>	<b>9661085</b>	<b>2346</b>	<b>31870</b>	<b>34216</b>	<b>1.55</b>	<b>3.54</b>	<b>3.91</b>

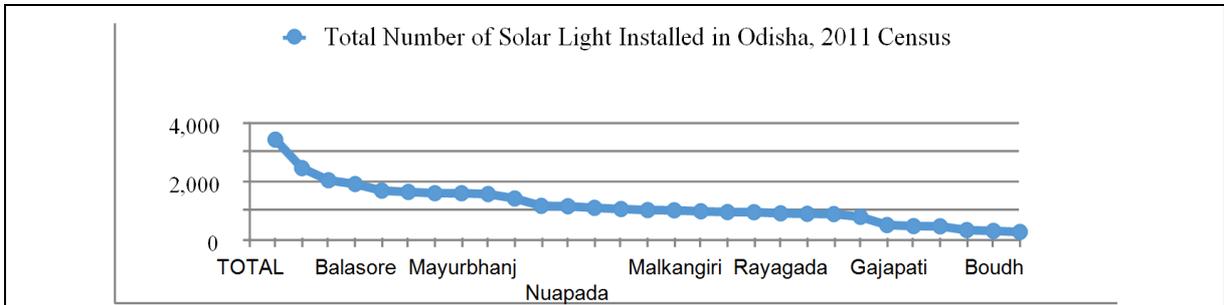


**Figure 1: Framework for Energy Access**

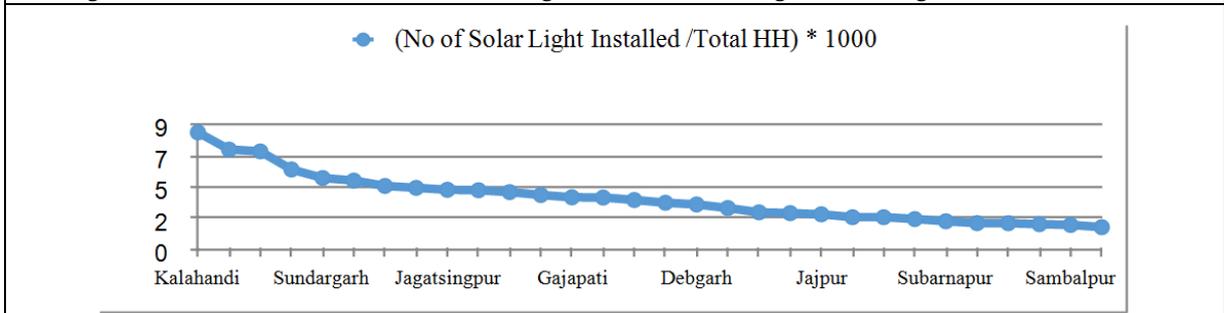




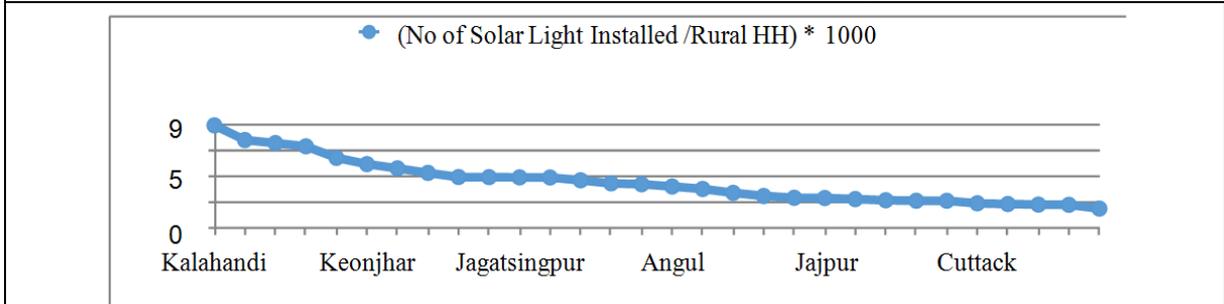
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**Figure 3: Diffusion Pattern of Solar Home Lights in Odisha starting with the Highest number Installed**



**Figure 4: Diffusion Pattern of Solar Home Lights in Odisha per 1000 HH**



**Figure 5: Diffusion Pattern of Solar Home Lights in Odisha per 1000 Rural HH**





## Corporate Social Responsibility Activities with Reference to Paper Industries

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### ABSTRACT

This paper attempts to make an exploratory study the conceptual approaches and practical information of Corporate Social Responsibility (CSR) activities in various paper industries in India. From the initial days of barter system to the recent trend of plastic money, the humankind has treated a long way. The theoretical concepts expounded by the deployment of current CSR practices in India. This paper examines how paper industries in India view and conduct the CSR, identifies key CSR practices and maps these against initiative standards by the Central Government of India.

**Keywords:** Paper Industries, CSR Practices

## INTRODUCTION

### Corporate social responsibility

(CSR) is a business approach that contributes to sustainable development by delivering economic, social and environmental benefits for all stakeholders. CSR is a concept with many definitions and practices. The evolution of corporate social responsibility in India refers to changes over time in India of the cultural norms of corporations' engagement of corporate social responsibility (CSR), with CSR referring to way that businesses are managed to bring about an overall positive impact on the communities, cultures, societies and environments in which they operate.[1] The fundamentals of CSR rest on the fact that not only public but even corporates should be responsible enough to address social issues. Thus companies should deal with the challenges and issues looked after to a certain extent by the states.





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**Scope**

It is a way of integrating the economic, social and environmental imperatives of business activities.

**Why There Is A Need For Corporate Social Responsibility?**

A responsible corporate recognizes that its activities have wider impact on the society in which it operates. Therefore, it takes account of the economic, social, environmental & human rights impact of its activities on all the stakeholders.

1. Better Public Image:
2. Conversion of Resistances into Resources
3. Long Term Business Interest:
4. Avoiding Government Intervention:

**CSR Practices & Trends**

As businesses and professionals identify and define their CSR role, they may well look to their trade or professional associations for advice and support. Even if members don't actively seek input on CSR, their associations have an opportunity, even a responsibility, to reach out proactively to their members to provide a valuable service in the following areas:

**Education and awareness –**

As associations seek new ways to serve members in a tough economy, providing help with CSR may be an untapped avenue of opportunity. However, many associations may face questions from their members, the media or the public about whether the industry or profession they represent has a policy or program to promote CSR.

**Providing support**

If there is sufficient interest in CSR among members, consider providing assistance to members in getting educated, setting policy, and implementing CSR programs. Among the areas where advice and supporting material may be particularly helpful include:

- Policy
- Program ideas and support
- Greening
- Pitfalls.

**History and Evolution of Indian CSR**

India has the world's richest tradition of corporate social responsibility. Though the term CSR is comparatively new, the concept itself dates back to over a hundred years. CSR in India has evolved through different phases, like community engagement, socially responsible production and socially responsible employee relations. Its history and evolution can be divided into four major phases.

**PHASE 1 (1850 TO 1914)**

The first phase of CSR is known for its charity and philanthropic nature. CSR was influenced by family values, traditions, culture and religion, as also industrialisation. The wealth of businessmen was spent on the welfare of society, by setting up temples and religious institutions. In times of drought and famine these businessmen opened up their granaries for the poor and hungry.. During this period social benefits were driven by political motives.

**PHASE 2 (1910 TO 1960)**

The second phase was during the Independence movement. Mahatma Gandhi urged rich industrialists to share their wealth and benefit the poor and marginalised in society. His concept of trusteeship helped socio-economic growth. According to Gandhi, companies and industries were the 'temples of modern India'.





### PHASE 3 (1950 TO 1980)

This phase was characterised by the emergence of PSUs (Public Sector Undertakings) to ensure better distribution of wealth in society. The policy on industrial licensing and taxes, and restrictions on the private sector resulted in corporate malpractices which finally triggered suitable legislation on corporate governance, labour and environmental issues.

### PHASE 4 (1980 ONWARDS)

In this last phase CSR became characterised as a sustainable business strategy. The wave of liberalisation, privatisation and globalisation (LPG), together with a comparatively relaxed licensing system, led to a boom in the country's economic growth.

### Paper Industry in India

The paper industry in India is one of the most thriving industries in the country. The Indian paper industry accounts for about 1.6 per cent of the world's production of paper and paperboard. Indian paper industry is the 15th largest in the world and provides employment to 1.3mn people in country contributing Rs25bn to the government. The first paper mill was set up in India more than 100 years ago. In India, the first paper industry was developed in Kashmir, established by Sultan ZainulAbidin (Shahi Khan) of Kashmir in 1417-67AD. (<http://www.infinityfoundation.com>). Paper was observed in common use almost all over India at the close of Akbar's reign. The growth in paper is inevitable and is likely to contribute significantly to the government's target of achieving an overall growth of 12 per cent in manufacturing. Unfortunately, the rising costs of raw materials, primarily wood and wood products, are a big challenge facing the industry. The industry has recorded a volume growth of CAGR of 5.47 per cent over the last 3 years. In 2003-2004, it recorded a volume growth of 6 per cent in line with the GDP growth.

Newsprint mainly uses for newspapers, flyers, and other printed material intended for mass distribution.

The Rs. 25,000-crore Indian paper industry accounts for about 1.6 per cent of the world's paper and paperboard production even though the country accounts for nearly 16 per cent of the global population. The Indian paper industry's market size has been estimated at Rs.321 billion, growing at a CAGR of 10.5 per cent from around Rs. 195 billion in 2003-04 to Rs. 321 billion in 2008-09. In 2009-10, the country produced 9.18 million tons of paper, growing at an average 6-7 per cent compared with 2 per cent growth in developed countries.

### Information & Activities and By Paper Mills

ITC- Paperboards and Specialty Papers Division (ITC-PSPD), is amongst the leading names in the business worldwide. Our innovative solutions to meet a diverse cross-section of packaging and communication needs have helped us carve a unique niche for ourselves. With emphasis on harnessing state-of-the-art technology, we have emerged as the largest manufacturer of Packaging and Graphic Boards in South Asia. In the endeavour to move up the value chain, our portfolio of products and services has consistently grown over the years. Today, our products and pool of knowledge-based services are much sought-after by discerning customers, both in India and internationally, for sustaining and improving their competitiveness.

To implement the Company's CSR Programmes through Company personnel or through external implementing agencies or through ITC Education Trust, ITC Rural Development Trust, ITC Sangeet Research Academy, ITC Bhadrachalam Education Trust, Tribeni Tissues Education Society (and other Trusts, Foundations and Section 8 companies that may be established by the Company from time to time). In such cases, the Company will specify the CSR Programmes which may be undertaken by those Trusts in accordance with their Objects and administrative and accounting processes laid down in the respective Trust Deeds/ Memoranda and Articles of Association.





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- e – Chou pal
- Social & Farm Forestry
- Watershed Development
- Women's Empowerment
- Livestock Development
- Primary Education

Tamil Nadu Newsprint and Papers Limited (TNPL) was established by the Government of Tami Nadu during early eighties to produce Newsprint and Printing & Writing Paper using bagasse, a sugarcane residue, as primary raw material. The Company commenced production in the year 1984 with an initial capacity of 90,000 tonnes per annum (TPA). Over the years, the production capacity has been increased to 2,45,000 tpa and the Company has emerged as the largest bagasse based Paper Mill in the world consuming about one million tonnes of bagasse every year. The activities conducting by the Industry are as follows

**i) Education**

- Scholarships for exceptionally talented children – based on merit
- Career Development
- Sports Development

**ii) Health Care**

- Disease Prevention
- Primary Health
- Help to Handicapped/ Disabled people
- Contribution to Hospitals and Medical Research
- Sanitation Infrastructure

**iii) Socio-Economic Development**

- Drinking Water facilities
- Community or Social Infrastructure \* Employment generation
- Vocational Training \* Integrated Farming
- Livestock and Animal Husbandry care
- Providing assistance for eradicating hunger and reducing poverty and malnutrition
- Road development
- Promoting gender equality and empowering women

**iv) Environmental Sustainability**

- Air pollution control
- TEWLIS related activities for improvement of land
- Water Shed Development
- Conservation of Flora, Fauna & Wild life

**V) Culture & Heritage promotion**

- Conservation of Heritage buildings, including places of worship and sites of historical importance
- Promotion of Literature/ Dance/Music/Theatre/ Arts, Architecture and Handicrafts.

West Coast Paper Mills Limited enjoys a pedigree standing over the past 61 years as premium brand in Paper industry,widely acknowledged both in India and abroad.The Company's commitment to its vision of constant up-gradation of its processes and technology to offer uniform quality of customized products and its sustained





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emphasis on achieving mastery over 'wood to paper product research' have enabled it to produce a wide portfolio of wood-free papers and boards of highest quality.

#### **Our CSR initiatives for the villages include the following:**

- Water supply projects.
- School uniform distributions.
- Subsidized notebook distributions.
- Cattle vaccination program.
- Distributions of medicines.
- Medical facilities such as mobile health care units.
- Drinking water arrangements.
- Drinking water arrangements for cattle.
- Organizing social awareness programmes.

Ballarpur Industries Limited (BILT), part of the US\$ 3 bnAvantha Group, is India's largest manufacturer of writing and printing (W&P) paper. More than 50% of India,s coated wood-free grades roll out of BILT's state-of-the-art plants. The company holds an impressive 85% share of the bond paper market and nearly 45% share of the hi-bright Maplitho market in India. BILT is the only Indian paper company to feature in the global top 100 list, with the recent acquisition of Malaysia's Sabah Forest Industries (SFI) having elevated BILT's global ranking to 87. In recent years, BILT has evolved as a knowledge driven and customer centric organization.

As of now the CSR programs of Bilt are carried out at the following levels

- Communities: Integrated Rural & Urban Community Development programmes with communities living in the periphery of our Mills
- Employee Volunteer Programme: employees are encouraged to volunteer time to work on social issues
- Workplace: HIV/AIDS prevention with employees, truckers and transporters
- Support to National Issues: Support to NGO's for Universalizing Primary Education and arresting school dropouts

#### **Community Development**

Out of all the stakeholders of BILT, the communities living around the manufacturing locations are the most marginalized and thus community development and upliftment of the marginalized have been identified as focus areas for CSR intervention. Today BILT's development programmes reach more than 2, 00,000 people living in more than 100 villages around the Mills.

#### **Employee Volunteer Programme (EVP)**

This programme covers employees at all levels and is an extension of the Company's sustained involvement with the communities at its various locations. This programme concentrates its efforts on volunteerism, allowing employees to participate in the process of social change. We have more than 300 employee volunteers who regularly volunteer their time for activities.

#### **Prevention of HIV/AIDS**

The prevention of HIV/AIDS programme was launched in the year 2005. The focus of the programme has been to create awareness about the disease. We have involved our own employee volunteers to deliver this prevention message.

International Paper APPM Ltd., is one of the largest integrated paper and pulp manufacturers in India. Established in 1964. The company produces writing, printing and copier papers for foreign and domestic markets. Our production facilities at Rajahmundry and Kadiyam have a total production capacity of 240,000 TPA. The company

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employs around 2,500 employees and is headquartered in Hyderabad. International paper is highly committed to values such as respect for people, communities, cultures and environment while producing paper.

#### EDUCATION

IP India Foundation promotes literacy by developing, assisting and supporting educational institutions in order to impart quality education.

#### ENVIRONMENT

IP India Foundation promotes environmentally & socially responsible business practices by assessing and mitigating the environmental & social impacts on sustainable economic growth.

#### ENGAGEMENT

IP India Foundation has been initiating, encouraging and supporting various initiatives and engaging with the community. SPB is the flagship company of ESVIN Group. The headquarters of the group is at Chennai. The other companies belonging to the group are:

- ESVIN Advanced Technologies
- Ponni Sugars
- High Energy Batteries
- SPB - PC

The activities are

- Lift Irrigation
- Contract Farming
- Community Development

JK Paper Ltd. has two large integrated paper manufacturing units – JK Paper Mills, Rayagada, Odisha and Central Pulp Mills, Songadh, Gujarat with a combined capacity of 4,55,000 TPA. It is the market leader in Branded Copier paper segment and among the top two players in Coated Paper and high-end PackagingBoards. Its products are sold through extensive distribution network of 188 wholesalers, 10 depots & 4 regional marketing offices, and covering nearly 4,000 dealers. It offers a wide product range and its brands are synonymous with premium quality paper.

#### ENVIRONMENT INITIATIVES

- Continuously pursuing enriching the green cover through its Social Farm Forestry drive
- Till date in excess of 81000 Ha of land has been planted covering states of Orissa, Andhra Pradesh, Chattisgarh, Gujarat, Maharashtra & West Bengal
- On average it has added 7000 Ha annually to its plantation drive by distributing over 40 million saplings to farmers
- This farm forestry activity since 1990 has cumulatively provided income for over 45,000 farmers

#### EDUCATION

- Schools - Three schools providing education to over 3000 students with significant portion of them from SC & ST
- Adult Literacy Programme enabling - 3250 illiterate to become literate.
- Adoption/ Upgradation of Industrial Training Institute ( ITI), Ukai, Gujarat under PPP route:Providing training in line with industry requirements. Close to 425 students trained in various trades





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**HEALTH CARE**

- Organising regular General/Disease specific Health Check up camps at the peripheral villages near the factory sites.
- Providing Financial assistance and support to District Administration for organising 'SwasthyaMela' (Health Fair)
- Helping tribal mothers to benefit from Janani SurakhyaYojana

**LIVELIHOOD INTERVENTIONS**

- To improve quality of life of rural poor in and around our Mills by helping them to organise self help group. Recognising the good work, Banks coming forward with loans to build confidence of SHGs & help them scale up their income generating activities.

**Government Norms on CSR activities of Paper Industries**

The Policy recognizes that corporate social responsibility is not merely compliance; it is a Commitment to support initiatives that measurably improve the lives of underprivileged by one or more of the following focus areas as notified under Section 135 of the Companies Act 2013 and Companies (Corporate Social Responsibility Policy) Rules 2014:

- Eradicating hunger, poverty & malnutrition, promoting preventive health care & sanitation & making available safe drinking water;
- Promoting education, including special education & employment enhancing vocation skills especially among children, women, elderly & the differently unable & livelihood enhancement projects;
- Promoting gender equality, empowering women, setting up homes & hostels for women & orphans, setting up old age homes, day care centres& such other facilities for senior citizens & measures for reducing inequalities faced by socially & economically backward groups;
- Reducing child mortality and improving maternal health by providing good hospital facilities and low cost medicines;
- Providing with hospital and dispensary facilities with more focus on clean and good sanitation so as to combat human immunodeficiency virus, acquired immune deficiency syndrome, malaria and other diseases;
- Ensuring environmental sustainability, ecological balance, protection of flora & fauna, animal welfare, agro forestry, conservation of natural resources & maintaining quality of soil, air & water;
- Employment enhancing vocational skills
- Protection of national heritage, art & culture including restoration of buildings & sites of historical importance & works of art; setting up public libraries; promotion & development of traditional arts & handicrafts;
- Measures for the benefit of armed forces veterans, war widows & their dependents;
- Training to promote rural sports, nationally recognized sports, sports & Olympic sports;
- Contribution to the Prime Minister's National Relief Fund or any other fund set up by the Central Government for socio-economic development & relief & welfare of the Scheduled Castes, the Scheduled Tribes, other backward classes, minorities & women;
- Contributions or funds provided to technology incubators located within academic institutions, which are approved by the Central Government;
- Rural development projects, etc.
- Slum area development.

Explanation: For the purposes of this item, the term slum area 'shall mean any area declared as such by the Central Government or any State Government or any other competent authority under any law for the time being in force.

**GAP ANALYSIS**

It has been found out that there is a difference between the actual and the standard performance by the Industries as





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per the Government norms. There is a gap found by this study between the two bodies which has mentioned below.

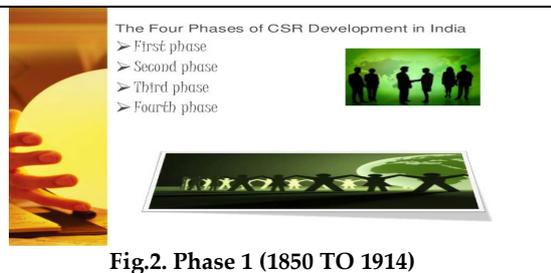
1. Industries should concentrate on Hunger, Poverty and Malnutrition
2. There should be a special focus on special education and also vocational skill education
3. Special focus should be on homes, hostels for orphans and also for old age homes
4. Some initiation towards public libraries
5. Observation on promoting activities on Regional/Traditional Arts and Handicrafts
6. Some benefits should be for War Widows, Armed Forces Veterans and their dependants
7. Special focus on semi urban development or slum area development

## CONCLUSION

The above mentioned statements are most necessary for concentration and implementation for the CSR activities by the paper industries as per the preliminary study. In addition, there should be a harmonious vision for the paper industries towards the implementation of more CSR activities.

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Fig. 3. Paper Mills





## A Study on Foreign Direct Investment in Indian Retail Sector

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### ABSTRACT

Indian retail industry is considered as the fifth largest one globally with huge growth potential. Retail contributes to 10% of India's GDP. India has highest retail density in the world with 15 million outlets. According to the Investment Commission of India, the retail sector in india is expected to grow almost three times its current levels to \$660 billion by the year 2015. Indian retail sector is one of the most sought after sectors that carry great potential for attracting FDI. The growth of retail, especially in 21st century is amazing and attracting the attention of retailers from all over the world. With the steady entry of top global single and multi-brand retailers such as Wal- Mart, Tesco, Carrefour, Nike, Ikea, Apple and many more in last couple of years despite conservative approach of the government, the sector has become more fascinating for the study. FDI is considered as an important tool in the economic development of the nation. Contribution of FDI through financial resources, technology and innovative techniques will raise the overall productivity of diverse sectors of economy. If properly navigated, FDI will truly acts as a catalyst for development of sectors such as agriculture, manufacturing, service, SME's and many more. The present paper attempts to outline the government's policy on FDI in Indian Retail Sector and tries to examine the advantages and adverse effects of FDI on various sectors of the Indian economy. A descriptive analysis is conducted to the present study.

**Keywords:** Foreign Direct Investment (FDI), FDI Policy, Indian Retail Sector, Multi-brand retail, Single-brand retail.

### INTRODUCTION

Indian retail industry is considered to be the fifth largest one globally with huge growth potential. Retail contributes to 10% of India's GDP. India has highest retail density in the world with 15 million outlets. According to the Investment Commission of India, the retail sector is expected to grow almost three times its current levels to \$660 billion by 2015. India is a land of retail democracy- hundreds of thousands of weekly haats and bazaars are located



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across the length and breadth of our country by people's own self-organizational capacities and interests. Our streets are bazaars – lively, vibrant, safe and source of livelihood for millions (Deepali Moghe, 2012).

In 2004, The High Court of Delhi defined the term 'retail' as a sale for final consumption in contrast to a sale for further sale or processing (i.e. Wholesale) a sale to the ultimate consumer. Thus, retailing is the interface between the producer and the individual consumer buying for personal consumption. This excludes direct interface between the manufacturer and institutional buyers such as the government and other bulk customers. Retailing is the last link that connects the individual consumer with the manufacturing and distribution chain. A retailer is involved in the act of selling goods to the individual consumer at a margin of profit.

Indian retail sector is one of the most sought after sectors that carry great potential for attracting FDI. The sector is rightly projected as sunrise sector of India. The growth of retail, especially in 21st century is mind boggling and attracting the attention of retailers world over. With steady entry of top global retailers such as Wal Mart, Tesco, Carrefour and many more in last couple of years despite conservative approach of the government, the sector has become more fascinating for research study. The recent decision of Indian government of opening up the sector for FDI in single and multi brand retail has stirred up the heat with intense agitational activities witnessed all over India. The whole issue needs dispassionate review from all - intellegensia, corporate world as well as from government so that Indian retail sector benefits in its onward march of progress. Moreover, India ranked on 5th position in its Global Retail Development Index (GRDI) and second in Asia after China, by the US-based global management consulting firm, A T Kearney in its annual Global Retail Development Index (GRDI) 2012.

**Objectives of the Study:**

- (a) To study the present regulatory framework for FDI in Indian retail sector.
- (b) To study and analyze likely impact of FDI in single and multi brand retail on different components of Indian Economy.

**RESEARCH METHODOLOGY**

The descriptive research methodology has been used to collect the data. To evaluate the overall position of the entry of FDI in multi brand retail in India, secondary data has been collected from Various published sources and also from websites from the year 1999 to few assumptions for the future. Analysis and Interpretation of the data is more on qualitative terms than on quantitative terms.

**Retail Marketing – Indian Scenario**

The Indian retail market, the fifth largest retail destination globally, has been ranked as the most attractive emerging market for investment in the retail sector by AT Kearney's latest annual Global Retail Development Index (GRDI). At present, the retail industry in India is estimated at US\$ 400 billion industry. With rising consumer demand and greater disposable income, further the retail sector is expected to rise to US\$ 833 billion by 2013 and to US\$ 1.3 trillion by 2018, at a compound annual growth rate (CAGR) of 10 percent. In absolute terms, this figure is very commendable but the actual contribution to the GDP comes only in the form of organized retail. Organized retail segment grew at the rate of 42.4 % in and is expected to maintain a much faster growth rate in next three years. As of now, the organized part accounts for around 6.5% of the Indian retail market. Though, it is expected to maintain a faster growth rate in the coming years with an estimation of touching 13% by the end of 2013. Over the last few years Indian retail has witnessed rapid transformation in many areas of the business by setting scalable and profitable retail models across categories. Indian consumers are rapidly evolving and accepting modern retail formats. New and indigenized formats such as departmental stores, hypermarkets, supermarkets, speciality and convenience stores,



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and malls, multiplexes and fun zones are fast dotting the retail landscape. Retailing in India is currently estimated to be a US\$ 200 billion industry, of which organized retailing makes up a paltry 3 percent or US\$ 6.4 billion. By 2013, organized retail is projected to reach US\$ 23 billion. For retail industry in India, things have never looked better and brighter. Challenges to the manufacturers and service providers would abound when market power shifts to organized retail and above all an experience that a consumer would like to repeat.

The retail sector has played a phenomenal role throughout the world in increasing the productivity of consumer goods and services. It is also the second largest industry in US in terms of numbers of employees and establishments (Chandu.K.L, 2012). There is no denying in the fact that most of the developed economies are very much relying on their retail sector as a locomotive of growth. The India Retail Industry is the largest among all the industries, accounting for over 10 percent of the country's GDP and around 8 percent of the employment. The Retail Industry in India has come forth as one of the most dynamic and fast paced industries with several players entering the market. But all of them have not yet tasted success because of the heavy initial investments that are required to break even with other companies and compete with them. The India Retail Industry is gradually inching its way towards becoming the next boom industry.

**Foreign Direct Investment in Indian Retail**

World Bank defined FDI as "Foreign direct investment (FDI) or foreign investment can refer to the net inflow of funds to acquire a long-term management interest in an enterprise operating in a foreign economy. It is the accumulation of equity, reinvestment of retained earnings, other long-term sources of capital, and short-term funds as presented in the balance of payments".

According to a recent survey by UNCTAD India is projected as the second most attractive destination for FDI (only after China) for multinational corporations during the years 2010- 2012. As per the data, the sectors such as telecom, services, infrastructure and computer hardware and software attract the FDI the most. The leading sources of FDI are from the economies such as the US, the UK, Singapore and Mauritius. The Indian retail market is currently unorganized and highly fragmented, with an estimated 13-15 million outlets countrywide. The overall retail market is expected to grow at a CAGR of about 11-13 percent by 2020-21, with the organized retail market expanding at 21-24 percent (Chandu.K.L,2012). Table 1 depicts the growth of the share of organized retail in the overall retail in India over years. From the table, it can be clearly understood that, in India, the growth of organized retail has been steadily rising since 1999 and is expected to continue in the years to come. This growth can be attributed to changes in FDI policy in retail trade.

**FDI in Single Brand Retail**

FDI up to 100 percent is now permitted in Single-Brand Product Retail Trading by only one non-resident entity, whether owner of the brand or otherwise, under the Government route subject to the terms and conditions issued by the Department of Industrial Policy & Promotion (DIPP), Ministry of Commerce & Industry, Government of India. The purpose for liberalizing FDI in single brand retail trading is to attract FDI in production and marketing, improving availability of goods to the consumer and increasing the competitive factor of the Indian enterprises by providing them access to global designs, technologies and management practices. Accordingly, in permitting such foreign investments, the Government of India has adopted a cautious approach and has made such permission for 100 percent FDI subject to certain terms and conditions explained herein below. FDI in single brand retail trading was permitted to the extent of 51 percent with the prior approval of the Government of India (Secretariat for Industrial Assistance) and was subject to the following conditions:

- Products to be sold should be of a 'Single Brand' only.
- Products should be sold under the same brand internationally i.e. products should be sold under the same brand in one or more countries other than India.
- 'Single Brand' product-retail trading would cover only products which are branded during manufacturing.





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- The foreign investor should be the owner of the brand.
- In respect of proposals involving FDI beyond 51%, atleast 30% of the value of products sold would have to be mandatory sourced from Indian 'small industries/ village and cottage industries, artisans and craftsmen.

**Advantages of FDI in Single-brand retail**

Majority of the single brand retailers which are investing in India has already a sourcing base in the country and the trend is set to increase manifold. The consequential benefits, such as the integration of global best practices in management, along with global standards in quality, design, packaging and production, would help build capacities of local producers, by making it worthwhile for them to scale-up their production, thereby creating a multiplier effect on employment and income generation. This also would lead to up-gradation of technology, which, in turn, would have a further multiplier effect on the economy.

**FDI in Multi Brand retail - A welcome move**

The another landmark decision for the Indian retail industry is the cabinet approved the DIPP's proposal of permitting 51% FDI in multi brand retail in India on September 14, 2012. The decision to allow 51 percent foreign direct investment (FDI) in multi-brand retail clears the deck for multi-national chains such as Carrefour, Tesco and Walmart to set up shop in India, but with riders. It clearly says that approval should be taken from the Foreign Investment Promotion Board (FIPB) for investments. Further, it says the foreign investor should make a minimum investment of \$100 million, 50 percent of which should be invested in "back-end infrastructure". Also, 30 percent of the products must be procured from small-scale industries.

It also states that fresh agricultural produce, including fruits, vegetables, flowers, grains, pulses, fresh poultry, fishery and meat products, may be unbranded. For the purpose of FDI in multi-brand retail, the note describes small industries as units which have a total plant and machinery investment not exceeding \$250,000 (around Rs.1.25 crore). This investment refers to the value at the time of installation, without providing for depreciation. The foreign retail chains will be required to comply with self-certification. They have to keep all records, and the government will have the first right to procure agricultural produce.

Retail sales outlets can be set up only in cities with a population of more than 10 lakh as per the 2011 Census. In States/ Union Territories not having cities with population of more than 10 lakh, retail sales outlets may be set up in the cities of their choice, preferably the largest city. Other conditions include a minimum FDI amount of US \$ 100 million with a mandate that at least 50% of the total FDI be invested in 'back-end infrastructure' within three years of the first tranche of FDI. As for the back-end investment, it states that investments made towards processing, manufacturing, distribution, design improvement, quality-control, cold chain, warehouses and packaging, will constitute back-end. Retail chains will be allowed only in cities with a population of more than 10 lakh as per 2011 Census. There are 51 cities with a population of more than one million, based on 2011 Census.

**Multi-brand Retail Sector: Benefits accruing from FDI**

Accelerated urbanization in India has brought in drastic changes in the consumption pattern. Emergence of new social classes and expansion of middle and upper middle classes, substantial rise in the income of the people and growth of the nuclear family system have brought in a great deal of change in the attitude of consumers. India's population predominantly consists of youth who are more brand-conscious and are ready to pay a premium for quality, environment and brands.

People, now a days, are keen to spend on lifestyle. Today, the typical Indian consumer expects everything to be available under a single roof. All this makes India a very attractive destination for foreign investment in retail sector. It is opined that FDI in Multi-Brand Retail Sector can be considered appreciable as it may bring the latest cutting-edge technologies to India that would benefit a host of the sectors of the economy such as, the





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retail traders, farming, cooperative, service sector in non corporate enterprises and end consumers. The face of the Indian Retail Industry will change with the entry of Global Retail Majors who are known for their quality, service, and technology of highest standards.

**Farmers – the Prime beneficiaries of the FDI Policy**

According to the FDI Policy, at least 50% of the Investment should be made in back end infrastructure such as investments in processing, manufacturing, distribution, warehouse, logistics, storage etc., which will help to reduce wastage of farm produce, improve livelihood of farmers, lower the prices of products and ease supply side inflation, food, safety, hygiene and quality. Direct farm initiatives shall also provide better remuneration to farmers. More investment is likely in farming sector. Since each retailer is expected to bring \$100 million, it will have notable investment in back end and logistics are likely to push employment further. Farmers have chances to gain greater market access, higher profits, better technology and linkages with consumers due to direct back end linkages. Key farmer issues can also be addressed which would help agricultural productivity.

**Real Estate sector likely to upscale their operations**

The decision to allow 51% in Multi brand retail is expected to prompt realtors to revive their plans to build malls and shopping complexes, which were shelved down in the past few years due to economic slowdown. As per Jones Lang Lasalle India, Global Consultant in real estate sector, Rs. 22,000 crores retail real estate market shall grow at CAGR of 25 % a year for the next five years, growing at 50- 100 %. With this, much needed capital too is expected to come into the country for retail which means more job creation in future.

**Consumers are going to be benefited the most**

The most advantaged section with the implementation of FDI policy would be the consumers. From the reduction in prices that would result from the supply chain efficiencies to the improvement in the quality of the products, the consumers are going to be benefitted the most. Along with this, food safety standards would also get better with improvised testing and aggregation facilities. The consumers would also have more choices to pick from. This policy measure is most likely to benefit the poorest sections of the society. Lowering of prices would arrest the erosion of real incomes and the current incomes of the economically disadvantaged sections would hence be able to buy more than before.

**Small Retailers Perspective**

Foreign direct investment in the retail sector would also incentivise the existing traders and retail outlets to upgrade and become more efficient. This would provide better services to the consumers, and also good remunerations to the producers from whom they source the products. A concern that the small retailers will get displaced by allowing FDI is completely misplaced. It is to be noted here that domestic organised retail services are already provided by entities like Big Bazaar, Shoppers Stop, Croma, Reliance Fresh among others in different parts of India. More interestingly, it constitutes only four percent of the retail trade and co-exists with small kirana stores and the unorganised retail sector.

There has been a strong competitive response from traditional retail to these organised retailers through technology upgradation. As a result, the organised retail chains have closed down in a number of locations, while others have reduced the scale and spread of their operations. Globally too organized and unorganized retail co-exist and grow. Small retailers would continue to be able to source high quality produce, at significantly lower prices, from wholesale cash and carry points. In countries such as China, Thailand, Indonesia, Brazil, Singapore, Argentina and Chile, where there are no caps on FDI and where there are no conditions, small retail stores have flourished, leading to more employment. Therefore, it is a white lie to state that FDI in multi-brand retail trade will force small retailers to shut down.





### **Advantages to SMEs**

Small and medium manufacturers are also going to be benefitted as 30 percent sourcing from these industries has been made mandatory. This would provide the necessary scales for these entities to expand their capacities in manufacturing, hence adding up to the employed population and also boosting the manufacturing sector of the country. These industries also stand to get added advantages of technology upgradation, which would give them an upper hand in productivity and local value addition, thereby raising the profitability and earnings of the small manufacturers. The 30 percent sourcing norm would also help the small enterprises to get integrated with the global retail chains. New manufacturing opportunities will also open for the country's micro, small and medium enterprises.

### **Opportunities for Rural Youth**

FDI in multi-brand retail trading will also help a large number of young people from rural areas to join the workforce. Youth from the villages spread across the country can engage themselves in activities ranging from backend to the frontend retail business, as also from the skills imparted to them by the prospective investors.

### **Provides Employment and Reduction in Inflation**

Investments in the organised retail sector will see gainful employment opportunities in agro-processing, sorting, marketing, logistic management, small manufacturing sector like textiles and apparel, construction, IT, and other infrastructure. The most important aspect of FDI in retail is that it will significantly increase the number of jobs in the front-end. According to a study conducted by the Indian Council for Research on International Economic Relations in 2011, as per the industry estimates of the employment of one person per 350-400 sq.ft. of retail space, about 1.5 million jobs will be created in the front-end alone in the next five years. Assuming that 10 percent extra people are required for the back-end, the direct employment generated by the organised retail sector in India over the coming five years will be close to 1.7 million jobs. The study also suggested that with direct buying from the farmers, improving supply chain inefficiencies, bettering storage capabilities to control supply/demand imbalances, inflation could also be tamed. It can thus be concluded that opening up multi-brand retail trading to foreign direct investment would have a multiplier impact on Indian economy. It would act as a strong catalyst for drawing investments in the food processing sector. This would also be a driver for economic growth by accelerating demand.

### **The other benefits of FDI in Multi –brand Retail are as follows**

#### **Long term cash liquidity**

FDI will provide necessary capital for setting up organized retail chain stores. It is a long term investment because unlike equity capital, the physical capital invested in the domestic company is not easily liquidated.

#### **FDI as a lead driver for the country's economic growth**

FDI in MBR would create a competition among the global investors, which would ultimately ensure better and lower prices thus benefiting people in all sections of the society. There would be an increase in the market growth and expansion. It will increase retail employment and suppress untrained manpower and lack of experience. It will ensure better managerial techniques and success. Higher wages will be paid by the international companies. Urban consumers will be exposed to international lifestyles.

#### **FDI opens new doors for Franchising**

Retail giants who are at their wings, seeking entry into foreign market look for other available alternatives. These restrictions on the global retailers regarding the inflow of Foreign Direct Investment, leads them towards acquiring the market entry through franchises. Thus, countries which offer promising market potentialities for retail growth offers substantial growth in the franchising sector as well.





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**Various Myths about FDI in Multi-Brand Retail sector are as follows**

**Myth1: Impact on supply chain intermediaries**

It is feared that foreign retailers will directly impact existing supply chain intermediaries that are being fed by SME's. Since sourcing from domestic SME's is not mandatory, foreign retailers may source the products from countries like China which is known as manufacturing hub of the world and it may put Indian SME sector in great danger. There may be a possibility of large scale unemployment if not checked. The current provision of 30% sourcing from Indian SME's should be made mandatory and should be strictly monitored. Due to predatory pricing strategies, vast class of India's merchants may get affected directly.

**Myth 2: Fear of survival of Small and unorganized retailers in the environment of intense competition**

The local kiranas, small shopkeepers, hawkers, peddlers still form major section of Indian economy. Retail sector acts as a shock absorbing sector, providing opportunities for self employment in case of economic slowdown. The local shopkeepers in the vicinity of big retailers might find it difficult to compete. The prices will be determined by modern retailers and small shopkeepers may have to loose their profit margin due to predatory pricing strategy. The entry of large global retailers such as Wal-Mart would kill local shops and millions of jobs, since the unorganized retail sector employs an enormous percentage of Indian population after the agriculture sector; secondly that the global retailers would conspire and exercise monopolistic power to raise prices and monopolistic (big buying) power to reduce the prices received by the suppliers; thirdly, it would lead to asymmetrical growth in cities, causing discontent and social tension elsewhere.

**Myth 3: About consumer exploitation in the long run**

It is argued that consumers shall benefit due to variety, quality and availability of wide merchandise. However, it is feared that in the long run, consumers may have to face the risk of higher prices, substandard quality and limited options, once these big retailers settle down comfortably in Indian market.

**CONCLUSION**

With the new FDI policy in retail trade, India will significantly benefit in terms of quality standards since the inflow of FDI in retail sector is bound to pull up the quality standards and cost- competitiveness of Indian producers and marketers in all the segments. It will also help in integrating the modern Indian retail market with that of the global retail market. On the other hand, FDI in multi-brand retailing must be dealt cautiously as it has direct impact on a large chunk of population. Foreign capital, if unchecked, may widen the gap between the rich and the poor. Thus, the entry of foreign capital into multi-brand retailing needs to be anchored in such a way that it results in a win-win situation both for India and global players. For example FDI in multi –brand retailing can be allowed in a calibrated manner with social safeguards so that the effect of possible labor dislocation can be analyzed at regular intervals and policy fine tuned accordingly. To ensure that the foreign investors make a genuine contribution to the development of India's infrastructure and logistics, it can be stipulated that a percentage of FDI should be spent towards building up of back end infrastructure, logistics or agro processing units and the claims must be critically evaluated. It can also be stipulated that at least 50% of the jobs in the retail outlet should be reserved for rural youth. On regulatory front, more clarity is required and the same is possible only when retail is recognized as a separate and independent sector of Indian economy. Thus, the priority step would be accordance of industry status to retail sector. Secondly, uniform regulatory structure need to be set up with respect to taxes and duties as regards modern retail sector. Exclusive national policy pertaining to this sector should be formulated. Enactment of national shopping mall regulation act would help to regulate fiscal and social aspects of modern retail sector and create investor friendly environment in India that as regards FDI in retail sector. Along with existing legal and regulatory framework, strong enforcement mechanism is necessary to ensure that big retailers do not dislocate small retailers by unfair means and there is peaceful coexistence of both the arms of retail sector.





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**Table 1: Share of Organised Retail in India**

Year	1	2	3	4	5	6
Total Retail (in billion INR)	7000	8250	10000	18450	19500	24000
Organized Retail (in billion INR)	50	150	350	920	1350	2400
Share of Organized Retail(%)	0.70%	1.80%	3.50%	5.00%	7.00%	10.00%

Source: [www.nielsen.com](http://www.nielsen.com)





## Drug Repurposing - New Age Science of Drug Discovery

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### ABSTRACT

New drug development is a series of lengthy and network of process, with maximum expenditure and minimum achievement rate. In current development years, there was major turn down in the number of finding the new lead candidate for approved clinical trial. The strategy of drug discovery programs is to improve the research and development process. Between all of the process the drug repurposing or, repositioning as a new area that involves clinical entreaty for already or existed approved drugs. This new method aimed to reduce cost and research time. So, repurposing is important, due to an area that has previously suffered from limited sources and an extensive urgency for effective therapies and offers advantages over traditional/ old approaches. Drug repurposing or repositioning find the new use of an already existing drug. Than the drug development process it provides affordable, cheap and faster treatment. However there are few barriers to drug repurposing which need to overcome to fasten for a new drug.

**Keywords:** Drug repurposing, Drug repositioning, Drug discovery, pharmaceutical development.

### INTRODUCTION

Drug repurposing is used for establishing other new medical usages for already known drugs including approved drugs. Drug repurposing or repositioning lies is the modification of an active pharmaceutical ingredient for a new indication that is already on the market. It is a new arena of success and is particularly appertain for the treatment of orphan hereditary condition and offers notable satisfaction to the field of pharmaceutical and medical sciences. At its simplest drug repurposing uses an existing drug and seeing whether it can be used as an effective treatment for another condition. Drug repurposing basically indicates to studying drugs or compounds that are already approved to treat one or more disease condition to check whether they are good, safe and effective enough for benefiting other disease condition. [1, 2, 3]. Therefore, in this mini review we discussed about how the drug repositioning serves as an important strategy for the development of new drug candidates.





### History

- In the year 2000, sildenafil which is used for treatment of angina was repositioned to treat erectile dysfunction and thalidomide which is used for treatment of morning sickness in pregnant women was repositioned to treat multiple myeloma. The success of these two drugs created a new environment for drug repurposing which evolved in the emergence of many repurposing engrossed leadoff pharmaceutical companies.
- Drug repurposing also since been extended and covers the active substances that cut out from clinical phase of their development due to the drugs toxicity, insufficient efficacy or withdrawn from the market
- In the year 1934, some company's uses chloroquine which is used as a known antimalarial drug was synthesized and was later on focused towards many other disease condition including parasitic disease, fever, lupus skin rashes and recently it is also being used for coronavirus affected patient. [4, 5, 6]

### Why go for Drug repurposing?

- The usual and traditional drug development process may detain the relocation of drug discovery of translational research.
- As the repurposing of old drugs involves the use of less risked compounds with potentially lower down overall drug development costs and minimizes development timelines thus it is an appealing postulation.
- With the expanding interest from pharmaceutical and clinical research organization and with the noticeable proof from different cheminformatics and bioinformatics centre findings, drug repurposing was initiated with huge investments.
- Out of all of the research nearly only 10% of repurposed drugs were get the approval from the regulatory bodies and 70% of repurposed drugs are there at various stages of clinical development. [3, 4]

### Drug discovery process

Researchers of various fields point out particular biogenetic, cellular and genetic factors which play a significant role in each of the disease condition. The drug discovery and development stages of new drug molecules or lead candidate includes lead compound identification (targets biogenetic, cellular and genetic markers analogous with a particular disease condition), lead compound upgradation/ standardisation/ validation (identify a existed developed molecule that have an ultimate effect on selected target), lead authentication (molecules that are being capable of treating the disease condition) and finally lead compound optimization (comparison of nature and properties of various lead compounds and selection of lead compound which is having the greatest prospective among all) [7, 8]

### Drug discovery and Drug repurposing

Preclinical study trail i.e, study of drugs on human candidate which always stick to the drug discovery process certify the safety of the drug candidate by laboratory and animal testing. After the preclinical study, investigational new drug (IND) application is being set forth to FDA as consent for conducting clinical trial testing. Clinical research/ trail phase includes phase I (human pharmacology and safety), II (therapeutic exploratory phase), and III (therapeutic confirmation) and is mainly deals with therapeutic safety and efficacy of drug in human subjects. In spite of the huge amount of investigation, the drug development process is time consuming process and the chances for the new drug candidate for clearing all the series of drug approval process are often negligible or minimal. So, the drug manufacturing companies mainly focus/ pivot on other types of feasible options for drug research and trail which defined and signifies drug repurposing process as examine the drugs that are already get the approval to treat/ prevent one disease condition to see if they are safe and effective enough for treating other disease condition. Thats why drug repurposing is the need for all and surpass the traditional method of development of drugs. [8, 3, 4]

### Pharmaceutical development

As an innovation stream/ science of pharmaceutical development and research, drug repurposing offers various advantages over traditional approach for drug developers/ scientist along with safer and effective medicines for patients. Several existing drug that have been successfully modified for repositioned to a new indication of use, with





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the most distinguished of them being viagra and thalidomide, which have engender authentically of high revenues and expenditure. Drug repurposing can be seen as a business opportunity/ criteria for clinical research and pharmaceutical companies, serving both challenges and opportunities of drug repurposing. In addition to this, Drug repurposing can be extended to provide a lower risk of cost effectiveness repurposing model for clinical research and pharmaceutical companies and illuminate the novel cooperative business occasion that help drug repositioning of existed and marketed candidate. [2, 9]

### **Drug repurposing in India**

In India, Drug repurposing overlay various diseases like tuberculosis, Human Immune deficiency Virus- Acquired Immune Deficiency Syndrome, Malaria, Leprosy, Lymphatic disorder, Visceral Leishmaniasis known as kala- azar. Apart from these this process also covers some lifestyle orientated diseases like diabetes mellitus, hypertension and cancer. Various pharmaceutical companies are reluctant to eagerly invest in research and development of drugs for various infectious diseases in drug repurposing, even now in COVID- 19 cases. Now drug repurposing in India take over global initiatives based on public private partnership mod; medicine for tropical, orphan and neglected diseases. [1, 2, 9, 10]

### **Benefits of drug repurposing**

- Less risky- the chance of failure due to adverse side effect is reduced
- Faster – patients with terminal cancers, orphan diseases and other incurable conditions often do not have a decade to spare.
- Cheaper- more patients will have access to and be able to afford their medication.[10, 11]

### **Barriers to drug repurposing**

- Lack of financial incentives
- Undermines existing market
- Legal and intellectual property issue
- Still a risky business
- Scientists rewarded for originality content [10, 11]

## **CONCLUSION**

Now pharmaceutical and clinical research industries is look forward to explore their full potential for the lead compound at a much earlier stage of development of drugs, even if in late stage of preclinical development, it offers additional option and opportunities for these companies. Drug repurposing is expected and also provide value to the product development and securities of the drug research companies and maximize the ability to provide new and low cost treatment/ prevention options for a multitude of serious and neglected diseases. Since drug development involves series of multiple process, time and huge investment, thus this type of innovative and creative ideas and novel concepts definitely will speed up the drug discovery and development process.

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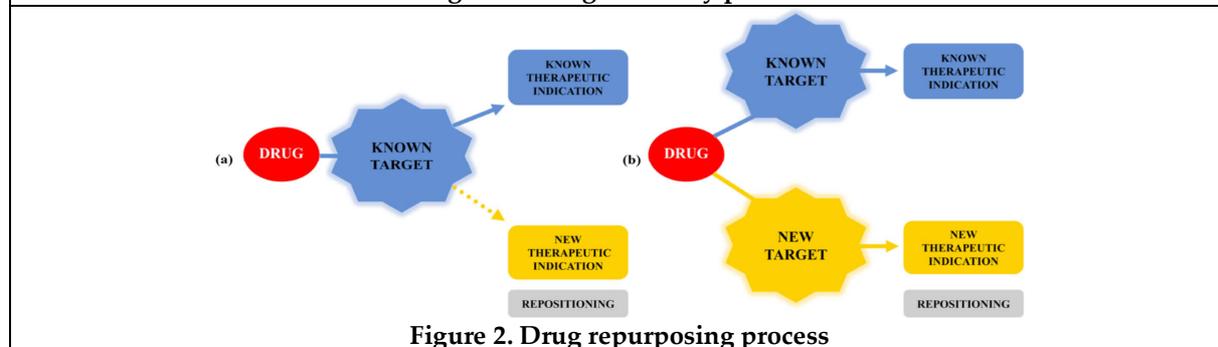
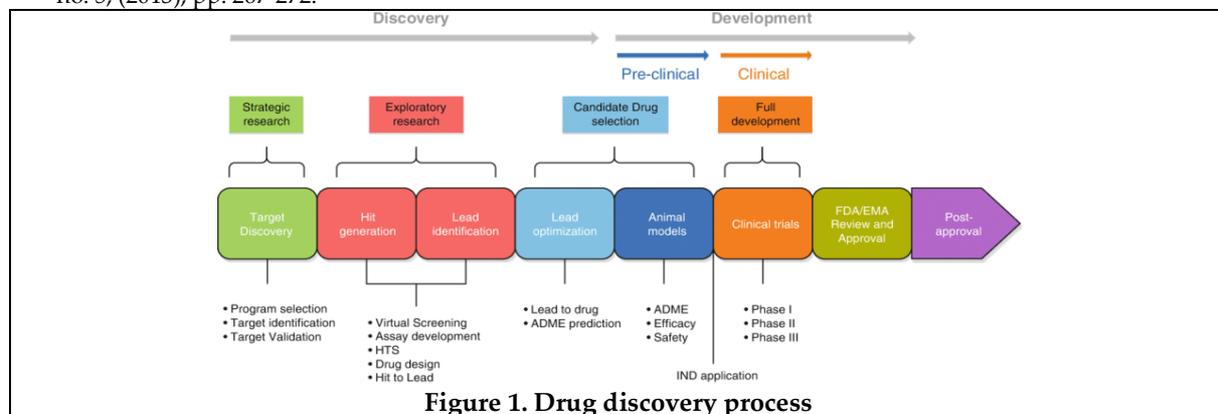
The authors would like to acknowledge Centurion University of technology and management, Odisha, India for encouraging to do some work in the recent advancement of drug repurposing.





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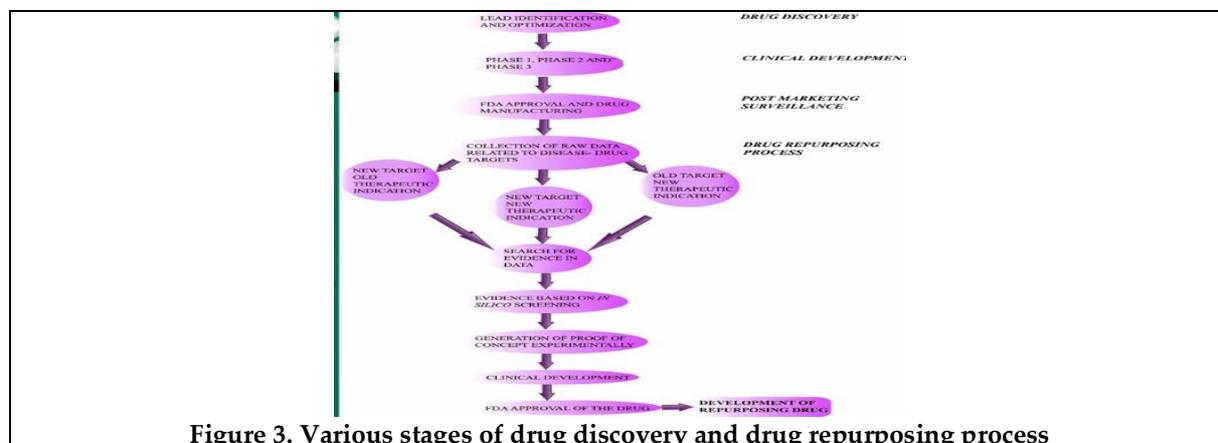


Figure 3. Various stages of drug discovery and drug repurposing process



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## ***In vitro* Evaluation of Antimicrobial Effect of *Azadirachta indica* (Neem) against Pathogenic Microorganisms**

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### **ABSTRACT**

Plants have been widely used as herbal remedies due to the presence of many active phytoconstituents. Numerous plants have been used for years in daily life to treat diseases across the world. In the present study, our result showed antimicrobial activity of *Azadirachta indica* against gram negative pathogenic bacteria (*Escherichia coli*, *Salmonella typhi* and *Vibrio cholerae*) and gram positive bacteria (*Bacillus subtilis*). Leaves of *Azadirachta indica* were collected from the fields of Botanical Garden in school of pharmacy and life sciences, centurion university, Bhubaneswar and pure cultures of the test organisms for the antimicrobial study were procured from the Dept. of Microbiology, centurion university, Bhubaneswar. In our study all the micro organisms were screened for their antibacterial activity against leaf extract of *Azadirachta indica* by agar well diffusion method. Here we revealed that the leaves extract of *Azadirachta indica* showed more Zone of inhibition against *Vibrio cholerae* and *Bacillus subtilis*, as compared to *E.coli* and *S.typhi*. Our research confirms further need to explore the impact of neem leaves on antimicrobial activity.

**Keywords:** *Azadirachta indica*, Antimicrobial activity, pathogenic microorganism, leaf extract.

### **INTRODUCTION**

Various parts of neem tree were used in traditional medicine due to the presence of many pharmacological active constituents. Its twigs are commonly used as chewing stick and are widely used in the Indian sub-continent. Earlier studies confirm the numerous medicinal properties of various parts of neem (Maragatharavalli et al., 2012). Aqueous extract of neem leaf has effective against IDDM and NIDDM due to its antihyperglycemic activity (Mossadek and Rashid, 2008; Patil et al., 2013). Another study revealed that neem leaves could control the airborne bacterial contamination in the residential areas (Saseed iand Aslam, 2008; El-Mahmood et al., 2010). Alcoholic extract of neem

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flower showed the antifertility activity due to its partial block in ovulation in sprague Dawley rats (Gbotolorun et al., 2008). Nimbin is the first bitter active compound isolated from neem oil and more than 135 compounds have been isolated from different parts of neem (Ganguli, 2002). Numerous medicinal properties of the plant *Azadirachta indica* were studied by several researchers. They were anti-pyretic (Okpanyi and Ezeukwk,1981; Khattakiet al.,1985), anti-malarial and anti-tumour effect(Fujiwara et al.1982), anti-ulcer effect (Pillai and Santhakumari, 1984), anti-diabetic effect(Patil et al., 2013), anti-fertility effect(Sinha et al.,1984), effect on central nervous system and antioxidant activity. Another study investigate the excellent antiseptic properties of boiled neem leaves to clean wounds, soothes, swellings and eases skin problems (Bonjar and Holland, 2004). Here we evaluate the antibacterial activity of neem parts against pathogenic bacterial strains.

## MATERIALS AND METHODS

### Collection of plant material and extract preparation

Leaves of *Azadirachta indica* were collected from the fields of Botanical Garden in school of pharmacy and life sciences, centurion university. The collected plant material was brought to the laboratory and shade dried and then blended into powder by mixture blender. The powder is then passed from the sieve to get the equal size particles. The powder should be kept in air tight container at the moisture free place in aseptic condition. About 30g of powder is accurately weighed and transferred to the conical flask containing 200mL distilled water and shaken well and powder mixed properly in water. Then kept the flask containing the mixture of powder and water is put on room temperature on aseptic condition for 7 to 8 days. Then extracted and filtered by using muslin cloth and Whatman filter paper. The filtered liquid is centrifuged at 4,000rpm for 5min and the pure extract was obtained in form of supernatant. This obtained extract was kept at 4°C for further experiments.

### Isolation of test organisms

The test organisms used for antimicrobial study were obtained from the Dept. of Microbiology, school of pharmacy and life sciences, centurion university, Bhubaneswar. Test organisms were cultured on nutrient agar slant medium. The cultures were maintained by sub-culturing periodically and preserved at 4°C prior to use.

### Antibacterial activity

The test organisms were screened for their antibacterial activity against leaf extract of *Azadirachta indica* by agar well diffusion method. The antimicrobial agent was allowed to diffuse out into the medium and interact in a petri plate freshly spreaded with the test organism. Antibacterial activity was performed by using Muller-Hinton agar.

### Preparation of stock solution

Stock solution of the extract was prepared to carry out the antimicrobial activities against selected cultures. For the preparation of the stock solution, 1g of the leaves extract was accurately weighed and dissolved in 10ml DMSO; giving concentration of the stock solution as 100 mg/mL. This solution was then centrifuged and supernatant liquid was collected in a separate test tube, covered with paraffin wax and stored at 4°C for further experiments.

### Agar well diffusion method

The Muller-Hinton agar plates were prepared for conducting the antibacterial activity of leaves extract of *Azadirachta indica*. About 0.1mL of the fresh 18h old broth culture was spread on the respective media. The wells were open with the help of sterile forceps. Then 100µL of original stock solution was added by using micropipette in each well. The final concentration in the well was 1mg/mL. The extract was allowed to diffuse and kept at room temperature for 30min and then 37°C for 24h.





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## RESULTS AND DISCUSSION

In our study the antibacterial activity of leaf extract of neem was evaluated against both gram positive and negative bacteria. Our investigation revealed that leaf extract of *Azadirachta indica* showed more zone of inhibition against *Vibrio cholerae* and *Bacillus subtilis*, as compared to *E. coli* and *S. typhi* (Table 1, Fig. 2a-d).

## CONCLUSION

In conclusion we have explored the antibacterial effects of neem leaves extracts against four different pathogenic bacteria. *Azadirachta indica* extract is an excellent source of active compounds having anti-microbial, anti-oxidant, anti-tumor, anti-malarial, anti-fungal, anti-inflammatory and anti-viral properties. In our study it provides the evidence that leaves extracts of neem can be used as antibacterial agents against various pathogenic bacteria. We can therefore affirm that in vitro studies provide mounting evidence that *Azadirachta indica* leaves extract may have beneficial effects to fight against various pathogenic bacteria.

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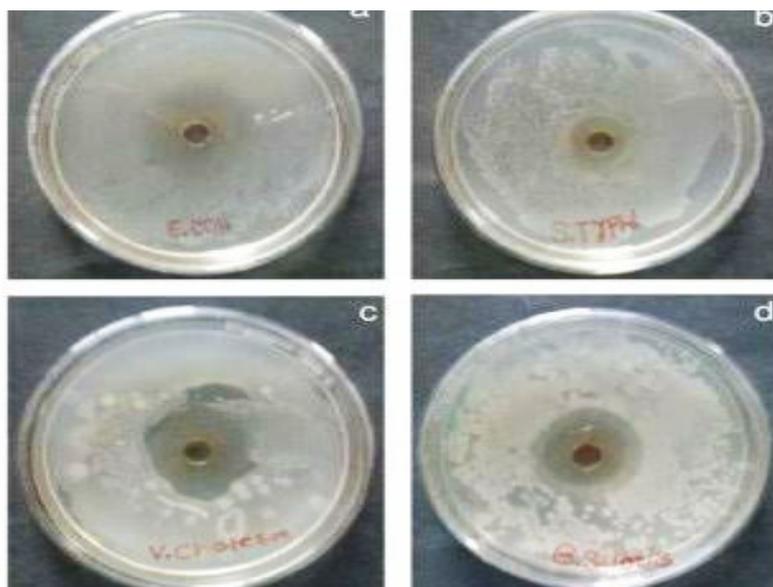


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**Table 1. Antimicrobial activity of leaf extract of *Azadirachta indica*.**

	Test microorganism	Zone of inhibition( in mm)
1	<i>Salmonella typhi</i>	10mm
2	<i>Escherichia coli</i>	12mm
3	<i>Vibrio cholerae</i>	18mm
4	<i>Bacillus subtilis</i>	18mm



**Fig. 1(a-d). Antimicrobial activity of leaf extract of *Azadirachta ndica* by agar well diffusion method.**





## Comparative Study on Effect of Natural Disintegrants in the Formulation of Valsartan Oral Disintegration Tablet

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### ABSTRACT

The key objective of this analysis was to compare & evaluate the feasibility of to prepare for oral disintegrating tablets of Valsartan using natural disintegrating agents like mucilage of *Cassia tora* and *Carica papaya* powder by direct compression method. *Cassia tora* mucilage and *Carica papaya* powder are extracted from raw seeds and tested separately using different concentrations (5 %, 10 %, 15 %, and 20 % w/w) for their physico-chemical properties in Valsartan tablets. The formulations obtained from above manner were evaluated for pre-compression, post-compression parameters and compared. According to the data acquired from the evaluated parameters the formulation F<sub>CM7</sub> (15% mucilage of *Cassia tora*) was found to be best and showed superlative disintegration and dissolution criteria. Accelerated stability studies on optimized formulation 40±0.50° C and 75±0.5 % RH were conducted for three months and analysed at 1, 2 and 3-month intervals of the physical parameters, disintegration time and drug content.

**Keywords:** Valsartan, *Cassia tora*, *Carica papaya*, Oral Disintegration Tablet, Comparative studies.

### INTRODUCTION

Owing to its convenience of self-administering, compactness and easy manufacturing, the route of administration through orally is measured as one of the most broadly recognized route. The oral disintegrant tablets (ODT) are designed to disintegrate or dissolve quickly when in contact with saliva, without the need for water, making them beneficial to traditional tablet formulations (1). ODTs are simply ingested by placing them on the tongue, thereby eradicating the need to chew the tablet, swallow an intact tablet or by help of water. New ODT technologies resolve numerous patient and pharmaceutical concerns such as improved lifecycle management, especially for pediatric, subconscious geriatric and psychiatric patients who have difficulty swallowing traditional tablets and capsules (2). It offers better stability, appropriate dosing, ease of manufacture, reduced packaging size; self-administration during





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the journey is possible, as no water is needed. However, the most noticeable limitation of widely used oral dosage forms such as tablets and capsules is difficulty in swallowing, leading to non-compliance with patients, and it also applies to people who are ill in bed and active working patients who are busy or traveling, particularly those without water. *Cassia tora* is a common annual herbaceous weed available in all over of India and belongs to the Leguminosae family. The seeds of the plant are suitable for tablet binder when comes in contact with water(4). *Carica papaya* plant is a large, single-stemmed herbaceous perennial tree having 20–30 feet height. Fruit of the *Carica papaya* possess carotenoids ( $\beta$ -carotene), lycopene, anthraquinones glycoside belongs to family Caricaceae (5).

## MATERIALS AND METHODS

Valasartan materials were collected from Hetero Laboratories, Baddi, (H.P.) Pearlitol SD 200, Croscarmellose Sodium obtained from Lotus chemicals, Vizag, Sorbitol, Magnesium Stearate obtained from Mumbai Fine Chemicals. *Cassia tora* and Papaya purchased from the local market. All the chemicals and reagents used in this experiment were analytical grade.

### Extraction of *Cassia tora* Mucilage

*Cassia tora* seeds were primarily immersed in enough water for a period of 10 hours. The resulting hydrated mucilage was then spread together with seeds onto the stainless steel tray as a thin layer and dried in an oven at 50°C for 4–5h. The dried mucilage was scraped from the tray by blade, and isolated from the seeds by passing 18 mesh sieve. The mucilage was further purified by winnowing to separate the seed husk.

### Extraction of *Carica papaya* Starch Powder

Unripe papaya bought from a nearby market, and the starch had been removed. The papaya pulp was extracted, dried, ground, and blended with a solution of 0.05 per cent w / v. The mass was then allowed for squeezed via muslin cloth and several times washed with saline solution to eliminate the present soluble substances, starch, and mucilage. The mass obtained was then repeatedly washed until the supernatant solution became clear. The starch from the sediment was washed with distilled water until neutral pH. It was then sieved, dried and milled to fine powder at room temperature. Extracted *Cassia tora* mucilage and *Carica papaya* starch powder studied for physico-chemical properties shown in Table 1.

### Formulation of oral disintegrating tablets [6]

In this investigation Valsartan ODTs were formulated by direct compression method using both isolated *Cassia tora* and *Carica papaya* starch powder at different concentrations of 5%, 10%, 15%, and 20% w/w. All the ingredients were passed through 60 mesh sieve before making formulation. Precise amounts of all the ingredients were weighed and combined carefully to produce a consistent mixture. 200 mg tablets were punched using Cadmach single station punching machine with 10 mm round flat punches. The composition of the formulations is shown in Table 2.

### Evaluation of Blend

#### Angle of Repose

Angle of repose was measured by using fixed funnel method. The funnel was fixed at height (h) where the tip of the funnel is secured above graph paper placed on the horizontal flat surface. The blend was forced through a funnel that can be lifted vertically until it obtained a full cone height (h). The heap radius(r) was determined, and the angle of repose was estimated.

$$\theta = \text{Tan}^{-1} \left( \frac{h}{r} \right)$$





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### Bulk Density and Tapped Density

An exactly weighed quantity of 10gm of powder from separately each formula, formerly evenly shaken to break if any agglomerates formed, was placed into a 20ml measuring cylinder. After the initial volume ( $V_0$ ) was observed, the cylinder was allowed to fall under its own weight onto a solid surface from the height of 2.5cm at 2sec intervals. The tapping was continued till no additional change in volume ( $V_f$ ) was noted. The bulk density and tapped density were evaluated by using the following equation.

$$\text{Poured density} = \frac{W}{V_0}$$

$$\text{Tapped density} = \frac{W}{V_f}$$

Where,

W = weight of the powder

$V_0$  = initial volume

$V_f$  = final volume

### Carr's Index

Carr's index is a significantly important phenomenon for determination of flowability of powder blend. It can be obtained by substituting the bulk density and tapped density values in the following equation.

$$\text{Carr's index (\%)} = \frac{\text{Tapped density} - \text{Bulk density}}{\text{Tapped density}} \times 100$$

### Hausner's Ratio

The ratio between both the tapped and bulk density indicates the flow properties of powder through Hausner's ratio [7].

$$\text{Hausner's Ratio} = \frac{\text{Tapped density}}{\text{Bulk density}}$$

### Evaluation of Oral Disintegration Tablets

#### Weight Variation

The weight variation test was carried out individually by weighing 20 tablets and by measuring average weight. By comparing individual weight with average by the following equation.

$$\% \text{ Weight Variation} = \frac{(\text{Average Weight} - \text{Individual Weight})}{\text{Individual Weight}} \times 100$$

### Hardness

The mechanical strength of the tablet is determined by the Monsanto hardness tester. Six tablets were taken randomly and kept between the jaws, and pressure is applied by screwing its base, which is connected to the lower jaw. The force required to break a tablet into pieces can be expressed in ( $\text{kg}/\text{cm}^2$ ) [8].





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### Friability

A sample of twenty pre-weighed tablets was taken in the plastic chamber of laboratory friabilator. These tablets are subjected to abrasion or shock, which was initiated by the rotation of the chamber at 25 rpm for 4 min. The tablets were dusted and weighed again for final weight. The percentage friability can be calculated by using the following formula [9].

$$\text{Percentage Friability} = \left[ \frac{(\text{Initial Weight} - \text{Final Weight})}{\text{Initial Weight}} \right] \times 100$$

### Disintegration test

One tablet from the each formulation was picked up and placed in each tube of disintegration apparatus without disk, containing 900ml of pH7.4 phosphate buffer at  $37 \pm 2^{\circ}\text{C}$ . The time required to disintegration of tablet was noted.

### Wetting Time

A simple procedure is carried out to determine the wetting time. A tissue paper of 10 cm diameter is placed in the petridish containing 10ml of water soluble dye. The tablet was carefully placed on the top of the tissue paper [10]. The required time taken by the water to reach the surface of the tablet is noted.

### Water Absorption time

Water absorption time can be measured by taking weight of the tablet before keeping in the petridish noted as ( $W_b$ ), the wetted tablet is taken out and reweighed and noted as ( $W_a$ ). The water absorption, R can be calculated by below equation [11].

$$R = 100 (W_a - W_b) / W_b$$

Where  $W_a$  = weight of tablet after absorption

$W_b$  = weight of tablet before absorption

### Dissolution rate study

*In-vitro*, drug release was studied in the USP (Electro-Lab TDT-06L) six station dissolution apparatus. 900ml of phosphate buffer pH 6.8 was taken as dissolution media maintained at  $37 \pm 0.5^{\circ}\text{C}$ . Paddles are inserted into dissolution media, which was rotated at 50rpm. 5ml of dissolution media was withdrawn through a filter  $0.45 \mu\text{m}$  at each time intervals. Samples are diluted with 1%w/v and assayed for Valsartan at  $\lambda_{\text{max}}$  209nm using UV spectrophotometer. Fresh fluid was replaced into the dissolution medium after withdrawn [12].

### Kinetic studies on dissolution rate

The drug release kinetic was studied with plotting cumulative % drug released vs. time, log % drug remained vs. Time as zero order and first order kinetic respectively. From the slopes of linear plots, dissolution rate constants (k), correlation coefficients (r) and half-lives were calculated [13].

### Stability study

The selected formulation  $F_{CM7}$  (15% *Cassia tora*) and  $F_{PM7}$  (15% *Carica papaya*) were subjected to stability studies. The ODT was stored at  $40 \pm 0.5^{\circ}\text{C}$  and  $75 \pm 0.5\%$  RH, for 3 months and analysed for their physical parameters, disintegration time and drug content at 1, 2 and 3 month interval [14].



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## RESULTS AND DISCUSSIONS (15-18)

In this present study, the effect of disintegration between the two disintegrants (*Cassia tora* and Carica starch powder) had compared. The both disintegrants selected for formulation are characterized and subjected to physico-chemical properties shown in table 2. Both mucilage and starch powder were showing good flow properties with % yield more than 30% and having well been swelling properties and soluble in water. As the both disintegrating agents were from natural sources might be contaminated from microorganisms, will significantly modify the properties of dosage form.

So the microbial load is a key issue for the appropriateness of the materials for the use as pharmaceutical excipients. The overall aerobic counts for bacteria and fungi were within the limit for both additives (as per IP aerobic count < 1000cfu/gm and fungi count < 100cfu/gm). Valsartan ODTs were prepared by direct compression method. In the formulations perlitol SD-200 was used as a direct compressible vehicle and sorbitol as diluents and humectants, whereas talc, aerosil were used as glidant and magnesium stearate as lubricant. Aspartame, Vanilla was used as sweetening agent and flavour respectively. The pre-compression parameters such as bulk density, tapped density, angle of repose and Carr's index were conducted. The poured density was in the range of 0.425 to 0.661(gm/cm<sup>3</sup>) and tapped density was in the range of 0.525 to 0.752(gm/cm<sup>3</sup>). Furthermore the angle of repose found in the range of 21.56 to 31.21 was below 40° indicates good flow properties. In addition, the Carr's index were in range of 11.23 to 25.69 respectively showing good flow properties of powder blend.

From the above results, it was concluded that the powder blends showed excellent flow properties and summarized in Table 3. The post compression parameters such as thickness, hardness, friability, wetting time, disintegration time were conducted and shown in Table 4. It is well known that hardness is directly proportional to disintegration time. Since the mechanical strength has a significant role in formulation of ODTs, the hardness of all formulations was found in the range of 2.9±0.52 to 3.3±0.11 (Kg/cm<sup>2</sup>) and this indicates good mechanical strength. Friability was observed in the range of 0.32 to 0.68% is below 1% indicates within the limits. The content uniformity was high (≤101.3±0.13) shows within the acceptable limits. Thickness of tablets was in the range of 3.0±0.27 to be 3.1± 0.71mm. The disintegration time values show an optimized formulation from both disintegrants at specific concentration, i.e. F<sub>CM7</sub> and F<sub>PM7</sub> provide less time to disintegrate, which is primary requirement of ODTs formulation.

The in-vitro dissolution study was conducted in phosphate buffer pH 6.8 for all formulations shown in Table 5 and Fig 3. The formulations F<sub>CM7</sub> and F<sub>PM7</sub> showed highest dissolution. The drug release of Valsartan follows first-order kinetics, which clearly shown linear graph on the plot between % drug released and time shown in Table 6 and Fig 4. In-vitro dissolution kinetics data was calculated and shown in Table.7. By the above data, F<sub>PM7</sub> was found to be optimized formulation for preparation of Valsartan ODT. The selected formulations F<sub>CM7</sub> (15% *Cassia tora* Mucilage) and F<sub>PM7</sub> (15% Caricastach powder) were subjected to stability studies. The ODT was stored at 40±0.5°C and 75±0.5% RH, for 3 months and analysed for their physical parameters, disintegration time and drug content at 1, 2 and 3 month interval shown in Table 8 and Fig 5. According to the stability data, formulation F<sub>PM7</sub> (15% *Caricapapaya* ) is subjected to in-vitro dissolution at 1, 2 and 3rd-month interval shown in Table.9.and Fig .6.

## CONCLUSION

From the present comparative study, finally it was concluded that formulation F<sub>PM7</sub> contains 15% *Caricapapaya* as a natural disintegrant has faster disintegration time and highest dissolution rate among all formulations. Stability studies showed better results in all parameters, studied at 40±0.50C and 75±0.5% RH, for 3 months. Therefore, F<sub>PM7</sub> was an optimized formulation for preparing Valsartan Oral disintegrating tablet.





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**Table 1: Physicochemical parameters of *Cassia tora* mucilage and *Cassia papaya* Starch Powder**

Parameters	<i>Cassia tora</i> Mucilage	<i>Carica papaya</i> Starch Powder
Angle of repose	21.45 <sup>0</sup>	29.34 <sup>0</sup>
Bulk density	0.524	0.432
Tapped density	0.592	0.511
Average particle size	199 $\mu$ m	183 $\mu$ m





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Compressibility ratio	16.25	15.408
Loss on drying	9.5%	14%
Percentage yield	31%	32%
Swelling ratio in water	12	22.32
Solubility	12.53%	19.32%
Total ash	18.35%	21.33%
Acid insoluble ash	2.75%	5.2%
Microbial Load Bacteria (CFUs/g)	8	5
Fungi(CFUs/g)	6	4

**Table 2: Formulation of Valsartan ODTs with *Cassia tora* mucilage and *Carica papaya* mucilage in different concentration.**

Ingredients(mg)	FCM5	FCM6	FCM7	FCM8	FPM5	FPM6	FPM7	FPM8
<b>Valsartan</b>	80 (40%)							
<b>Pearlitol SD 200</b>	74 (37)	64 (32)	54 (27)	44 (22)	64 (32%)	54 (27%)	44 (22%)	34 (17%)
<b><i>Cassia tora</i> mucilage</b>	10 (5%)	20 (10%)	30 (15%)	40 (20%)	---	---	---	---
<b><i>C.papaya</i> mucilage</b>	---	---	---	---	10 (5%)	20 (10%)	30 (15%)	40 (20%)
<b>Sorbitol</b>	20 (10%)							
<b>Other excipients</b>	12 (6%)							
<b>Aspartame</b>	4 (2%)							

**Table 3: Pre-compression Parameters**

Formulation (Product Code)	Poured density (gm/cm3)	Tapped density (gm/ cm3)	Angle of repose°	Carr's Compressibility Index (%)
FCM5	0.531	0.612	27.12	13.23
FCM6	0.524	0.651	30.14	19.50
FCM7	0.583	0.695	27.9	16.11
FCM8	0.661	0.752	31.21	12.10
FPM5	0.425	0.572	22.68	25.69
FPM6	0.445	0.563	25.61	20.95
FPM7	0.461	0.532	23.22	13.34
FPM8	0.466	0.525	21.56	11.23



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Table-4: Post Compression Parameters

Parameters	Formulation code							
	FCM5	FCM6	FCM7	FCM8	FPM5	FPM6	FPM7	FPM8
Average weight (mg)**	198.55±0.22	200.23±0.12	199.76±0.14	200.14±0.2	197.33±0.13	198.34±0.33	199.21±0.61	199.1±0.61
Content Uniformity (%) <sup>‡</sup>	98.34±0.63	97.19±0.53	98.71±0.31	98.16±0.27	98.03±0.64	98.32±0.23	98.78±0.29	98.14±0.61
Weight variation (%) <sup>‡</sup>	0.61	0.53	0.71	0.33	0.77	0.68	0.71	0.81
Thickness (mm) *	3.0±0.51	3.1±0.31	3.01±0.42	3.0±0.65	3.0±0.33	3.0±0.17	3.1±0.71	3.0±0.27
Hardness (Kg/cm <sup>2</sup> )*	3.1±0.61	3.0±0.12	3.0±0.41	2.9±0.52	3.2±0.46	3.2±0.33	3.2±0.56	3.3±0.11
Friability (%) <sup>‡</sup>	0.68	0.44	0.51	0.34	0.55	0.48	0.32	0.53
Wetting time (sec) **	64	63	52	58	36	32	29	39
Water Absorption ratio (%) **	62±0.34	60±0.35	69 ±0.28	56±0.41	82±0.25	85±0.45	80±0.56	78±0.38
Disintegration Time(sec)*	66±0.34	65±0.56	55±0.22	61±0.46	40±0.21	35±0.22	33±0.31	42±0.33
Residual remain on the screen <sup>‡22</sup>	No	No	No	No	No	No	No	No
Taste /mouth feel*	Palatable	Palatable	Palatable	Palatable	Palatable	Palatable	Palatable	Palatable



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Table 5: Dissolution time profile

Time (min)	FCM5	FCM6	FCM7	FCM8	FPM5	FPM6	FPM7	FPM8
0	0	0	0	0	0	0	0	0
2	8.41	7.23	8.51	6.29	6.71	7.98	12.66	11.36
5	24.63	22.21	20.4	20.78	20.14	25.43	34.08	30.44
10	45.61	48.77	51.13	44.33	47.42	56.16	62.57	60.64
15	61.23	65.41	68.41	64.11	66.89	71.32	80.44	73.46
25	90.45	83.39	93.55	89.63	83.59	87.17	93.55	90.55

Table 6: Log% drug remained

Time(min)	FCM5	FCM6	FCM7	FCM8	FPM5	FPM6	FPM7	FPM8
0	2	2	2	2	2	2	2	2
2	1.9618	1.9674	1.9613	1.9717	1.9698	1.9638	1.9412	1.9746
5	1.8772	1.8909	1.9009	1.9009	1.9023	1.8725	1.8190	1.8423
10	1.7355	1.7095	1.6890	1.6890	1.7208	1.6418	1.5732	1.5950
15	1.5885	1.5389	1.4995	1.5549	1.5199	1.4575	1.2913	1.4239
25	0.9800	1.220	0.8095	1.0157	1.2151	1.1082	0.8095	0.9754

Table 7: In vitro drug release kinetics

Formulations	Zero Order			First Order		
	Slope	r <sup>2</sup>	K <sub>0</sub>	Slope	r <sup>2</sup>	K <sub>1</sub>
FCM5	3.6288	0.9927	3.6288	-0.0397	0.9775	0.0914
FCM6	3.4800	0.9755	3.4800	-0.0320	0.9984	0.0738
FCM7	3.8700	0.9853	3.8770	-0.0471	0.9798	0.1085
FCM8	3.7105	0.9910	3.7105	-0.0392	0.9845	0.0903
FPM5	3.5343	0.9755	3.4572	-0.03264	0.9969	0.0751
FPM6	3.6507	0.9625	3.656	-0.03689	0.9981	0.0849
FPM7	3.8295	0.9517	3.7249	-0.0487	0.9986	0.1121
FPM8	3.6930	0.9584	3.5792	-0.04148	0.9986	0.0955

Table 8: Evaluation of optimized formulations subjected to stability study

Time in Months	Formulation FCM7 stored at 40±0.50C and 75±0.5% RH				Formulation FPM7 stored at 40±0.50C and 75±0.5% RH			
	Hardness (kg/cm <sup>2</sup> )	Disintegration Time (Sec)	Wetting time (sec)	Drug content (%)	Hardness (kg/cm <sup>2</sup> )	Disintegration Time (Sec)	Wetting time (sec)	Drug content (%)
0	3.0±0.41	55±0.15	52	98.71±0.31	3.2±0.56	33±0.31	75	98.78±0.29
1	3.0±0.66	56±0.22	53	98.55±0.51	3.2±0.34	31±0.61	75	97.01±0.23
2	3.0±0.14	55±0.31	53	98.15±0.18	3.1±0.66	34±0.35	77	97.33±0.43
3	2.9±0.33	57±0.44	53	97.89±0.62	3.1±0.26	34±0.22	77	97.54±0.37

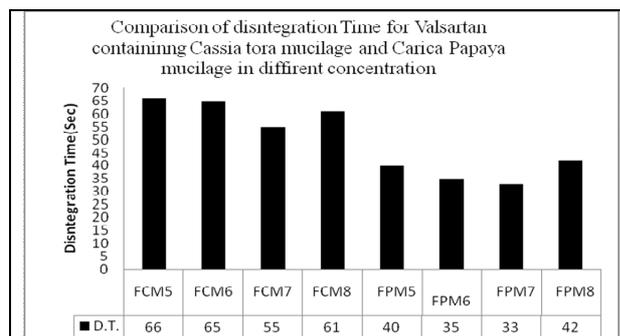




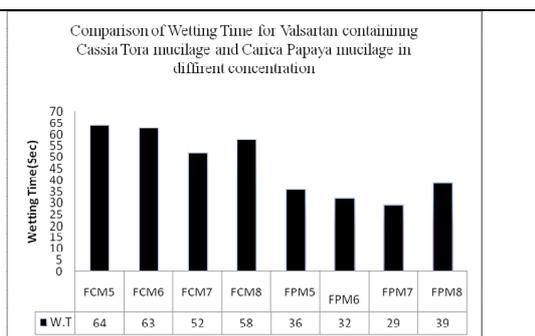
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**Table 9: Dissolution study of Optimized Formulation F<sub>PM7</sub> subjected to stability study**

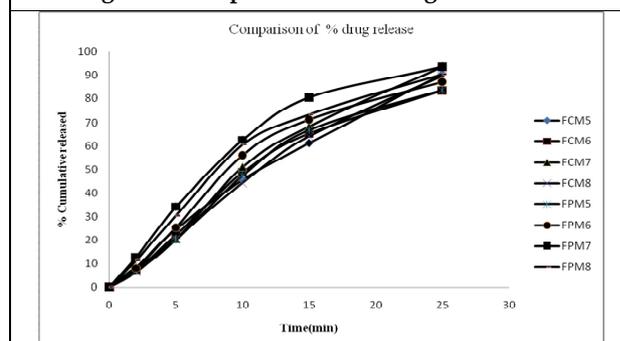
Time (months)	Cumulative % Drug Released of F <sub>PM7</sub> stored at 40±0.05°C and 75±0.05 % RH					
	At 0 min	At 2 min	At 5 min	At 10 min	At 15 min	At 25 min
0	0	11.04	32.18	60.54	77.56	90.35
1	0	10.89	30.54	59.61	76.12	89.55
2	0	11.25	31.21	59.22	75.14	88.22
3	0	10.42	30.24	58.45	75.77	89.75



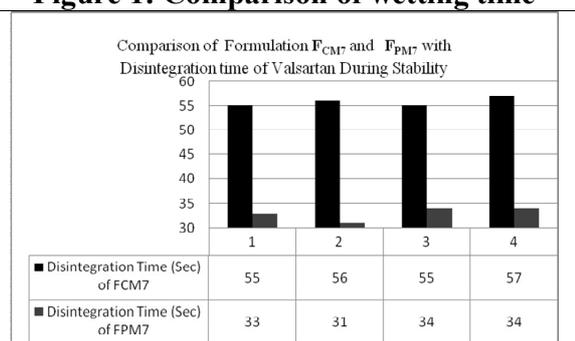
**Figure 1: Comparison of Disintegration Time**



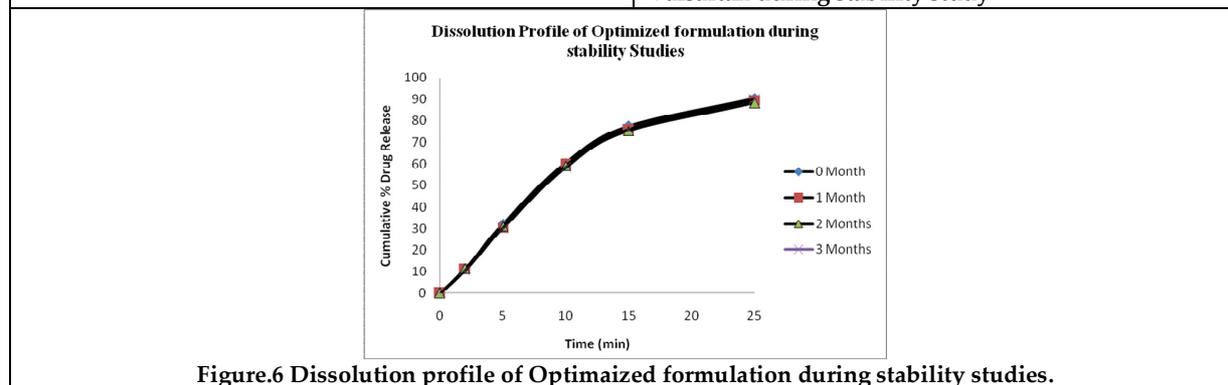
**Figure 1: Comparison of wetting time**



**Figure 3: Comparison of Cumulative drug release**



**Figure 5: Comparison of Disintegration time of Valsartan during stability study**



**Figure.6 Dissolution profile of Optimaized formulation during stability studies.**





## Nano Carrier System: A Novel Approach for Ocular Drug Delivery

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### ABSTRACT

Nanoformulations (nanodrug) are superior to traditional medicine with respect to control release, targeted delivery and therapeutic effects. Such nanomedicine targeting capabilities are influenced by particle size, surface charge, surface modification, and hydrophobicity. Among these, it is important to determine the size and size distributions of nanoparticles for their interaction with the cell membrane and their penetration across the physiological drug barriers. The size of nanoparticles used to cross different biological barriers depends on the tissue, target site and circulation. For the cellular internalization of the nanoparticles, surface charge is important in determining whether the nanoparticles would cluster in blood flow or would adhere to, or interact with oppositely charged cell membranes. Persistence of nanoparticles is needed in systemic circulation of the body For the targeted delivery. But the fixed macrophages of the mononuclear phagocytic system organs rapidly opsonize and massively clear the conventional nanoparticles with hydrophobic surface. The surface of conventional nanoparticles are modified with different molecules to improve circulation time and persistence in the blood. Coating of hydrophilic polymers can create a cloud of chains at the particle surface which will repel plasma proteins. Finally, morphological characteristics, surface chemistry, and molecular weight influence the performance of nanoparticles in- vivo. Surface modified nanoparticles have anti-adhesive properties by virtue of the extended configuration on the particle surface which acts as steric barrier reducing the extent of clearance by circulating macrophages of the liver and promoting the possibility of undergoing enhanced permeation process. Release mechanism can be modulated by the molecular weight of the polymer used. Higher the molecular weight of polymer slower will be the in- vitro release of drugs. Nanoparticles are receiving considerable attention for the delivery of therapeutic drugs. The literature emphasizes the advantages of nanoparticles over microparticles and liposomes.

**Keywords:** Nanoparticle, ocular, current trends, drug delivery, controlled release.





## INTRODUCTION

In the delivery of ophthalmic drugs rapid elimination of the dosage form is the main problem thus reducing the residence time of drug product, for which frequent instillation dosage is required. Frequent instillation of dosage form may create systemic toxicity and side effects. Therefore a controlled and prolonged delivery is necessary. The idea for controlled drug delivery system, which was a bystander for a time being, paved the way for a nanoparticulate drug delivery system. To circumvent the complex anatomical structure of human body this type of drug delivery system can be a better way. As the human body or finely speaking the cell is concerned, is accustomed to take foreign matters in finest form as per the permeability is concerned. Drug to be delivered to a particular site is entrapped in a polymeric matrix as particulates. The particulate could be in nano form (nanocapsules, nanocrystals or nanoparticulate).

Albert Franks, an early promoter of nanotechnology, defined it as the field of science and technology in which dimensions and tolerances range from 0.1 to 100 nm (1). Drug delivery system containing nanoparticles have made a significant increase in targeting of drugs to organs having special pharmacokinetic properties and also nanoparticulate drugs have much more surface area, making the drug more bioavailable. With this concept in mind nanoparticulated drugs are playing a major role in ocular drug delivery system. Nanoparticles receive considerable attention when supplying therapeutic drugs. The literature highlights nanoparticles' advantages of over microparticles and liposomes. Nanoparticles submicron size offers a number of distinct advantages over microparticles, including relatively higher intracellular absorption compared to microparticles.

The surface of nanoparticle is also a very important consideration when it comes to targeting drug delivery. In fact, once in the bloodstream; the fixed macrophages rapidly opsonize and massively clear conventional nanoparticles (no surface modifications) and negatively charged particles. It is well known that the reticuloendothelial system, primarily the liver and spleen, is a major obstacle to active targeting due to its ability to identify these systems, eliminate them from systemic circulation and thus prevent the effective delivery of the nanospheres to organs other than those of the reticuloendothelial system. Surface modification of these hydrophilic polymers nanoparticulate systems is the most common way of controlling the opsonization process and improving the surface properties of the system, or coating modifications with polymers, such as the attachment of polyethyleneglycol (PEG) chains to biodegradable polymer such as polylactic acid (PLA) and polylactic-co-glycolic acid (PLGA). The hydrophilic PEG chains thus enable protein and peptide absorption to be controlled and, in addition enable regulation of cell behavior at the polymer surface (5).

These nanoformulations drugs (nanodrug) are superior to traditional medicine with regard to release control, targeted delivery and therapeutic effect. These nanomedicine targeting capabilities of are affected by particle size, surface charge, surface modification, and hydrophobicity. Among these, it is important to determine the size and size distributions of nanoparticles for their interaction with the cell membrane and their penetration across the physiological drug barriers. The size of nanoparticles used to cross various biological barriers depends on the tissue, target site and circulation. For the cellular internalization of nanoparticles, surface charging is important in determining whether the nanoparticles would cluster or adhere to blood flow or interact with cell membranes charged to the opposite end. Persistence of nanoparticles is needed in the systemic circulation of the body for targeted delivery. But the fixed macrophages of the mononuclear phagocytic system (MPS) organs are rapidly opsonizing and massively clearing typical nanoparticles with a hydrophobic surface. The surface of conventional nanoparticles is modified with different molecules to increase the circulation time and persistence in the blood. Coating of hydrophilic polymers at the particle surface can create a cloud of chains that will repel plasma proteins. Finally, morphological characteristics, surface chemistry, and molecular weight influence the performance of nanoparticles in- vivo. Surface modified nanoparticles have anti-adhesive properties due to the extended particle surface configuration that acts as steric barrier minimizing the degree of clearance by circulating liver macrophages



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and promoting the possibility of enhanced permeation. The molecular weight of the polymer used can modulate the release mechanism. Higher the polymer's molecular weight slower would be drug release in- vitro (12). The development of hydrophilic drug delivery strategies emerges as an important research area for several reasons: (i) increasing interest in macromolecules, such as nucleic acids, peptides or proteins, for the treatment of a wide range of diseases such as cancer, infectious and inflammatory diseases, and (ii) the importance of small, hydrophilic drugs currently under production. It is clear that when macromolecules and small drugs are administered the problem is different. Therefore, although the discovery of macromolecules has opened up many perspectives in therapeutics, their use is often limited by low bioavailability due to their poor stability against proteolytic and hydrolytic degradation, low barrier permeability across and short biological half-life in the circulatory system, whereas the use of small, hydrophilic drugs such as anticancer agents is often associated with harmful side effects, or improper bio distribution. For several years, nanomedicines have been used for many years to encapsulate and target drugs to get through those crucial points. Drug encapsulation in colloidal systems offers many benefits, such as: (i) protecting the drug against in- vivo degradation, (ii) reducing the potential toxic side effects of direct solution administration, (iii) increasing patient comfort by avoiding repetitive bolus injections or using perfusion pumps, and (iv) achieving more favorable drug pharmacokinetics (2).

**Rationale**

The drug is applied to the surface of the eye for two purposes: to treat the outside of the eye for such infections as conjunctivitis, blepharitis, keratitis sicca and to treat diseases such as glaucoma or uveitis intraocularly via the cornea. The majority of ocular diseases are treated as eye-drops with topical application. For soluble drug eye drops require frequent instillations of highly concentrated solutions. The practical reasons for choosing solutions are the generally favorable cost advantage, the greater simplicity in the development and manufacturing of formulations and the patient's strong acceptance despite a little blurring (3). Upon instillation of an eye drop, usually less than 5% of the drug used penetrates the cornea and reaches intraocular tissues, whereas a large fraction of the instilled dose is often systemically absorbed through the conjunctiva and nasolacrimal duct (4). Therefore repeated formulation administration is needed. Prolonged dosage forms of action can modestly increased bioavailability and duration of activity, but patients have not gained broad acceptance. Even from the modified formulations the absorption of the ocular drug is restricted by the eye's corneal and conjunctival epithelial barriers.

Topical ocular drugs do not reach the drug targets of the posterior segment. High doses of drugs given intravenously or by intravitreal can be used to treat the posterior segment. There is currently a rapidly increasing interest in the posterior segment drug delivery. This is caused by the advances in understanding the retinal and choroid pathophysiological processes. Many posterior segment diseases (age related macular degeneration, retinitis pigmentosa, diabetic retinopathies and glaucoma-induced neural changes) cannot be effectively treated using current methods. Delivery of both small molecules and larger bio-organic compounds such as proteins and DNA in the posterior segment is problematic. Only drugs with large therapeutic index (such as antibiotics) can be administered to blood stream in massive doses for treatment of the posterior segment. On the other hand, intravitreal injection is an invasive procedure, and may even cause endophthalmitis. Hence, for large numbers of patients, it is not considered to be an ideal method of drug administration.

There is therefore an increasing interest in developing new, prolonged action dosage forms for subconjunctival and periocular administration. The residence time of the drug is much more important, which depend upon the property of the vehicle used in the formulation of dosage form. Furthermore, there is also possibility of over flowing of excess amount of drug through the nasal route and systemic circulation. Thus increasing the chances of systemic toxicity (5). It is known that for most of the drugs applied ocularly are having the elimination rate constant much greater than the absorption rate constant, thus, showing a flip-flop model. Reducing the dose volume from 25 microliter to 0 brings a fourfold improvement in bioavailability (6). But it is practically impossible to have zero dosing volume. It can be concluded that instead of adding much more volume of drugs, appropriate vehicle should be introduced so that drugs could be incorporated into it easily and show a sustained release profile.



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As the name indicates, nanoparticles have more surface area than particles having nano size range. They also have a long shelf-life, safe materials, including synthetic biodegradable polymers, natural biopolymers, lipids and polysaccharides, and have the potential to overcome major mucosal barriers, such as the intestinal, nasal and ocular barriers (7).

**Findings of various workers**

Nanoparticles were revealed to be effective as ocular drug delivery systems by prolonging the duration of the drug action. The first experiment included piloplex systems using a poly (methyl methacrylate-acrylic acid) copolymer consisting of pilocarpine-loaded nanospheres (8). Piloplex has lowered the intra-ocular pressure in clinical trials (9). Wood et al. (1985) showed that after administration of poly alkyl cyanoacrylate (PACA) nanospheres labeled with [14]-C to rabbit, the degradation of nanoparticles in tears occurred at a relatively rapid rate for the first hour with a degradation of about 19 percent. It was interesting to note that in the cornea and conjunctiva, only 0.1 percent of the initial amount was found. However, after instillation, that concentration was relatively constant for 6 h. This result suggested that nanospheres adherence to the corneal and conjunctival surfaces was possible (10). Further research was carried out by Harmia et al. (1986), studying pilocarpine containing polybutylcyanoacrylate nanospheres.

Two formulations were tested: the first containing pilocarpine within the matrix of the particle, the second containing pilocarpine adsorbed onto the particle surface. For both formulations the intensity of miotic response was same. However, the formulation on the surface of the particle containing the drug retained the effect for a longer time. As described above, the result, which was not significant with pilocarpine included within the nanospheres, was associated with a slow and incomplete degradation of the polymer in tears (11). Diepold et al. (1989) made the same conclusions when pilocarpine nitrate loaded onto nanospheres (12). These results were confirmed in a poly butyl cyanoacrylate nanospheres study (13).

The lipophilic nature of the drug (progesterone) resulted in an encapsulation rate in the carrier of about 100 percent, but the drug's strong affinity for the polymer and the polymer's slow degradation did not provide an adequate release of the drug. Thus, the main problem with the use of alkylcyanoacrylate nanospheres appears to be very slow drug release out of the matrix compared to the particle's residence time in the precorneal area. The same experiment was carried out with the incorporation of a hydrophilic antibiotic, amikacin sulfate into poly-isobutylcyanoacrylate nanospheres (14). Increase the concentration of amikacin in the aqueous humor and cornea was statistically important with respect to the control solution for nanospheres. The matrix system used for hydrophilic drugs was limited due to a slow drug desorption from the polymeric nanospheres. Such findings are in line with the conclusion of Marchal-Heussler et al. (1990), which found that surface charge and the binding form of the drug to nanospheres were the most significant factors in enhancing another drug's therapeutic response, betaxolol (15).

The same authors compared the efficiency of nanoparticles in further studies as a function of the polymer that constitutes the drug delivery system. In various nano formulations, Marchal-Heussler et al. (1992, 1993) tested poly-ε-caprolactone, polylactic-co-glycolic acid copolymers and poly-isobutylcyanoacrylate polymer. The decrease in intraocular pressure of antiglaucomatous drugs such as betaxolol and carteolol has become more pronounced with poly-ε-caprolactone (nanospheres or nanocapsules) used by colloidal carriers. The hydrophobic the carrier seems to be, the higher the drug's ocular activity. The mechanism of action appeared to be directly related to the agglomeration in the conjunctival sac of the poly-ε-caprolactone nanoparticles. In addition, the nanocapsules showed a better effect for poly-ε-caprolactone than nanospheres, probably because the entrapped drug was unionized in the oily core of the carrier and could spread more frequently into the cornea.

It appears that diffusion of the drug from the oily phase to the corneal epithelium is more efficient than diffusion from the nanospheres internal matrix. This new method of dosage form provided an improved therapeutic effect with a much lower concentration of drugs, thereby reducing systemic effects (16, 17). Losa et al. (1991, 1992, 1993) proved this by integrating the ophthalmic administration of metipranolol in either poly-ε-caprolactone or



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polybutylcyanoacrylate nanocapsules (18, 19, 20). In an ex-vivo study, Le Bourlais et al. (1997) showed that poly-isobutylcyanoacrylate nanocapsules increased bovine corneal absorption of cyclosporin (5.8%) compared to an oily vehicle as the control (2.5%) (21). They also found that there was minimal penetration of the drug into the cornea with a partitioning that was basically located on the epithelium's superficial layers and no complete penetration (22, 23, 24). Alonso et al. (1995) showed that poly-ε-caprolactone nanocapsules, nanospheres and nanoemulsions provided two lipophilic drugs (cyclosporin and indometacin) for corneal absorption.

They showed that compared to the oily solution, the corneal absorption of cyclosporine was five times superior with poly-ε-caprolactone nanocapsules (25). Calvo et al. (1996) compared corneal penetration through isolated cornea using encapsulated nanoparticles of indomethacin, poly-ε-caprolactone nanocapsules and emulsions of submicron indomethacin. The increased penetration for the three formulations examined during the 6 h of the study was more than 3-fold than that of the commercial eye-drops. The authors concluded that the principal factor responsible for indomethacin's favorable corneal transport was the colloidal character of these carriers, rather than their internal structure or composition (26). Most authors accepted that nanoparticles don't tend to be responsible for corneal toxicity or irritation. Some authors (Marchal- Heussler et al., 1992, 1993; Calvo et al., 1994; Zimmer et al., 1991), however found that PACA nanoparticles damaged the corneal epithelium by disrupting the cell membranes. However, they did not mention any toxicity to the corneal epithelium cells in their observations of PELC nanocapsules (16, 17, 27, and 28). In conclusion, the results of the various studies demonstrate the potential of colloidal systems as ocular drug delivery systems for either hydrophobic or hydrophilic drugs in liquid dosage forms that do not interfere with vision.

Keeping these things in eye novel nano particulate system have been developed enhancing the hosting capacity, targeting to the site etc. These are explained below briefly SLN (solid lipid nanoparticle), NLC (nanostructured lipid carrier), LDC (lipid drug conjugate) (29, 30). SLN This type of particulate form is having following advantages. Excellent physical stability, protection of incorporated labile drugs from degradation, controlled drug release, good tolerability, site specific targeting. Though some amount of novelty has been brought forward still some lacuna has been found out. They are insufficient loading capacity because incorporated drugs are located between fatty acid chain thus forming highly ordered crystal lattice, so less accommodation. Drug explosion after polymeric transition during storage (29).

NLC To overcome the above mentioned disadvantages NLC was introduced (31). The problem regarding the accommodation of drug molecules was solved by this particulate system. This particulate system denied the crystal lattice formation of the lipid outer layer. This was achieved by three methods like adding spatially different lipid glycerides composed of different fatty acids. Thus leading to an imperfect NLC. The best hosting was achieved by mixing the solid lipids with small liquid lipid. In the second formulation type the drug was dissolved in the lipid environment and it was entrapped in the solid lipid envelope the solid envelope provides a protecting environment around the lipid. This type is multiple NLC. Since drug explosion is caused by ongoing crystallization and transformation solid lipid. This paved the way for again modulation of the particulate system thus an amorphous type of NLC which was created by not adding hydroxyoctacosanylhydroxystearate and isopropylmyristate (60) (32).

LDC SLN are useful for lipophilic drugs incorporation. only highly potent hydrophilic drugs that are effective in low concentrations can be firmly incorporated into solid lipid matrix due to partitioning effects during the development process (33). The so called LDC nanoparticles with drug loading capacity of up to 33% were developed at the end of the millennium to overcome this limitation (30). An insoluble drug-lipid conjugate bulk is prepared either by formation of salt or by covalent bonding. The free drug base and fatty acid are dissolved in an appropriate solvent during the salt formation process. The solvent then evaporates under reduced pressure. The drug in the form of a salt and a fatty alcohol reacts in presence of a catalyst for the covalent linking and the LDC bulk is then processed with an aqueous surfactant solution to a formulation of nanoparticle using high pressure homogenization (HPH).





Most notably the interaction of the colloidal carriers with the phagocytes requires some serum components and then subsequently interaction with complement receptors.  $F_c$  receptors and sugar lecithin receptors on the macrophase, lymphocytes or other cells. Due to this type of peculiar drug delivery characteristics the nanoparticulate drug delivery system can be used for drug targeting in critical and special part of the body having peculiar anatomical characteristics. Mainly the drug formulations are administered in the cul-de-sac region of the eye, the drug is absorbed through the conjunctiva or corneal route as per the lipophilicity and hydrophilicity of the drug is concerned.

### Management and control of ocular diseases

The eye is a unique organ, being relatively unprotected as it is constantly exposed to atmospheric oxygen, environmental chemicals and physical abrasion. Anatomically human eye can be broadly divided into anterior segment and posterior segment. The major diseases affecting the eye include retinopathy, diabetic retinopathy, corneal neovascularization, keratitis, conjunctivitis, age-related macular degeneration (AMD), diabetic macular edema (DME), cataract, proliferative vitreoretinopathy (PVR), uveitis, cyto-megalovirus (CMV), and glaucoma. Various classes of drugs, such as antiviral, antibacterial, corticosteroids, sympathomimetics, antioxidants, antihistaminics, carbonic anhydrase inhibitors, angiotensin blockers etc. are widely used as therapeutic agents for the cure of these ailments (7).

### Role of nanoparticulate carrier to overcome the limitations

Prior to understand nanoparticle and its role in ocular drug delivery we should have a brief idea about ocular anatomy and drug transportation channels. The most prominent method of ocular drug delivery is to deliver the drug in to the cul-de-sac. Absorption may be corneal or non corneal at this site. The so called non corneal route of absorption involves penetration into the intra ocular tissues through the sclera and conjunctiva. This absorption mechanism is usually non-productive, as drug penetrating the surface of the eye beyond the limbus of the corneal sclera is taken up by the local capillary beds and added to the general circulation. In general, this non-corneal absorption prevents entry into the aqueous humour.

Non corneal absorption may be significant for drug molecules with poor corneal permeability. Studies with inulin, timolol maleate, gentamicin, and prostaglandin  $PGF_{2\alpha}$  suggest that these drugs gain intraocular access by diffusion across the conjunctiva and sclera. The noncorneal route of absorption may be significant for poorly cornea-permeable drugs; however, corneal absorption represents the major mechanism of absorption for most therapeutic entities. Topical absorption of these agents is considered to be rate limited by the cornea. The anatomical structure of the cornea exerts unique differential solubility for drug candidates. In terms of transcorneal flux of drugs, the cornea can be viewed as a trilaminar structure consisting of three major diffusional barriers: epithelium stroma and endothelium. The epithelium and endothelium contain on the order of 100-fold the amount of lipid material per unit mass of the stroma. Depending on the physicochemical properties of the drug entity, the diffusional resistance offered by this tissue varies greatly.

The outer most layer, the epithelium, represents the rate-limiting barrier for transcorneal diffusion of most hydrophilic drugs. The epithelium is composed of five to seven cell layers. The basement cells are columnar in nature, allowing for minimal paracellular transport. The epithelial cells, however narrow distal to Bowman's membrane, forming flattened epithelial cells with zonulae occludens interjunctional complexes. This cellular arrangement precludes paracellular transport of most ophthalmic drugs and limits lateral movement within anterior epithelium. Corneal surface epithelial intracellular pore size has been estimated to be about  $60\text{\AA}$ . Small ionic and hydrophilic molecules appear to gain access to the anterior chamber through these pores, however for most of the drugs paracellular transport is precluded by the interjunctional complexes to improve ocular bioavailability. This approach has however only met with moderate success and has the potential to severely compromise the corneal integrity.



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Sandwiched between the corneal epithelium and endothelium is the stroma. The stroma constitutes 85-90% of the total corneal mass and is composed of mainly hydrated collagen. The stroma exerts a diffusional barrier to highly lipophilic drugs owing to its hydrophilic nature. There are no tight junction complexes in the stroma, and paracellular transport through this tissue is possible. The innermost layer of the cornea, separated from the stroma by Descemet's membrane, is the endothelium. The endothelium is lipoidal in nature; however it does not offer a significant barrier to the transcorneal diffusion of most drugs. Endothelial permeability depends solely on molecular weight and not on the charge or hydrophilic nature of the compound. Transcellular transport on the corneal epithelium and stroma is the major mechanism of ocular absorption of topically applied ophthalmic pharmaceuticals.

Nanoparticles provide controlled drug release and prolonged therapeutic effect. For this property the particles have to be retained in the cul-de-sac after topical administration, and the entrapped drug must be released from the particles at an appropriate rate. The utility of nanoparticle as an ocular drug delivery system may depend on optimizing lipophilic-hydrophilic properties of polymer drug system, optimizing rates of biodegradation in precorneal pocket and increasing retention efficiency in precorneal pocket. It is highly desirable to formulate the particles with bioadhesive materials in order to enhance the retention time of particles in the ocular cul-de-sac. Without bio adhesion could be eliminated as quickly as aqueous solution from the precorneal site. Bioadhesive systems can be either polymeric solutions or particulate systems. Several studies using natural bioadhesive polymers demonstrating improvements in ocular bioavailability, synthetic biodegradable and bioadhesive polyalkylcyanoacrylate systems were developed they may prove to be most promising particulate ocular drug delivery system in the future. Polyalkylcyanoacrylates gained popularity because of their apparent lack of toxicity and can be successfully used in surgery. This is from a toxicological view of referred pharmaceutical drug delivery system.

Efflux pumps have been identified and significant enhancement in ocular drug absorption was achieved following their inhibition. To maintain minimum inhibitory concentration the agent used to be frequently dosed resulting in poor patient compliance. Blood retinal barrier is selectively permeable to more lipophilic drugs or molecule this results in frequent administration of high amount of drug leading to systemic side effect. Intravitreal administration offer high concentration of drug in retina. This may cause various short term complication like retinal detachment, endophthalmitis (34). Periocular route has been considered as the most promising and efficient route for administration of drugs to posterior segment of eye. Injecting of drugs produces many complications rises in intra ocular pressure, cataract, hyphema strabismus and corneal decompensation.

An optimum ocular drug delivery system would be one which can be delivered in eye drops with no creation of blurred vision or irritancy and which would need no more than one to instillation each day. Owing to leakiness of the conjunctiva rich blood flow and large surface area, conjunctival uptake of a topically applied drug from tear fluid is typically an order of magnitude greater than corneal uptake. Physicochemical drug properties such as lipophilicity solubility molecular size and shape, degree of ionization affect the route and rate of permeation in cornea. Drugs penetrate across the corneal epithelium via transcellular and paracellular pathways. Lipophilic drugs prefer the transcellular pathways hydrophilic drugs prefer the paracellular path. Nanoparticles formed from bioadhesive polymers forms a covalent bond with the mucine coating. Covering the conjunctiva and corneal surfaces of the eye is the mucin coat. The mucous layer secreted by goblet cells of conjunctiva is multifunctional in role. It hydrates, cleanses, lubricates and serves as a defense against pathogens; ocular mucoadhesion relies on the interaction the polymer. Bioadhesive polymers are usually macromolecular hydrocolloids with numerous hydrophilic functional groups. Gellan gum a polysaccharide secreted by *Pseudomonas ebolain* aqueous solution forms a clear anionic gel. They have been studied for their ocular and percutaneous tolerability. Some commercial formulations hydrogels are widely accepted as tear substitutes because of their prolonged residence time on the eye surface. Gulsen et al. (2004) have recently developed a disposable soft contact lens of drug containing microemulsion dispersed in a poly-2-hydroxyethylmethacrylate (HEMA) hydrogel suitable for ophthalmic delivery, in an attempt to reduce drug loss and side effects (35). The use of water soluble polymer to enhance the contact time and possibly also the penetration of



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drug was first proposed by Swan et al. (1945). Cyclodextrin a complexing agent entraps the hydrophilic and photo unstable drug molecule and enhances the stability. The hydrolytic stability of curcumin under alkaline condition was strongly improved by complex formation while the photo decomposition rate was increased compared to curcumin in organic solvent (effect of polymer in stability of curcumin). The cavity size and the charge and bulkiness of the cyclodextrin side chain influenced the stability constant for complexation and the degradation rate of curcumin molecule (36).

### Preparation technique

PNPs (polymeric nanoparticles) can be prepared conveniently either from preformed polymers or by direct monomer polymerization using classical polymerization (46). Methods such as solvent evaporation, salting-out, dialysis and supercritical fluid technology, which include the rapid expansion of a supercritical solution or the rapid expansion of a supercritical solution into liquid solvent, can be used to prepare PNP from preformed polymers. On the other hand, the polymerization of monomers can directly synthesize PNPs by using various polymerization techniques such as micro-emulsion, mini-emulsion, surfactant-free emulsion and interfacial polymerization. The method of preparation is chosen based on a number of factors such as the type of polymeric system, area of application, size requirement, etc. For instance, a polymeric system that is developed for use in the biomedical or environmental fields should be fully free from reactants such as surfactants or organic solvents traces. In this case it is possible to choose techniques such as RESS (rapid expansion of a supercritical solution) or RESOLV (rapid expansion of a supercritical solution into a liquid solvent) because they do not use any surfactant or organic solvent during the PNP preparation (polymeric nanoparticles preparation technique and size control method).

Solvent displacement and interfacial deposition are related methods based on the spontaneous emulsification of the internal organic phase, which includes the dissolved polymer in the external aqueous phase. Solvent displacement, however, forms nanospheres or nanocapsules, while interfacial deposition forms only nanocapsules. In the presence or absence of a surfactant, solvent displacement involves precipitation of a preformed polymer from an organic solution and diffusion of the organic solvent into the aqueous medium (59, 60, and 61). The polymer, usually PLA, is dissolved in an intermediate polarity water-miscible solvent which leads to the precipitation of nanospheres. This phase is injected into a stirred aqueous solution containing a surfactant like stabilizer.

The polymer deposition on the water and the organic solvent interface, caused by the rapid diffusion of the solvent, leads to the instant formation of a colloidal suspension. In order to facilitate the formation of colloidal polymer particles during the first step of the procedure, phase separation is done with a completely miscible solvent which is also a nonsolvent of the polymer. The solvent displacement technique allows the nanocapsules to be prepared while adding a small amount of nontoxic oil in the organic phase. In general, high loading efficiencies are reported for lipophilic drugs when nanocapsules are prepared, considering the oil-based central cavities of the nanocapsules. The usefulness of this simple technique is limited to water-miscible solvents, where the rate of diffusion is sufficient to produce spontaneous emulsification.

Then, although some water-miscible solvents produce certain instability when mixed in water, spontaneous emulsification is not observed if the rate of coalescence of the droplets formed is high enough. While, acetone/dichloromethane (ICH, class 2) are used for dissolving and increasing the entrapment of drugs, dichloromethane increases the mean particle size and is known to be toxic. Because of the miscibility of the solvent with the aqueous phase, this method is basically applicable to lipophilic drugs (Barichello et al., 1999) and it is not an effective way of encapsulating water-soluble drugs. Indeed, it seems impossible to select a drug/ polymer/ solvent/ nonsolvent system in which particles would be produced and the drug efficiently entrapped, since the solvent and the nonsolvent of the polymer must be mutually miscible. The gradual addition of the polymer solution to the nonsolvent generally results in the formation of nanospheres nearly 200 nm in size. A mechanism comparable to the diffusion and standing process found in spontaneous emulsification seems to form nanoparticles. Due to the mutual



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diffusion of the third liquid, this phenomenon was explained by local variations of the interfacial tension between the two immiscible liquids.

This method was applied to different polymeric materials such as PLA, PLGA, PCL, and poly (methyl vinyl ether-co-maleic anhydride) (PVM/MA) (60). This method was well adapted to incorporate cyclosporin A, because entrapment efficiencies were obtained as high as 98%. Interfacial deposition is a process used to produce nanocapsules; however, this is not a technique for polymerization but a technique for emulsification/solidification. A fifth compound is introduced in interfacial deposition, of oil nature, miscible with the solvent of the polymer but immiscible with the mixture. The polymer deposits between the finely dispersed oil droplets and the aqueous phase on the interface, forming nanocapsules. An aqueous solution is used as the dispersing medium. The main difference is that polymers such as PLA dissolve in a solvent mixture (eg, benzylbenzoate, acetone, and phospholipids) along with the drug. This mixture is slowly injected into a stirred aqueous medium, resulting in the deposition of the polymer in the form of nanoparticles of about 230 nm in size. At the interface between water and benzoyl nanodroplets, polymer deposition occurs forming nanocapsules with a shell-like wall (54).

Emulsification-solvent evaporation involves two steps. The first step requires that of the polymer solution be emulsified into an aqueous phase. Polymer solvent is evaporated during the second step and induces polymer precipitation as nanospheres. Using a dispersing agent and high-energy homogenization [50], a polymer organic solution containing the dissolved drug is dispersed into nanodroplets in a nonsolvent or suspension medium such as chloroform (ICH, class 2) or ethyl acetate (ICH, class 3). The polymer precipitates in the form of nanospheres where the drug is finely distributed in the network of polymer matrixes. Subsequently, the solvent is evaporated by increasing the temperature under pressure or by stirring continuously (62).

The size can be controlled by adjusting the stir rate, type and amount of dispersing agent, organic and aqueous phase viscosity, and temperature (63). While different types of emulsions may be used, oil/water emulsions are of interest because they use water as the nonsolvent; this simplifies and therefore improves process economics, because it eliminates the need for recycling, facilitate the washing step and minimize agglomeration. However, this method can only be applied to liposoluble drugs, and the scale-up of the high energy requirements inhomogenization imposes limitations (62). PLA, PLGA, ethylcellulose (EC), cellulose acetate phthalate, poly(E-caprolactone) (PCL), and poly(h-hydroxybutyrate) (PHB). Drugs or model drugs encapsulated were albumin, texanus toxoid, testosterone, loperamide, praziquantel, cyclosporin A, nucleic acid, and indomethacin are frequently used polymers.

**Salting out technique**

Salting -out is based on salting-out effect separating a water miscible solvent from aqueous solution. The salting-out process can be considered as a modification of the emulsification/solvent diffusion. Initially, polymer and drug are dissolved in a solvent such as acetone, which is then emulsified into an aqueous gel containing the salting-out agent (electrolytes, such as magnesium chloride, calcium chloride, and magnesium acetate, or non- electrolytes such as sucrose) and a colloidal stabilizer such as polyvinyl pyrrolidone or hydroxyl ethyl cellulose. This o/w (oil/water) emulsion is diluted with a sufficient volume of water or aqueous solution to increase the diffusion of acetone into the aqueous phase, thereby inducing the formation of nanospheres. It is important to select the salting out agent, because it can play an important role in the drug's encapsulation efficiency. Cross-flow filtration then eliminates both the solvent and the salting-out agent. This procedure used in PLA, poly-(methacrylic) acid, and EC nanospheres preparation leads to high efficiency and is easily scaled up (64). Salting out has the main advantage of minimizing stress on protein encapsulants. Salting out does not need an increase in temperature and, hence, may be useful when processing heat sensitive substances (65). The main drawbacks are exclusive application to lipophilic drugs and the extensive washing steps of nanoparticle.



**Shubhashree Das et al.****Emulsification technique**

This is a technique where we can use natural sources to prepare nanoparticles. Chitosan nanoparticles were developed to encapsulate proteins such as bovine serum albumin, tetanus and diphtheria toxoid, vaccines (66), anticancer agents, insulin (67), and nucleic acids. Chitosan significantly improved the peptide (such as insulin and calcitonin) absorption across the nasal epithelium. The methods proposed for the preparation of chitosan nanoparticles are based on the spontaneous formation of complexes between chitosan and polyanions (68) or the gelation of a chitosan solution dispersed in an oil emulsion (70). Chitosan nanoparticles obtained through the formation of a spontaneous complex between chitosan and polyanions such as tripolyphosphate have small diameters (200–500 nm) and under transmission electron microscopy show a quasi spherical shape. Chitosan nanoparticles produced using an emulsification-based method by a promoting gelation, as illustrated above. Compared with the method described above, this technique has a main disadvantage when it involves organic solvents during the isolation of the particles; these are difficult to remove and may cause toxicity.

Similarly agarose nanoparticles can be prepared. These are prepared for the administration of therapeutic proteins and peptides (71). Agarose aqueous solution forms thermally reversible hydrogels when cooling below the gelling temperature (318–368C). Thermal gelation results from the formation of helicoidal structures responsible for a three-dimensional network in which large amounts of water can be entrapped. Hydrophilic, inert, and biocompatible, the hydrogel forms an appropriate matrix for proteins and peptides that can be entrapped in the gel during formation. Agarose nanoparticles were formed using a technology based on emulsion. This methodology requires the preparation of an agarose. Initially, peptides and proteins to be encapsulated are added to the agarose solution. Homogenization achieves the small size of the dispersed aqueous nano droplets. Gelation of agarose is then induced by diluting the emulsion under agitation at 58 °C with cold corn oil. The liquid nano droplets then gel to nanoparticles containing protein agarose hydrogel (69).

**Ionic gelation method**

In the presence of multivalent cations such as calcium, sodium alginate gels which is a water-soluble polymer. Drop wise extrusion of sodium alginate solution into calcium chloride solution usually results in alginate particles. The particle size of alginate depends on the size of the initial extruded droplet. The smallest formed particles, obtained by air atomization had a minimum size of 1 to 5 μm. Preparation of alginate nanoparticles was first achieved in a diluted solution of aqueous sodium alginate in which gelation was induced by the addition of a low calcium concentration. This leads to the development of invisible clusters of calcium alginate gels. In an additional advance, alginate particles were produced by using a modified method of emulsification/internal gelation as illustrated in. Preparing of alginate nanoparticles using this method requires no specialized equipment and can be done at ambient temperature. The major difficulty of this technique is the step of washing nanoparticles to remove the residual oil droplets, but new strategies have been devised (70).

**Recent development**

Increasing the retention time of the drug alone cannot increase the drug's permeability inside the ocular chamber. Administration of drugs neglecting the presence of the ocular barriers, which make the ocular system invincible and isolated from the foreign substances, makes the drug's fate nowhere to reach the target area. Blood ocular barrier is of two types a) blood aqueous barrier and b) blood retinal barrier. The former one makes permeation impossible for lipophilic drugs to pass through the aqueous humor. But trace amount of horseradish peroxidase was found in the aqueous humor chamber which made a sense of presence of trace amount of plasma proteins. But horse radish peroxidase cannot pass through the iris blood vessels; it can penetrate through the fenestrated capillaries of the ciliary process and reach the aqueous humor. Small and lipophilic drugs can enter the uveal blood circulation through the blood aqueous barrier also they are constantly eliminated more rapidly from the anterior chamber in contrast to the larger and more hydrophilic drug. The iris tissue is porous and makes it easy for the lipophilic drugs to permeate in to the uveal blood circulation. It was also observed that the lipophilic drugs get eliminated more rapidly than the larger hydrophilic drugs from the anterior chamber. Thus lowering the concentration of drug in the



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anterior chamber. Blood retinal barrier resembles blood brain barrier so the paracellular and transcellular transport is restricted. Developing an efficient and accurate drug delivery system should be the matter of discussion. For this reason some formulas using well known pharmacokinetic relationship and a first order drug decay model for the tear film have been established. The time integration of the tear film concentration is then related to the ocular bioavailability. According to this it was found out that a) high corneal permeability with respect to lipophilic drugs produces the highest bioavailability b) drug volume does not play a major role in bioavailability of the drugs and c) making the dose volume relatively small the bioavailability increase by 4 fold (69). Using a lot of bioadhesive can decrease the drug's steady state. The permselectivity of cornea was investigated in vitro by measuring electrokinetic potential generated by ionic concentration gradient or hydrostatic pressure gradient (66).

This study suggested the dual permeability character of the cornea. At physiological pH above isoelectric point 3.2 the cornea behaves as it is negatively charged and allows positively charged ions to permeate through. It becomes the reverse in altered condition. Not only this has the transepithelial electrical resistance (TEER) played a key role in transportation of molecules across the cornea. Although these much constrains in ocular drug delivery still some development have been brought forward. They are as follows- A natural sourced cationic polymer chitosan is having unique biological characteristic in case of muco adhesion and biocompatibility so it has been extensively used in drug delivery. PEG along with chitosan sodium has a good compatibility with ocular structure. PEG is having good shielding effect so it can protect the drug molecule from the hydrolytic enzymes.

Poly- $\epsilon$ -caprolactone nano particles decrease the systemic absorption of ocular drugs. Polyalkylcyanoacrylate nano particles could also be used for anti-inflammatory drugs to target inflamed ocular tissue compared to healthy tissue (68). Pz-peptide (4-phenylazobenzoxycarbonyl-Pro-Leu-Gly-Pro-D-Arg) a hydrophobic collagens labile pentapeptide. Thus facilitating the opening of the tight junction in a reversible manner facilitating the paracellular transport (72).

**Future scope**

Finding effective treatment for ophthalmic diseases is a tremendous challenge for research scientists due to the nature of diseases and presence of the different ocular barriers. An ideal therapy should maintain effective levels of the drug following a single application for the desired period. Scientists have focused on designing a strategy with a multidisciplinary approach in recent years, e.g. microneedle, iontophoresis and MRI. Continued gene delivery research seems to be very exciting for a gamut of diseases. In ocular drug delivery systems, there are likely to be multiple applications of nanotechnology. Nanotechnology can be helpful in making nanodevices for complex eye surgeries, such as glaucoma, retinal vascular surgery, etc. In addition, it can be used in the development of new lens material to treat cataracts. This technology would also become useful in developing various delivery formats, such as parenteral, oral, implantable, transscleral, ect. Moreover, the development of different nanotechnology-based tools can be used to improve imaging, screening and research techniques, including nanolithography, nanoarrays, mass spectrometry, etc., that can be used in the field of discovery of novel ophthalmic drugs. Nanotechnology can also be used to solve the solubility problems associated with poorly soluble drugs and to increase the number of compounds available for potential development of formulations. Beside this, nanotechnology can also help to develop an effective and robust DNA nanoparticle therapy for the treatment blinding diseases based on genes.

It can aid in generation of scaffolds for tissue bioengineering, particularly for neural stem cells and can also be used to delivery growth factors and the stem cells. In the future, much of the emphasis will be placed on achieving non-invasive sustained drug release in both anterior and posterior segments for eye disorders. A clear understanding of the complexities of ocular tissues under normal and pathological conditions, physiological barriers and multi-compartmental pharmacokinetics would greatly enhance further development in the field. P-glycoprotein (P-gp) is a transport membrane protein that exists in many tissues of the human body. In the eye, P-gp is expressed in retinal capillary endothelial cells, iris and ciliary muscle cells and retinal pigmented cells (18), ciliary nonpigmented cells (50) corneal cells and conjunctival epithelial cells . P-gp is functionally active in the blood aqueous barrier. Studies



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with Cyclosporine A, verapamil and dexamethasone which are some of the functional sub units of P-gp, were investigated to determine the presence of P-gp in the conjunctival epithelium (56). According to that study it was investigated that the efflux of Cyclosporine A was reduced in the presence of verapamil and P-gp inhibitors. Solubilizing agents often used in pharmaceutical formulation have been reported to have P-gp inhibitory activity (55). Another protein named multi drug resistance-associated protein is of same importance as that of P-gp. Only the main difference is that this type of proteins has high affinity toward compounds conjugated to glutathion, glucuronide and sulfate (29).

Development of nanotechnologies require better understanding of cell-surface interaction on the nanometer scale. Advances in nanometer scale patterning and detection have allowed the fabrication of appropriate substances and the study of cell surface interaction (1). Especially topographed nanosurfaces are more selective than the smooth surface ones. This can be a new direction for the development of nanoparticulate formulation for targeting to specific tissues. Surface resistance is also a main hindrance for drug penetration. Corneal permselectivity was investigated *in-vitro* by measurement of membrane electrokinetic potential generated either by ionic concentration gradient (diffusion potential) or hydrostatic pressure gradient (transport mechanism of cornea: characterization of barrier permselectivity). Studies on the effect of pH on these potentials indicate dual-selective character to passage of ions across the cornea. The cornea represents an isoelectric point (pI) at 3.2. At physiological pH and pH above pI, the cornea behaves as if it is negatively charged and allows preferential passage of positively charged ions with respect to negative ions. The reverse is valid below pI. Lowering the bathing solution's ionic strength results in increased ionic discrimination as well as membrane electric resistance. Validity and integrity of tissue, the two important properties of membrane involved in the overall transportation process.

It is useful to first investigate corneal tissue in order to understand the effect of charge type on corneal transport of peptides. The transport characteristics of L-(14C) lysine and L-(14C) glutamic acid were based on measurements of *in vitro* flux. Net L-lysine flux occurs via a co-transport mechanism that is dependent on sodium. L-lysine transport involves the Na-K-ATPase pump and requires a transportation system mediated by a stereospecific carrier. By blocking the carrier system, the lysine permeability co-efficient was lowered. However, it appears that L-glutamic acid was absorbed by a passive aqueous transport mechanism which was insensitive to ouabain. Overall the cornea was 2-3 fold more cation permeable than an anion. Additionally, salicylic acid which is charged negatively is 2-3 times less permeable than the cationic drug. Though anionic drugs having less permeability through the membrane, still it can be incorporated into the cationic nanoparticles, thus increasing its permeability.

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**Table-1: Role of nanoparticulate carrier to overcome the limitations**

Polymer	Loaded drug/gene/protein	Comments	Ref.
Eudragit RS 100, RL 100	Flubiprofen Chloricromene Ibuprofen Piroxicam Methyl prednisolone	Drug level was improved in aqueous humor after application of the drug loaded nano suspensions which did not show toxicity in ocular tissues. Improved in stability in chloricromene.	Pigantello et al.(2002) (37) Pignatello et al. (2006) (38) Bucolo et al. (2004) (39) Bucolo et al. (2002) (40) Adibika et al. (2007a) (41) Adibika et al. (2007b) (42)
Chitosan	Cyclosporine A Dorzolamide Pilocarpine gene	A promising approach for management of ocular inflammatory and auto immune disorders.	Calvo et al.(1996) (26) Papadimitriou et al. (2008) (43) Funte et al. (2008) (44)
Polyisobutylcyanoacrylate	Amikacin sulfate Progesterone Betaxolol chlorehydrate	This polymer was able to release the drug in a controlled manner. Also increased the drug concentration in ocular medium.	Pignatello et al. (2002) (37)
Poly-ε-caprolactone	Cyclosporin A, Cartilol, metipranolol	Improvement in ocular penetration. Therapeutic results were much more pronounced by decreased intra ocular pressure	Calvo et al. (1996b) (45)
Albumin	Pilocarpin, hydrocortisone, gancyclovir	Prolonged residence time minimized the opification.	Bucolo et al. (2002) (40)
Gelatin	Hydocortisone acyclovir	The release parten was closed to zero order	Bucolo et al. (2004) (39)
Polylactic acid	Beta methasone phosphate	Potential ocular drug delivery system for ocular viral infection.	Calvo et al. (1994) (27)

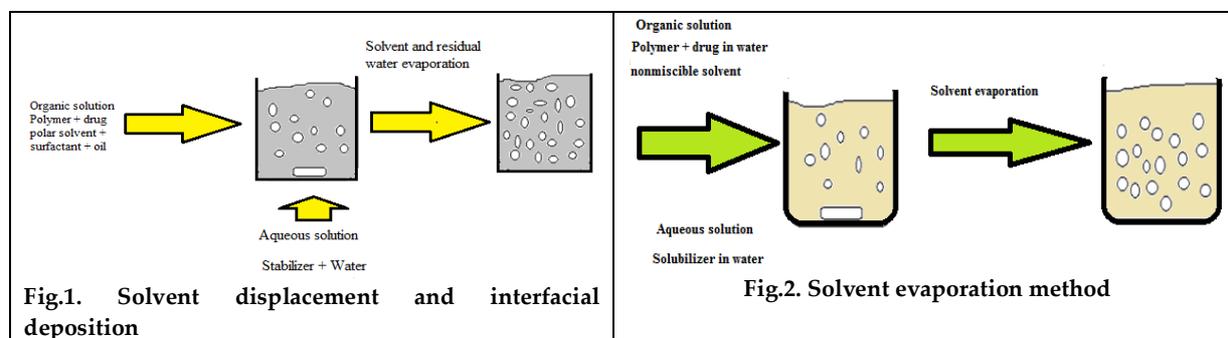


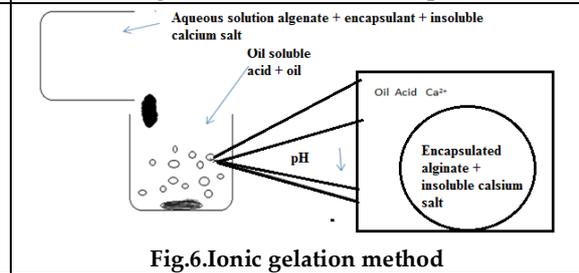
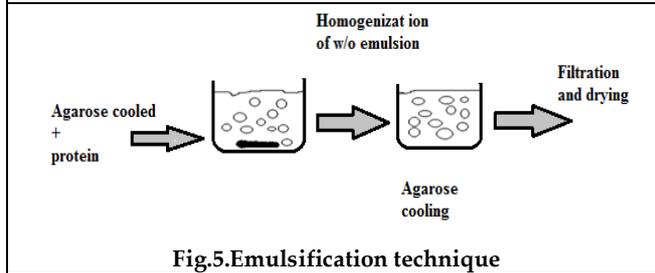
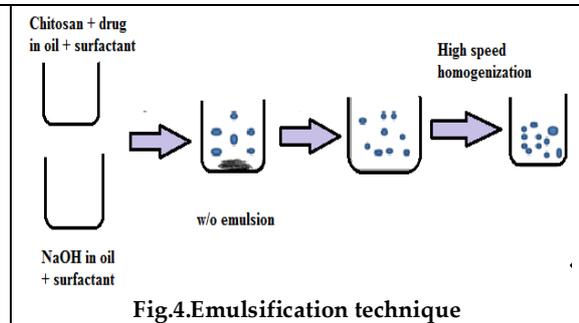
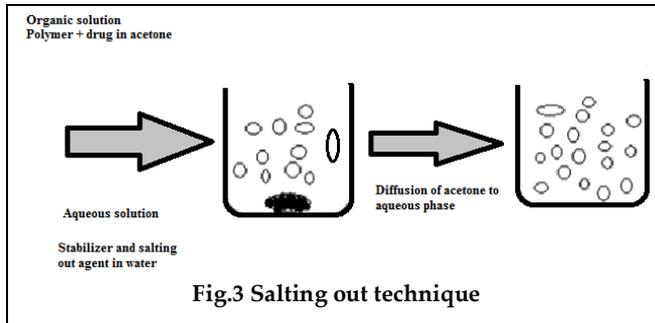


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Table-2 : Preparation technique

Polymer	Drug encapsulated	Synthesis method	Entrapment efficacy	Release method	Reference
gelatin	paclitaxel	desolvation	33-78%	diffusion	(Lu, et al., 2004) (47)
	chloroquine phosphate	Solvent evaporation method	15-19%		(Bajpai et al., 2006) (48)
chitosan	cyclosporine A	ionic gelation method	73%	diffusion	(Campos et al., 2001) (49)
	ammonium glycyrrhizinate	ionic gelation method	35%	diffusion and polymer degradation	(Wu et al., 2005) (50)
	BSA	ionic gelation method	92%	diffusion	(Bhattarai et al., 2006) (51)
poly alkyl cyano acrylates	ftorafur	anionic polymerization	-	diffusion	(Arias et al., 2007) (52)
	indomethacine	interfacial polymerization	76.6%		Shozo et al., 2003) (53)
poly-e-caprolactone	tamoxifen	solvent displacement	90%	diffusion	(Shenoy et al., 2005) (54)
	clonazepam	solvent evaporation	72.6-95.1%		Changyong et al., 2006) (55)
	saquinavir	solvent displacement	60%		(Shah et al., 2006) (56)
	insulin		96%		(Dange et al., 2007) (57)
	docetaxel	nanoprecipitation method	90%		Zheng et al., 2009) (58)
	vinblastin	emulsion method	48%		(Prabha et al., 2008) (59)







## New Drug Application- Criteria for New Drug Approval Process

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### ABSTRACT

Drug development and approval is very long and complex process. For the approval of drug product we have to go through a series of guideline document and application procedure intended to aid applicants and sponsors making regulatory proposal and submission in computerize automatic or electronic submission format to the Center for Drug Evaluation and Research (CDER), Center for Biologics Evaluation and Research (CBER) and Food and Drug Administration (FDA). In some cases, guideline differs from CDER to CBER to FDA because of the differences in the procedure and expert review guideline and availability of computer infrastructure in the respective centers. Agency guidance and guideline documents on electronic submissions or computerize automatic format will be upgraded regularly to show the progressing nature of the technology and encounter of those using the same technology. This specific guideline discuss various issues resemblance to the computerize automated submission of the new drug applications (NDA) and modification to those submission to CDER.

**Keywords-** NDA, CDER, FDA, Drug development, Regulatory requirement.

### INTRODUCTION

For recent development years, in the United States the regulation and control of new drug product has been based on the guideline of New Drug Application (NDA). From 1938, each new drug product has been subjected to approval of NDA before U.S authentication and commercialization of drugs. The report gathered during the clinical studies and preclinical study of an Investigational New Drug (IND) became the part of NDA. In 1938, when Food, Drug and Cosmetic Act (FD & C Act) was enforced, NDA were only required to restrain information concerning to the safety of investigational drug. The Kefauver-Harris Amendment in 1962 modify the FD & C act required and provide guidance to NDA for providing evidence that a new drug was relatively safety and effective for its intended and that the given therapeutic application of the drug must overcome the risks. When the FDA completed a comprehensive revision of the regulation subjecting to NDA in the year 1985 the NDA was again the matter of change. This revision



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and modification commonly called the **NDA Rewrite**. It was mainly focused to rearrange the ways in which information, content and data are assembled and presented in the NDA to easily approach FDA reviews. [1, 3, 7] In this review we tried to explain about the process of approval and rejection of a new drug that is going to be marketed.

**Fundamentals of NDA Submissions**

The quantity and quality of content and data offered in NDA can vary remarkably, the key components of NDA are simple, uniform and given in Form FDA-356h. The application to Market a new drug for use in human or an antibiotic (biological) drug for human use contains basically of 15 parts i.e,

1. Index
2. Summary
3. Chemistry
4. Manufacturing and Control
5. Samples, Methods Validation, Package and Labeling
6. Nonclinical Pharmacology and Toxicology
7. Human Pharmacokinetics and Bioavailability
8. Microbiology (for anti-microbial drugs only)
9. Clinical Data
10. Safety update Report
11. Statistical
12. Case report Tabulations
13. Case report Forms
14. Patent Information
15. Patent registration certification
16. Other information (the previous marketing history of the drug inside and outside the U.S, approved discussion regarding the benefit and risk consideration and if any provided additional study or post marketing surveillance plans etc.) [2,7,8]

**NDA Format- Content and Requirements**

NDA guideline must provide all the relevant information and data that a sponsor or investigator has collected throughout the product research and development. The FDA also has various guidelines and guidance that are relate to NDA issue of content and format. These numerous guideline can be obtained from CDER website of Drug information branch (DIB).

1. New molecule entity
2. New Salt form of previously approved and existed drug ( not new molecule entity)
3. New formulation of already existed or approved Drug (not new salt form or, molecule entity)
4. New combination or rearrangement of two or more drug product
5. Already marketed drug Product – Duplication of product
6. New indication or claim for existed marketed drug
7. Already marketed drug Product - Not previously approved by NDA [7,8,9]

**Summary of application**

- According to the new or, present NDA regulation the application must be submitted in 2 copies,
- An archival copy- serves as a permanent record of the submission
- A review copy- by the scientific committee
- The review copy again is made up off a number of separate technical volume, each volume signifies the need of the discipline that is involved in the review.



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- Both the archival and review copies are submitted in the form of hard copy, but according to the guideline archival copy must be submitted as microfiche.

Generally the application form is supplied with detailed and technical guideline or guidance to improve the quality of submissions,

- The format and content of summary of an application
- Formatting, arranging and submitting new drug and antibiotic (biological) application
- The microfiche submission of archival copy
- The format, content and report of the human Pharmacokinetics and bioavailability section The format, content and report of the clinical and statistical section data
- The format, content and report of the chemistry, manufacturing and control section
- Post marketing surveillance and reporting of adverse drug reaction [1, 4, 7, 8]

The chemistry section because of its length, complex and highly detailed section basically deals with the manufacturing and control process, is required to be submitted between 90-120 days prior to the submission of the application for the identification of deficiencies in the application filed. Submission of proposal to the chemistry section earlier than 120 days and less than 90 days before the remainder of the application will not be accepted. The archival copy of the application should include a detailed index by volume and page number. It is always recommendable to prepare additional copies of the index and must be included with application form submitted to FDA for the NDA. This will aid in easily access the location of important parts of the submission which will be needed for meetings or, review by individual technical reviewers. It has been always recommendable that the summary consists of 50 - 200 pages. The summary should explain all the aspects of the application and needs to be written at ultimate level of detail required for publication and must meet the editorial board standard that applied by various referred scientific and medical journals. It is advantageous to provide the data in the summary in the form of table and graphic with clear explanation and distinction of all the terminology used in the table or graphics. The required safety and efficacy data must be submitted in same format that described under clinical data section of the NDA content and format. [5, 8, 10]

- **Chemistry, manufacturing and control summary-** provide a general and detailed overview of the drug substance and drug product
  - Drug substance: Description regarding physical and chemical characteristics and stability study.
  - Drug product: Description regarding composition and type of dosage form, manufacture, analytical methods, container/closure system, stability and investigational formulation.
- **Nonclinical laboratory studies-** include any in-vivo and in-vitro experiment with the test drug to determine its safety, activity or disposition. This section includes Toxicological effects of drugs on reproduction and the developing fetus, ADME animal experiments of the drugs. This section should provide a description, tabulation and graphics from Nonclinical laboratory studies of drug.[7, 8, 10]
  - First section: There should be an overall tabulated summary of all in-vivo biopharmaceutics studies carried out on the drug grouped by type of study.
  - Second section: The summary of bioavailability or pharmacokinetic data and overall conclusions ( $C_{max}$ ,  $T_{max}$ , AUC etc.)
  - Third section: List of all formulations used in clinical trials and in vivo bioavailability or pharmacokinetic studies together with each formulation used in studies.
  - Fourth section: Analytical methods used to measure the levels of drug and major metabolite (Bioanalytical)
  - Fifth section: Dissolution data on each strength and dosage form for which approval is being sought. A comparative dissolution study with the lot(s) used. In vivo biopharmaceutics studies should also be included.





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➤ **Statistics section** should include:

- A statistical evaluation of the clinical data
- A copy of the data given in the description and analysis of each controlled clinical study, along with the statistical analysis.
- A copy of the data included in the integrated summary of all available information about the safety of the drug. [7, 8, 10, 11]

**Review Time Frames of the NDA Application**

This time frame includes:

- Within 180 days of date of filing of an application, the FDA will review and issue an approval, approvable, or not approvable letter. This 180-day period is called the “review-clock”
- During the review period an applicant may withdraw an application and later resubmit it.
- The time period may be extended by mutual agreement between the FDA and the applicant or as the result of submission of a major amendment.

**Filing Time Frames of the NDA Application**

- Within 60 days after the FDA receives an application, a determination will be made whether the application may be filed.
- This will determine whether sufficient information is provided to proceed with an in-depth review of application.
- If FDA files the application, the applicant will be notified in written. The date of filing will be the date 60 days after the FDA received the application.
- The date of filing begins the 180-days period of the review. If FDA refuses to file the application, the sponsor will be given the opportunity to meet with FDA to discuss the reasons why the application is not fileable. [2, 6, 7, 10]

**APPROVAL OF NDAs BASED SOLELY ON FOREIGN DATA**

Clinical data will be considered on merit regardless of country of origin. Foreign Clinical data meeting U.S. criteria for approval may be approved if:

- The foreign data are applicable to the U.S. population and U.S. medical practice
- The studies have been performed by clinical investigators of recognized competence
- If an inspection is necessary, FDA is able to validate the data through an on-site inspection or other appropriate means or the data may be considered valid without the need for an on-site inspection by FDA.
- India is a signatory to an international agreement on "mutual acceptance of data" (MAD), the country is obliged to accept the results of such animal testing conducted in other countries and there is no need for the tests to be repeated.
- FDA will apply this policy according to the nature of the drug and the data being considered.
- The FDA is willing to explore all areas to remove the need to conduct repetitive clinical testing in U.S.
- When adequate foreign data have been generated a pre-NDA submission meeting is encouraged when approval being solely on foreign data is sought. [3, 8, 11]

**FDA DIALOGUE ON SCIENTIFIC & MEDICAL ISSUES**

- Approximately 90 days after the NDA is received, the FDA will provide applicants with an opportunity to meet with reviewers to discuss the general progress and status of the application
- Particularly for new chemical entities and major new indications of marketed drugs, this meeting will generally be held at the applicant’s option and may be held by telephone.
- With the issuance of an approvable/not approvable letter, an opportunity will be provided to applicants to meet with the FDA and discuss what further steps need to be taken before the applications can be approved. [7, 8]
- Priority for these meetings will be given to applications for new chemical entities and major new indications for marketed drugs.





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### NDA PRE-APPROVAL AND POST- APPROVAL SAFETY REPORTS

- CDER( the center for drug evaluation and research) provide guideline for the approval of NDA.
- The FDA details the necessity to periodically update a pending application with new safety information which affects the statements of contraindications, warnings, precautions and adverse reactions in the draft labeling.
- The safety update reports are required to include the same kinds of information from clinical or animal studies as well as other sources, and must be submitted in the same format as the previously described in integrated summary of safety.
- Safety update reports must be submitted at:
  - 4 months after the initial submission of an application
  - Following receipt of an approvable letter and
  - Any other times as requested by the FDA
- In case of any adverse drug experience, the surveillance system requires the reporting of such experience as soon as possible within 15 working days of initial receipt of the information.
- These 'alert reports' are required to be submitted on Form FDA 1639 (Drug Experience Report).
- All reactions subject to 15 day alert report require follow-up reports within 15 working days of receipt of new information
- Even if no such reports are reported, the follow up reports has to be submitted in separate cover and as a summary / tabular form to be presented in periodic report
- NDA holders must review periodically (quarterly for the first three years and yearly thereafter) the frequency of adverse drug experience reports that are serious and unexpected and report any significant increase in frequency (e.g. a doubling) within 15 working days to determine whether a significant increase in frequency exists or not
- Applicants must adhere to a reporting schedule that calls for submission of each quarterly and each annual report within 60 days of the anniversary date of approval of the application
- A 15-day alert report based on information from the scientific literature must be accompanied by a copy of the published article.
- These literature reports should be either case reports or the reporting of a formal clinical trial
- Applicants should not include in post-marketing adverse experience reports of any adverse experiences that occurred in clinical trials if they were previously submitted as part of the approved application. [7,8,9,10, 11]

### NDA approval process

CDER uses advisory committees to obtain outside advice and opinions from expert advisors so that final agency decisions will have the benefit of wider national expert input. Committee recommendations are not binding on CDER, but the agency considers them carefully when deciding drug issues. CDER may especially want a committee's opinion about:

- A new drug
- A major indication for an already approved drug
- A special regulatory requirement being considered, such as a boxed warning in a drug's labeling
- Advise CDER on necessary labeling information
- Help with guidelines for developing particular kinds of drugs
- May also consider whether a proposed study for an experimental drug should be conducted
- Whether the safety and effectiveness information submitted for a new drug are adequate for marketing approval

#### Notification of Easily Correctable Deficiencies

CDER communicates promptly inform about applicants of the need for more data or information, or for technical changes in the application needed to facilitate the agency's review. Major scientific issues are usually addressed in an action letter at the end of the initial review process. CDER makes every effort to grant requests for meetings that involve important issues and that can be scheduled at mutually convenient times. After the end of Review Conference there are three possible action letters:





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- Not Approvable Letter: Lists the deficiencies in the application and explains why the application cannot be approved.
- Approvable Letter: Signals that, ultimately, the drug can be approved. Lists minor deficiencies that can be corrected, often involves labeling changes, and possibly requests commitment to do post-approval studies.
- Approval Letter: States that the drug is approved. May follow an approval letter, but can also be issued directly
- “End of review conference”: Applicants get an opportunity to meet with Agency officials and discuss the deficiencies

An applicant may seek to augment the information provided in the original NDA during the review process. E.g. the applicant may submit a new analysis of previously submitted data or information needed to address a deficiency in the drug application. Any such information provided for an unapproved application is considered an “NDA amendment”. Result in an extension of FDA's time line for application review The review is likely to involve a reanalysis or an extension of the analysis performed by the sponsor and presented in the NDA. There is also extensive communication between review team members. If a medical reviewer's reanalysis of clinical data produces results different from those of the sponsor, for example, the reviewer is likely to forward this information to the statistical reviewer with a request for a statistical reanalysis of the data. Likewise, the pharmacology reviewer may work closely with the statistical reviewer in evaluating the statistical significance of potential cancer-causing effects of the drug in long-term animal studies. After reviews are completed, each reviewer develops a written evaluation of the NDA that presents their conclusions and their recommendations on the application. The division director or office director then evaluates the reviews and recommendations and decides the action that the division will take on the application. The result is an action letter and a justification for that recommendation. Each element of the proposed labeling, including indications, use instructions and warnings, is evaluated in terms of conclusions drawn from animal and human testing. All claims, instructions and precautions must accurately reflect submitted clinical result. [1, 2, 7,8,10, 11]

CDER comments can relate to almost any aspect of the proposed labeling For example, CDER can comment upon drug indications and warnings or suggest general changes in wording and format. The labeling "negotiation process," through which a drug's final approved labeling is agreed upon, can take a few weeks to many months. The length of the process depends upon the number of agency comments and an applicant's willingness to reach agreement. Sometimes a sponsor will submit several revisions of labeling before agreement with FDA on the labeling can be reached. The labeling is organized in the following sections:

- Description: Proprietary and established name of drug; dosage form; ingredients; chemical name; and structural formula.
- Clinical Pharmacology: Summary of the actions of the drug in humans; in vitro and in vivo actions in animals if pertinent to human therapeutics; pharmacokinetics
- Indications and Usage: Description of use of drug in the treatment, prevention or diagnosis of a recognized disease or condition
- Contraindications: Description of situations in which the drug should not be used because the risk of use clearly outweighs any possible benefit
- Warnings: Description of serious adverse reactions and potential safety hazards, subsequent limitation in use, and steps that should be taken if they occur
- Precautions: Information regarding any special care to be exercised for the safe and effective use of the drug. Includes general precautions and information for patients on drug interactions, carcinogenesis /mutagenesis, pregnancy rating, labor and delivery, nursing mothers, and pediatric use
- Adverse Reactions: Description of undesirable effect(s) reasonably associated with the proper use of the drug
- Drug Abuse/ Dependence: Description of types of abuse that can occur with the drug and the adverse reactions pertinent to them
- Over dosage: Description of the signs, symptoms and laboratory findings of acute over dosage and the general principles of treatment



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- Dosage/ Administration: Recommendation for usage dose, usual dosage range and if appropriate, upper limit beyond which safety and effectiveness have not been established
- How Supplied: Information on the available dosage forms to which the labeling applies [3,4,5,7,8]

Division may initiate a request for a preapproval inspection of the sponsor's manufacturing facilities and clinical trial sites. The FDA conducts inspections to:

- Verify the accuracy and completeness of the manufacturing-related information submitted in the NDA;
- Evaluate the manufacturing controls for the preapproval batches upon which information provided in the NDA is based;
- Evaluate the manufacturer's compliance with CGMPs and manufacturing-related commitments made in the NDA;
- Collect a variety of drug samples for analysis by FDA field and CDER laboratories. These samples may be subjected to several analyses, including methods validation, methods verification and forensic screening for substitution. [5, 6, 7, 8]

According to CDER policy, product-specific preapproval inspections generally are conducted for products:

- That are new chemical or molecular entities
- That have narrow therapeutic ranges
- That represent the first approval for the applicant;
- That are sponsored by a company with a history of CGMP problems or that has not been the subject of a CGMP inspection over a considerable period.[ 8, 9, 10]

CDER's preapproval inspection program is available from CDER's Compliance Program Guide.

- The results of the preapproval inspection may also affect the final approval decision
- When such inspections discover significant CGMP problems or other issues, the reviewing division may withhold approval until these issues are addressed and corrected.
- The division's response to such deficiencies is likely to depend on several factors:
  - The nature of the problem
  - The prognosis for the problem's correction
  - The potential effect of the problem on the safety and efficacy of the drug. [7,8,9]

Once a recommendation is reached by the reviewers and their supervisors, the decision must be evaluated and agreed to by the director of the applicable drug review division or office. For the director's review, the consumer safety officer assembles an "action package" that contains the action letter and any data, CDER reviews and memo, and other information supporting the reviewers' recommendation. Following the review of the action package, the division director may begin a dialogue with the reviewers and their supervisors. The division director generally serves as the final FDA ruling. The division director is said to have "sign-off" authority for such drugs. Once the division director (or office director, as appropriate) signs an approval action letter, the product can be legally marketed starting that day in the United States. [5, 9, 10]

## CONCLUSION

For many years, the regulation and control of new drugs in the United States has been based on the New Drug Application (NDA). Since 1938, every new drug or therapy has been the subject of an approved NDA before US commercialization. The NDA application is the vehicle through which drug sponsors, such as biotech and pharmaceutical companies, formally propose that the FDA approve a new pharmaceutical for sale and marketing in





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the US. The data gathered during the animal studies and human clinical trials of an Investigational New Drug (IND) become part of the NDA.

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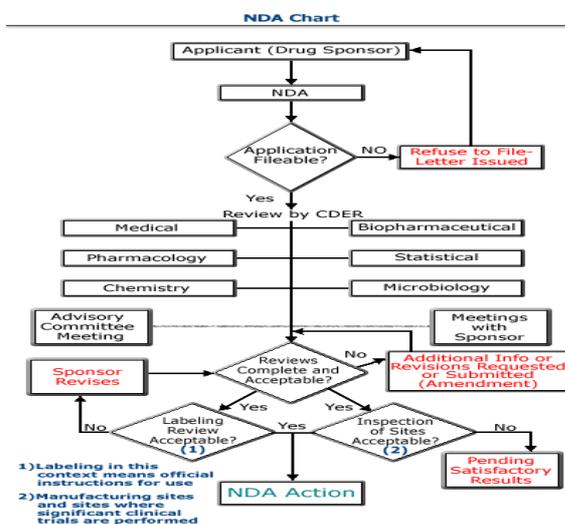


Figure 1. NDA approval chart



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## Essential Antioxidant Biomedicines on Verge of Viral Infection- A Short Review

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### ABSTRACT

Oxidative damage is the key factor for initiation of various diseases which directly or indirectly related with immune system. Antioxidants have significant inhibitory effect on oxidative stress and free radical. Plant derived antioxidants may strengthen body's antioxidant defense mechanism to sort out various diseases. In this time of corona, human community can be safe guarded by boosting up their immunity so it is essential to take antioxidants which may rejuvenate the immune system and can be used for prevention of various diseases. This study aims to emphasis on natural antioxidants which prevent oxidative damage and strengthen immune system. This can be helpful in prevention of many diseases and for health benefits. This study also encourages investigating further in the field of natural antioxidants for less side effects.

**Keywords**-oxidative stress, free radicals, antioxidants, immunity

## INTRODUCTION

oxidative stress causes cellular and tissue damage, which means the change of free radicals or other reactive oxygen species (ROS) that can result direct or indirect damage to the body.[1] Creation of free radicals due to faulty mechanism of immune system, initiate a large number of diseases including AIDS,[2] carcinogenesis, liver damage, inflammatory diseases, cataract formation and Alzheimer's disease are recognized.[3,4] Antioxidant and radical scavenging compounds can be considered as essential dietary nutrients because these safe guard health from various sensitive disorders since they play a crucial role by preventing oxidative stress and restoring biological pathways and membrane function.[4] . Many studies has been carried out and reported that ROS mediates more than 100 disorders such as rheumatoid arthritis, hemorrhagic shock, cardiovascular disorders, cystic fibrosis, metabolic disorders, neurodegenerative diseases, gastrointestinal ulcerogenesis and AIDS etc. Some specific ailments



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mediated by ROS include Alzheimers disease, Parkinson's disease, Atherosclerosis, Cancer, Down's syndrome and ischemic reperfusion injury in different tissues including heart, liver, brain, kidney and gastro intestinal tract. [5]

Intracellular protection of inflammatory stresses involve antioxidant enzymes, including superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GP) in tissues. It has been shown that faulty cellular antioxidant systems cause organisms to develop a series of inflammatory or malignant diseases and unhealthy conditions. [6]Objective of enzymatic antioxidants is to protect living things from excessive generation of oxidative stress during inflammation phase, which emphasise studies to focus on the role of natural products in suppressing the production of oxidation so as oxidative stress by increasing enzymatic antioxidants in tissues. [7]. Complex antioxidant immune system of body control the exceeding level of ROS under normal condition and maintains an equilibrium between ROS formation and oxidative damage.[5] Overproduction of ROS and/or inadequate antioxidant defence disturbs this equilibrium in favor of a ROS upsurge that results in oxidative stress. A deficiency in the body's natural antioxidant defense mechanisms is the key factor which induces several clinical disorders and It has the measure role on initiation of unhealthy conditions. This has led to scientific research focusing on identifying safe and effective sources of antioxidants. Plant extracts and plant-derived antioxidant compounds may potentiate the body's antioxidant and anti-inflammatory defence mechanisms. [5]

The mechanism behind cancer development involves the induction of three to seven mutations in the tumour suppressor gene and oncogenes. [8] These mutations created by free radicals that are produced during normal body metabolism and due to chronic oxidative stress and inflammation.[9]. In cell, mitochondrias are the primary source of oxidative stress which initiate several critical biochemical pathways involved in the pathogenesis of diabetic problems .The initial oxygen free radical produced by the mitochondria is superoxide, which then converted to other destructive species which may strengthen the primary serious effects of hyperglycaemia. [10]The detrimental effects of free radicals and reactive oxygen/nitrogen species are due to the removal of electrons from any biomolecule in their path. Due to this phenomenon as well as enzymatic and non-enzymatic glycation of the natural antioxidants, the antioxidant capacity of the body would be decreased. Such conditions lead to intracellular and extracellular accumulation of advanced glycation end products (AGEs), deactivation of enzymes, lipid peroxidation and eventually diabetes complication including coronary artery disease, nephropathy, neuropathy, retinopathy and stroke.[11]Fibroblast growth factor 21 (FGF21) an indigenous member of the FGF family mainly synthesized in the liver. It has a key role in diminishing oxidative stress.[12]

**Mechanism of antioxidant [13-15]**

- Agents that catalytically remove free radicals and other reactive species like SOD, CAT, peroxidase and thio specific antioxidants.
- Proteins that minimize the availability of peroxidase such as iron ions and copper ions.
- Proteins that protect biomolecules against oxidative damage example heat shock proteins.
- Low molecular mass agents that scavenge ROS e.g. ascorbic acid and tocopherol.

**Plants with antioxidant activity**

Some selected plants having antioxidant capacity of the traditional therapeutic applications under study are listed here so as to understand their medicinal importance.

**CONCLUSION**

Many antioxidants are consumed daily by knowingly or unknowingly in form of drugs or dietary supplements. Biomedicines contains antioxidant property protect the living organism against oxidative damage. Oxidative stress is





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the key factor induces several serious ailments like cancer, diabetes, AIDS, Alzheimer's disease, inflammation associated with rheumatoid arthritis, osteo arthritis etc. Many drugs are disease oriented and specific for disease. Oxidative damage is not a disease but initiate many diseases so it is necessary to focus on antioxidants. This study aims to emphasis on natural antioxidant which prevent oxidative damage and strengthen immune system. This can be helpful in prevention of many diseases and for health benefits. This study encourage to investigate further in the field of natural antioxidants for less side effects. In this time of corona, human community can be safe guarded by boosting up their immunity so it is essential to take antioxidants which may rejuvenate the immune system and can be used for prevention of various disease.

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Table1

Plant	Family	Common name	Parts used	Activities other than antioxidant	Reference number
<i>Acanthus mollis</i>	Acanthaceae	Bear's breeches	Leaves & root	Analgesic, Anti-inflammatory	[16]
<i>Acorus calamus</i>	Acoraceae	Sweet flag	Rhizomes	Anti-inflammatory Antiulcer, Bronchodilator	[17]
<i>Aegle marmelos</i>	Rutaceae	Bael,wood apple	Leaves	Antiulcer, Laxative	[18]
<i>Aloe vera</i>	asphodelaceae	Ghrit kumari	Leaves	Anti-diabetic, Laxative	[19]
<i>Andrographis paniculata</i>	Acantheaceae	Creast,green chireta	Whole plant	Anti-leprosy Anti-cancer	[20]
<i>Asphodelus tenuifolius</i>	Asphodelaceae	Jungle piyaz	Whole plant	Hypotensive, Antioxidant, Antibacterial	[21]
<i>Carica papaya</i>	Caricaceae	Papaw,pawpaw	Leaves	Laxative, Dyspesia, Anti-hypertensive	[22]
<i>Cassia fistula</i>	Fabaceae	Purging cassia	Bark	Laxative, Anti-leprosy, Anti-malaria	[23]



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<i>Curculigo orchoides</i>	Hypoxidaceae	Golden eye glass	Rhizomes	Anti-asthma, Diuretic	[24]
<i>Cyperus rotundus</i>	Cyperaceae	Coco-grass	Rhizomes	Diuretics, Analgesic, Stimulant, anti-bacterial	[25]
<i>Dalbergia sisoo</i>	Fabaceae	Indian rose wood	Leaves and flower	Antipyretics, Analgesic, Anthelmintic	[26]
<i>Emblica officinalis</i>	Phyllanthaceae	Malaka tree, amla	Seeds	Antipyretic, Anti-inflammatory	[27]
<i>Ficus bengalensis</i>	Moraceae	Indian babyan, banyan fig	Aerial root	Antileprotic, Anti-inflammatory, Antipyretic	[28]
<i>Hemidesmus Indus</i>	Apocyanaceae	Ananta bel	Stem	Antileprotic, Antiasthma	[29]
<i>Lagopsis supina</i>	Lamiaceae	Bung	whole plant	Anti-inflammatory, Hepatoprotective	[30]
<i>Magnifera indica</i>	Anacardiaceae	Mango	Stem bark	Antiseptic, Antiasthma, antihypertensive	[31]
<i>Momordica charantia</i>	cucurbitaceae	Bitter apple, Bitter gourd	Fruit	Anticancer, Antipyretics	[32]
<i>Moringa olifera</i>	Moringaceae	Moringa, drums tick tree	Seeds	Anti-infective, Anticancer	[33]
<i>Ocimum sanctum</i>	Laminaceae	Holy basil, Tulsi	Leaf	Anti malaria Anti-inflammatory	[34]
<i>Petroselinum crispum</i>	Apiaceae	Parsley, Garden parsley	Seed	Hypotensive, Anti-inflammatory	[35]
<i>Plumbago zeylanica</i>	plumbaginaceae	Doctorbush	Root	Anti-inflammatory, Antidiuretic	[36]
<i>Psidium guajava</i>	Myrtaceae	Yellow guava, lemon guava	Leaves	Anti-hypertensive, Diuretic	[37]
<i>Solanum nigrum</i>	Solanaceae	Paneer phool	Fruit	Anti-hypertensive, Diuretic	[38]
<i>Syzygium cumini</i>	Myrtaceae	Malabar plum	Leaf	Antirheumatic	[39]





## Recent Development of Marketing Strategy in Pharmaceutical Industry

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### ABSTRACT

The recent trends among pharmaceuticals firms of implementing marketing and integrating new mechanisms for upgrading the innovation process also a new challenge for integrating marketing inputs is one of the fundamental challenges for the pharmaceutical industry. At the same time it is expected that after 1 January 2005, when international patent Laws will be implemented, Indian pharmaceutical industry will undergo phenomenal changes. Indian domestic pharmaceutical industry experienced a significant increase in expenditure on research and development to be competitive on the world market. Although the Indian pharmaceutical market is very limited and has no enough funding for the development of new drugs. In order to remain competitive in this highly regulated field the primary purposes of this paper is to address the evolution of marketing strategies employed by pharmaceutical industries.

**Keywords:** Indian pharmaceutical industry, Business Strategies, Market Development Strategies, Pharmaceutical Branding.

## INTRODUCTION

The pharmaceutical business is the world's largest industry due to revenues of about US\$ 2.8 trillion worldwide. The pharmaceutical industry has been significant changes in the recent period that place new demands on the payers, the suppliers and the producers customers now-a-days thinking that the pharmaceutical industry having more convenient than other products deliver by a multitude of factors compression to other products Indian pharmaceutical industry is posed over the next few years for quick and steady growth. [1] Top Indian companies like Sunpharma, ZydusCadilla and Lupin have already established their presence, the Pharma industry is an industry powered by expertise that release heavily on research and production. It is also a time consuming and costly process because some basic research (discovering new molecules) where some multinational Indian companies are also involved. [2]



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Orphan drugs is another area that has become very popular in recent years. The shorter and less expensive regulatory path gives incentives particularly for smaller speciality pharmacies. However clinical studies on orphan medicines in many countries required a large network of clinical operations to recruit enough patients. [3]. Big Pharma works also on orphan drugs starting with a small initiative, hoping to enlarge the indication into a blockbuster status. [4]

Business awareness is still overlooked in science based enterprise management. Such kinds of companies belong to industries where the main investment is in basic and applied research. [5] Bengal Chemicals (1901) is the first Indian pharmaceutical industry comes into being; the company started its first operation in Kolkata and the pharmaceutical industry many stages over the next few decades. Starting with the repackaging and preparation of manufactured bulk drug formulations, the use of medical members for selling goods to physicians and the exercise of order is difficult. [6] The country has a developed domestic pharmaceutical industry with a large network of 3000 drug companies and approximately 10,500 production units of these, 1,400 production units are approved by Good Manufacturing Practice (GMP) the World Health Organisation (WHO), 1105 have European Certificate of Suitability (CEPs), more than 950 TGA guidelines, and 584 sites are approved by the US Food and Drug Administration (USFDA) In 2019, domestic pharmaceutical market turnover reached US\$20.03 billion, up to 9.3 percent from 2018, increasing as health insurance and pharmaceutical penetration rise. [7] The influence of decision makers has been a time tested tradition in the hierarchy. Revenue force spending usually accounts for an additional 15 percent to 20 percent of total business sales of the balance sheet item with the highest line item. Notwithstanding the extra cost still troubled by some very severe strategic and organizational issues, the organization has gone on to level become a net. [8]

**Evolution of Indian Pharmaceutical Industry**

Indian pharmaceutical manufacturing company began during private initiatives in the 1910s started Bengal Chemical and Pharmaceutical Works in Kolkata and Alembic Chemicals in Baroda and the establishment of tropical pharmaceutical research institutes. Chennai (in Tamil Nadu), King College of Preventive Medicine, Central Institute for Drug Research, Kasauli, Pastures Institute, Coonoor etc. through British initiatives. [9] The nascent industry has earned however post World War II losses resulting from new medical advances in tranquilizers, the Western countries causing natural transition of older medicinal products from the use of new medicinal products such as sulpha drugs, antibiotics, vitamins, hormone, and antihistamine, pharmacological substances, etc.

Company that wind up in local production of indigenous materials caused and the industry importing bulk drugs intended to be manufactured into formulation and for sale on domestic market. [10] We can divide the Indian pharmaceutical sector into four main stages. The pre 1970 era is the first stage in which foreign companies dominated the Indian market. The period between 1970 to 1990 is the second stage in which many domestic companies began operation. The third stage is between 1990-2010 in which the Indian companies lunch service in foreign countries. [11]

**Pharmaceutical Company Business Strategies**

The secret for achievement in business is always withstands by new concepts. Although best Indian firms concentrate on antibiotics and anti-infective drugs, Sun Pharma has concentrated on treating of cancer, depression and hypertension. The company has lunched whole product line and has owned more place of leadership in all these regions. [12] The company having a skilled role for the organization in any of these fields. The results for first quarter of FY02 justify this to some extension. Although the domestic sector was largely affected by a slowdown and, Sun Pharma posted sales growth of 26% over the years on the formulations market. Sun also used acquisitions and fusions to expand rapidly. This was acquired the bulk product facility to Knoll Pharma, Gujarat Lyka Organics, 51.5 percent. The Tamilnadu Dadha Pharma & Milmet Labs and acquired Natco's brands. Fax combining with Tamilnadu Dadha Pharma and acquiring the Natco's products, the firm has established presence in gynaecology and mergers with Tamilnadu Dadha Pharma segment Oncology. [13]





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### **Market or product development strategies:**

A plan for product or business growth includes the production of new products or the alteration of existing products and the sale of such goods to current or future customers. The four most common strategies in this category are

1. Entering into market
2. Market growth
3. Product enhancement
4. The Diversification. [14]

### **How are drugs promoted?**

The estimated cost of selling block-buster drugs is recently measured at \$895 million (EFPIA, 2002). Companies spending this money naturally need to recover their costs. Industry experts further point out that the pressure on Top Pharma Industry science less pipeline products to sustain present growth levels, by launching one new drug per year, companies will have to sell \$4.9 million.

Per 1-1.5% of the world's Pharmaceutical industry. [15] "A Company the size of recently combined Glaxo Wellcome Smith Kline Beecham needs 3 to 7 products per year, whereas one of the size of Astra Zeneca needs 2 to 4 products per year. The problem is that the quality of research productivity is declining. None of the top companies is nearer to the goal". [16] Nature of the marketing mission is different depending upon the drug category. There are generally two separate type of medications: self-medication or over the counter (OTC) medicine and prescribed drugs also called ethical medicine. [17]

### **Development of new drug and the therapeutically market place**

The motivation behind the pharma industry has been and will continue to be the discovery of new patentable molecular entities when registered and authorised person introduced into the market, significant profit can be made. [18] Overall however, the expense of research activities increases as their performance declines. It is difficult for large pharmaceutical companies to find new drugs at the rate required to continue the expected rise in profit. [19] This indicates that the issue of the cost of manufacturing products is starting to become More important following the recent mergers and acquisition activities, there is a push to cut costs by raising the number of research, development and production facilities. [20]

### **Marketing as a source of innovation:**

Marketing is the originator of new product ideas in many sectors and determines exact criteria of new products. Due to a very high degree of technological uncertainty, the entire development process focuses on developing innovations and requires a significant element of chance in pharmaceutical products, if marketing focuses on particular areas of study and product attributes serendipitous findings cannot be identified, acknowledged or followed. [21] Process of marketing: [22]

For several decades, product executives and marketing managers have used branding tactics to attain competitive advantage of consumer product and services. [23]. The Pharma industry has also prepared the fast moving consumer goods market (FMCG) where brands are seen like the main assets of a business, and where all sources are used to produce brands while the core concepts and techniques for branding a medicinal products are similar to any other product, marketing and sells difference have changed the pharmaceutical industry to develop new acceptable strategies. [24]

### **The key to branding**

1. In order to be effective customers, branding campaigns must be persuaded that Product or service Category has full sense of discrepancies between brands.
2. Consumers shouldn't believe all brands in this group are the same.
3. Perception=Value [25].





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### **Brand Management is the HUB of Pharmaceutical marketing: [26]**

#### **Maximising Brand Loyalty**

However in order for this approach to work it must be probable to distinguish the current version from the original medication or generics to offer a direct advantage to patients and Doctors. [27].

Promoting the reformulated anti-depressant Remeron by Oregano before patent expiry was unsuccessful as patients Receive Minimum incentives / benefits to switch. second generation or reformulation approaches may take time and expenditure for testing, approval and promotion and may not expand the patent in other countries. [28]. IN spite of challenges, market share may be maintained by brand loyalty if the enhanced product is launched still the original product is on the market. For example by launching extended release reformulation of their drug a few months before generic drug, they maintained success on the attention deficit hyperactivity disorder market. With sales down minimally, the brand has remained strong. [29]

#### **Important Industry Developments**

Significant developments on both the need and supply sides have influenced the development of the generic drug industry over the past 20 years. [30] One main event was the 1984 drug price competition and patent term restoration act, better known as the Hatch Waxman Act, which was passed through the establishment of an abbreviated New Drug Application (ANDA) procedure, which significantly minimised the entry cost and time for generic drugs. [31] Generic firms with an ANDA need only demonstrate that their products are bioequivalent to the branded product in order to obtain Federal Drug Administration (FDA) approval.

Furthermore, the law establish research exclusion so that generic firms could carry out their bioequivalence tests and obtain conditional FDA approval before the expiry of the brand product patents. The 1984 law also attempted to hit a balance between generic price rivalry and innovation by offering the prospect to brand name firms. [32]

#### **The process of new drug development**

New drug production is usually a continuous process. The decision must be focused on potential therapeutic advantages, expected incidence and harshness of adverse reaction, projected increased growth marketing, distribution and development costs and future reaction prediction. [34] The firm can start clinical testing 30 days after filing unless the FDA holds this application. Marketing clearance for clinical trials the sequence typically runs like the following chemists and biologists conduct extensive discovery work before synthesis to establish hypotheses for novel compound. [35]

Once a new compound has been used for drugs that make it all the way to synthesised FDA it will be Screened for pharmaceutical action and toxicity in vitro, and then in animals. [36] If the medication is still deemed to be potential candidate for further development at this stage the company must usually file an investigations still deemed to be a potential candidate for further development at this stage the company must usually file an investigation with the FDA in three separate stages each of which requires dissimilar quantities and forms of safety and efficacy information occur. [37]

Phase I experiments are carried out on a limited numbers of healthy volunteers. Such experiments are primarily performed to collect knowledge on human toxicity and appropriate dosing ranges. Data on the absorption and distribution of the drug in the body, its metabolic effects, and the way in which the drug is removed from the body are also collected Part II, the drug is given to a large number of people in the second step of human study. The selected groups include patients for whom the medication is accepted to be profitable. [38]





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### The Food Amendments of 1962:

The Drug and cosmetics Act 1938(FD and C) provides clear proof of the efficacy of the planned application of the medication before marketing authorisation can be given.

**Phase II** studies generally provide the first major evidence of their effectiveness when they are successful. Step III, the third and final step of pre-marketing drug research includes large –scale patient trials. During this phase additional evidence of the effectiveness is sought. [38]. The big sample size enhance the probability that statistically meaningful profit will be found to be true and after approval of the marketing several drugs will be used while comprehensive toxicology tests on animals occur during the preclinical period. [39] Typically, patients are enrolled in studies to detect teratological and carcinogenic effects, and Phase III testing is also useful in detecting adverse reactions rarely seen in patient populations. Furthermore, This test can approximate more closely how longterm animal testing is conducted by the concurrent with phases II and III. Long term stability checks and sometimes additional dosage formulation work and process improvement to manufacture the compound in sufficient amounts of the clinical trials also occur during the clinical era. After completion of various phases of clinical development, the company believes it has enough proof and acceptance it will send a New KE Mattson et al. (1988) for trend analysis of the number of INDs submitted by U.S. firms. [40].

## CONCLUSION

Through various base of marketing of a pharmaceutical industry can achieve success in the market. The relationship between three factors that is company, customer and competitors are always determine the growth and loss of a pharmaceutical industry at last the role of supply change also place an important in both acute and chronic therapy in the market. The company also have to plan release of new drugs and upgrading of old drugs is also as a major process in the market. We hope that our study create some light on present development of marketing strategies on pharmaceutical industry.

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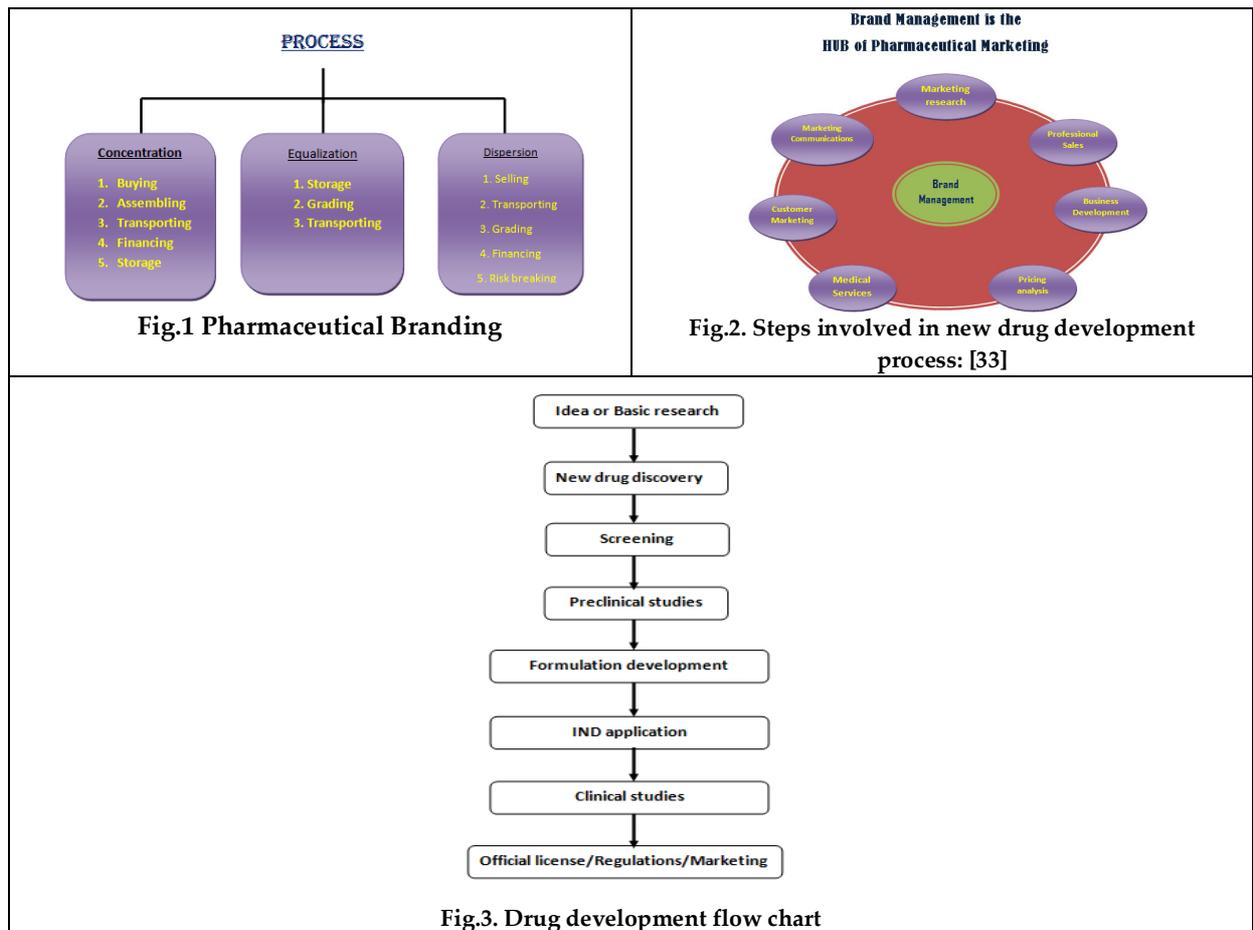
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## Comparative Study of *Cinerea Maritima* and Vanadium Salicylic Acid Coordination Complex in Diabetic Cataract Induced *In vitro* in Goat Lens

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### ABSTRACT

Diabetes is one of the major health problems that affect a large number of human populations. Diabetic cataract is one of the most frequent ocular complications rising secondarily to the diabetes vanadium and its various coordination metal complex plays a significant role in reduction of diabetes as well as cataract. *Cinerea maritima* is one of the common herbal remedy used to manage diabetic cataract affecting the aldose reductase pathway. The current work had been done with the aim of comparing the role of *Cinerea maritima* and Vanadium Salicylic Acid Coordination Complex in Diabetic Cataract Induced *in vitro* in Goat Lens model. In the study it was concluded that the effect of *Cinerea maritima* is more effective in reducing the opacity of the goat lens as compared to the diabetic cataract.

**Keywords:** Diabetes, cataract, salicylic acid, *Cinerea maritima*, Coordination Complex.

### INTRODUCTION

Diabetes is one of the major health problems that affect a large number of human populations. Diabetic cataract is one of the most frequent ocular complications rising secondarily to the diabetes vanadium and its various coordination metal complex plays a significant role in reduction of diabetes as well as cataract. *Cinerea maritima* is one of the common herbal remedy used to manage diabetic cataract affecting the aldose reductase pathway. *Cinerea maritima* is also more effective in reducing the opacity of the goat lens as compared to the diabetic cataract.





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## MATERIALS AND METHODS

### Chemicals and Reagents

Salicylic acid, VOSO<sub>4</sub> were purchased from Hi-media and other various chemicals and diagnostic kits were of analytical grade. *Cinreria maritima* was given as gift sample from Beckson Homeopathic, New Delhi.

### Synthesis of Metal Complex

Metal complex had been synthesized using the method given by Bhattacharya. Salicylic acid and 50% aqueous solution of VOSO is mixed in a molar ratio of 2/1 in 96% ethanol. The product formed was then stirred under nitrogen atmosphere. The pH was maintained at 3.5. The temperature was maintained between 0–8°C. The green oil was formed indicating formation of complex. Successive washings with bidstilled water produced a light green solid. The analytical data was as per the previous work of Bhattacharya *et al* [21], [22].

### Induction of in-vitro Cataract

Glucose at a concentration of 55 mM was used to induce cataracts, when there is high concentrations of glucose in the lens, it metabolizes through the sorbitol pathway leading to accumulation of polyols (sugar alcohols) which causes over hydration leading to oxidative stress. A total of 24 lenses were used for the study. These lenses were incubated in artificial aqueous humour with concentration of glucose 5.5 mM served as normal control and 55 mM served as toxic control for 72 hours. The lens were divided into three groups each group containing 6 lenses:-

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Group I: Glucose 5.5 mM (normal control).

Group II: Glucose 55 mM (toxic control).

Group III: Glucose 55 mM + Vanadium-salicylic acid

Group IV: Glucose 55 mM + *Cinreria maritima*

### Morphological and Photographic Evaluation

Goat lenses were placed on a graph paper with its surface posterior part touching the graph. The lens were observed. Photographic evaluation was done using the Nikon-Cybershot Camera.

## RESULT

**Synthesis of complex** ; A green coloured complex was formed. [Figure 1]

### Induction of the Cataractogenesis and Treatment with the Synthesized Complex and *Cinreria maritima*

All lenses in normal group remained transparent whilst all lenses in diabetic cataract and nicotine developed dense opacities indicating cataract. The opacity gradually increased towards the centre with complete opacification by 72 hours indicating complete cataract formation. In the study it was observed that the toxic control group showed more opacity as compared to the normal group. The opacification is less in the *Cinreria maritima* group as compared to the diabetic control as well as the *Cinreria maritima* group. Figure 2: Opacity in the various treatment groups. Group I: Glucose 5.5 mM (normal control). Group II: Glucose 55 mM (toxic control). Group III: Glucose 55 mM + Vanadium-salicylic acid. Group IV: Glucose 55 mM + *Cinreria maritima*

## DISCUSSION

Opacification in the lens is one of the most common complications of the diabetes mellitus.[23,24] The current approach to manage the cataract is the surgical approach. The major drawback that was associated with the surgical approach is the complications arising from the surgical approach [25]. In a previous cross-sectional study it was conducted that the evidence that subject in one of the developing state of India had average income less than 10000



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rupees per month. Most of the subjects were not very literate. The above evidence compels us draw conclusion that in a state where a large number of population had been not been educated, the awareness toward the health is very less and post-operative chances of complications arise due to lack of follow up visits after the surgery, an easy, patient compliance and economical system for diabetic cataract should be devised for maximum therapeutics effects with minimum obnoxious effects [21]. Development of the pharmacotheruputical approach is the best suited alternative to the surgical approaches. In the study it was observed that *Cinneria maritima* is more effective in management of lenticular opacity as compared to the synthesized complex in the toxic control group. The probable mechanism of action *Cinneria maritima* is well known homeopathic drug, this current work emphasis the scientific explanation to the homeopathic system of medicine which is always under the suspicion of a “fringe science”. The current work also emphasis the role of Vanadium-Salicylic acid coordination complex against the diabetic cataract. The current work had laid the impetus regarding the *In vivo* studies of Vanadium-Salicylic acid coordination, antioxidant parameters like GSH, MDA, GPx, SOD and CAT, the pathway it effects to show the biological actions, the structural elucidation of the complex formed. Thus it could be concluded in the nutshell that more homeopathic formulation and novel approaches should be explored to get a system with maximum benefits and minimum side effects.

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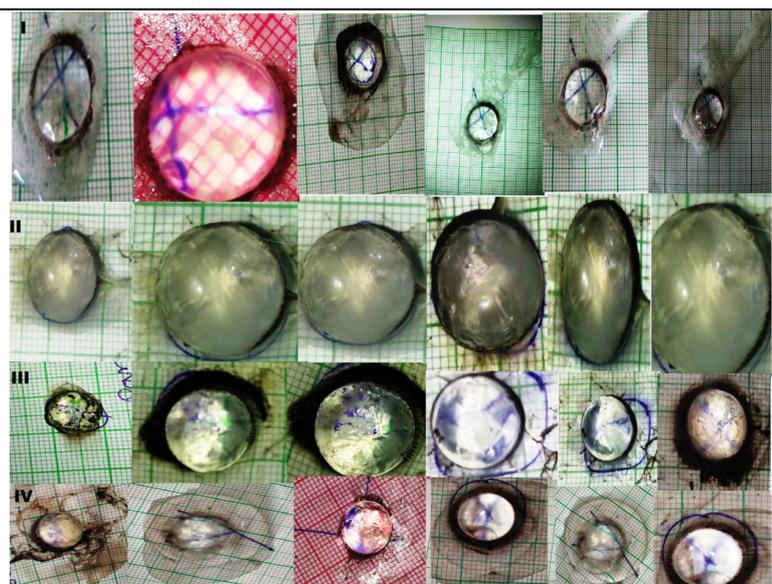


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**Figure 1: Vanadyl –Salicylic acid synthesized complex**



**Figure 2: Opacity in the various treatment groups**





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Cis-Isoprene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and cis-isoprene composite were studied. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the parameters will increase with increase in mass fraction of acrylic acid. This study will help in determining pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** blend, polyacrylic acid, Cis-isoprene composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their individuality in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire resistant materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments. Usually blends are primed by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have to focus on the use of Insilico approach [7] to develop new blends. This study intends to envisage the permeability related properties of polyacrylic acid and cis-isoprene composite.





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## MATERIALS AND METHODS

For the analysis part “Materials studio module of Biovia software (Dassault Systemes of France)” was used. The structures of polyacrylic acid and cis-isoprene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. From Figure 1 we can find that, the heat capacity ( $C_p$ ) of the composite increases linearly with the increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 shows that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSION

The probable use of polyacrylic acid and cis-isoprene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicate that all the three parameters increased with increase in mass fraction of acrylic acid. This In-silico study will help to determine the components of a blend without performing laboratory experiments saving materials, money and time.

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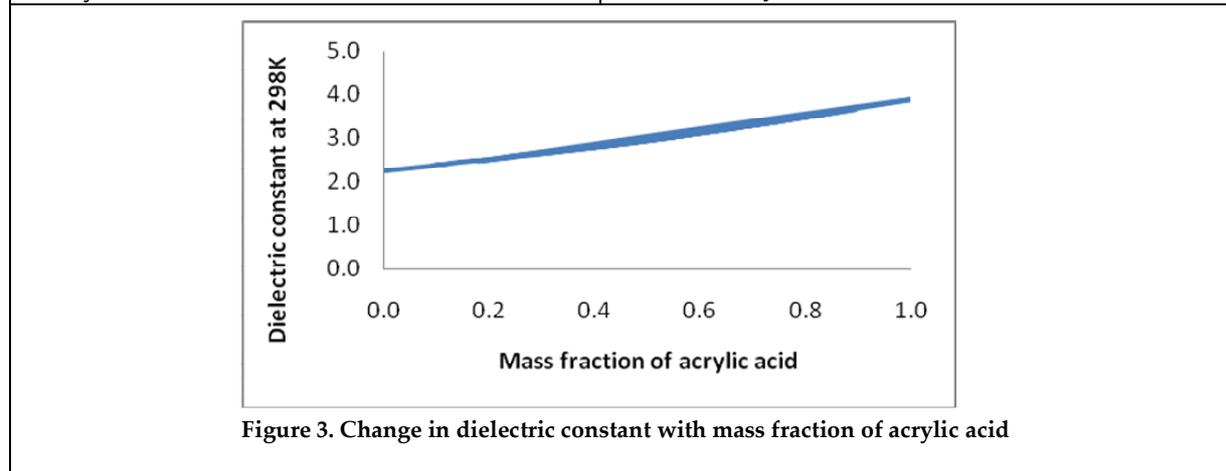
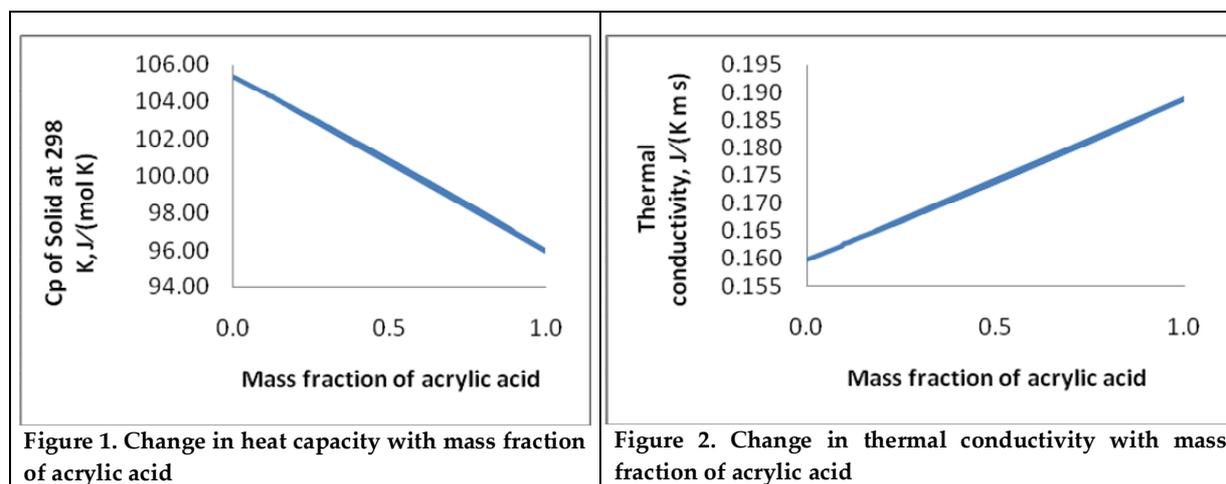
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## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Cis-Isoprene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and cis-isoprene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties increased with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, polyacrylic acid and cis-isoprene, Biovia Materials Studio

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error technique which helps it in reducing wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and cis-isoprene composite.





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## MATERIALS AND METHODS

For the analysis of the experiment “Materials studio module of Biovia software (Dassault Systemes of France)” was used. The structures of polyacrylic acid and cis-isoprene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS & DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. From Figure 1 we can see that, the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain”. From Figure 2 we can see that, the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. From Figure 3 we can see that, the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is known as the ratio of lateral strain to longitudinal strain”. From Figure 4 we can find that, the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. From Figure 5 we can see that, the brittle fracture stress of the composite increases linearly with increase in mass fraction of acrylic acid.

## CONCLUSION

The possible usage of polyacrylic acid and cis-isoprene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to its mechanical properties. The results specified that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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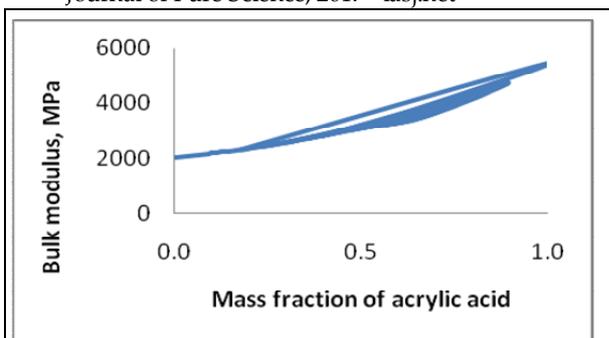


Figure 1. Change in bulk modulus with mass fraction of acrylic acid

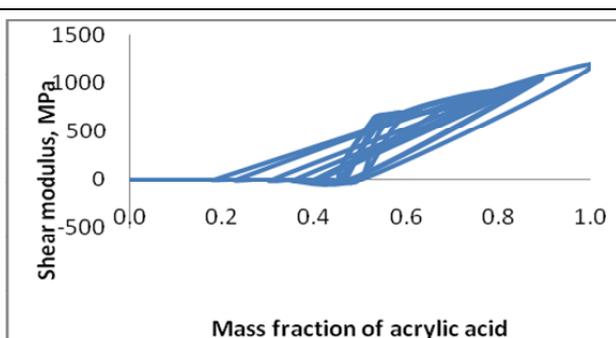


Figure 2. Change in shear modulus with mass fraction of acrylic acid

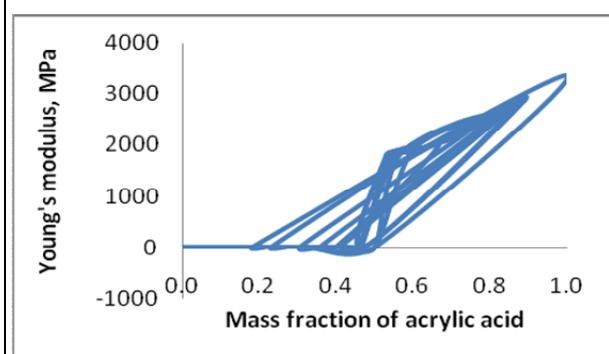


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

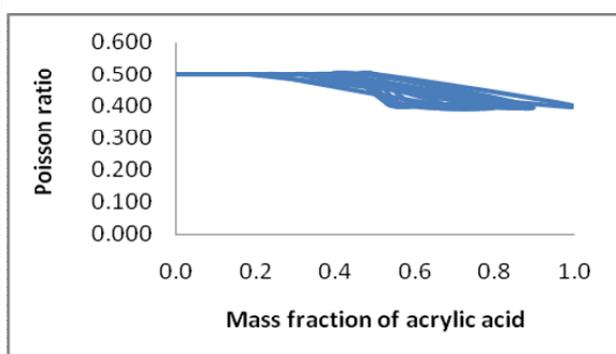


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

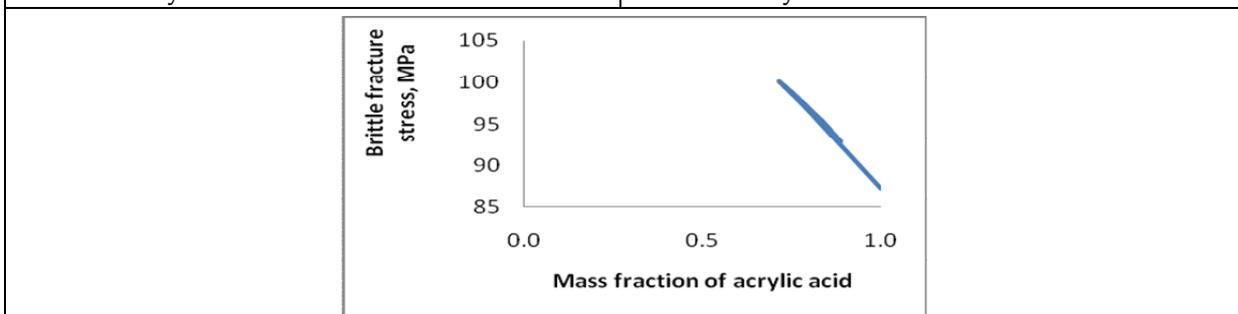


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Cis-Isoprene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and cis-isoprene composite were studied. The molar volume and density declined with the increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, polyacrylic acid, cis-isoprene composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and cis-isoprene composite.





Suchismita Dash and Ankita Subhramita Gadtya

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and cis-isoprene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 shows that the molar volume of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 shows that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymeric membrane after the gas has come to equilibrium”. Figure 3 shows that the permeability of oxygen through the composite decreases with increase in mass fraction of acrylic acid.

Figure 4 show that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Figure 5 shows that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and cis-isoprene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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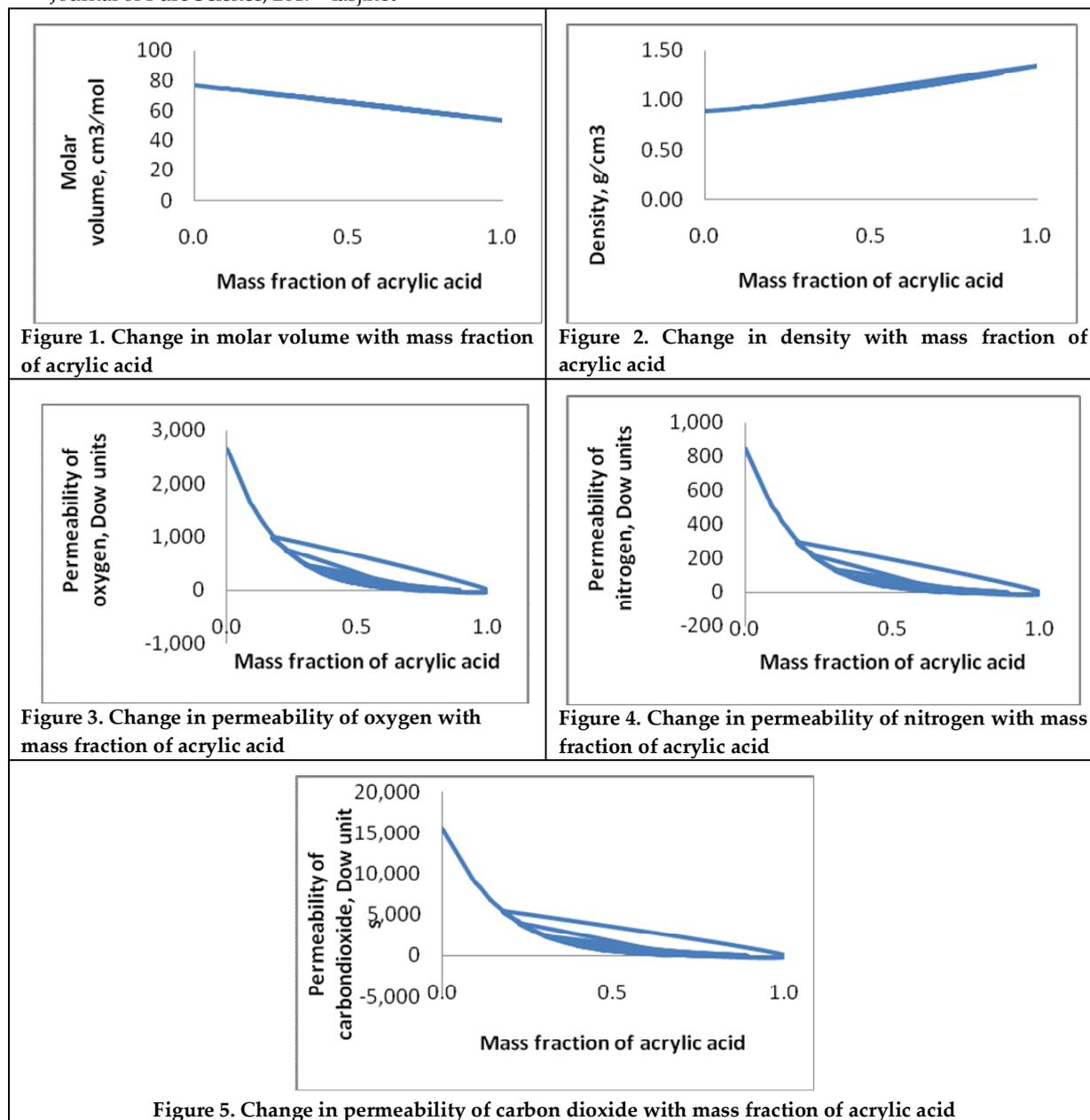
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## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Poly14ad-Glucose Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly14aD-glucose composite were studied. The proportion of the blend was examined with respect to heat capacity, thermal conductivity and dielectric constant. The results show that all those parameters increased with increase in mass fraction of acrylic acid. This analysis will help to determine pairs without executing laboratory experiments saving materials, money and time.

**Keywords:** Blend, polyacrylic acid, poly14aD-glucose

## **INTRODUCTION**

Blends are the combination of more than one component. The components remain same their identity in the blend. They integrate and provide the property of the blend to improving the quality of the material. To develop a single material with the needed property requires notable research and time. A blend saves time to develop a new material with reducing the cost of development of products with needed properties. Polymer blends can be modified into nano material polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly14aD<sub>2</sub>glucose composite.





Asha Rani Dalai

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly14aD\_glucose were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. As shown in the Fig. 1 it is observed that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. As shown in the Fig. 2 it is observed that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. As shown in the Fig.3 it is observed that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and poly14aD\_glucose to form a blend was explored using Biovia Materials Studio. The proportion of the blend was examined with respect to permeability properties. The composition of the blend was examined with respect to heat capacity, thermal conductivity and dielectric constant. The results show that all the three parameters increased with increase in mass fraction of acrylic acid. This silico analysis will help to determine components of a blend without executing laboratory experiments saving materials, money and time.

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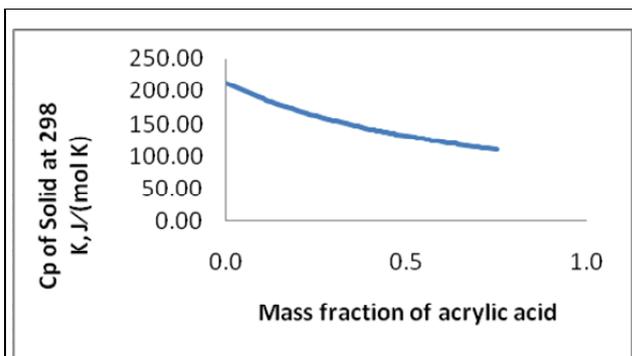


Fig. 1. Change in heat capacity with mass fraction of acrylic acid

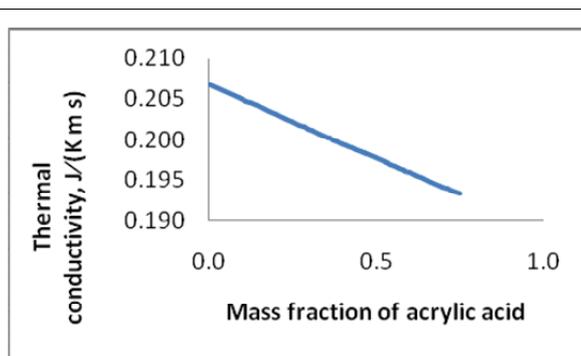


Fig. 2. Change in thermal conductivity with mass fraction of acrylic acid

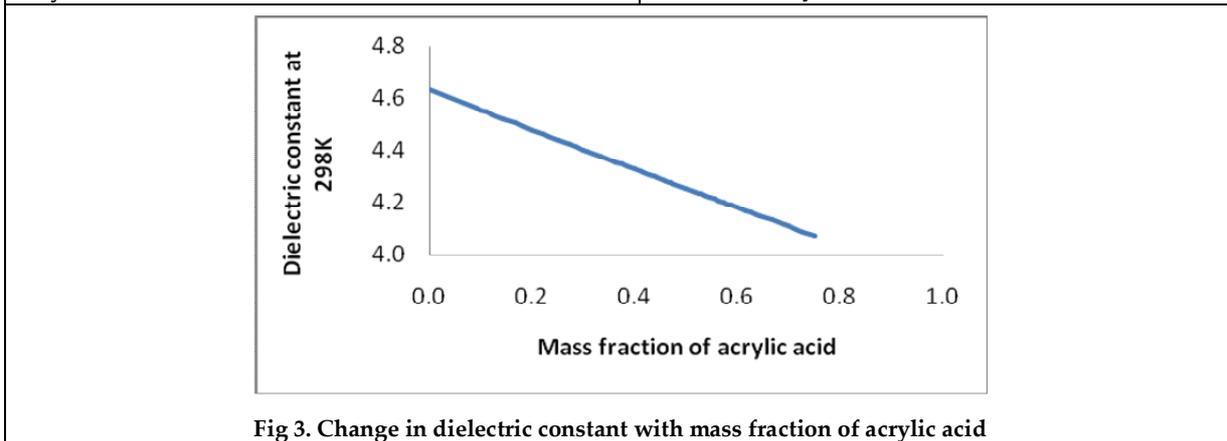


Fig 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Poly 14ad\_Glucose Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and poly14aD\_glucosecomposite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results show that the values of all the properties increased with increase in mass fraction of acrylic acid. This analysis will help determine pairs without executing laboratory experiments saving materials, money and time.

**Keywords:** Blend, polyacrylic acid, poly14aD\_glucose composite

## **INTRODUCTION**

Blends are the combination of more than one component. The components remain same their identity in the blend. They integrate and provide the property of the blend to improving the quality of the material. To develop a single material with the needed property requires notable research and time. A blend saves time to develop a new material with reducing the cost of development of products with needed properties. Polymer blends can be modified into nano material polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus; researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and poly14aD\_glucose composite.





D Nikita Patra and Asha Rani Dalai

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly14aD\_glucose were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. As shown in Fig.1 it is observe that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.”As shown in the Fig 2 it is observe that the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. As shown in the Fig 3 it is observe that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. As shown in the Fig 4 it is observe that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. As shown in the Fig 5 it is observe that the brittle fracture stress of the composite increases linearly with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and poly14aD\_glucose to form a blend was explored using Biovia Materials Studio. The proportion of the blend was examined with respect to mechanical properties. The results show that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This silico analysis will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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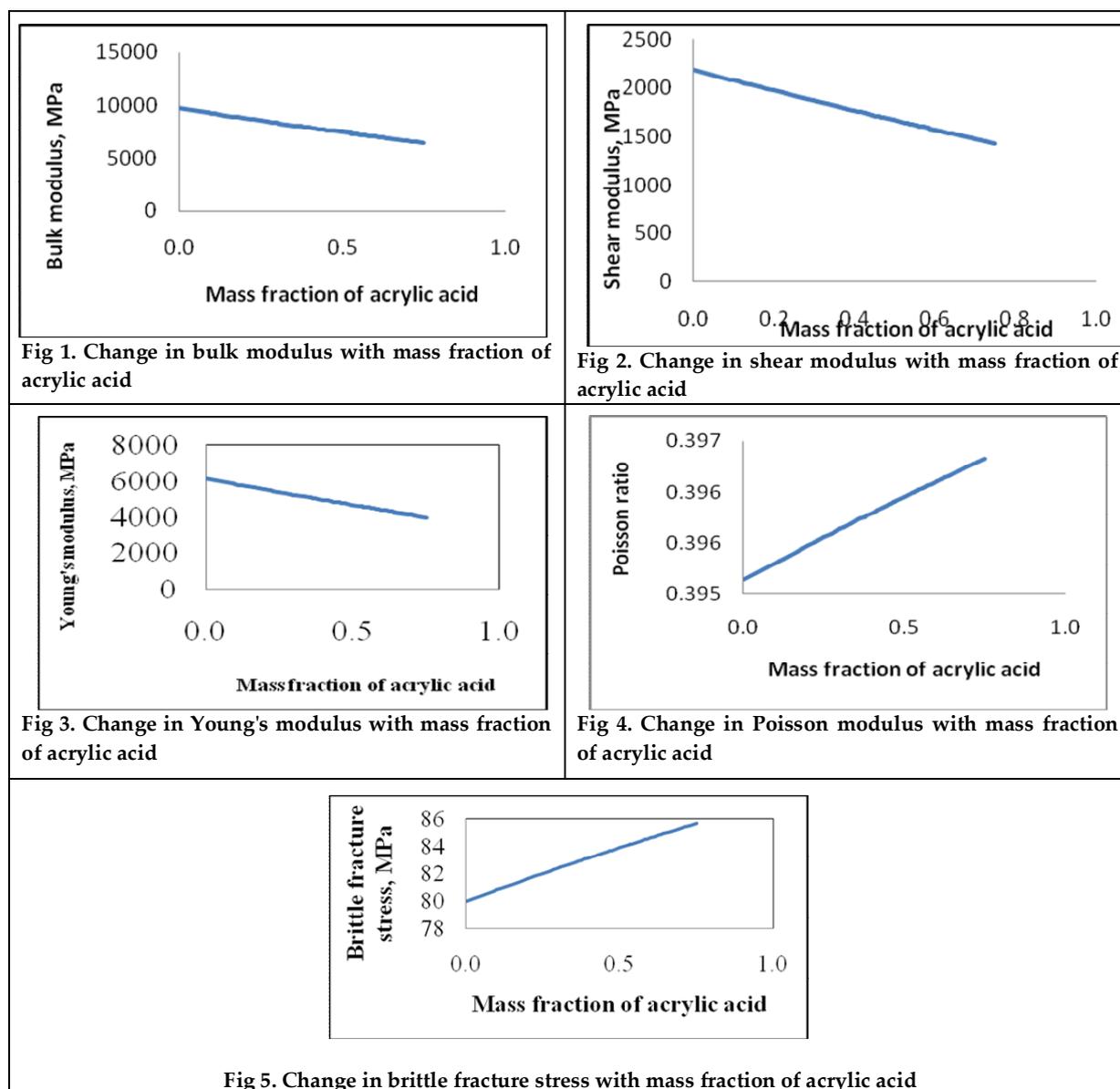
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## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Poly 14ad\_Glucose Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly14aD\_glucose composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This analysis will help to determine pairs without executing laboratory experiments saving materials, money and time.

**Keywords:** blend, Biovia, polyacrylic acid, poly14a D\_glucose composite

## **INTRODUCTION**

Blends are the combination of more than one component. The components remain same their identity in the blend. They integrate and provide to the property of the blend with improving the quality of the material. To develop a single material with the needed property requires notable research and time. A blend saves time to develop a new material with reducing the cost of development of products with needed properties. Polymer blends can be modified into nano material polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly14aD\_glucose composite.





Alisha Rath and Asha Rani Dalai

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly14aD\_glucose were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. As shown in the Fig 1 it is observe that the molar volume of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. As shown in the Fig 2 it is observe that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. As shown in the Fig 3 it is observe that the permeability of oxygen through the composite decreases with increase in mass fraction of acrylic acid.

As shown in the Fig .4 it is observe that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid.

As shown in the Fig 5 it is observe that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and poly14aD\_glucose to form a blend was explored using Biovia Materials Studio. The proportion of the blend was examined with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results show that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This silico analysis will help to determine components of a blend without executing laboratory experiments saving materials, money and time.

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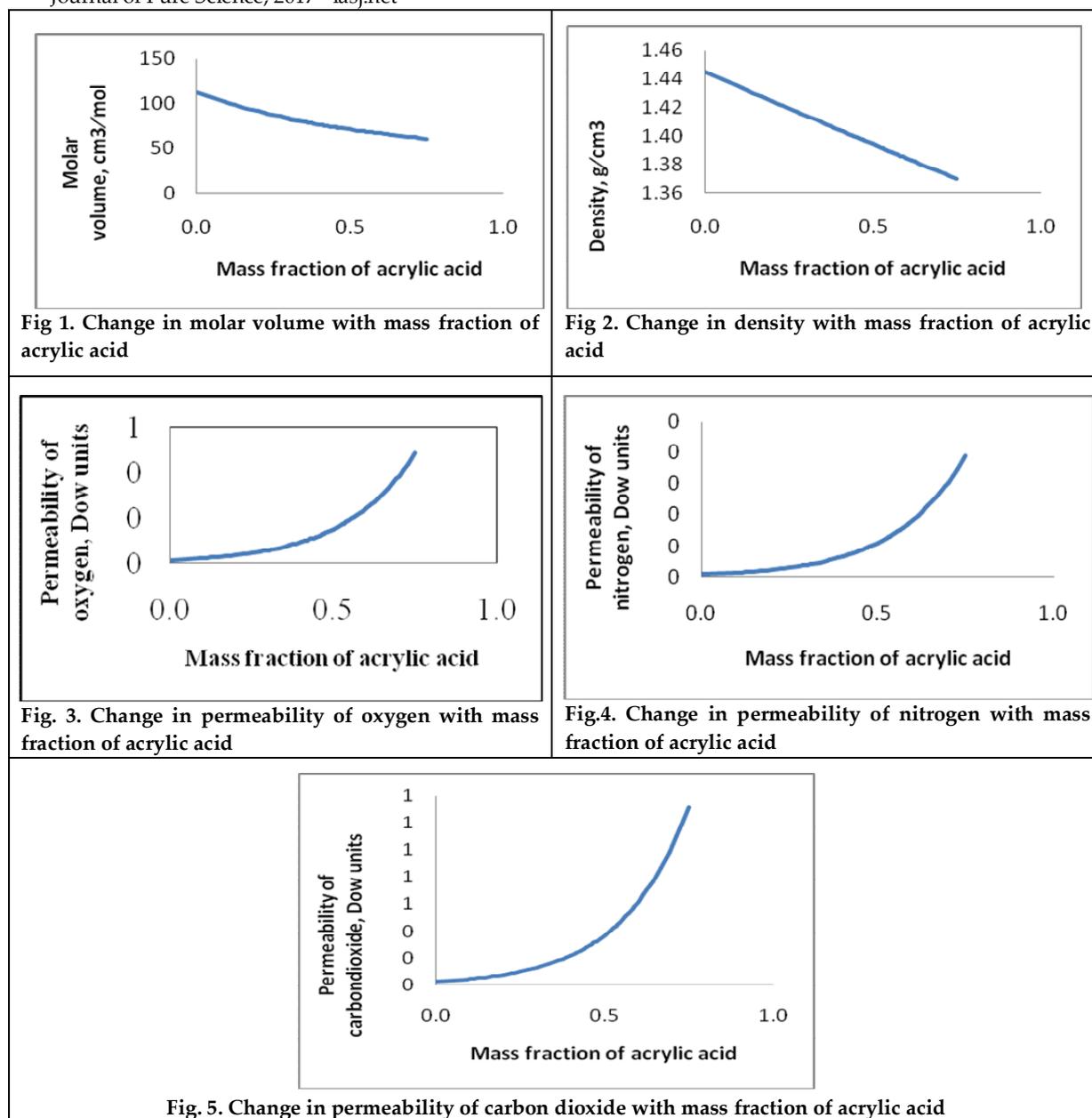
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**Alisha Rath and Asha Rani Dalai**

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## ***In silico* Analysis of Mechanical Properties of Acrylic Acid-Oxymethelene Composite**

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### **ABSTRACT**

A complex is a combination of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the Acrylic acid-Oxymethelene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The outcome signifies that the values of all the properties enhanced with increase in mass fraction of Acrylic acid-Oxymethelene. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blends, Biovia, Acrylic acid-Oxymethelene composite

## **INTRODUCTION**

Blends are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the mechanical properties of Acrylic acid-Oxymethelene composite.





Shiba Joshi et al.

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of Acrylic acid-Oxymethelene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the diminish in volume with an boost in pressure”. Figure 1 shows that the bulk modulus of the blend increases with increase in mass fraction of Acrylic acid-Oxymethelene linearly.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.”Figure 2 shows that the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”.Figure 3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”.Figure 4 shows that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”.Figure 5 shows that the brittle fracture stresses of the composite increases linearly with increase in mass fraction of Acrylic acid-Oxymethelene

## CONCLUSION

The possibility of use of Acrylic acid-Oxymethelene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results point to the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) improved with increase in mass fraction of acid-Oxymethelene. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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**Shiba Joshi et al.**

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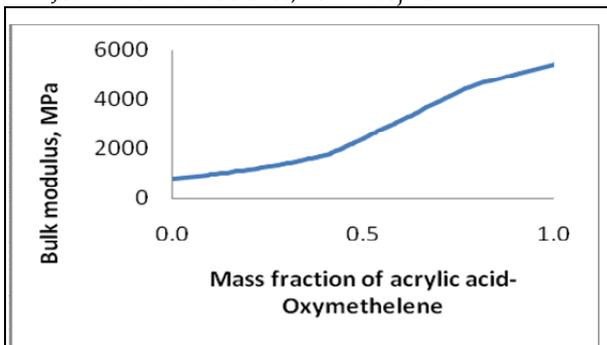


Figure 1. Variation in bulk modulus with mass fraction of Acrylic acid-Oxymethelene

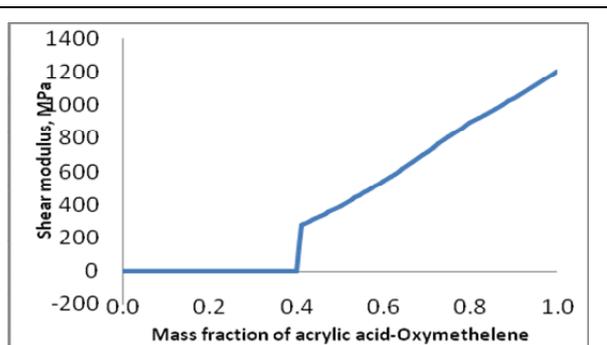


Figure 2. Variation in shear modulus with mass fraction of Acrylic acid-Oxymethelene

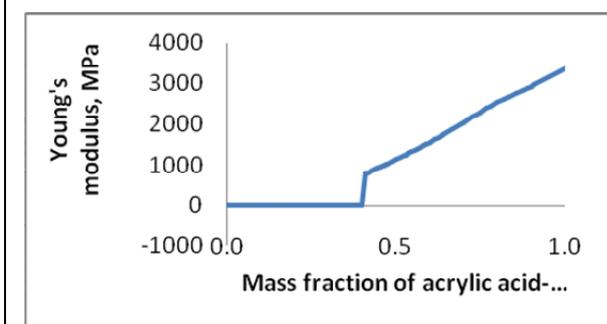


Figure 3. Variation in Young's modulus with mass fraction of Acrylic acid-Oxymethelene

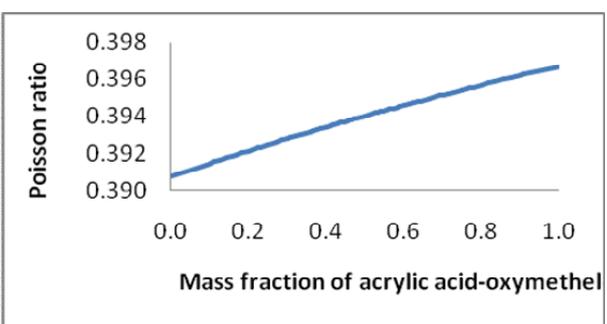


Figure 4. Variation in Poisson modulus with mass fraction of acrylic acid

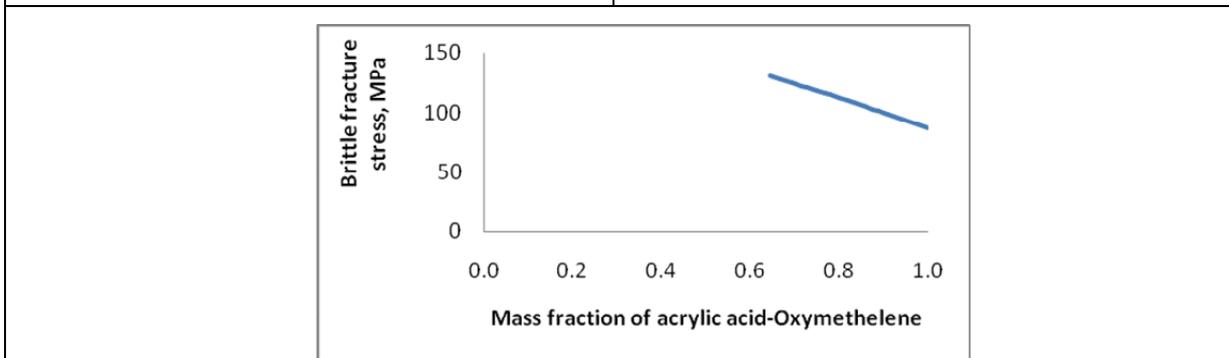


Figure 5. Variation in brittle fracture stress with mass fraction of Acrylic acid-Oxymethelene





## ***In silico* Analysis of Thermal and Dielectric Properties of Acrylic Acid and Oxymethelene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the Acrylic acid and oxymethelene studied. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all those parameters increased with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blends, Biovia, Acrylic acid, oxymethelene

## **INTRODUCTION**

Composites are materials containing more than one component. The components intact their identity in the mixture. They unite and give to the property of the blend thereby enhancing the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired characteristics. Polymer composites can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of Acrylic acid and oxymethelene composite.





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## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of Acrylic acid and oxymethelene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 demonstrates that the heat capacity ( $C_p$ ) of the Acrylic acid and oxymethelene composite is increased with increase in mass fraction linearly.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. In Figure 2, it has been observed that the thermal conductivity of the composite increases linearly with enhancing the mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 exhibits variation of the dielectric constant of the composite. It signifies that dielectric constant increases with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of **Acrylic acid and** oxymethelene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the three parameters increased with increase in mass fraction of Acrylic acid and oxymethelene.

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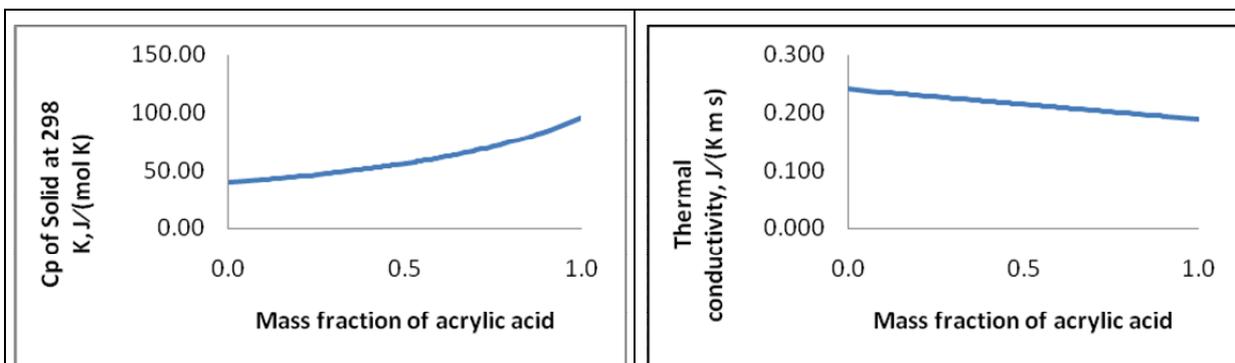


Figure 1. Change in heat capacity with mass fraction of acrylic acid

Figure 2. Change in thermal conductivity with mass fraction of acrylic acid

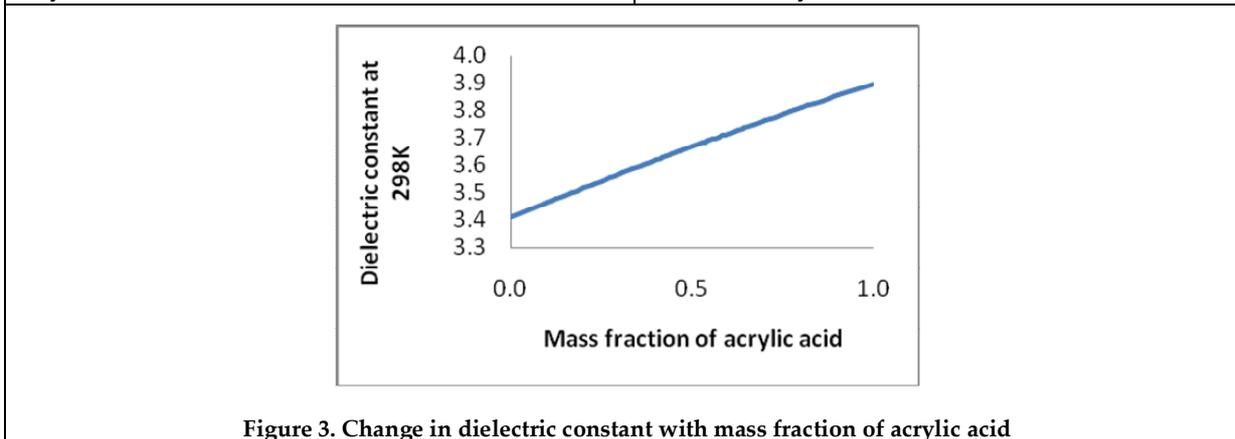


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Acrylic Acid-Oxymethelene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the Acrylic acid-Oxymethelene composite were studied. The molar volume and density reduce with increase in Acrylic acid-Oxymethelene fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The outcomes presents that the permeability for all the gases decreased with increase in mass fraction of Acrylic acid-Oxymethelene composite

**Keywords:** Blend, Biovia, Acrylic acid-Oxymethelene,

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the superiority of the material. A blend save time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high potency for transportation industries [5], glass fiber reinforced polymers, latex polymer cementations composites [6] etc.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study propose to predict the permeability related properties of Acrylic acid-Oxymethelene composite





Pranabdatta Swain *et al.*

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of Acrylic acid-Oxymethelene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 exhibits that the molar volume of the composite diminish with increase in mass fraction of acrylic acid linearly.

**Density:** “Density is mass per unit volume”. Figure 2 shows that the density of the composite decreases linearly with increase in mass fraction of Acrylic acid-Oxymethelene.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 shows Acrylic acid-Oxymethelene composite at the permeability of oxygen through the composite decreases with augment in mass fraction of Acrylic acid-Oxymethelene.

Figure 4 shows that the permeability of nitrogen through the composite decreases with increase in mass fraction of Acrylic acid-Oxymethelene. Figure 5 shows that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of Acrylic acid-Oxymethelene.

## CONCLUSION

The possibility of use of Acrylic acid-Oxymethelene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density lessen with augment in Acrylic acid-Oxymethelene fraction. The permeability properties of the composite were analysed based on permeability of oxygen, nitrogen and carbon dioxide. The consequences state that the permeability for all the gases decreased with increase in mass fraction of Acrylic acid-Oxymethelene.

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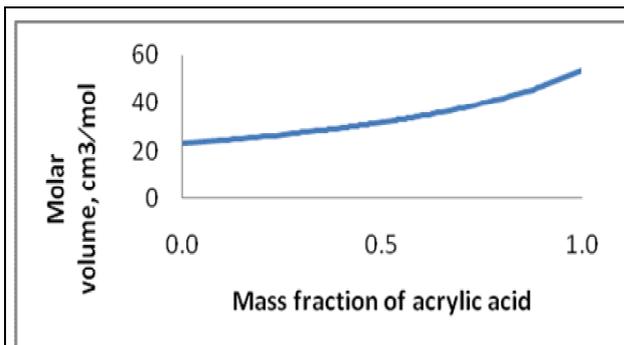


Figure 1. Change in molar volume with mass fraction of Acrylic acid-Oxymethelene

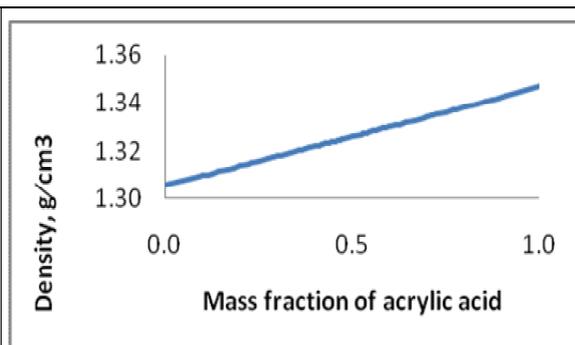


Figure 2. Change in density with mass fraction of Acrylic acid-Oxymethelene

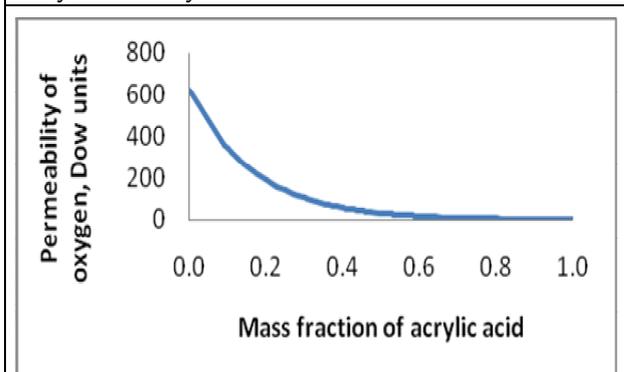


Figure 3. variation in permeability of oxygen with mass fraction of Acrylic acid-Oxymethelene

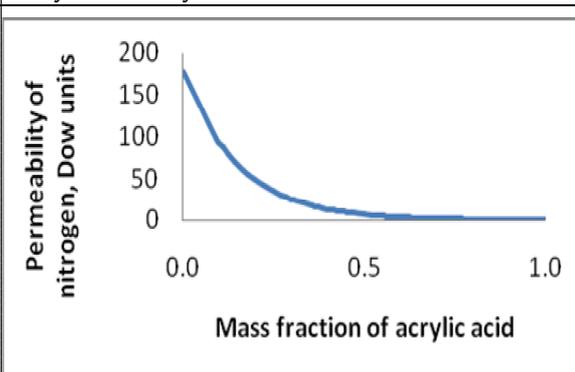


Figure 4. Change in permeability of nitrogen with mass fraction of Acrylic acid-Oxymethelene

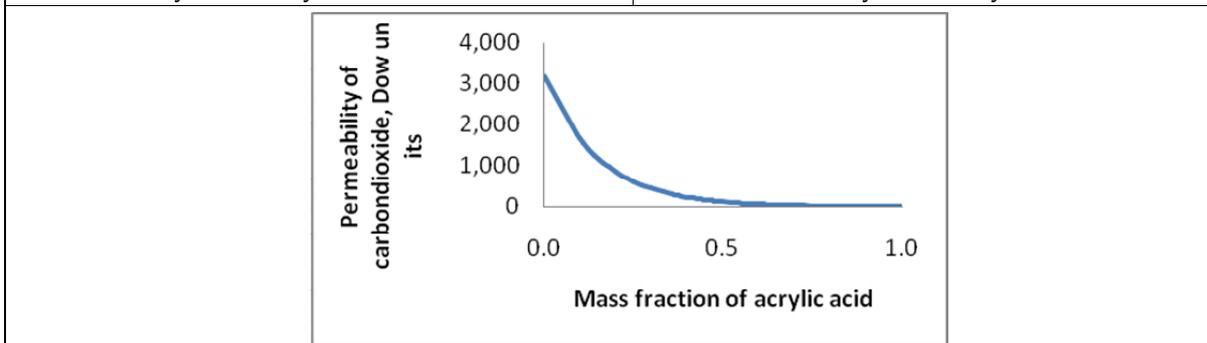


Figure 5. Variation in permeability of carbon dioxide with mass fraction of Acrylic acid-Oxymethelene





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and 1,4-Beta –D-Glucose composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and 1,4-beta-D-glucose composite were studied. The composition of the blend was examined with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all those parameters are present, increased with increase in mass fraction of acrylic acid. This work will help determine pairs without performing laboratory and industrial experiments saving materials, money and time.

**Keywords:** Blend, biovia, polyacrylic acid, 1,4-beta-D-glucose composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component. In the mixture, the components do not lose their identity. They combine and contribute to the material goods of the blend thereby civilizing the quality of the material. Development of a single material with the most wanted property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of expansion of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and 1,4-beta-D-glucose composite.





## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and 1,4-beta-D-glucose were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 display the performance that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 display the performance that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 display the performance that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSION

The prospect of use of polyacrylic acid and 1,4-beta-D-glucose to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The domino effect indicated that all the three parameters increased with increase in mass fraction of acrylic acid. This in silico study will help to determine components of a blend without performing any laboratory experiments saving materials, money and time.

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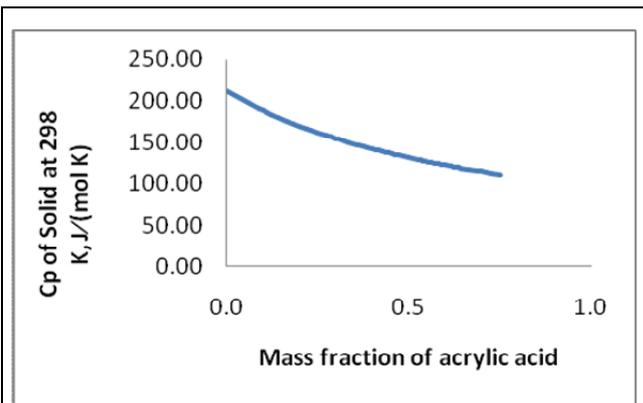


Figure 1. Change in heat capacity with mass fraction of acrylic acid

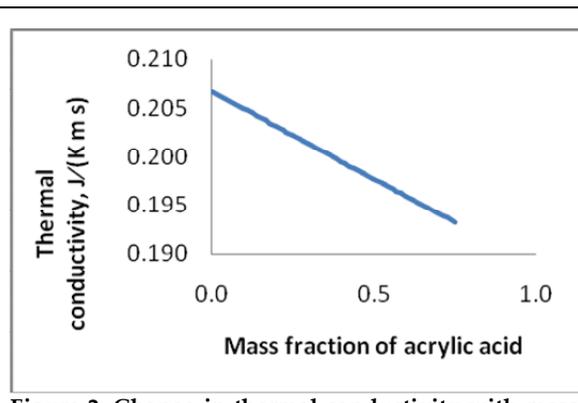


Figure 2. Change in thermal conductivity with mass fraction of acrylic acid

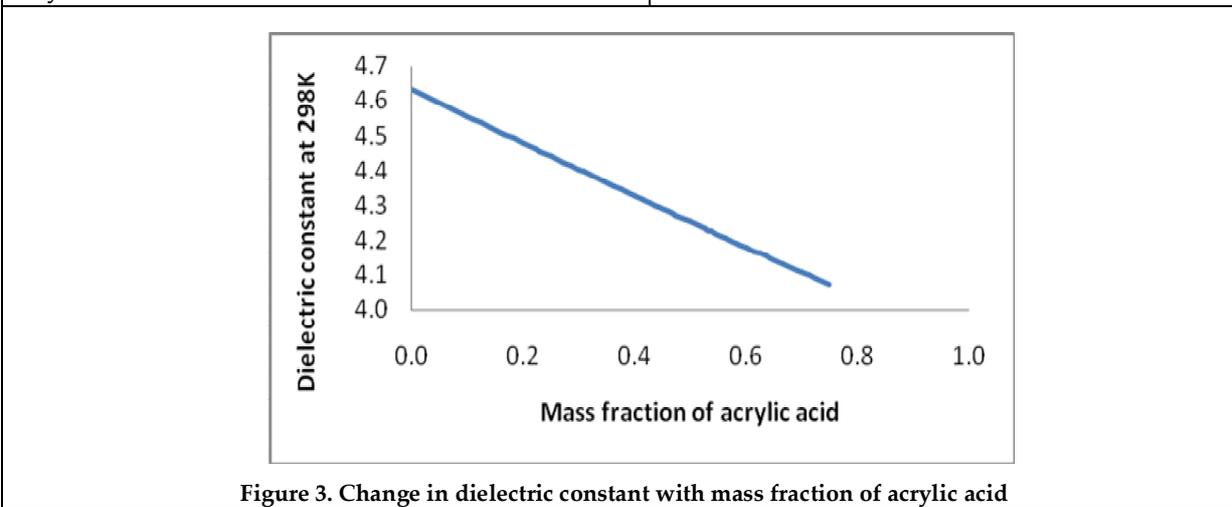


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid 1,4-Beta-D-Glucose Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and 1, 4-beta-D-glucose composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The consequences indicated that the values of all the properties amplified with amplify in mass fraction of acrylic acid. This work will help to determine pairs without performing laboratory and industrial experiments saving materials, money and time.

**Keywords:** Blend, Biovia, polyacrylic acid, 1,4-beta-D-glucose composite

## **INTRODUCTION**

Blends or composites are materials containing additional than one components. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby civilizing the quality of all the material. Development of a single material with the preferred property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with preferred properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and 1,4-beta-D-glucose composite.





Suchismita Dash and Debajani Tripathy

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and 1,4-beta-D-glucose were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:**“Bulk modulus is the evaluate of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the compound increases linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:**“It is defined as the ratio of shear stress and shear strain.”Figure 2 shows that the shear modulus of the compound increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:**“It is defined as the ratio of stress and strain and compares relative stiffness”.Figure 3 shows that the Young's modulus of the compound increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”.Figure 4 shows that the Poisson ratio of the compound increases linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:**“Brittle Fracture is the sudden, rapid furious of a material under stress”.Figure 5 shows that the brittle fracture stress of the compound increases linearly with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and 1,4-beta-D-glucose to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The domino effect indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This in silico study will help find out components of a blend without performing laboratory experiments saving materials, money and time.

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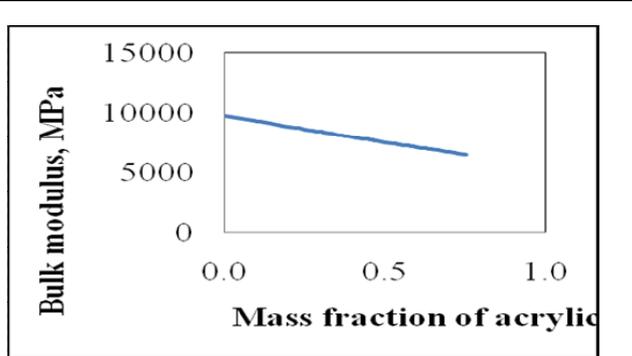


Figure 1. Change in bulk modulus with mass fraction of acrylic acid

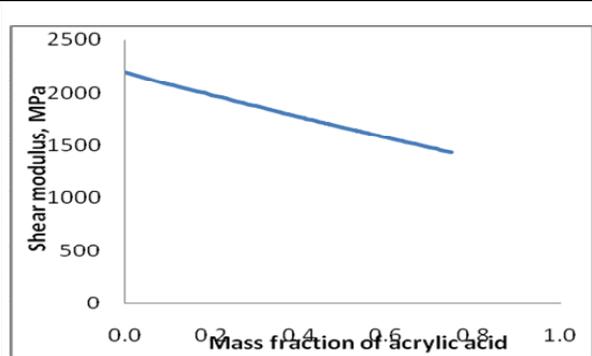


Figure 2. Change in shear modulus with mass fraction of acrylic acid

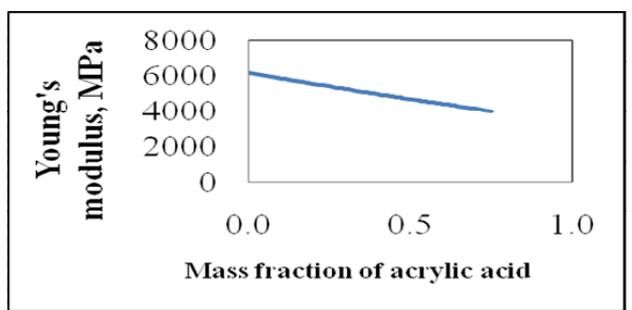


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

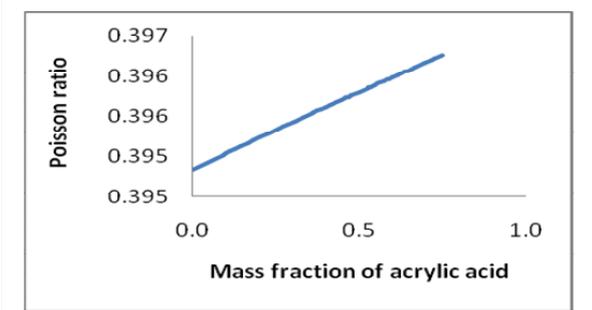


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

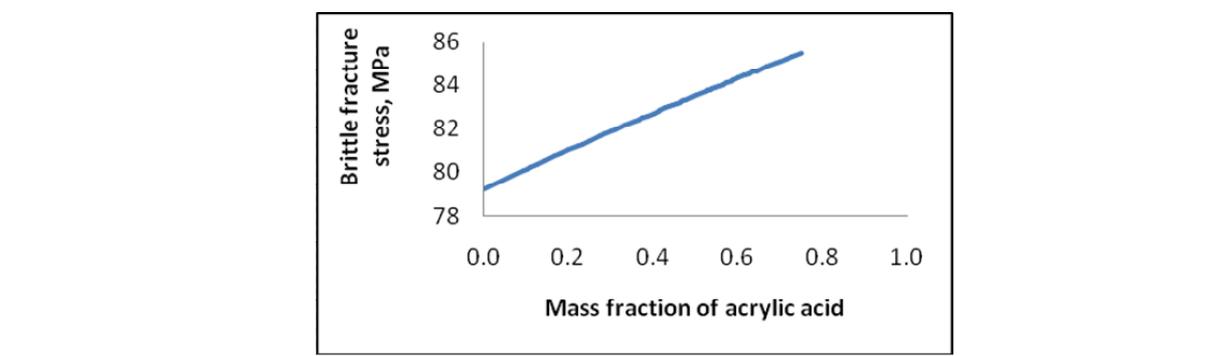


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and 1,4-Beta-D-Glucose Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and 1,4-beta-D-glucose composite were considered. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the complex were considered based on permeability of oxygen, nitrogen and carbon dioxide. The outcome showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This analysis will help to settle on pairs without performing any laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, polyacrylic acid and 1, 4-beta-D-glucose composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component combine to make unique materials having significant properties. The components do not lose their identity in the mixture. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new unique material thereby dropping the cost of development of products with desired properties. Polymer blends can be nano material customized polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and 1,4-beta-D-glucose composite.





Himan Meher and Debajani Tripathy

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and 1,4-beta-D-glucose were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 looks that the molar volume of the complex decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 looks that the density of the complex decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 looks that the permeability of oxygen through the complex decreases with increase in mass fraction of acrylic acid.

Figure 4 looks that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid.

Figure 5 looks that the permeability of carbon dioxide through the complex decreases with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and 1,4-beta-D-glucose to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the complex were studied based upon permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This in silico study will help find out components of a blend without performing laboratory experiments saving materials, money and time

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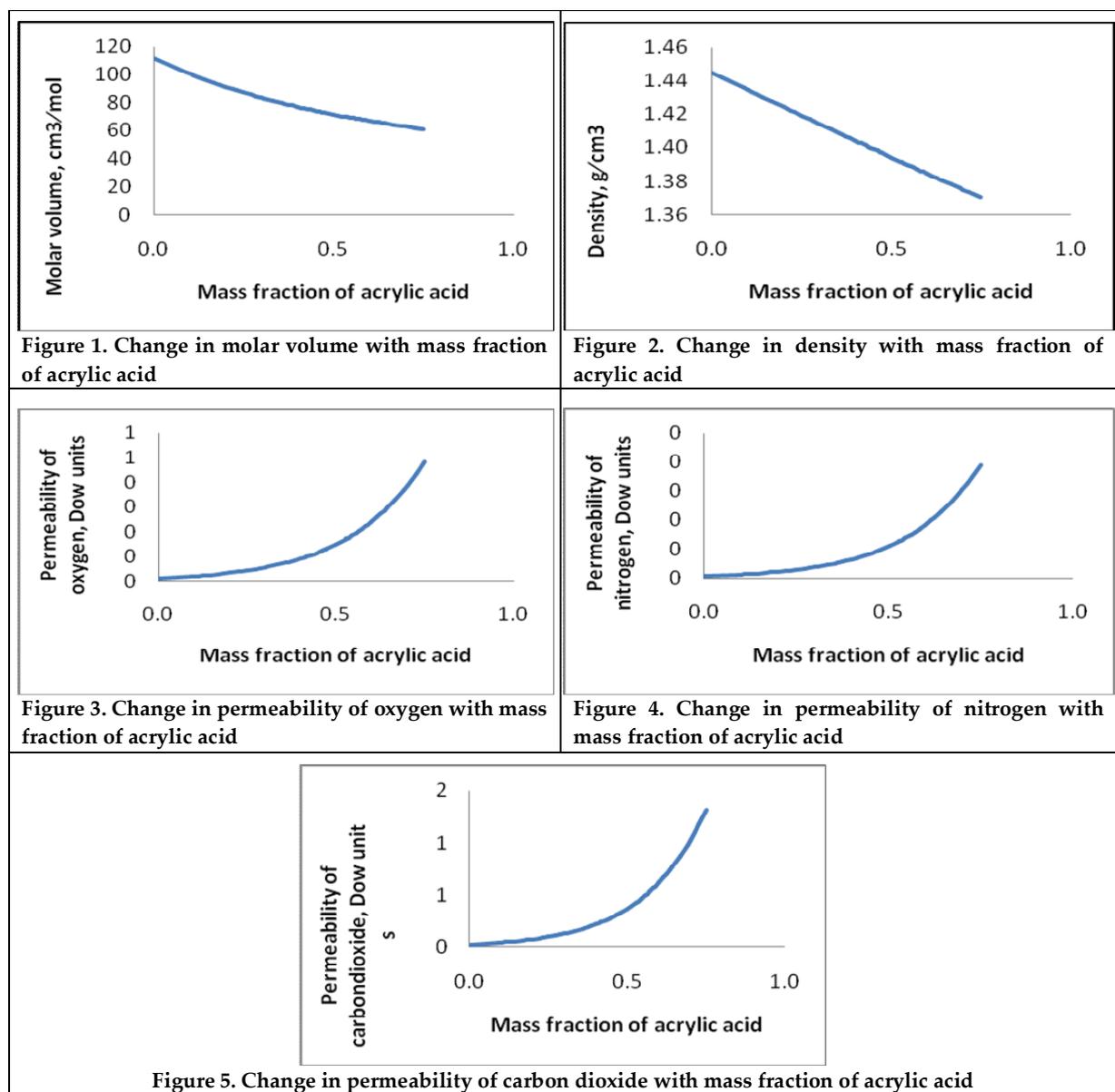
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## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Silica Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and silica composite were studied. The structure of the blend was analyzed with respect to the heat capacity, thermal conductivity and the dielectric constant. The outcome indicates that all those parameters increased with rise in mass fraction of acrylic acid. This study will help to determine the pairs without having laboratory experiments and saving materials, money and the time.

**Keywords:** Blend, silico, Biovia, poly acrylic acid, silica composite

## **INTRODUCTION**

Blends or composites are materials which have contain more than one component. The elements don't lose their identification in the mixture. They fuse and contribute to the belongings of the blend to improving the characteristics of the material. Evolution of a single material with the craving property involves major research and the time. A blend saves time to come about a new material thereby reducing the cost of development of products with preferred properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples based on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and silica composite.



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## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and silica were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 reveals that the heat capacity (Cp) of the composite rise linearly with rise in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 reveals that the thermal conductivity of the composite rise linearly with rise in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 reveals that the dielectric constant of the composite rise with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and silica to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The outcomes how that all the three parameters rise with increase in mass fraction of acrylic acid. This in silico study will help in determining components of a blend without having laboratory experiments and it will save materials, money and the time.

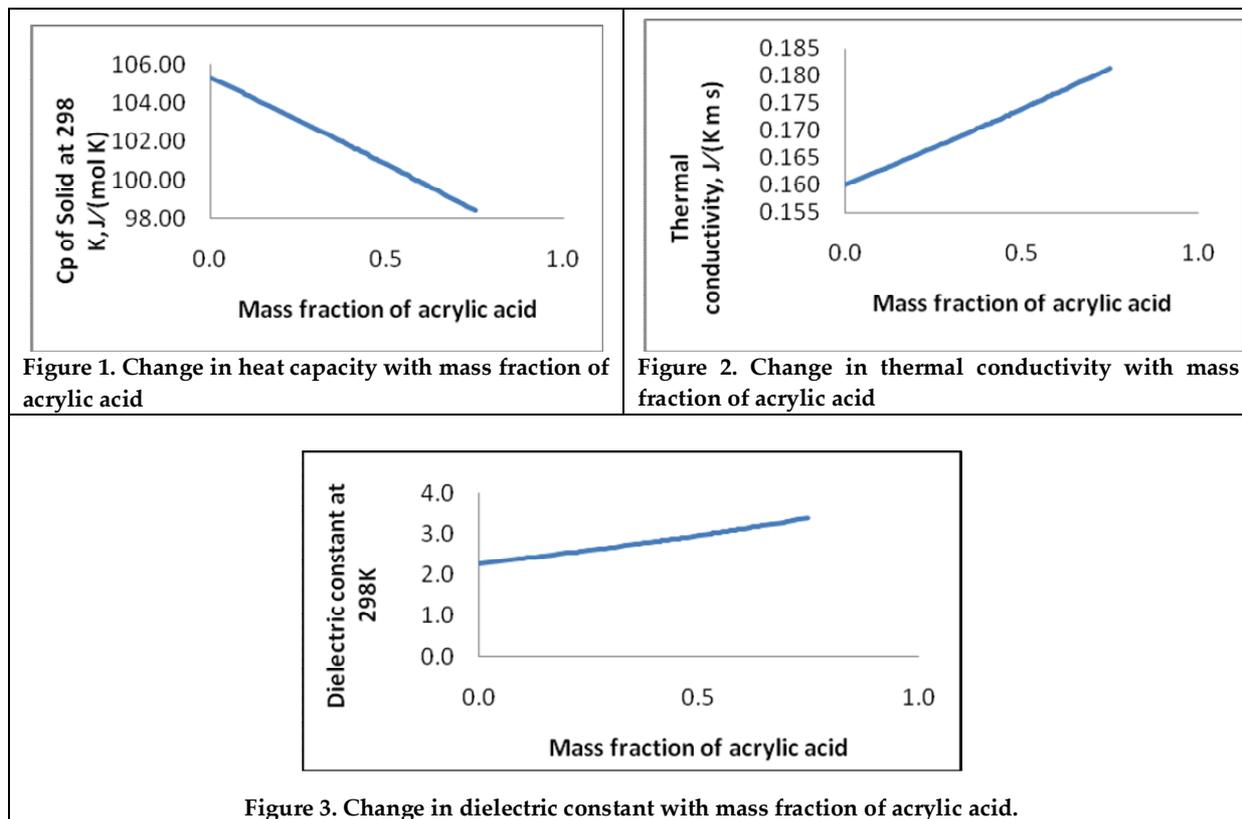
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## ***In silico* Analysis of Mechanical Properties of Poly Acrylic Acid and Silica Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and silica composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The outcome indicates that the values of all the properties rise with the growin mass fraction of acrylic acid. This study will help to determine the pairs without having any laboratory experiments and it saves materials, money and the time.

**Keywords:** Blend, Biovia, poly acrylic acid and silica composite

## **INTRODUCTION**

Blends or composites are the materials which have contain more than one component. The components do not lose their identity in the mixture. They come together and contribute to the property of the blend for improving the quality of the material. Development of a single material with the required property involves major research and time. A blend saves time to develop a new material thereby lowering the cost of development of products with craving properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples lied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and silica composite.





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## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyacrylochloride were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 reveals that the bulk modulus of the compound grows linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:** “It is described as the ratio of shear stress and shear strain.” Figure 2 reveals that the shearmodulus of the compound rises linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Figure 3 reveals that the Young's modulus of the compound increases linearly with rise in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to the longitudinal strain”. Figure 4 reveals that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Figure 5 reveals that the brittle fracture stress of the composite grows linearly with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and silica to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The outcome shows that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) rise with increase in mass fraction of acrylic acid. This in silico study will help determine the components of a blend without having laboratory experiments which saves materials, money and time.

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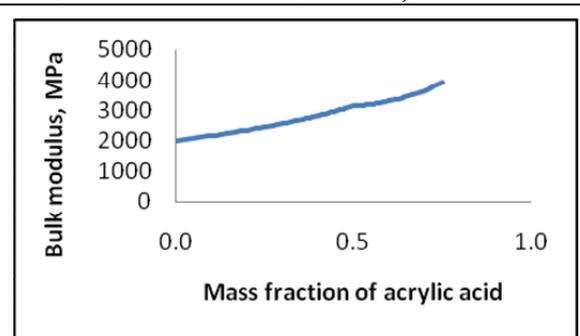


Figure 1.The change in bulk modulus with mass fraction of acrylic acid

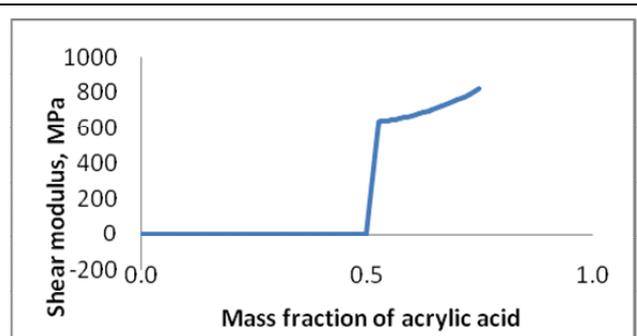


Figure 2. Change in shear modulus with mass fraction of acrylic acid

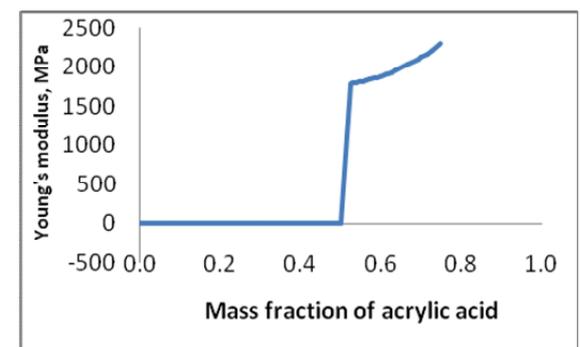


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

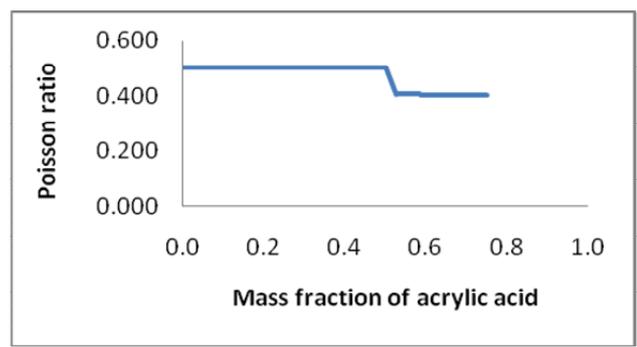


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

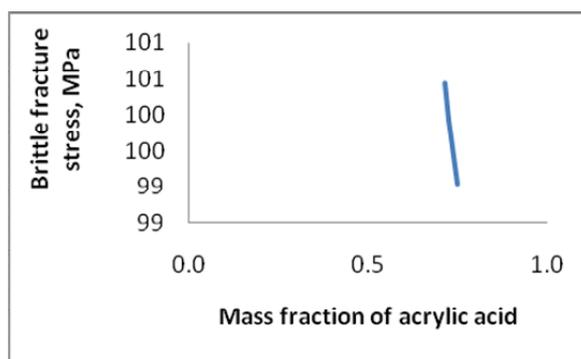


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Silica Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and silica composite were studied. The molar volume and the density will be low with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study will help determine the pairs without having any laboratory experiments and it saves materials, money and the time.

**Keywords:** Blend, poly acrylic acid and silica composite

## **INTRODUCTION**

Blends or composites are a kind of material which contains more than one component. The components do not lose their identity in the mixture. They come together and contribute to the property of the blend for improving the quality of the material. Development of a single material with the craved property involves major research and the time. A blend saves the time to develop a new material thereby lowering the cost of development of products with craved properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire resistance materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples lie on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and silica composite.



Srabani Mishra *et al.*

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and silica were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 reveals that the molar volume of the compound will be lower linearly with rise in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 reveals that the density of the compound lower linearly with rise in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 reveals that the permeability of oxygen through the composite lower with increase in mass fraction of acrylic acid.

Figure 4 show that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Figure 5 indicates that the permeability of carbon dioxide through the composite will decreases with rise in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and silica to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to the permeability properties. The molar volume and density will decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on the permeability of oxygen, nitrogen and carbon dioxide. The outcomes shows that the permeability for all the gases decreased with rise in mass fraction of acrylic acid. This in silico study will help to determine the components of a blend without performing laboratory experiments and it will save materials, money and the time.

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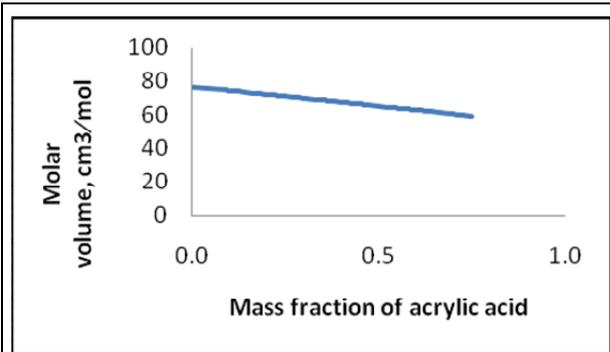


Figure 1. Change in molar volume with mass fraction of acrylic acid

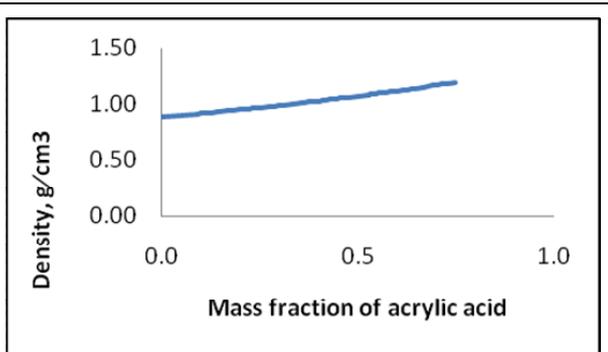


Figure 2. Change in density with mass fraction of acrylic acid

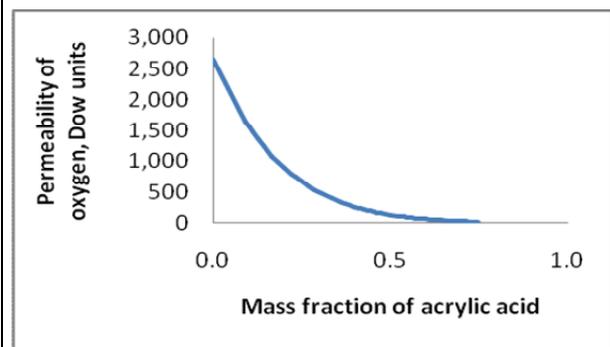


Figure 3. Change in permeability of oxygen with mass fraction of acrylic acid

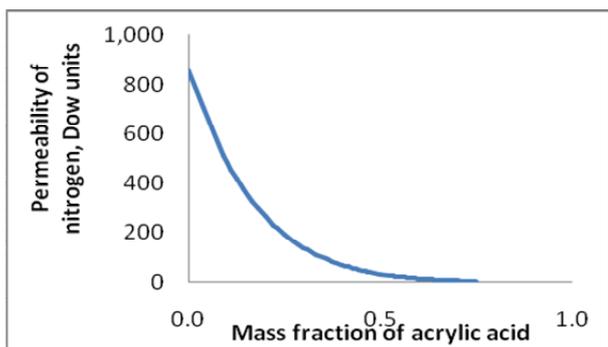


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid

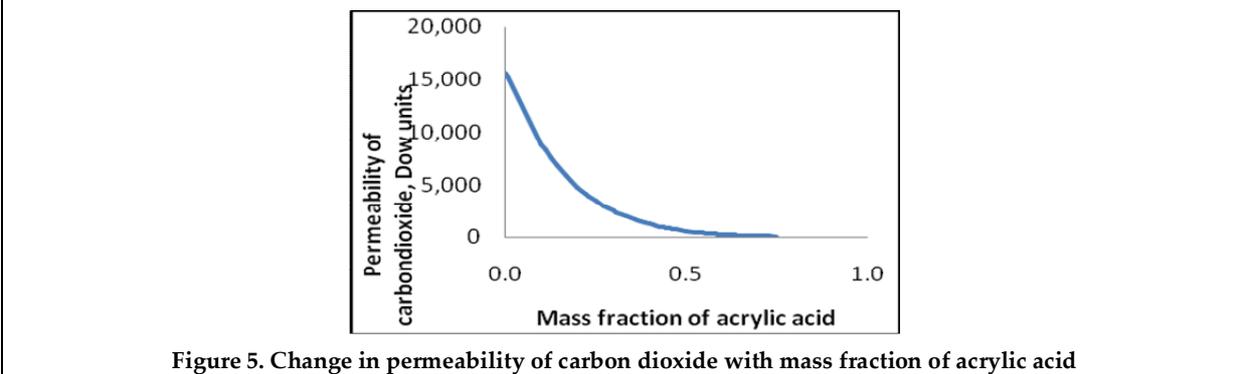


Figure 5. Change in permeability of carbon dioxide with mass fraction of acrylic acid





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Polyvinyl Amide Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and polyvinyl amide composite were studied. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all those parameters increased with increase in mass fraction of acrylic acid. The study helps in finding pairs without undergoing laboratory experiments.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyvinyl amide composite

## **INTRODUCTION**

Blends contain more than one material. However, the constituents of the mixture do not lose their identity in the mixture. Again with combination they improve the quality of the mixture as compared to the single components. Blend or composite saves much time thus saving cost. The examples of polymer blends are nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6]. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and polyvinyl amide composite.

## **MATERIALS AND METHODS**

"Materials studio module of Biovia software (Dassault Systemes of France)" was used for analysis. The structures of polyacrylic acid and poly-vinyl amide were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.





G. Padhan and B. Barik

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 shows that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of polyacrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of polyacrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 shows that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and polyvinyl amide to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the three parameters increased with increase in mass fraction of acrylic acid.

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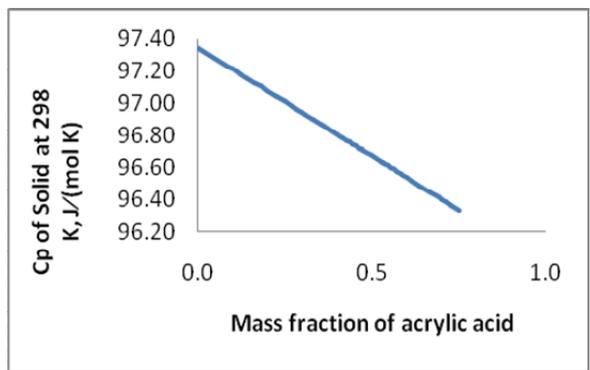


Figure 1. Change in heat capacity with mass fraction of polyacrylic acid

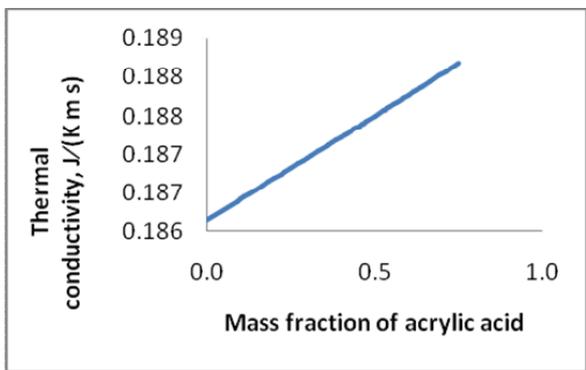


Figure 2. Change in thermal conductivity with mass fraction of polyacrylic acid

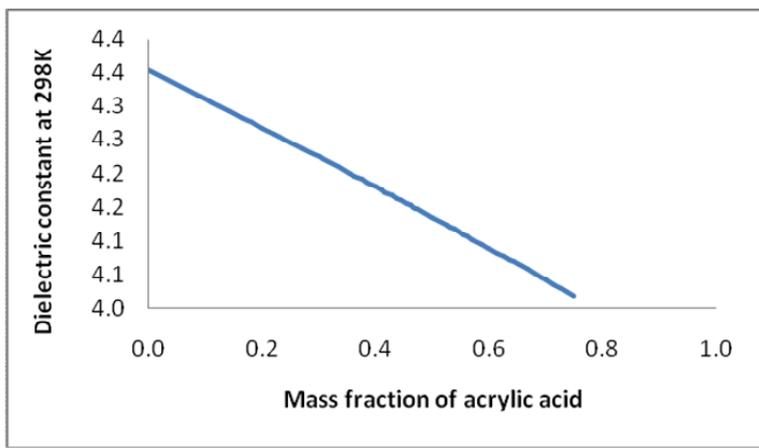


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Poly Vinylamide Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and vinyl amide composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties increased with increase in mass fraction of poly acrylic acid. This type of studies will help find pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and vinyl amide composite

## **INTRODUCTION**

A blend contains more than one material. But, these components do not lose their identity in the mixture. Blend saves much time [1]. It is biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6]. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and polyvinylamide composite.

## **MATERIALS AND METHODS**

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyvinylamide were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.





G. Padhan and B. Barik

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the composite increases linearly with increase in mass fraction of polyacrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” Figure 2 shows that the shear modulus of the composite increases linearly with increase in mass fraction of polyacrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Figure 3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of poly acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Figure 4 shows that the Poisson ratio of the composite increases linearly with increase in mass fraction of polyacrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Figure 5 shows that the brittle fracture stresses of the composite increases linearly with increase in mass fraction of polyacrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and polyvinylamide to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of polyacrylic acid. The in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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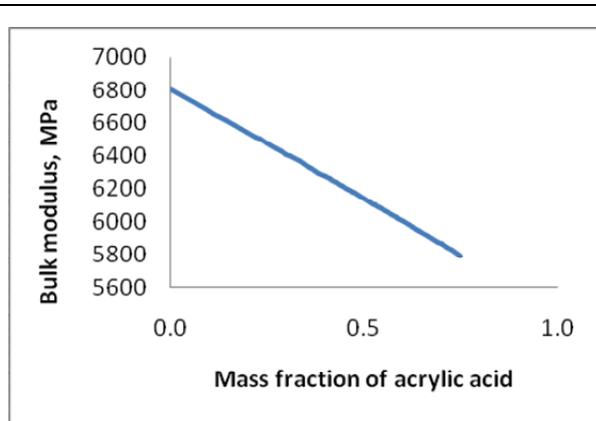


Figure 1. Change in bulk modulus with mass fraction of acrylic acid

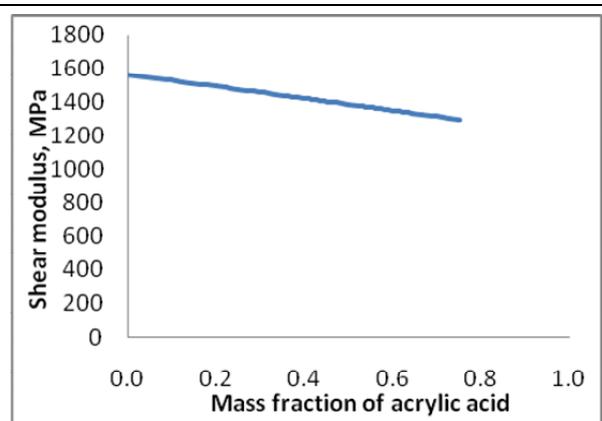


Figure 2. Change in shear modulus with mass fraction of poly acrylic acid

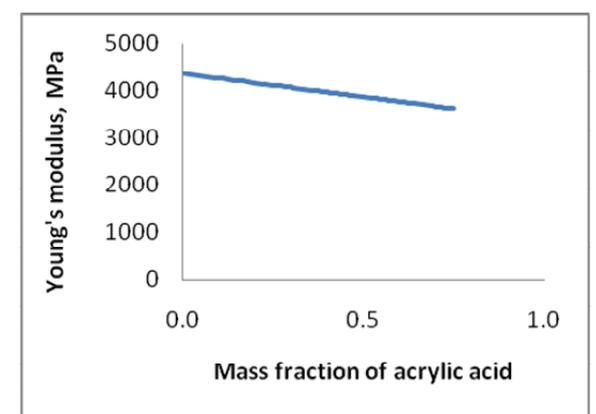


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

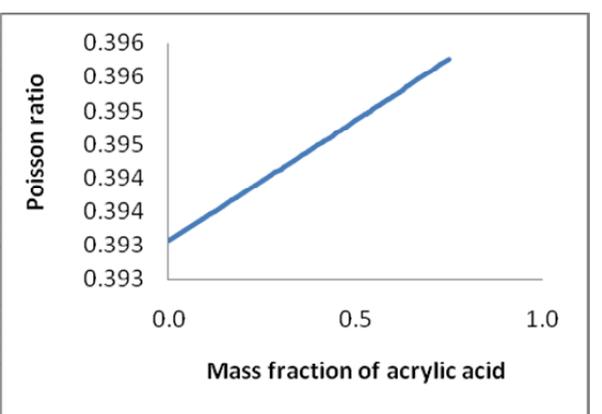


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

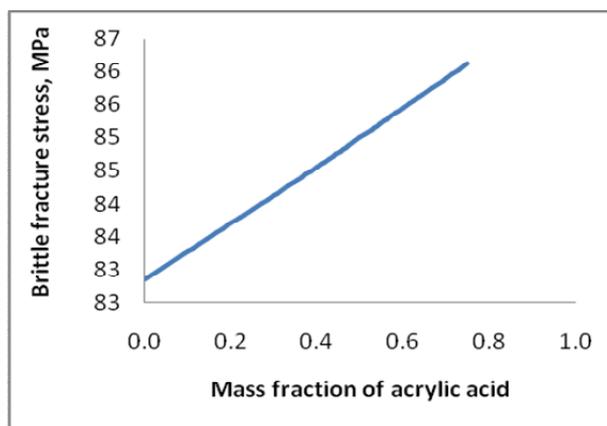


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Polyvinylamide Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and polyvinylamide composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid.

**Keywords:** Blend, silica, polyacrylic acid and polyvinylamide composite

## **INTRODUCTION**

Blends are materials containing more than one component. The components do not lose their identity. The examples of blends are nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6]. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and polyvinylamide composite.

## **MATERIALS AND METHODS**

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyvinylamide were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.





G. Padhan and B. Barik

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 shows that the molar volume of the composite decreases linearly with increase in mass fraction of polyacrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 shows that the density of the composite decreases linearly with increase in mass fraction of polyacrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 shows that the permeability of oxygen through the composite decreases with increase in mass fraction of polyacrylic acid.

Figure 4 shows that the permeability of nitrogen through the composite decreases with increase in mass fraction of polyacrylic acid. Figure 5 shows that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of polyacrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and polyvinylamide to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of polyacrylic acid.

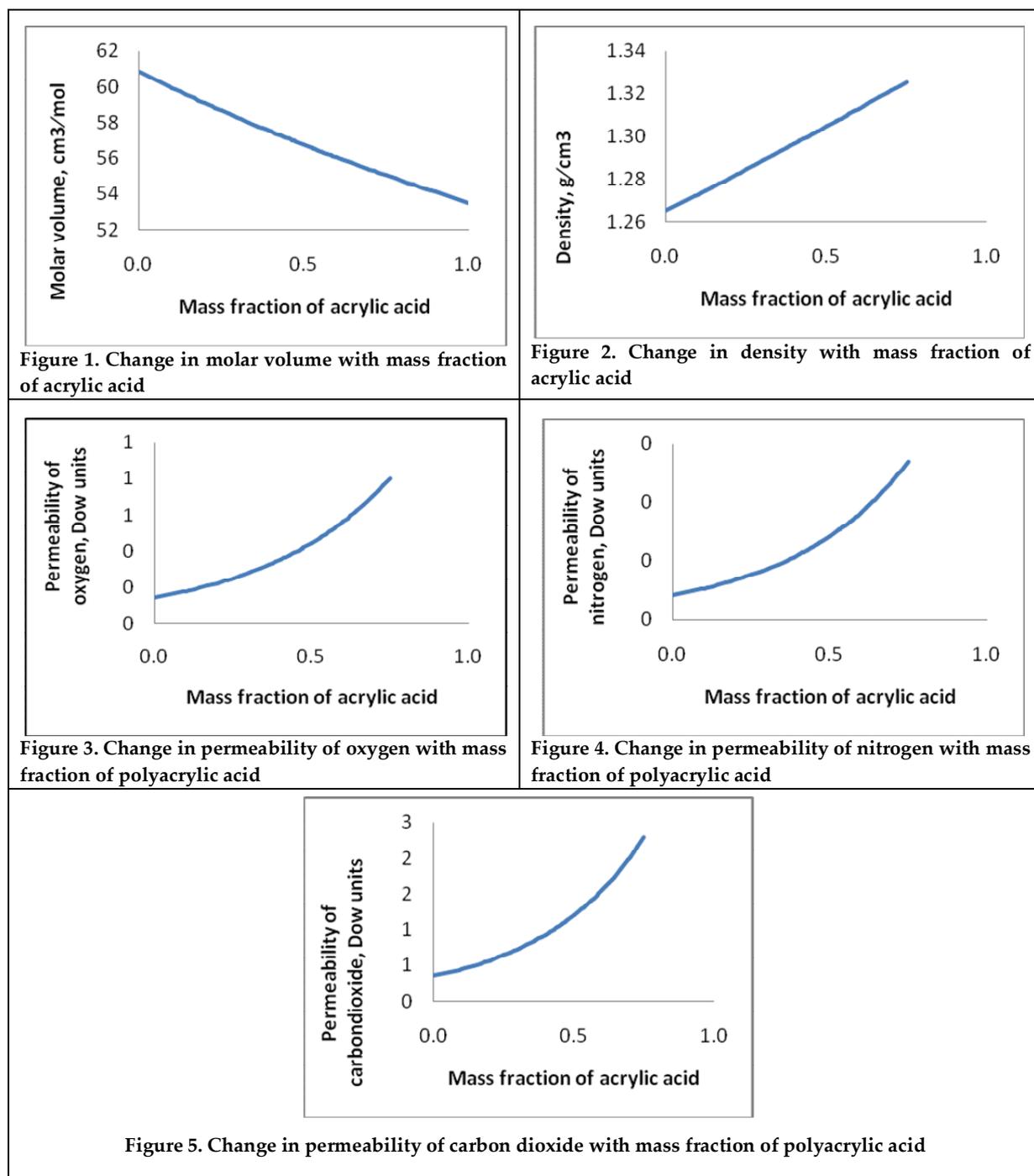
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## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Dimethylbutene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and dimethyl butane composite were studied. The composition of the blend was checked with respect to the heat capacity, the thermal conductivity and the dielectric constant. The results indicated that those entire variables increased with increase in mass fraction of acrylic acid. This study will help to determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, polyacrylic acid and dimethyl butene composite

## **INTRODUCTION**

Blends or composites are materials, those which contain more than one component. The components don't lose their specification in the mixture. They combine and contribute to the feature of the blend thereby improving the superiority of the material. Growth of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby dropping the cost of development of products with desired properties. Polymer blends can be nano material tailored polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples lean on laboratory experiments.

Usually blends are equipped by trial and error method. Thus it involves in wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and dimethyl butene composite.





## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and dimethylbutene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 signify that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 clarify that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 elucidate that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and dimethyl butene to form a blend was searched using Biovia Materials Studio. The composition of the blend was analyzed with regard to permeability properties. The composition of the blend was examined with respect to the heat capacity, the thermal conductivity and the dielectric constant. The results demonstrate that all the three parameters increased with increase in mass fraction of acrylic acid. This in silico study will help to determine components of a blend without performing laboratory experiments saving materials, money and time.

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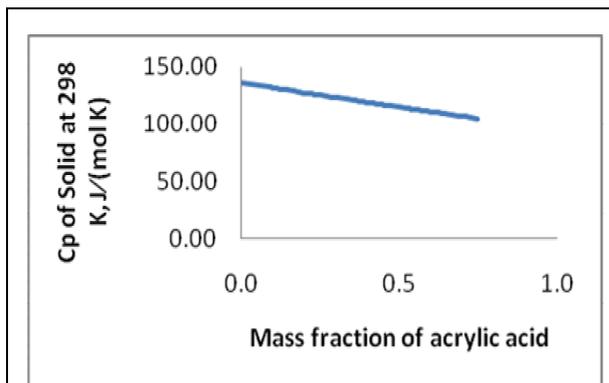


Figure 1. Change in heat capacity with mass fraction of acrylic acid

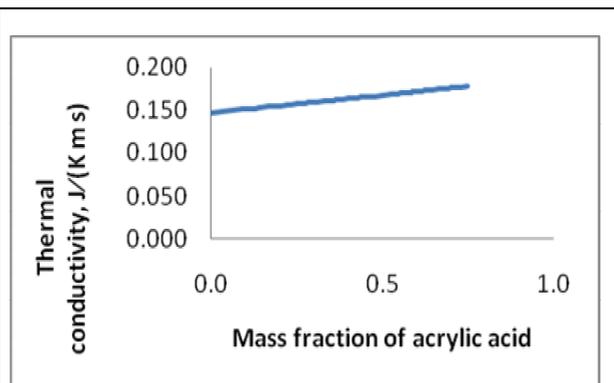


Figure 2. Change in thermal conductivity with mass fraction of acrylic acid

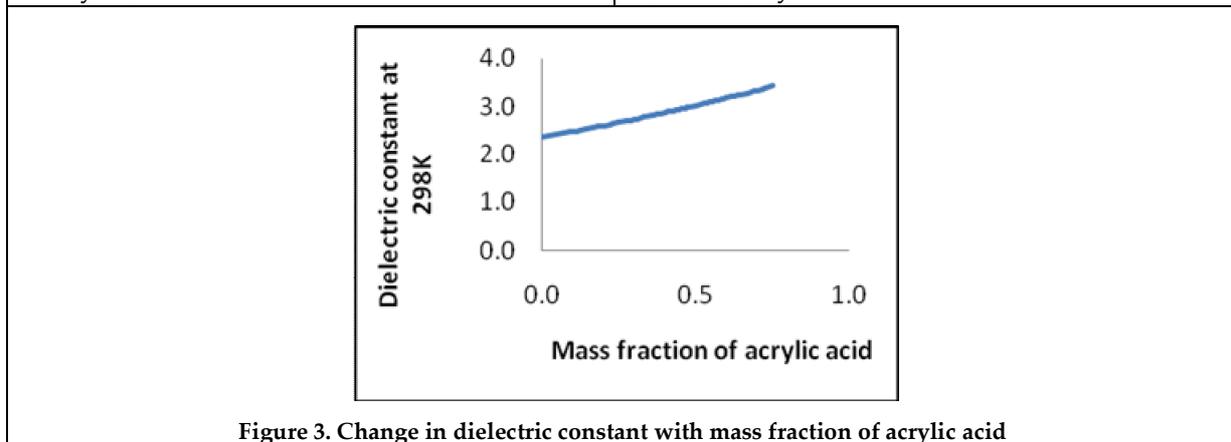


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Poly Acrylic Acid and Dimethylbutene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired possession of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and dimethylbutenecomposite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The outcome indicated that the values of all the properties increased with increase in mass fraction of acrylic acid. This study will help to determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and dimethylbutene

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components don't lose their uniqueness in the mixture. They combine and contribute to the property of the blend in that way improving the quality of the material. Improvement of a single material with the desired property involves noteworthy research and time. A blend saves time to develop a new material thereby dropping the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composite [2], fire retardant/fire proof equipment [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Generally blends are geared up by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have all ears on the use of *in silico* approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and dimethyl butane composite.





Leepsa Nanda and R. Sahu

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and dimethyl butane were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 exhibits that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

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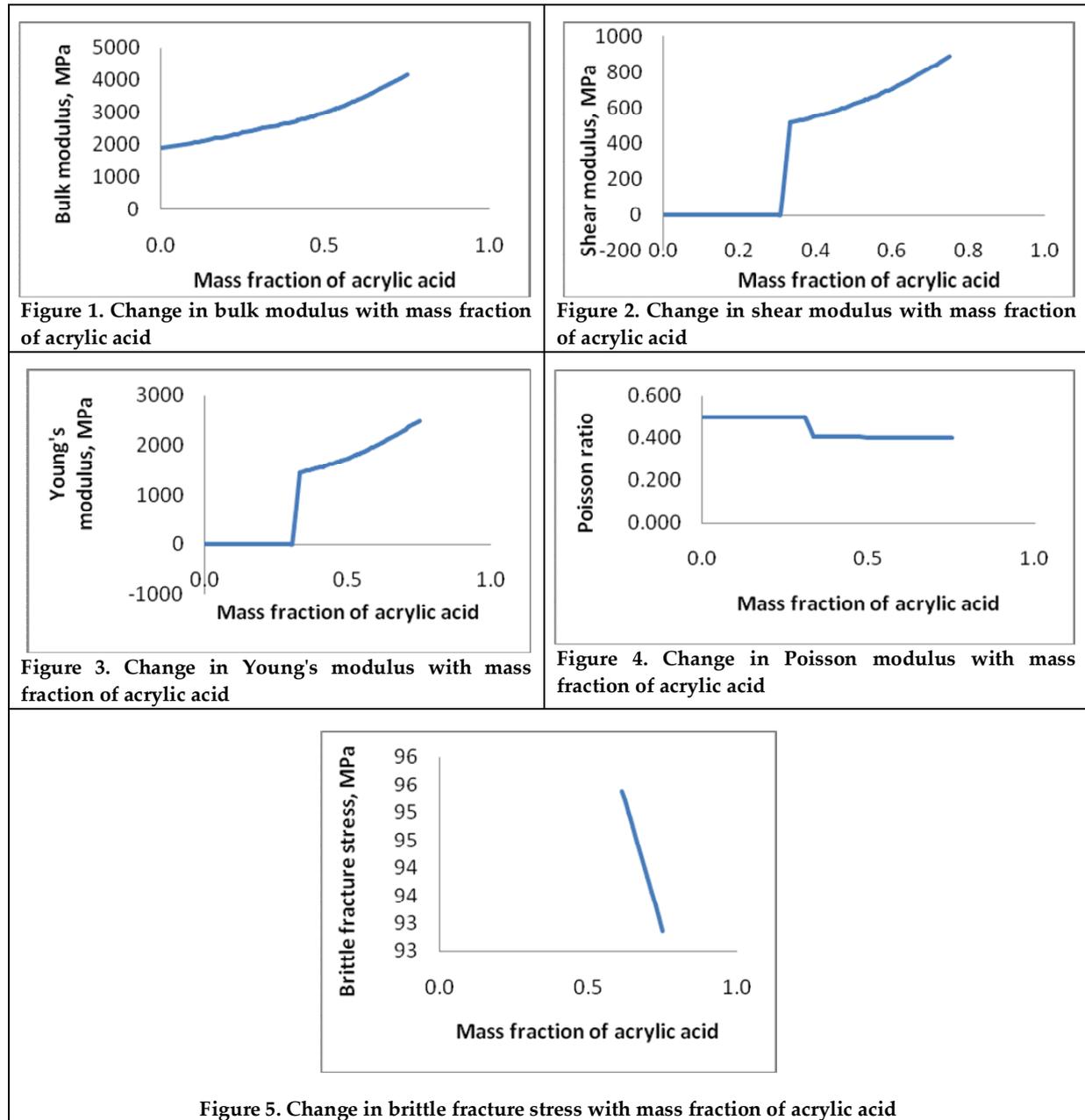
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## ***In silico* Analysis of Permeability Properties of Poly Acrylic Acid and Dimethylbutene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The preferred property of a blend is its homogeneity. Different properties of the polyacrylic acid and dimethylbutene composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were premeditated based on permeability of oxygen, nitrogen and carbon dioxide. The consequences showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study will help to determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and dimethylbutene

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their characteristics in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Expansions of a single material with the desired property involve major research and time. A blend saves time to expand a new material by this means reducing the cost of development of products with preferred properties. Polymer blends can be nano material customized polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are geared up by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and dimethylbutene composite





## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and dimethylbutene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 signify that the molar volume of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 elucidate that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 signify that the permeability of oxygen through the composite decreases with increase in mass fraction of acrylic acid.

Figure 4 clarify that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Figure 5 that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of polyacrylic acid and dimethylbutene to form a blend was explored by means of Biovia Materials Studio. The composition of the blend was analyzed with admiration to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The consequences indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This *in silico* study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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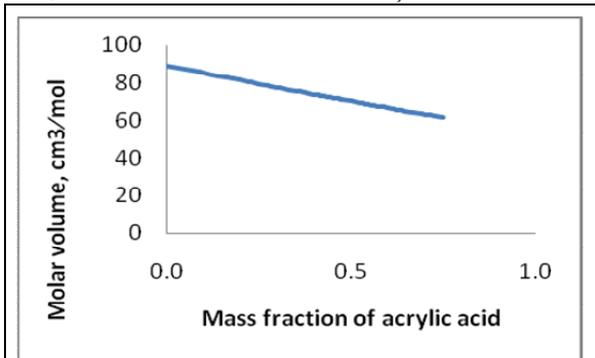


Figure 1. Change in molar volume with mass fraction of acrylic acid

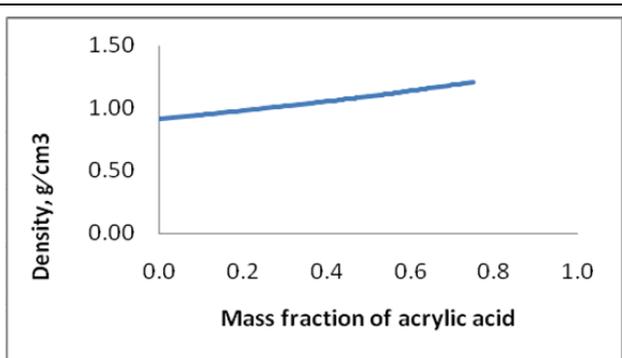


Figure 2. Change in density with mass fraction of acrylic acid

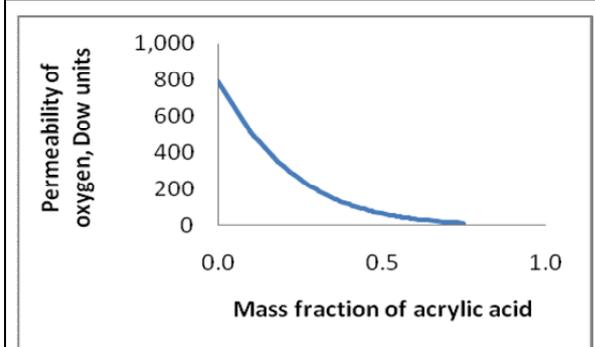


Figure 3. Change in permeability of oxygen with mass fraction of acrylic acid

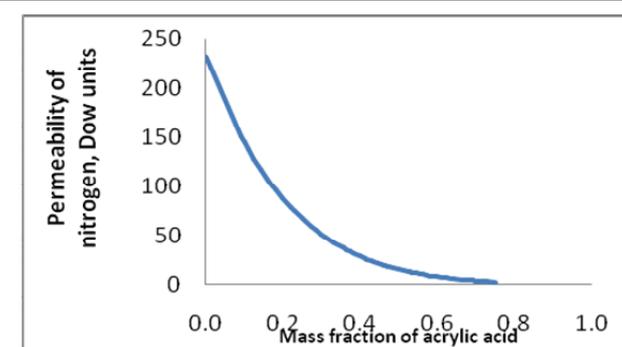


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid

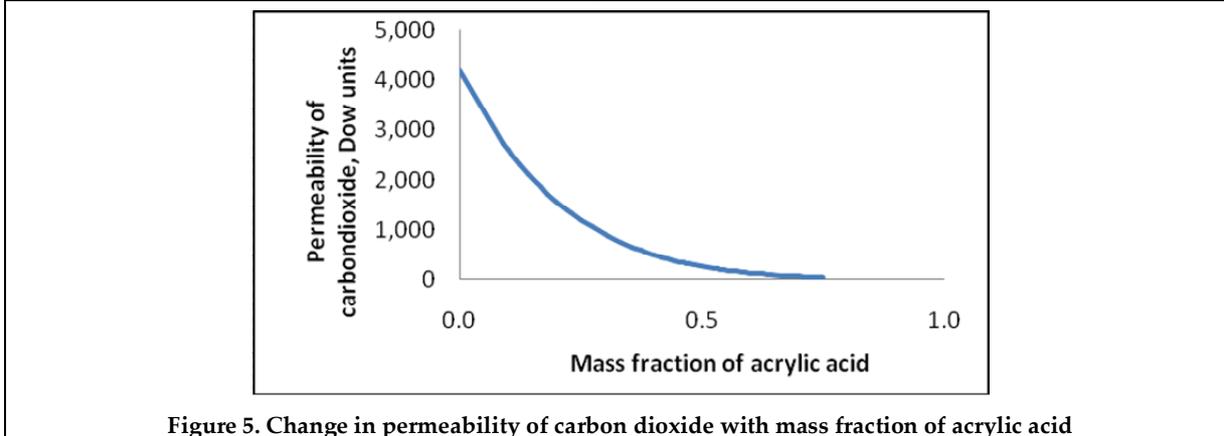


Figure 5. Change in permeability of carbon dioxide with mass fraction of acrylic acid





## ***In silico* Analysis of Thermal and Dielectric Properties of Acrylic Acid and Dichloro Ethylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the acrylic acid and dichloro ethylene composite were studied. The blend was analyzed with respect to the properties like to heat capacity, thermal conductivity and dielectric constant. The result of this composition blend indicates that the above properties of this blend was increased with increase in mass fraction of acrylic acid. This study will help to reduce the laboratory experiment work, saving materials and time.

**Keywords:** Blend, silico, Biovia, acrylic acid and dichloroethylene composite

## **INTRODUCTION**

blends or composition are the materials that contain one or more than one components. The compositions or blend do not lose their identity in the mixture. They combine and contribute to the property of the blend for improving the quality of the materials. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby decreasing the cost of development of products with desired properties. Polymer blends can be nanomaterials that can be up to nano size modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experimental work.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of acrylic acid and dichloro ethylene composite.





Lokanath Meher

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of acrylic acid and dichloro ethylene were found to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. A graph was plotted between the mass fraction of acrylic acid taking along x-axis and heat capacity along y-axis. The figure 1 indicates that the value of heat capacity of solid at 298 was increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. A graph was plotted between Mass fraction along x-axis and Thermal conductivity along y-axis. The figure 2 show that the value of thermal conductivity was increases very small with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. A graph was plotted between mass fraction along x-axis and dielectric constant along y-axis. The figure 3 indicates that the value of dielectric constant at 298 K was increases very little with increase in mass fraction of acrylic acid.

## CONCLUSION

The possibility of use of acrylic acid and dichloro ethylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. From the above study of blend we concluded that the three parameters of the acrylic acid were increases with increases in mass fraction. This in silico study will help determine components of a blend without performing laboratory experiments work, saving materials, money and time.

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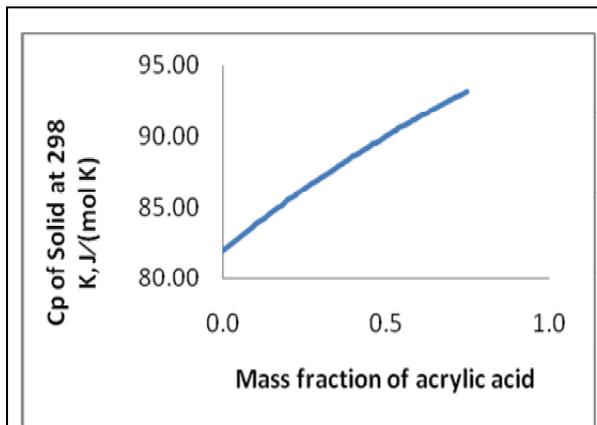


Figure 1. Change in heat capacity with mass fraction of acrylic acid.

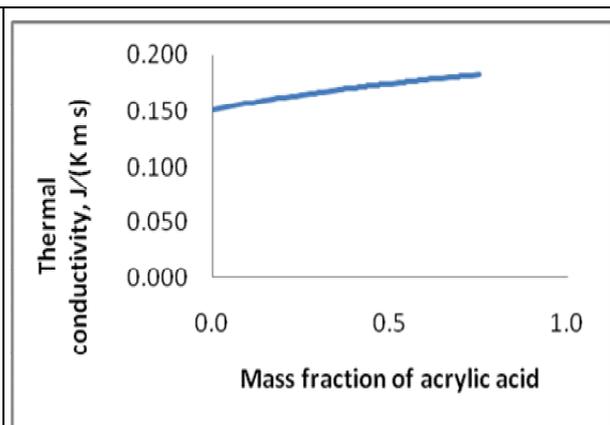


Figure 2. Change in thermal conductivity with mass fraction of acrylic acid.

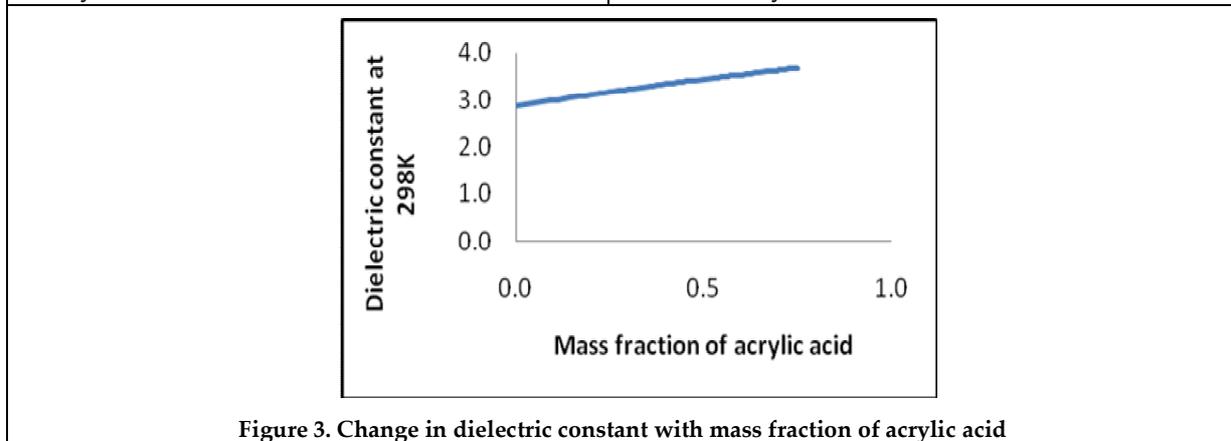


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Acrylic Acid and Dichloro Ethylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the acrylic acid and dichloro ethylene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The result of this blends indicate that the parameters like young modulus, bulk modulus and shear modulus were first decreases and then increases with increase in mass fraction of acrylic acid. And the properties like Poisson ratio and brittle fracture stress increases with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments work, saving materials, money and time.

**Keywords:** Blend, silico, Biovia, acrylic acid and dichloro ethylene composite

### **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not hide their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby decreasing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.



**Lokanath Meher**

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of acrylic acid and dichloroethylene composite

**MATERIALS AND METHODS**

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of acrylic acid and dichloro ethylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

**RESULTS AND DISCUSSION**

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. A graph was plotted between mass fraction of acrylic acid along X-axis and Bulk modulus along Y- axis. The figure 1 indicates that the value of Bulk modulus was decreases first then increases linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” A graph was drawn between mass fraction along X-axis and shear modulus along Y-axis. The figure 2 shown that the value of shear modulus was first decreases for some time then increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. A graph was plotted between mass fraction along X-axis and Youngs modulus along Y-axis. The figure 3 indicate that the value of Youngs modulus first decreases for some value of mass fraction then increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. A graph was plotted between mass fraction along X-axis and Poisson ratio along Y-axis. The figure 4 shown that the value of poission ratio was linearly increases with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. A graph was plotted between mass fraction along X-axis and brittle fracture stress along Y-axis. The figure 5 indicate that The value of Brittle fracture stress was increases linearly with increase in mass fraction of acrylic acid.

**CONCLUSION**

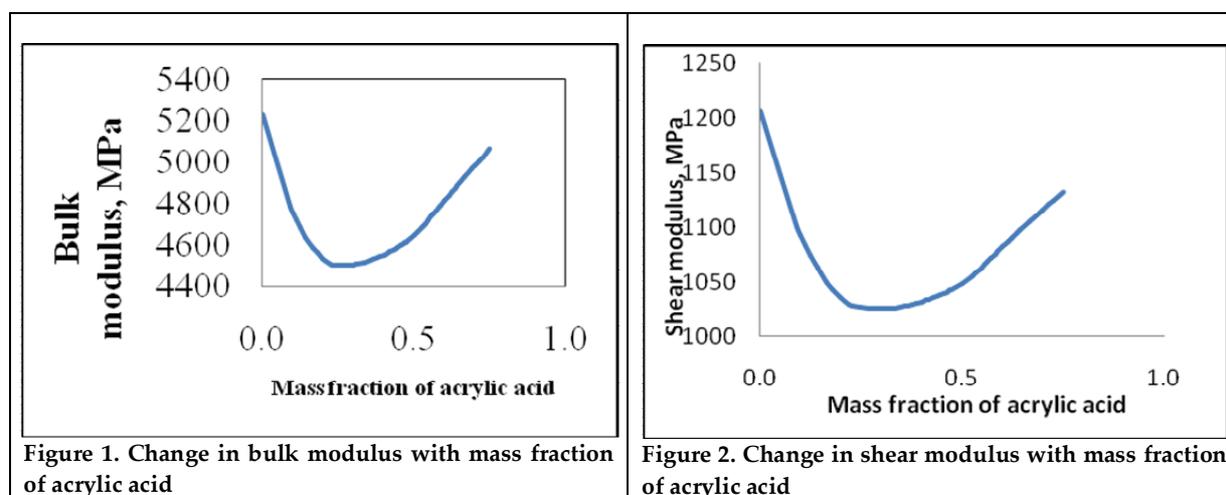
The possibility of use of acrylic acid and dichloro ethylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of the properties like (bulk modulus, shear modulus, Young' modulus,) first decreases then increases with increase in mass fraction of acrylic acid. The property like Poisson ratio and brittle fracture stress increases with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments work, saving materials, money and time.





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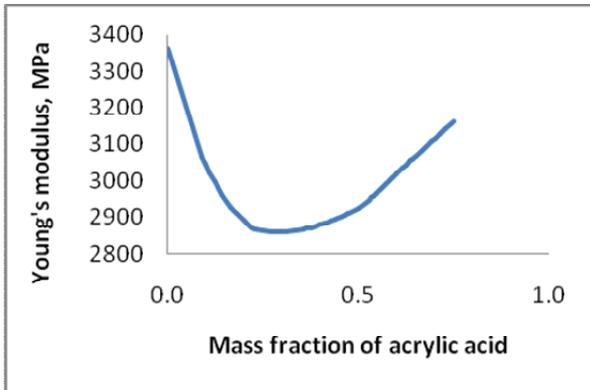


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

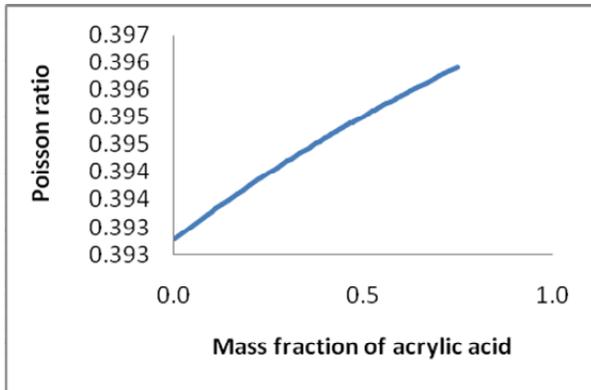


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

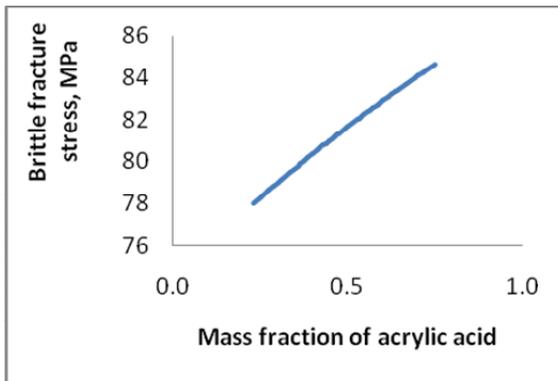


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Acrylic Acid and Dichloro Ethylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the acrylic acid and Dichloroethylene composite were studied. The molar volume and density of acrylic acid decreases with an increase in the mass fraction of acrylic acid the properties of the composite is study as based on the permeability of gas oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases increases with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments work, saving materials, money and time.

**Keywords:** Blend, silico, Biovia, acrylic acid and Dichloroethylene

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not hidden their identity in the mixture. They combine and contribute to the property of the blend thereby increasing the quality of the material. Development of a single material with the desired property involves significant research and time. A blend consumes time to develop a new material thereby minimising the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of acrylic acid and Dichloroethylene composite.

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Lokanath Meher

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of acrylic acid and Dichloroethylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. A graph was plotted between mass fraction along X-axis and molar volume along Y-axis. The figure 1 indicate that the molar volume decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. A graph was tted between the mass fraction along X-axis and density along Y-axis. The figure 2 shown that the density decreases linearly with increase in mass fraction.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. A graph was plotted between permeability of oxygen along Y- axis and mass fraction along X- axis. The figure 3 indicates that the permeability of oxygen increases with the increase in mass fraction.

A graph was plotted between permeability of nitrogen along Y-axis and mass fraction along X-axis. The figure 4 shows that the permeability of nitrogen gas increases with increase in mass fraction. A graph was drawn between permeability of carbon dioxide along Y-axis and mass fraction along X-axis. The figure 5 shown that the permeability of carbon dioxide increases with increase in mass fraction.

## CONCLUSION

The possibility of use of acrylic acid and Dichloroethylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases increase with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experimental work, saving materials, money and time.

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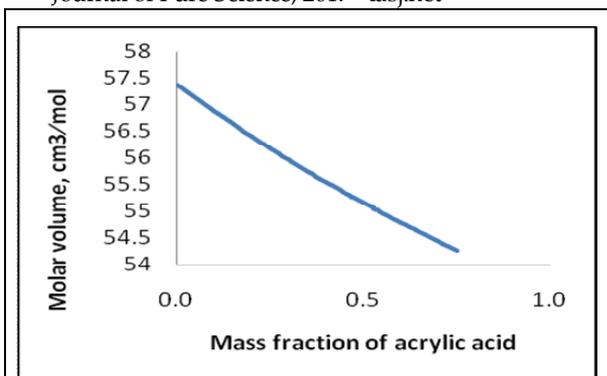


Figure 1. Change in molar volume with mass fraction of acrylic acid.

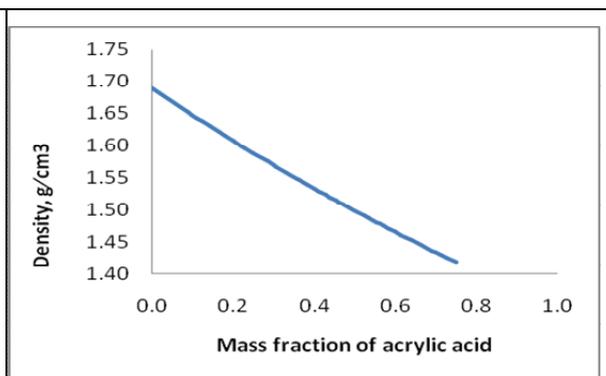


Figure 2. Change in density with mass fraction of acrylic acid.

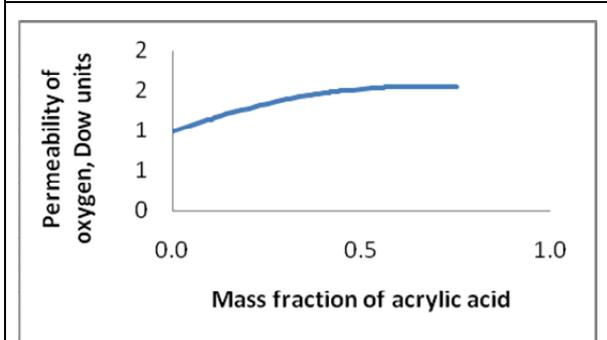


Figure 3. Change in permeability of oxygen with mass fraction of acrylic acid.

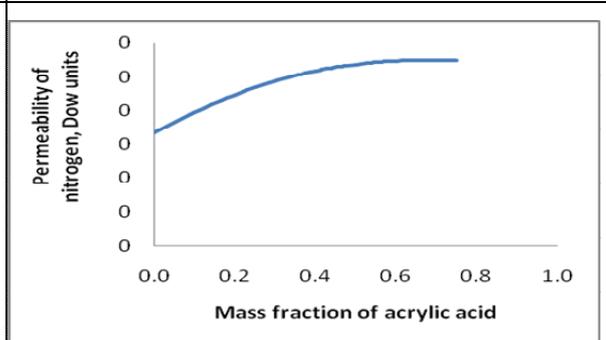


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid.

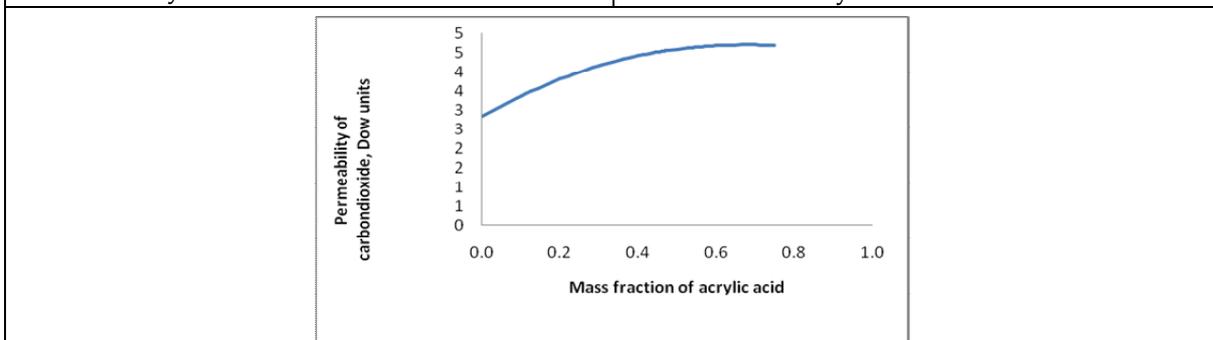


Figure 5. Change in permeability of carbon dioxide with mass fraction of acrylic acid.





## ***In silico* Analysis of Thermal and Dielectric Properties of Acrylic Acid-Tetmeth Bisphen Carbonate Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the acrylic acid-tetmeth-bisphen carbonate composite were studied. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all those parameters increased with increase in mass fraction of acrylic acid tetmeth bisphen carbonate. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, acrylic acid-tetmeth bisphen carbonate composite

## **INTRODUCTION**

The properties of Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of acrylic acid-tetmeth bisphen carbonate composite.





P. K. Dash and M.Palei

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of acrylic\_acid-tetmeth\_bisphen\_carbonate were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 shows that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 shows that the dielectric constant of the composite increases with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

## CONCLUSION

The possibility of use of acrylic\_acid-tetmeth\_bisphen\_carbonate to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the three parameters increased with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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**P. K. Dash and M.Palei**

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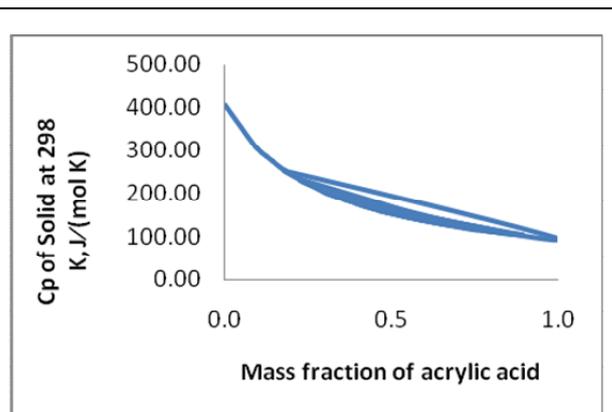


Figure 1. Change in heat capacity with mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

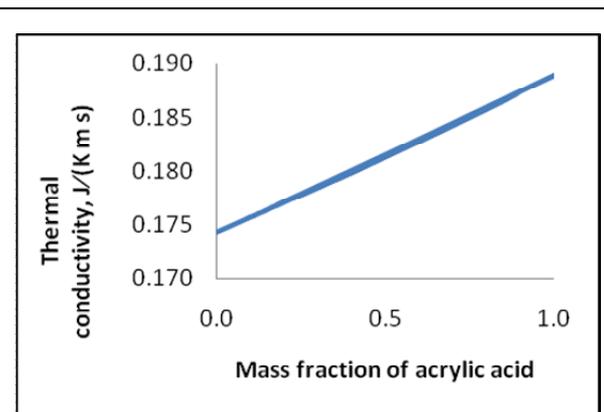


Figure 2. Change in thermal conductivity with mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate

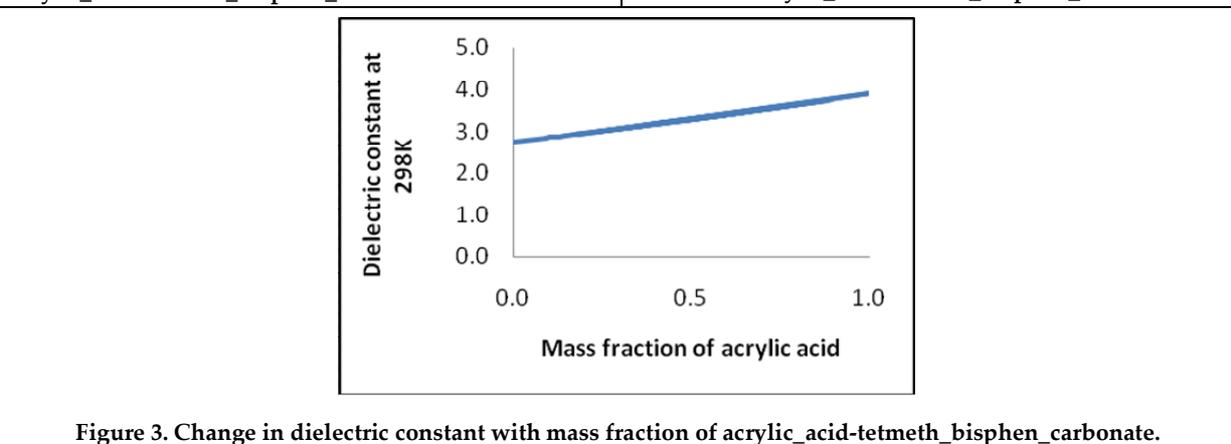


Figure 3. Change in dielectric constant with mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.





## ***In silico* Analysis of Mechanical Properties of Acrylic Acid-Tetmeth Bisphen Carbonate Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the acrylic\_acid-tetmeth\_bisphen\_carbonate composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties increased with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate. It will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, acrylic\_acid-tetmeth\_bisphen\_carbonate composite

## **INTRODUCTION**

The properties of Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers , biodegradable polymers- natural fiber composites , fire retardant/fire proof materials , lightweight composite materials having high strength for transportation industries , glass fiber reinforced polymers, latex polymer composites etc. All above are mentioned examples relied on laboratory experiments

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of acrylic\_acid-tetmeth\_bisphen\_carbonate composite.





P. K. Dash and M.Palei

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of acrylic\_acid-tetmeth\_bisphen\_carbonate was fed to the synthia menu of Materials Studio and run for different weight fractions of the components

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that there is a increase in bulk modulus of the composite with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” Fig 2 this shows that the shear modulus of the composite increases linear with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Fig 3 it shows that the Young's modulus of the composite increases linear with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Fig 4 shows that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Fig 5 this shows that the brittle fracture stress of the composite increases linearly with increase in mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

## CONCLUSION

The possibility of use of acrylic\_acid-tetmeth\_bisphen\_carbonate to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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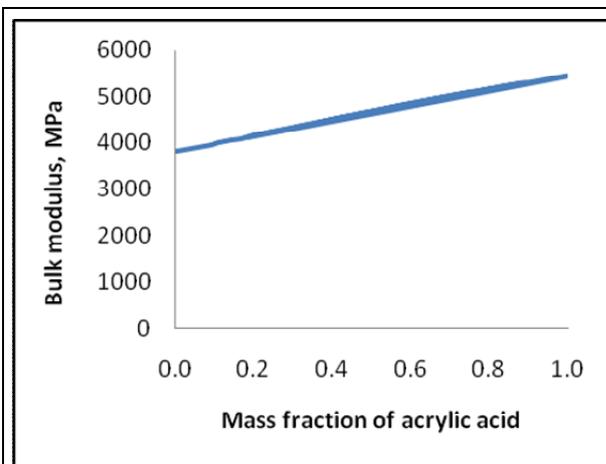


Figure 1. Change in bulk modulus with mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate

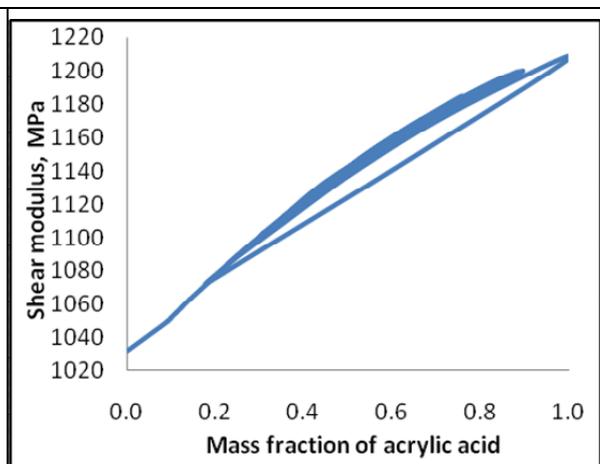


Figure 2. Change in shear modulus with mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

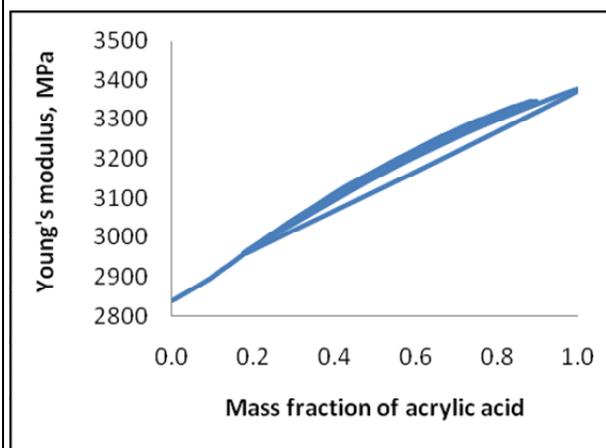


Figure 3. Change in Young's modulus with mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.

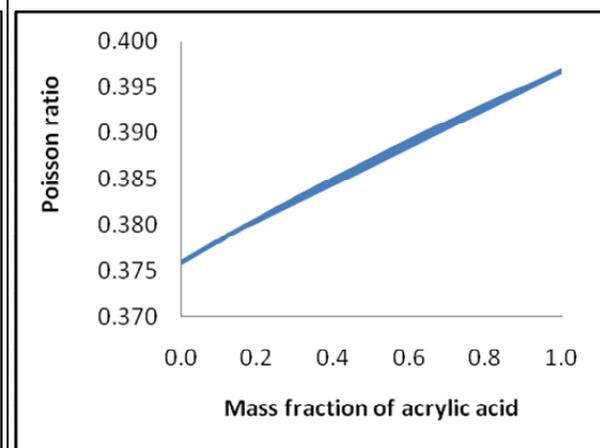


Figure 4. Change in Poisson modulus with mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.



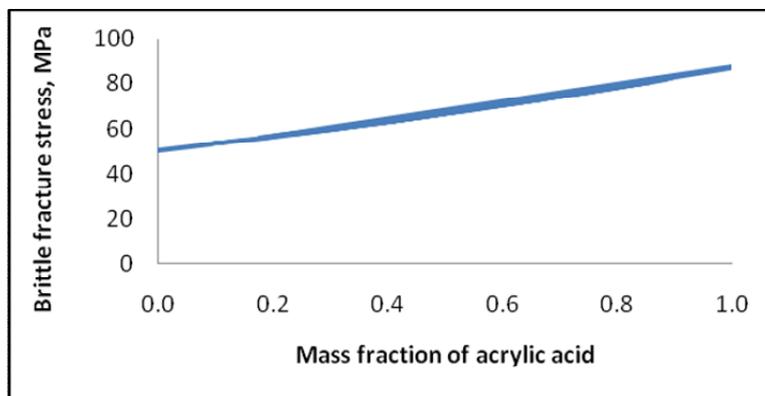


Figure 5. Change in brittle fracture stress with mass fraction of acrylic\_acid-tetmeth\_bisphen\_carbonate.





## ***In silico* Analysis of Permeability Properties of Acrylic Acid-Tetmeth Bisphen Carbonate Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the acrylic acid-tetmeth bisphen carbonate composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid-tetmeth bisphen carbonate. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, acrylic acid-tetmeth bisphen carbonate composite

## **INTRODUCTION**

One of the finest property of Blends or composites are these components do not lose their identity in the mixture. And as named this material contains more than one component. They improve the quality of material by combining and contribute to the property of the blend. It involves significant research and time in development of a single material with the desired property. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Blends are usually prepared by trial and error method. It involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of acrylic acid-tetmeth bisphen carbonate composite.





P. K. Dash and M.Palei

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of acrylic acid-tetmeth bisphen carbonate were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 shows that the molar volume of the composite decreases linearly with increase in mass fraction of acrylic acid-tetmeth bisphen carbonate.

**Density:** “Density is mass per unit volume”. Figure 2 shows that the densities of the composite decreases linearly with increase in mass fraction of acrylic acid-tetmeth bisphen carbonate.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 shows that the permeability of oxygen through the composite decreases with increase in mass fraction of acrylic acid-tetmeth bisphen carbonates.

Figure 4 show that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid-tetmeth bisphen carbonate. Figure 5 shows that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid-tetmeth bisphen carbonate.

## CONCLUSION

The possibility of use of acrylic acid-tetmeth bisphen carbonate to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid-tetmeth bisphen carbonate fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid-tetmeth bisphen carbonate. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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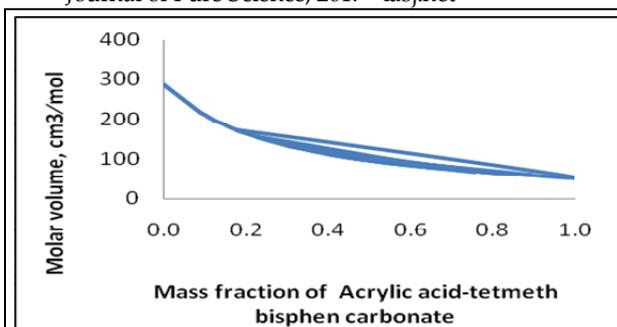


Figure 1. Change in molar volume with mass fraction of acrylic acid-tetmeth bisphen carbonate

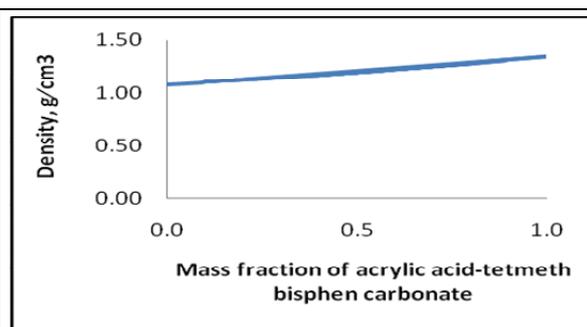


Figure 2. Change in density with mass fraction of acrylic acid-tetmeth bisphen carbonate

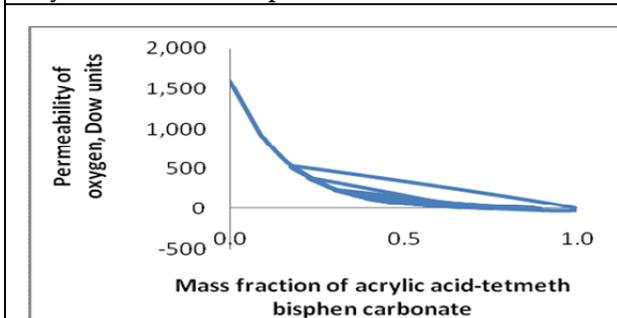


Figure 3. Change in permeability of oxygen with mass fraction of acrylic acid-tetmeth bisphen carbonate

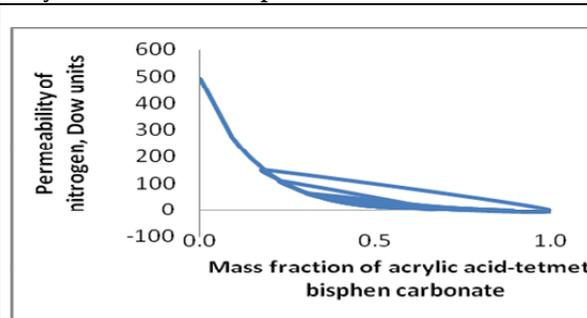


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid-tetmeth bisphen carbonate

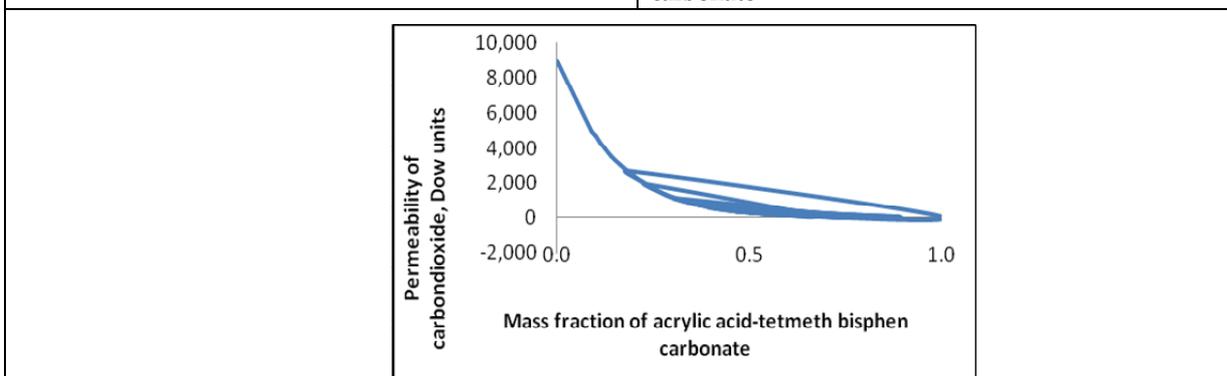


Figure 5. Change in permeability of Co<sub>2</sub> with mass fraction of acrylic acid-tetmeth bisphen carbonate





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Poly-Butadiene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its. Different properties of the polyacrylic acid and poly-t\_butadiene composite were studied. The composition of the blend was analyzed with respect to thermal conductivity, heat capacity and dielectric constant. In this experiment the results is indicating that all those parameters increased with increase in mass fraction of acrylic acid. This study will help to determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly-t\_butadiene composit

## **INTRODUCTION**

Blends or composites are materials are containing more than one component. The components do not ever lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials are having high strength for transportation industries [5], glass fiber reinforced polymers and latex polymer cementitious composites [6] etc. All the above mentioned examples are relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly-t\_butadiene composite.



**Monalisa Joshi**

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systems of France)” was used for analysis. The structures of polyacrylic acid and poly-t-butadiene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Here Figure 1 graph shows that the heat capacity (Cp) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 graph shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Here Figure 3 graph shows that the dielectric constant of the composite increases with increase in the mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly-t-butadiene heat capacity to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the three parameters increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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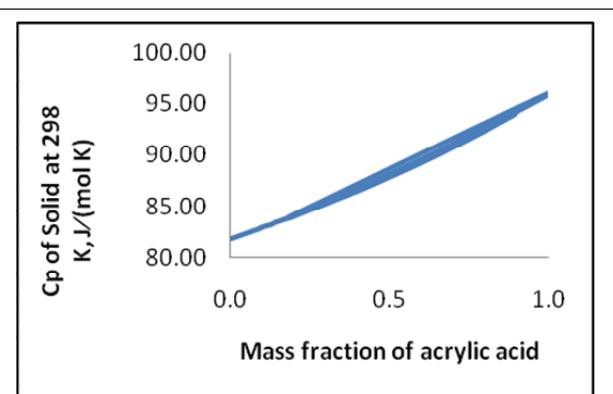


Figure 1. Change in heat capacity with mass fraction of acrylic acid

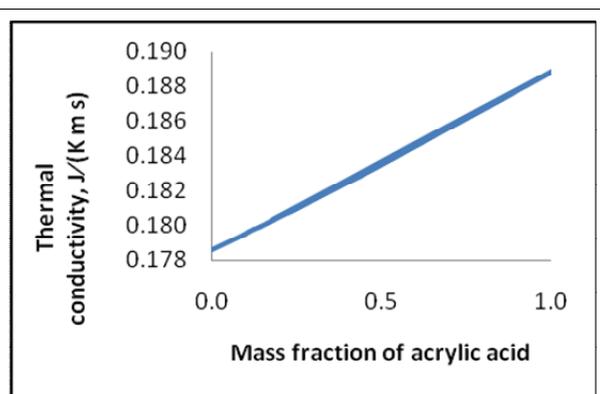


Figure 2. Change in thermal conductivity with mass fraction of the acrylic acid

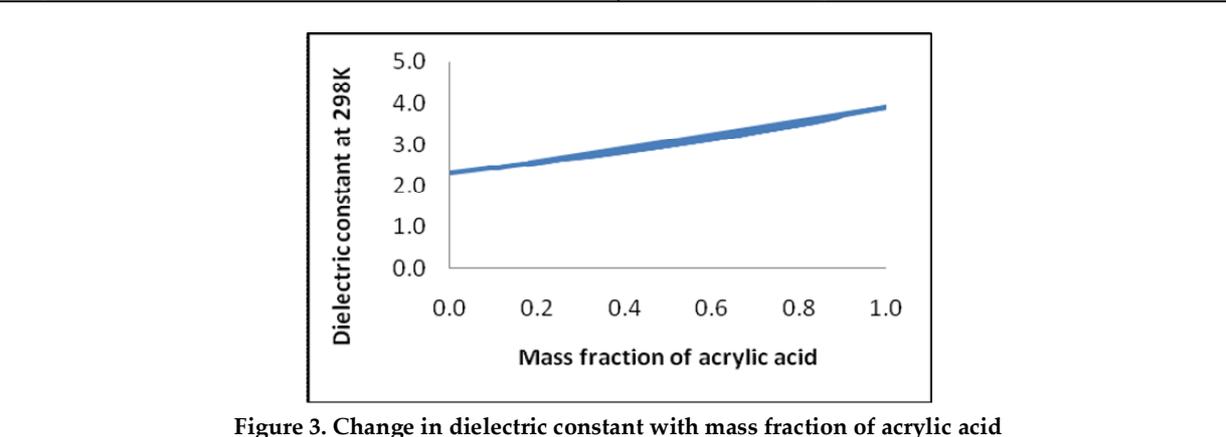


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Poly-T-Butadiene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and poly-t\_butadiene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties increased with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly-t\_butadiene composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and poly-t\_butadiene composite.





S. Mahana and M. Joshi

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly-t\_butadiene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” Figure 2 shows that the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Figure 3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Figure 4 shows that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Figure 5 shows that the brittle fracture stress of the composite decreases linearly with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly-t\_butadiene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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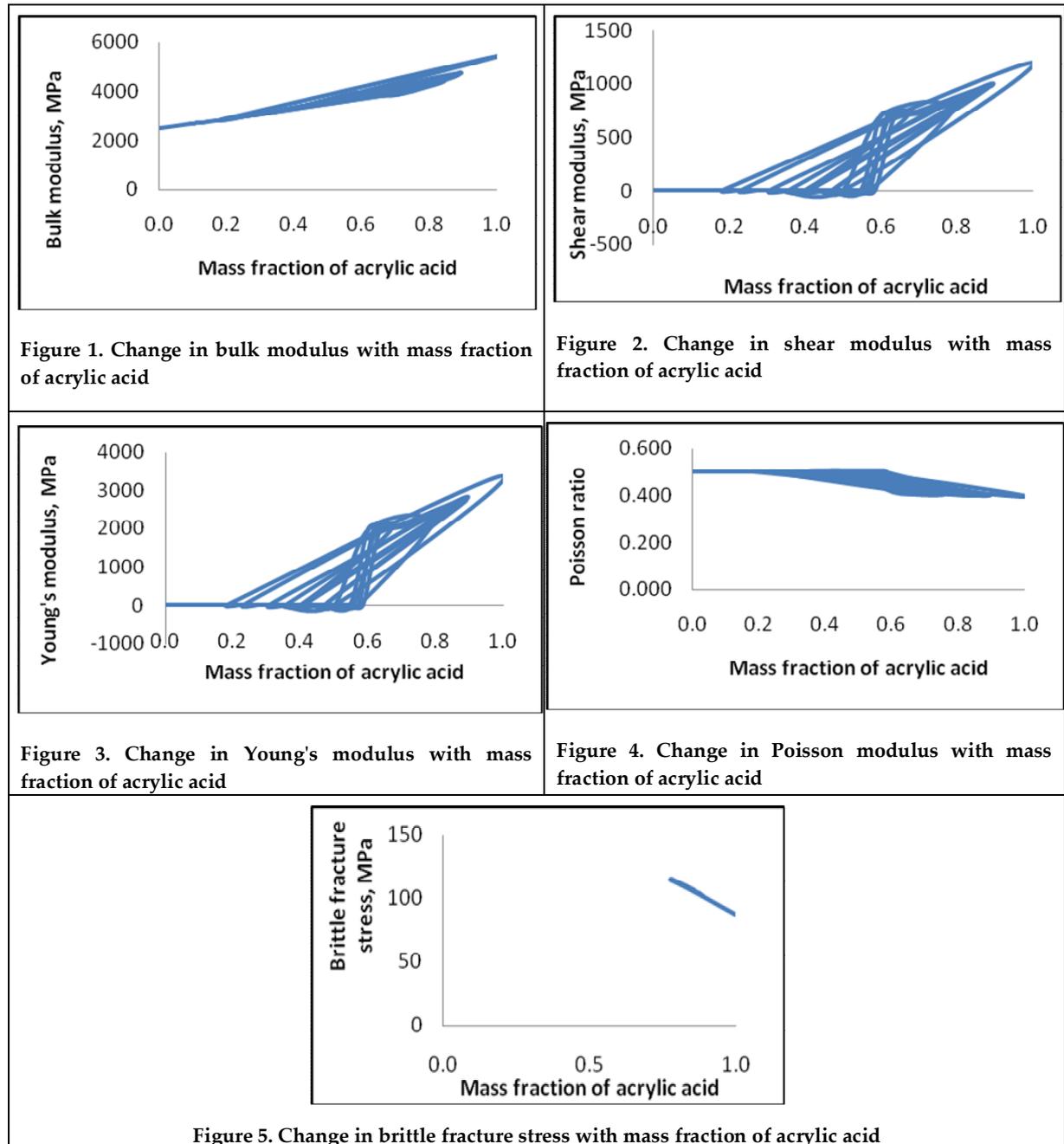
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## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Poly-T Butadiene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly-t\_butadiene composite were studied. The molar volume and density decreased with increase in the acrylic acid fraction. The permeability properties of the composite were studied based on permeability of the carbon dioxide, oxygen and nitrogen. The results showed that the permeability for all the gases decreased with increasing in mass fraction of acrylic acid. This study will help to determine pairs without performing the laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly-t\_butadiene composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of material. Development of a single material with desired property involves the significant research and time. A blend saves time to develop a new material, thereby reducing the cost of development of the products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All of the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly-t\_butadiene composite.





## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly-t<sub>2</sub>butadiene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 graph shows that the molar volume of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 shows that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 graph shows that the permeability of oxygen through the composite decreases with increase in mass fraction of acrylic acid.

Figure 4 graph shows that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Figure 5 graph shows that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly-t<sub>2</sub>butadiene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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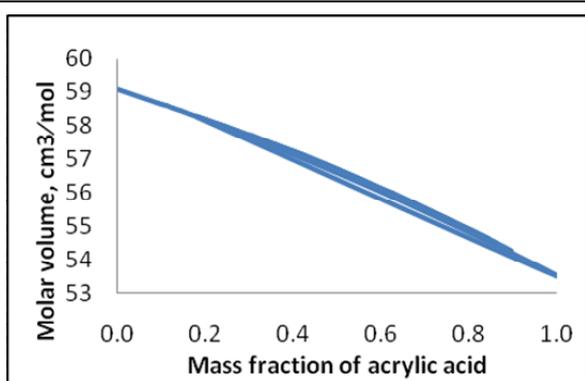


Figure 1. Change in molar volume with mass fraction of acrylic acid

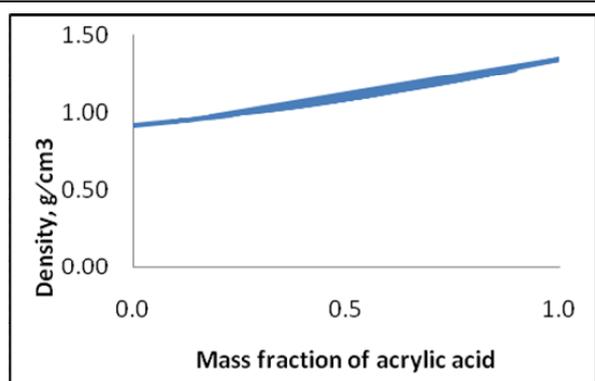


Figure 2. Change in density with mass fraction of acrylic acid

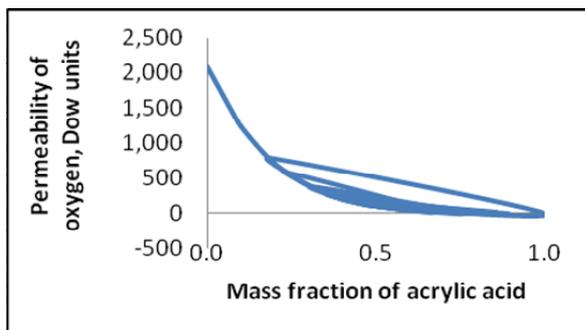


Figure 3. Change in permeability of oxygen with mass fraction of acrylic acid

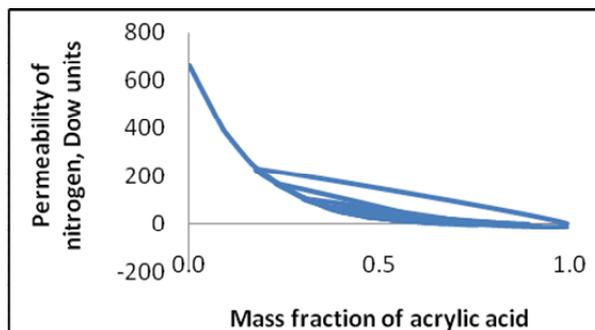


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid

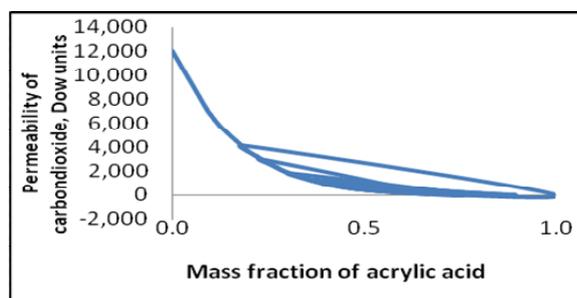


Figure 5. Change in permeability of carbon dioxide with mass fraction of acrylic acid





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Neoprene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and t-neoprene composite were studied. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all those parameters increased with increase in mass fraction of acrylic acid. This study will help to determine pairs without performing in vivo experiments reducing the requirements for resources, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and t-neoprene composite

## **INTRODUCTION**

Blends or composites are defined as materials containing more than one component. These components present in blend do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property requires significant research and time. A blend to develop a new material is a great option as it saves time thereby cut back the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. The above mentioned examples are mainly categorized based on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and t-neoprene composite.



**Rinku Khamari et al.**

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and t-neoprene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 shows that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 shows that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and t-neoprene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the three parameters increased with increase in mass fraction of acrylic acid. This *in silico* study will help to determine components of a blend without laboratory experiments reducing the requirements for materials, money and time.

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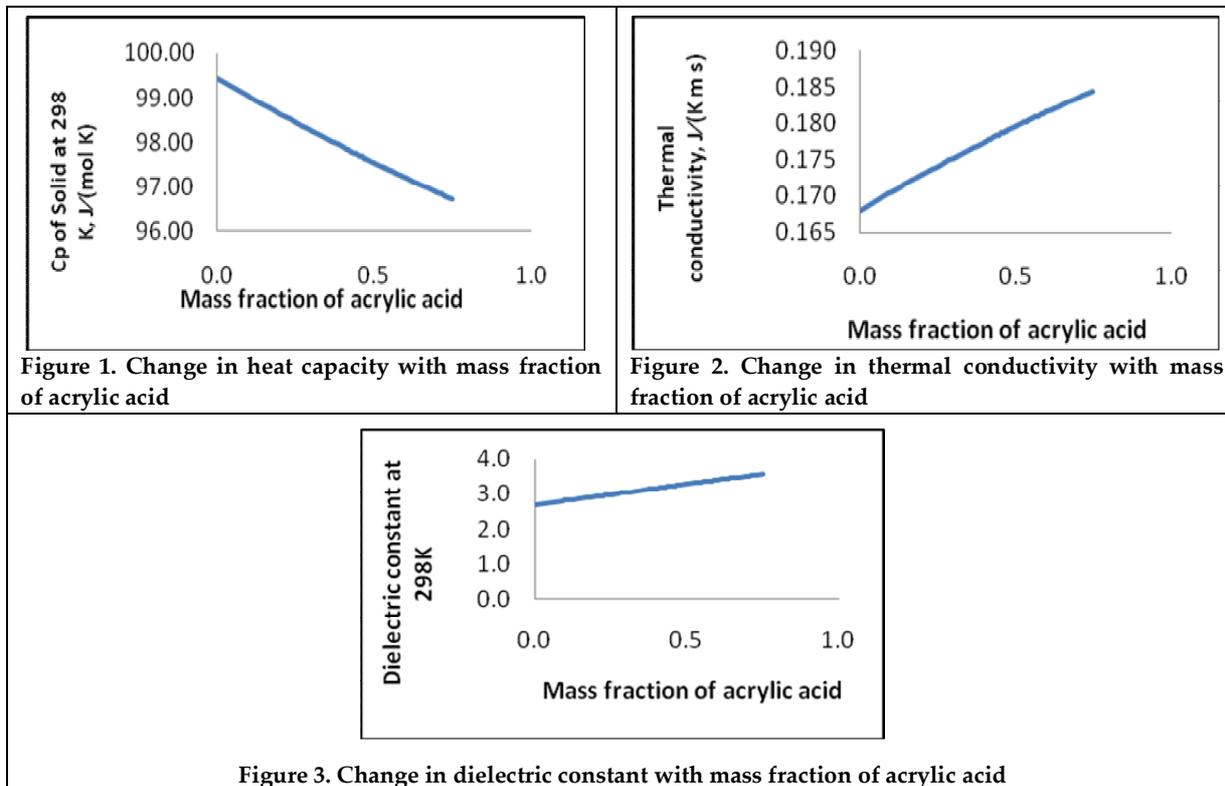
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## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Neoprene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and t-neoprene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties increased with increase in mass fraction of acrylic acid. This in silico study will help one to determine blending pairs reducing the cost, materials and time without in-vivo study.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and t-neoprene composite

## **INTRODUCTION**

Blends or composites are mainly made up of materials containing more than one component and makes a mixture. In the mixture the components contained do not lose their identity. Further these components combine and contribute to the property of the blend hence, improving the quality of the material. The development of a single material with the desired property requires investment of significant research and time. Whereas a new material with desired properties can be developed by a blend at the same time by reducing the cost of development of products and also saves time. Blends are of various types but in this study only polymer blends has been considered for study. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. The above mentioned examples are reported from experiments conducted at laboratory.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and t-neoprene composite.





## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and t-neoprene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” Figure 2 shows that the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Figure 3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Figure 4 shows that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Figure 5 shows that the brittle fracture stresses of the composite increases linearly with increase in mass fraction of acrylic acid.

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The possibility of use of polyacrylic acid and t-neoprene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This in silico study will help to determine components of a blend without performing laboratory experiments cutting back the cost, resources, and time.

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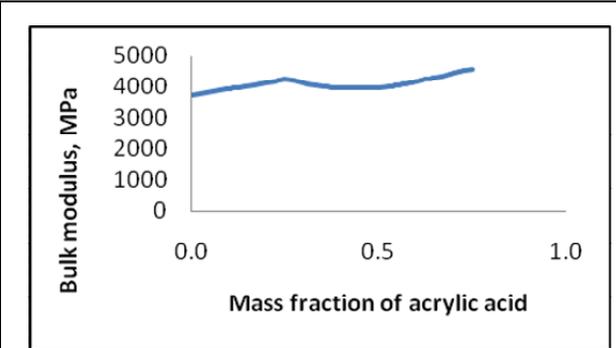


Figure 1. Change in bulk modulus with mass fraction of acrylic acid

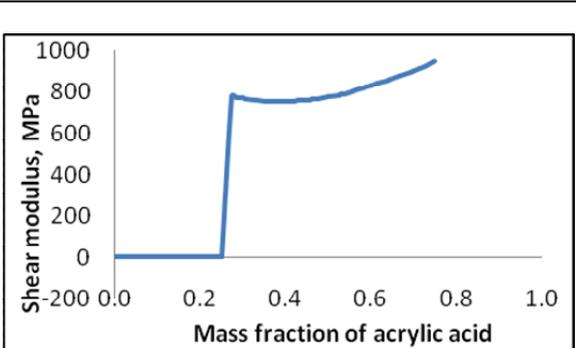


Figure 2. Change in shear modulus with mass fraction of acrylic acid

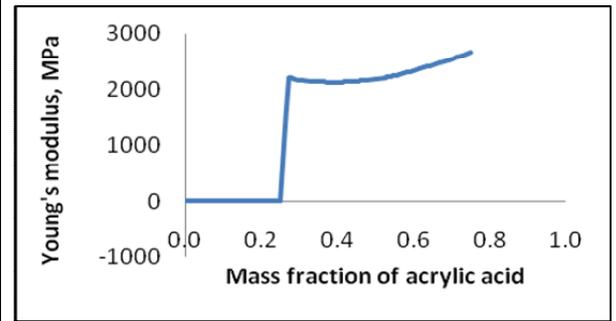


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

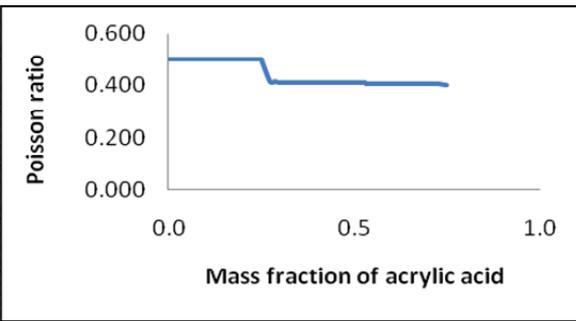


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

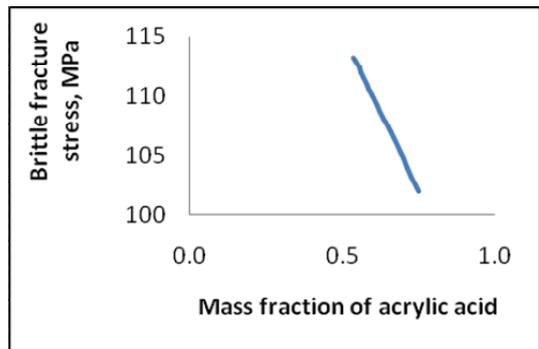


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Neoprene Composite**

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A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and t-neoprene composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. To determine pairs without performing laboratory experiments this study is of great help reducing the requirements for materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and t-neoprene composite

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P. Deep and R. Sahu

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**Density:** “Density is mass per unit volume”. Figure 2 shows that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

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Figure 4 shows that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Figure 5 shows that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and t-neoprene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing in-vivo experiments saving materials, cost and time.

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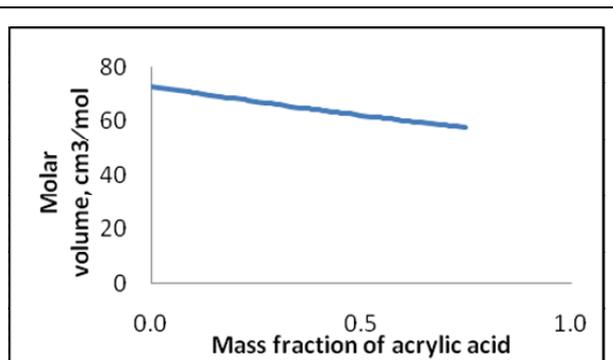


Figure 1. Change in molar volume with mass fraction of acrylic acid

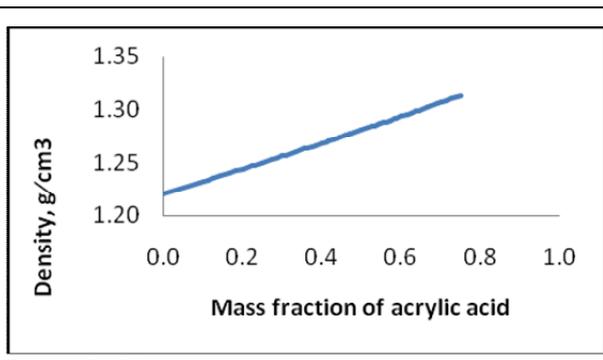


Figure 2. Change in density with mass fraction of acrylic acid

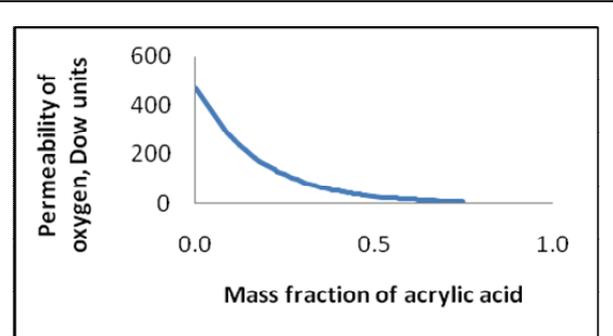


Figure 3. Change in permeability of oxygen with mass fraction of acrylic acid

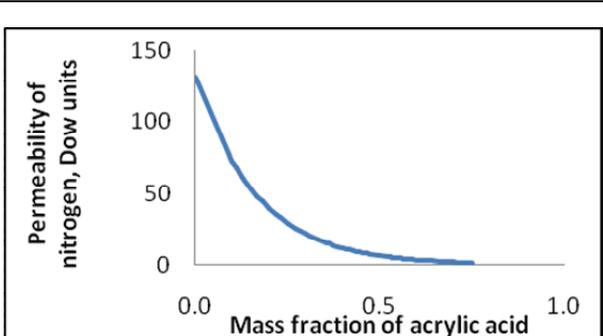


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid

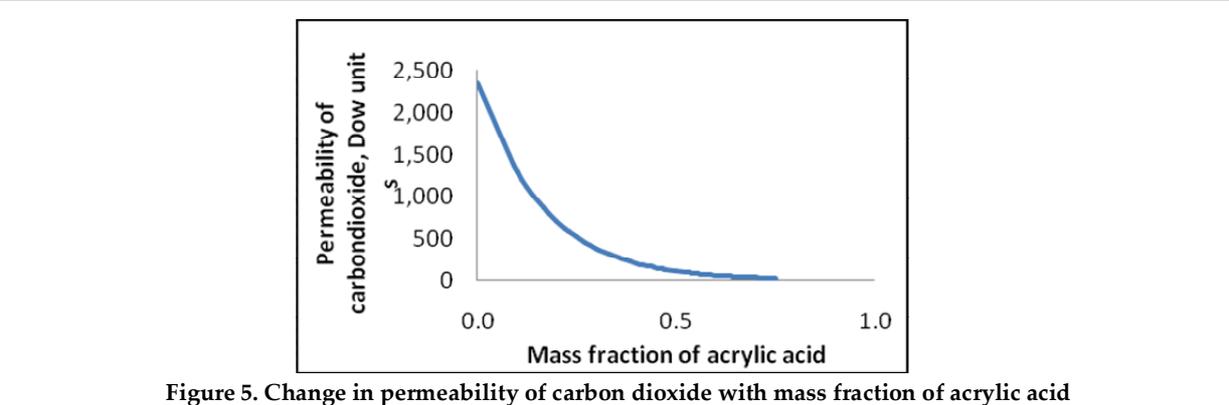


Figure 5. Change in permeability of carbon dioxide with mass fraction of acrylic acid





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Polyacrylic Acid-C Butadiene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid polyacrylic acid-c\_butadiene composite were studied. The composition of blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results will indicated that all these parameters increased with increase in mass fraction of acrylic acid. This study will help to determine the pairs without performing any laboratory experiments.

**Keywords:** Blend, silico, Biovia, polyacrylic acid polyacrylic acid-c\_butadiene composite

## **INTRODUCTION**

Blends or composites are those materials which containing more than one components. The components will not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research.. A blend can saves time to develop a new material by reducing the cost of development of products with desired properties. Polymer blends can be a Nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by applying trial and error method. Thus it involves wastage of materials, time and money. Thus researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly acrylic\_acid-c\_butadiene composite.





Prativa Satpathy

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly acrylic\_acid-c\_butadiene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Fig 1 shows that the heat capacity ( $C_p$ ) of the composite increases linearly with gradual increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Fig 2 shows that the thermal conductivity of the composite increases linearly with the increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Fig 3 shows that the dielectric constant of the composite will increase with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly acrylic\_acid-c\_butadiene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results will give an idea that all the three parameters increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments.

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**Prativa Satpathy**

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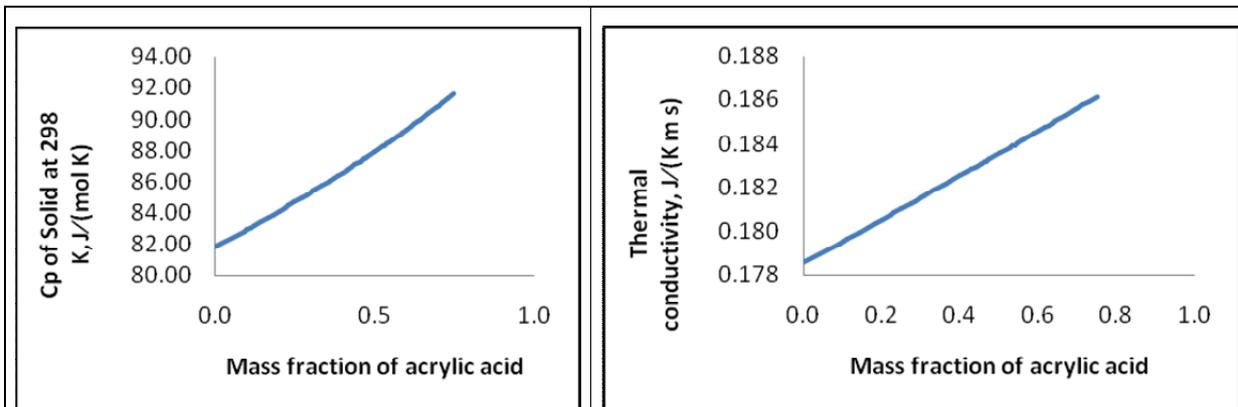


Fig 1. Change in heat capacity with mass fraction of acrylic acid

Fig 2. Change in thermal conductivity with mass fraction of acrylic acid

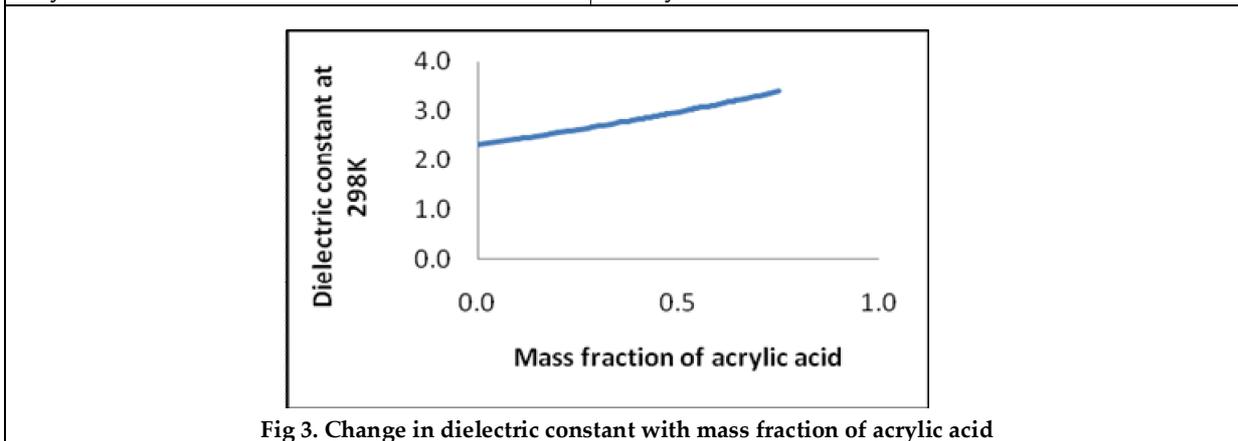


Fig 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Polyacrylic Acid-C\_Butadiene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and polyacrylic\_acid-c\_butadiene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties gradually increased with increase in its mass fraction of acrylic acid. This study will help to determine pairs without performing laboratory experiments saving materials.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyacrylic\_acid-c\_butadiene composite

## **INTRODUCTION**

Composites are materials those containing more than one components. The components will not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. so the researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and polyacrylic\_acid-c\_butadiene composite.





P.Satpathy and A. Patel

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyacrylic\_acid-c\_butadiene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid. From a certain point and after that it reaches some point and curve like graph have found.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” Fig 2 shows that the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid for some specific point.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Fig 3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Fig 4 shows that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid, but point fluctuate after achieving some fixed point.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Figure 5 shows that the brittle fracture stresses of the composite increases linearly with increase in mass fraction of acrylic acid.

## CONCLUSIONS

Polyacrylic acid and polyacrylic\_acid-c\_butadiene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results shows that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased gradually with the increase in mass fraction of acrylic acid

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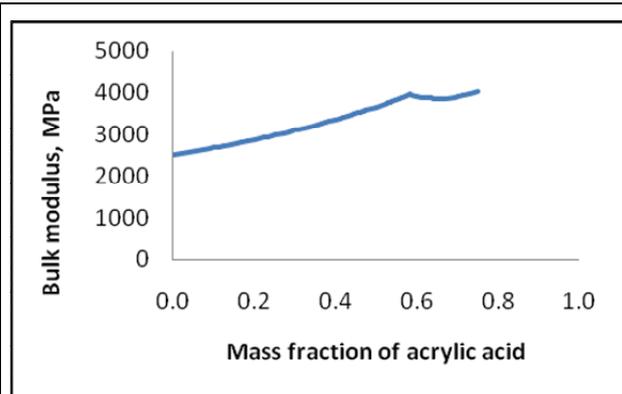


Fig 1. Change in bulk modulus with mass fraction of acrylic acid

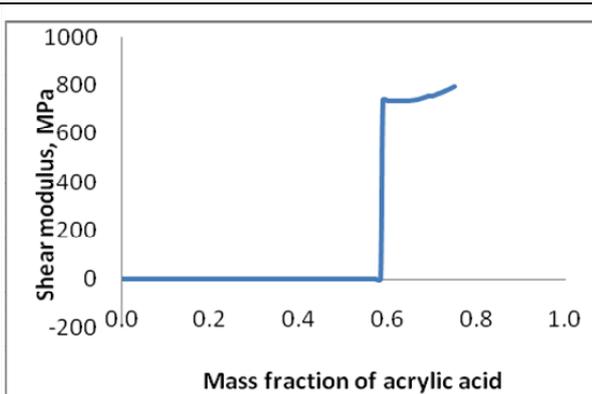


Figure 2. Change in shear modulus with mass fraction of acrylic acid

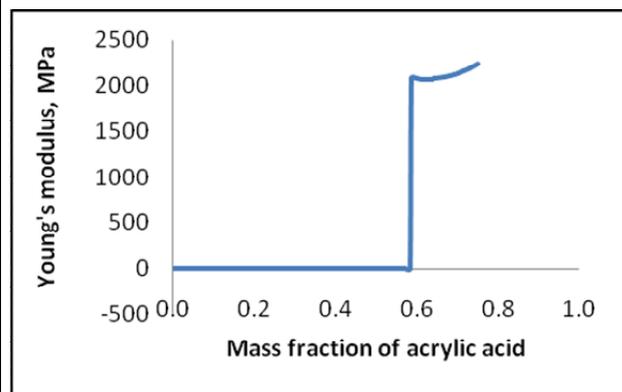


Fig 3. Change in Young's modulus with mass fraction of acrylic acid

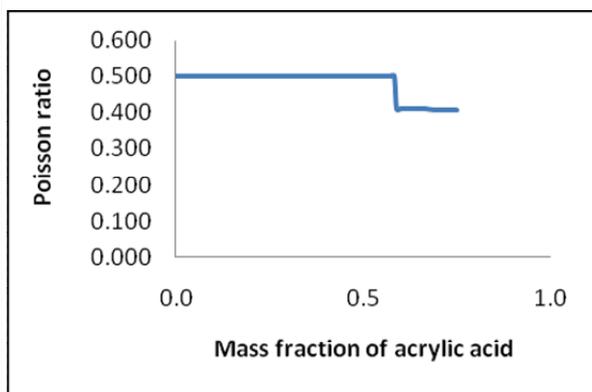


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

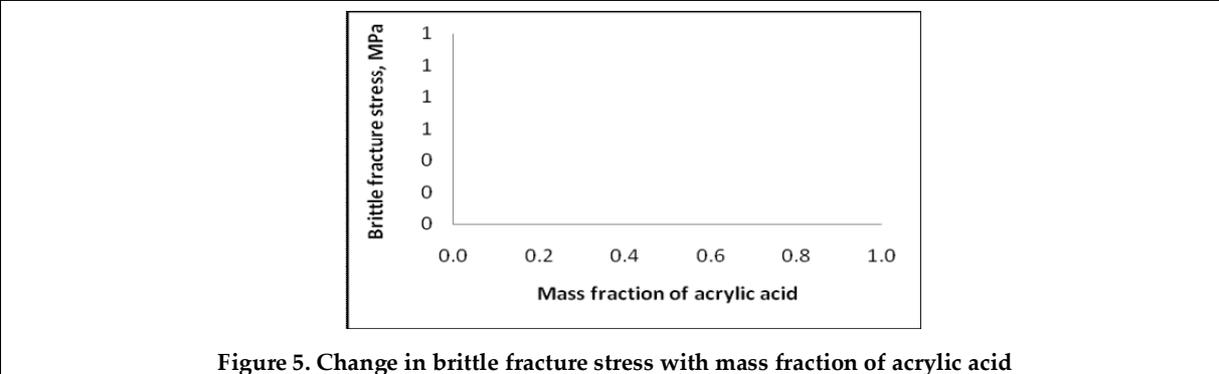


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Polyacrylic Acid-C Butadiene Composite**

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### **ABSTRACT**

A blend is a mixture of one more than one components. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and polyacrylic\_acid-c\_butadiene composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study will help to determine pairs without performing laboratory experiments saving materials, efforts and times.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyacrylic\_acid-c\_butadiene

### **INTRODUCTION**

Blends or composites are materials containing more than one component. Those are combined and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend can save time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. That's why the researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and polyacrylic\_acid-c\_butadiene composite.





Prativa Satpathy and Alisha Rath

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyacrylic\_acid-c\_butadiene were fed to the synthia of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Fig 1 shows that the molar volume of the composite gradual decreases linearly with its increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Fig 2 shows that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Fig 3 shows that the permeability of oxygen with the composite decreases with increase in mass fraction of acrylic acid.

Fig 4 shows that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Fig 5 shows that the permeability of carbon dioxide through the composite decreases with its increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and polyacrylic\_acid-c\_butadiene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density are decreasing with the increase in its acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid.

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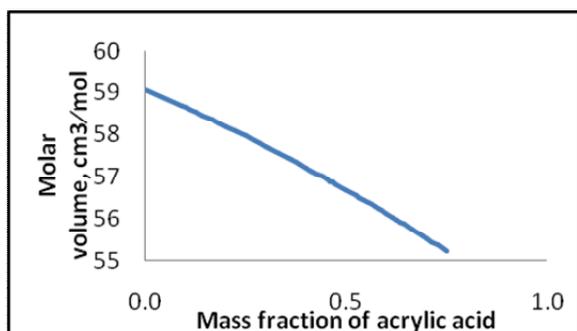


Figure 1. Change in molar volume with mass fraction of acrylic acid

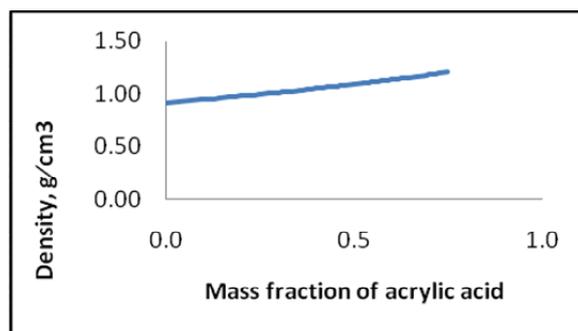


Figure 2. Change in density with mass fraction of acrylic acid

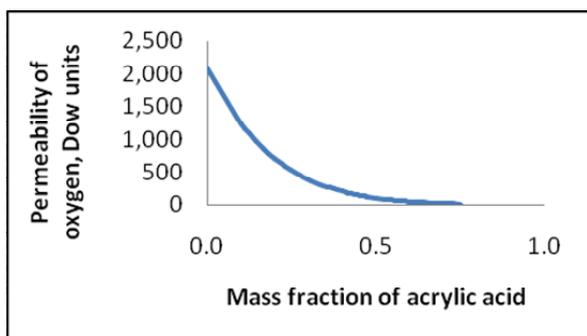


Fig 3. Change in permeability of oxygen with mass fraction of acrylic acid

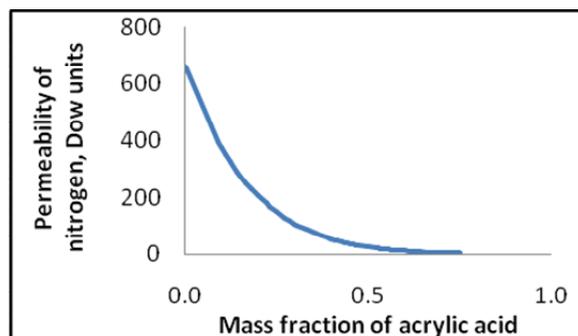


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid

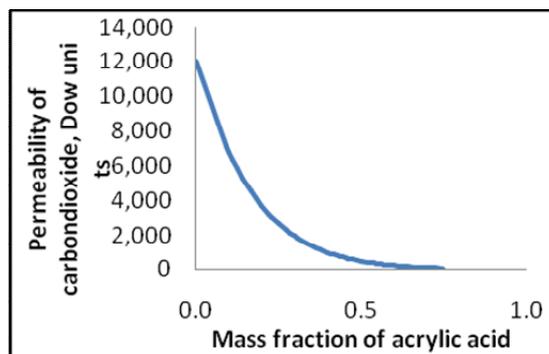


Figure 5. Change in permeability of carbon dioxide with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Polyvinylchloride Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and polyvinylchloride composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties increased with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyvinylchloride composite

## **INTRODUCTION**

Blends or composites are materials which contain more than one component and the components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time while a blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and polyvinylchloride composite.





Pritam K. Dash and T. Mishra

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systems of France)” was used for analysis. The structures of polyacrylic acid and polyvinylchloride were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the composite gradually increases with the increase in the mass fraction of the acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” Figure 2 show that when the mass fraction of the acrylic acid increases the value of shear modulus of the composite also increases gradually.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Figure 3 shows that the Young's modulus of the composite increases along with the increasing value of the mass fraction of the acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Figure 4 shows that when the value of mass fraction of the acrylic acid increases the poisson ratio of the composite decreases.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Figure 5 shows that the value of brittle fracture stress decreases with increasing value of mass fraction of the acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and polyvinylchloride to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the bulk modulus, shear modulus, young's modulus increases with the increase in mass fraction of the acrylic acid and the poisson ratio and brittle fracture stress of the composite decreases with the increase in the mass fraction of the acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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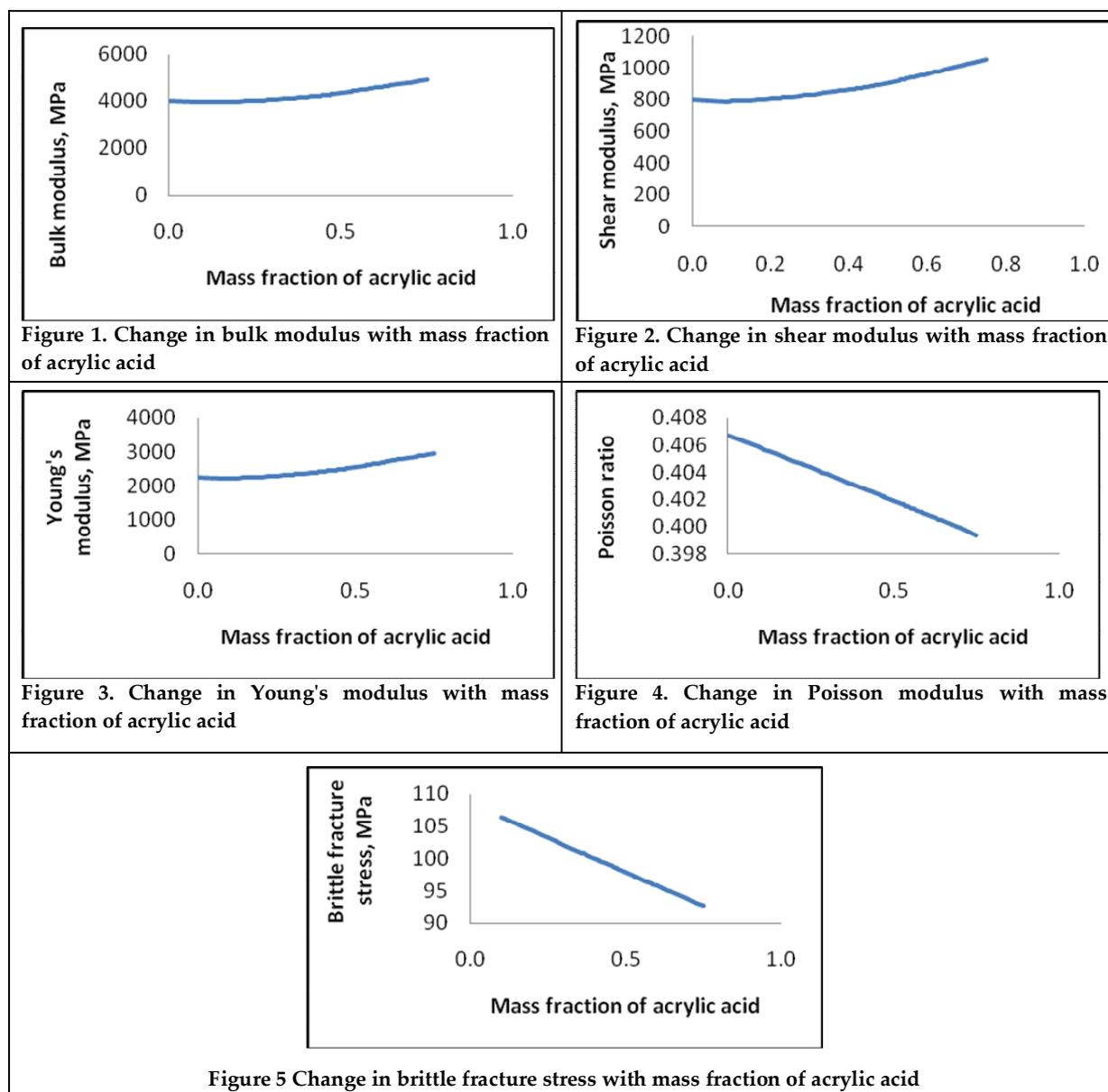
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## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Polyvinyl Chloride Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and polyvinyl chloride composite were studied. With the increasing value of mass fraction of acrylic acid the molar volume and density of the composite decreases. Based on the permeability of oxygen, nitrogen and carbon dioxide the permeability of composite were studied. Results showed that when the mass fraction of acrylic acid increases the permeability for all the gases decreases. This study will be helpful because it is time, money, material savings and we did this experiment without performing any laboratory experiments.

**Keywords:** Blend, *in silico*, Biovia, polyacrylic acid and polyvinyl chloride composite

## **INTRODUCTION**

Blends or composites are materials which contain more than one component and the components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time while a blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and polyvinylchloride composite.





Pritam K. Dash and T. Mishra

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyvinylchloride were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 shows that while the mass fraction of acrylic acid increases the molar volume of the composite also increases accordingly.

**Density:** “Density is mass per unit volume”. Figure 2 shows that with the increase in the value of mass fraction of acrylic acid the density of the composite decrease linearly.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 show that when the mass fractions of acrylic acid increase the permeability of the oxygen through the composite gradually decreases.

Figure 4 shows that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Figure 5 shows that with the increase in the value of mass fraction of acrylic acid the value of permeability of carbon dioxide through the composite decreases gradually.

## CONCLUSIONS

The possibility of use of polyacrylic acid and polyvinylchloride to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume of the composite increases and the density of the composite decreases with the increasing value of mass fraction of the acrylic acid. Based on permeability of oxygen, nitrogen and carbon dioxide the permeability properties of the composite determined. The results indicated that the when the mass fraction of the acrylic acid increases the permeability of all the mentioned gases are decreases gradually. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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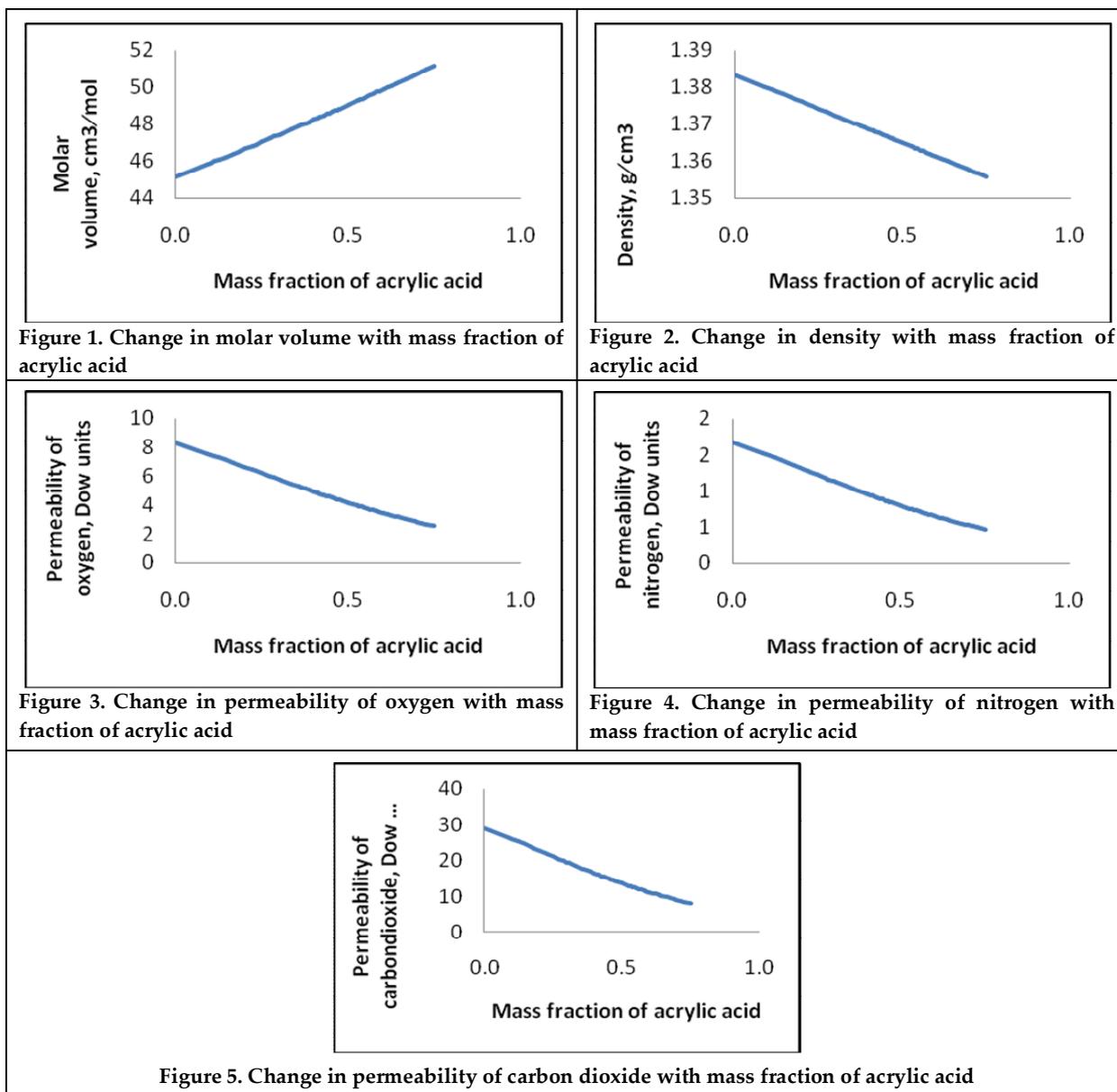
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## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Polyvinylchloride Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and polyvinylchloride composite were studied. With the help of heat capacity, thermal conductivity and dielectric constant the composition of the blend was analyzed. Through this experiment we know that with the increase in mass fraction the above three parameters are increased as well. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyvinylchloride composite

## **INTRODUCTION**

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## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyvinylchloride were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 show that with the increasing value of mass fraction the heat capacity also increase linearly to a certain instant.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 shows that with the increase in mass fraction of acrylic acid the heat capacity also increase.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 shows that with the increasing value of the mass fraction of the acrylic acid the dielectric constant of the composite increases and stop at some point.

## CONCLUSIONS

The possibility of use of polyacrylic acid and polyvinylchloride to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicates that with the increase in the mass fraction of acrylic acid the heat capacity, thermal conductivity and the dielectric constant of composite also increses. With the savings of money and time and without performing any laboratory experiment we find the component of the blend through computer based study.

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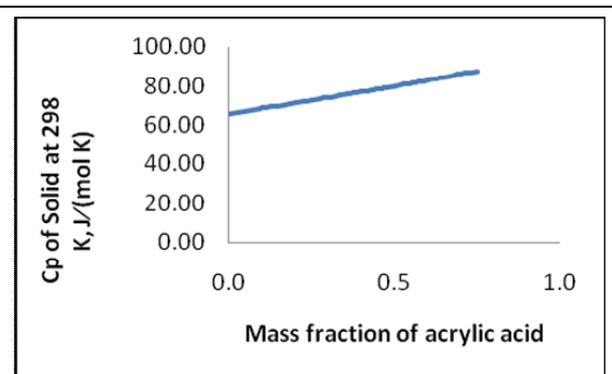


Figure 1. Change in heat capacity with mass fraction of acrylic acid

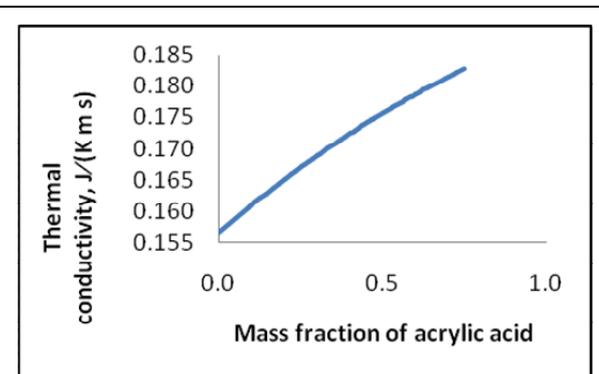


Figure 2. Change in thermal conductivity with mass fraction of acrylic acid

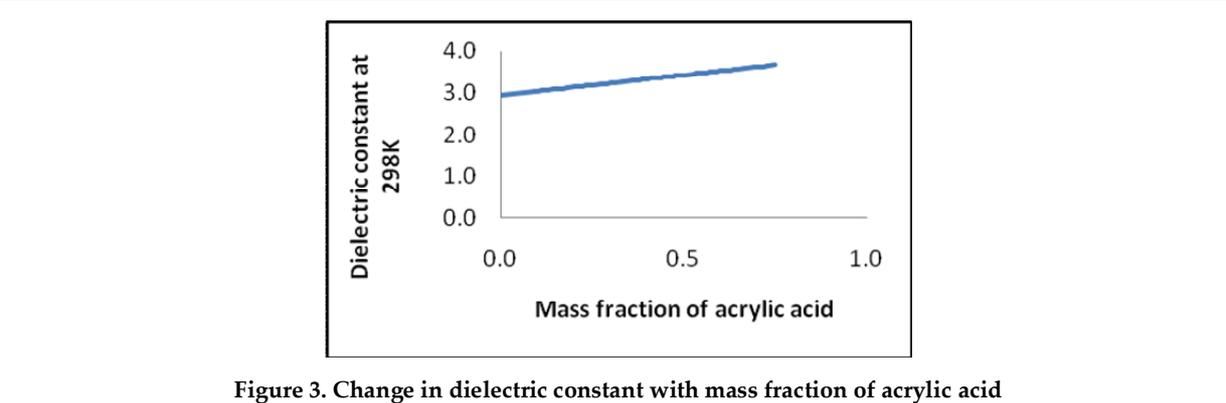


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Polyneoprene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and polyneoprene composite were studied. Thermal conductivity, dielectric constant, heat capacities are the parameters which are responsible for the synthesis of the composition of the blend. We concluded that these parameters are increased with increased in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyneoprene composite

## **INTRODUCTION**

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Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and polyneoprene composite.





## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyneo-prene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Image 1 indicates that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “a measure of the ability of a material to transfer heat. Thermal conductivity is the heat transfer per unit time & per unit surface area, divided by the temperature differences.” Image 2 shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as a material is its absolute permittivity expressed as a ratio relative to the vacume permittivity”. Image 3 shows that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly neo-prene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. Thermal conductivity, dielectric constant, heat capacity are the parameters which are responsible for the synthesis of the composition of the blend. We concluded that these parameters are increased with increased in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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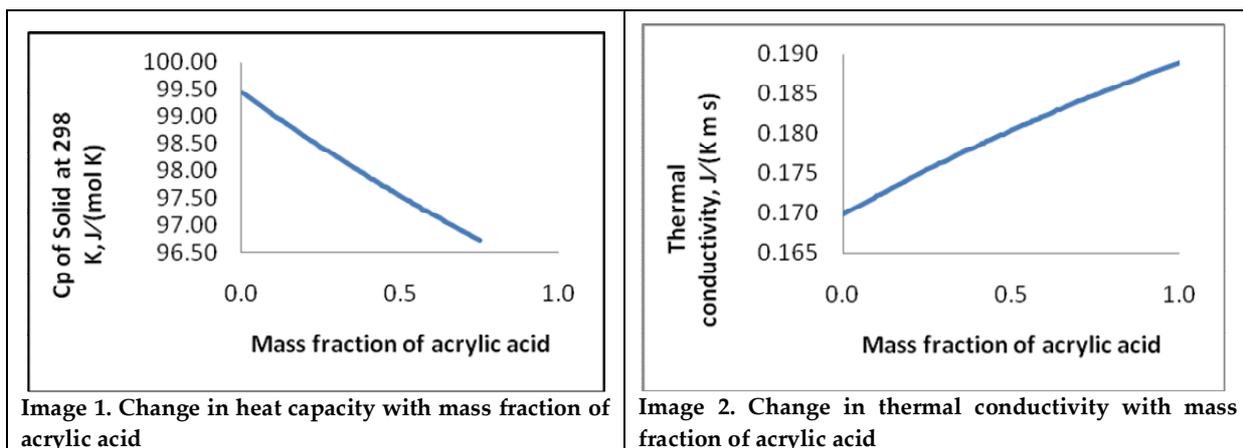


Image 1. Change in heat capacity with mass fraction of acrylic acid

Image 2. Change in thermal conductivity with mass fraction of acrylic acid

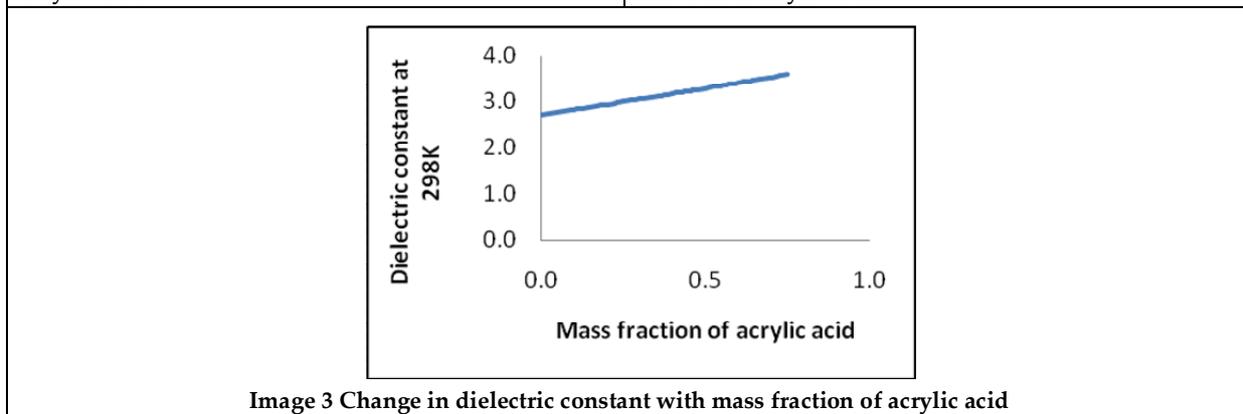


Image 3 Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Polyneoprene Composite**

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A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and polyneoprene composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** blend, polyacrylic acid and polyneoprene composite

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## RESULTS AND DISCUSSION

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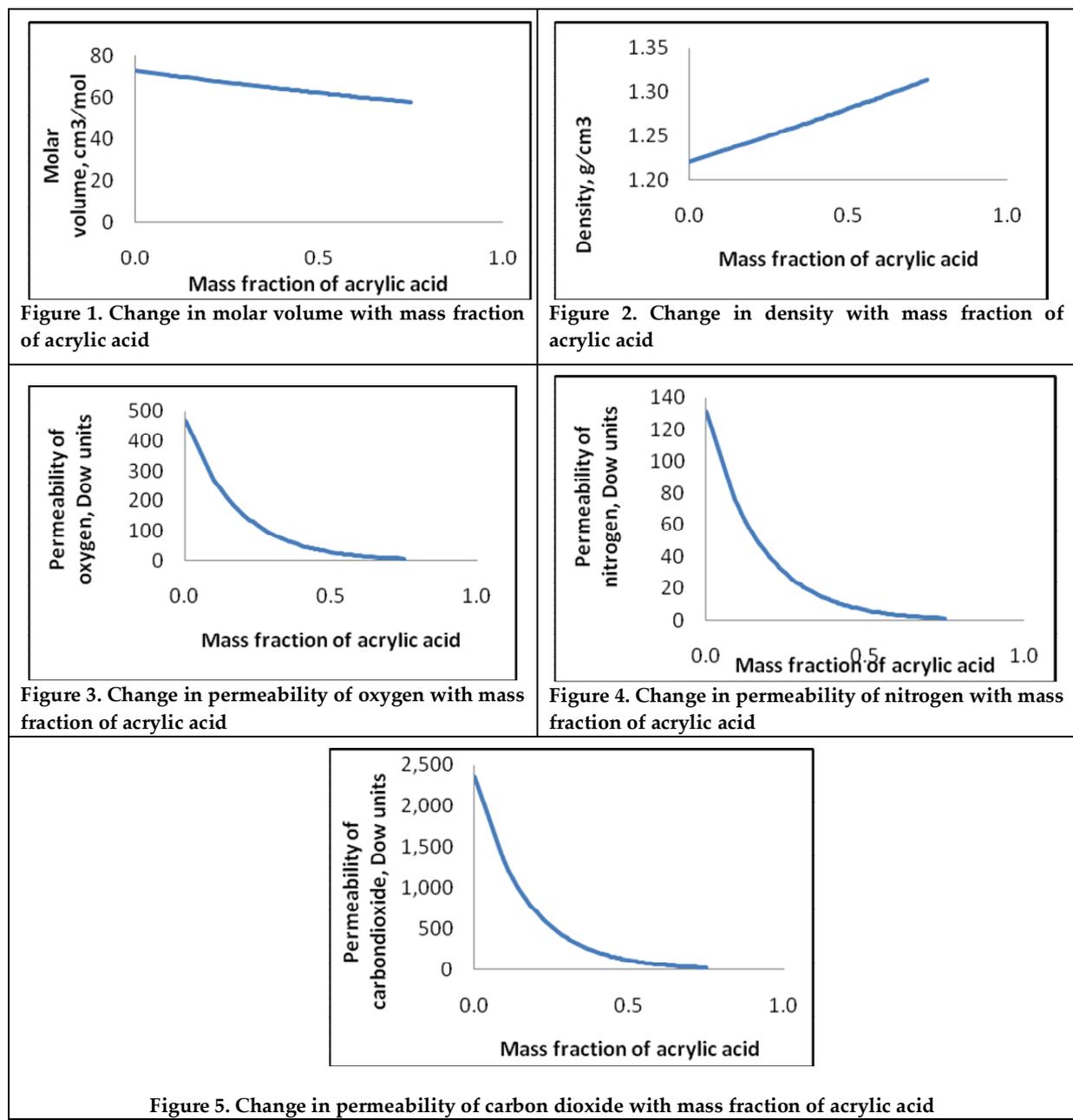
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**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyneoprene composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus; researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and polyneoprene composite.





P. P. Udgata and T. Mishra

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyneo prene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the relative change in the volume of a body produced by a unit compressive or tensile stress acting uniformly over its surface.” Figure 1 shows that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress to the shear strain.” Figure 2 shows that the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Figure 3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Figure 4 shows that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Figure 5 shows that the brittle fracture stresses of the composite increases linearly with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly neo prene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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P. P. Udgata and T. Mishra

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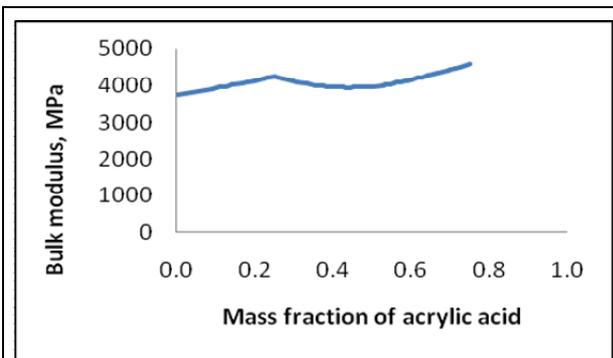


Figure 1. Change in bulk modulus with mass fraction of acrylic acid

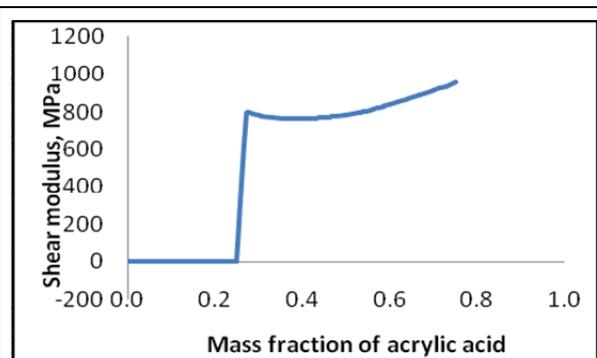


Figure 2. Change in shear modulus with mass fraction of acrylic acid

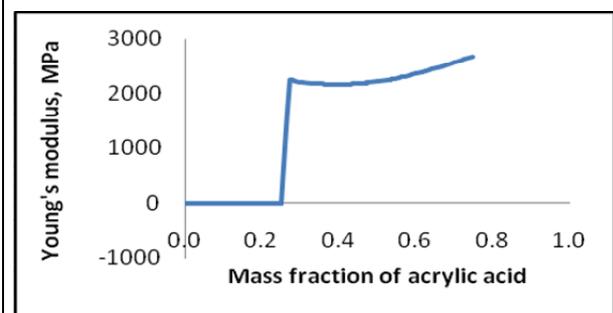


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

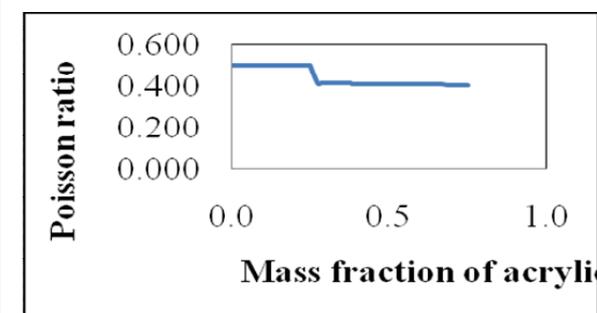


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

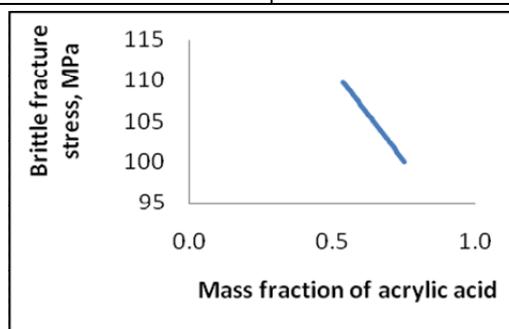


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Poly Oxypropylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly oxypropylene composite were studied. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all those parameters increased with increase in mass fraction of acrylic acid. This will help to determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly oxypropylene composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All of the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly oxypropylene composite.





S. Naik and A Patel

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly oxypropylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 shows that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 shows that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly oxypropylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the three parameters increased with increase in mass fraction of acrylic acid. This *in silico* study will help to determine components of a blend without performing laboratory experiments saving materials, money and time.

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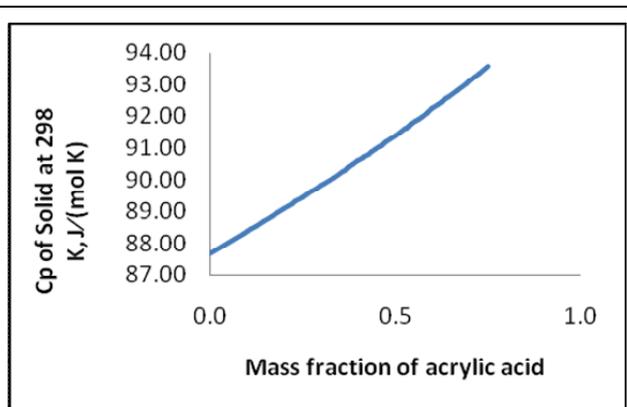


Figure 1. Change in heat capacity with mass fraction of acrylic acid

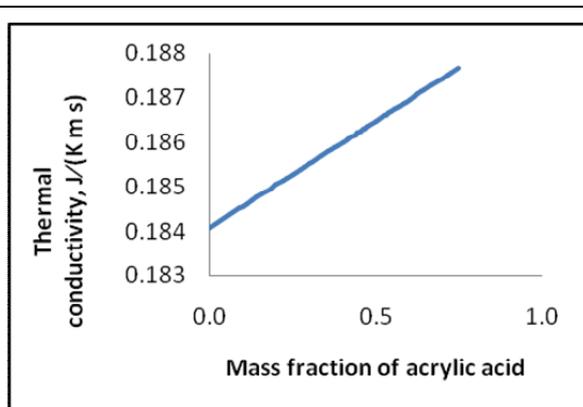


Figure 2. Change in thermal conductivity with mass fraction of acrylic acid

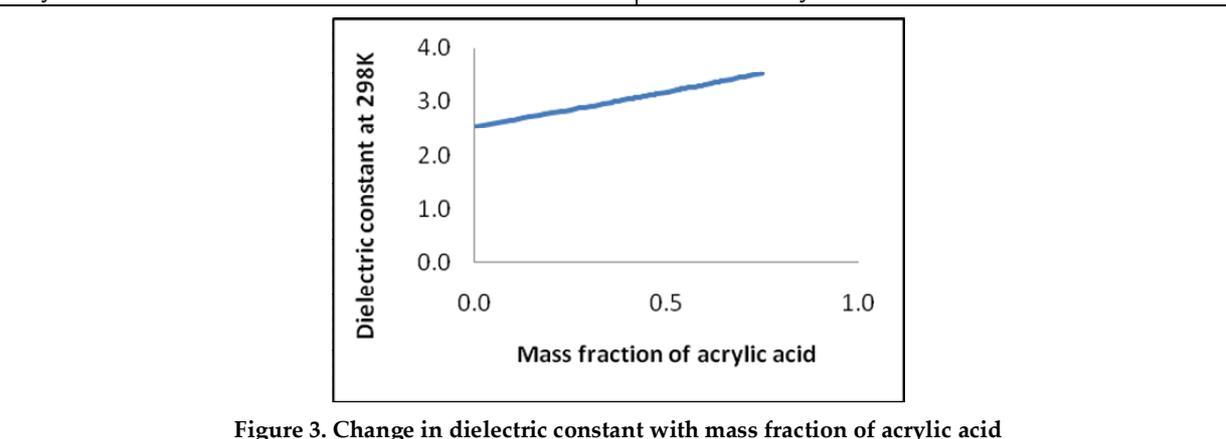


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Poly Oxypropylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and poly oxypropylene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties increased with increase in mass fraction of acrylic acid. This study will help to determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly oxypropylene composite

## **INTRODUCTION**

Blends or composites are materials containing more than one components. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of the products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and poly oxypropylene composite.





S. Naik and A Patel

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly oxypropylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.”Figure 2 shows that the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Figure 3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Figure 4 shows that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

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## CONCLUSIONS

The possibility of use of polyacrylic acid and poly oxypropylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This is silico study will help to determine components of a blend without performing laboratory experiments saving materials, money and time.

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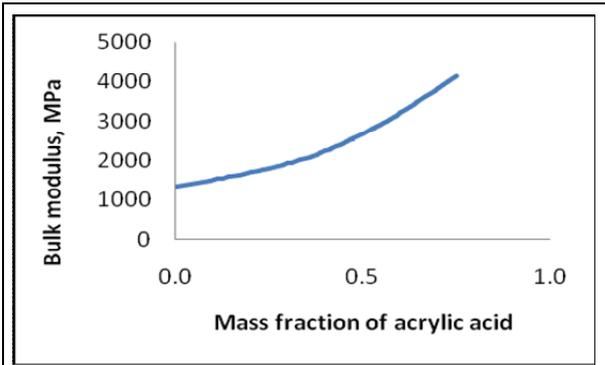


Figure 1. Change in bulk modulus with mass fraction of acrylic acid

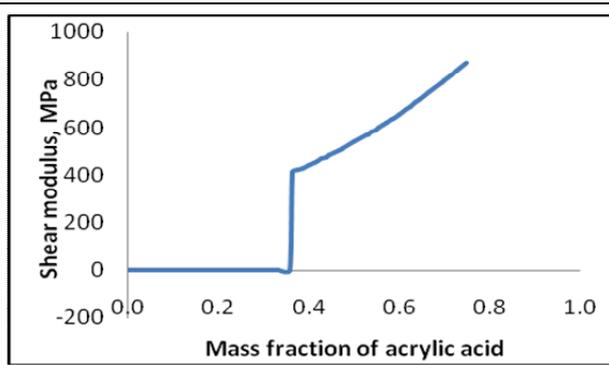


Figure 2. Change in shear modulus with mass fraction of acrylic acid

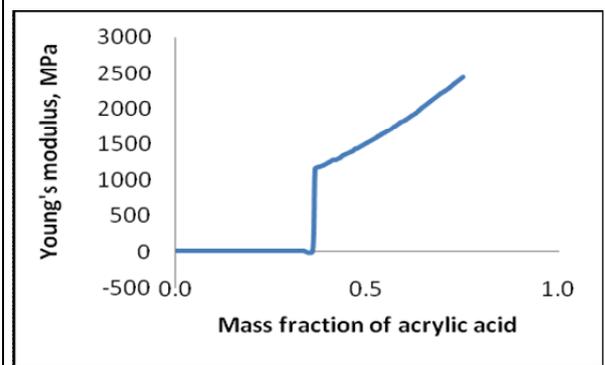


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

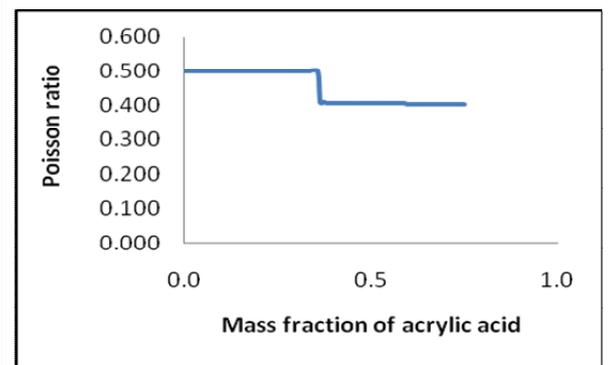


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

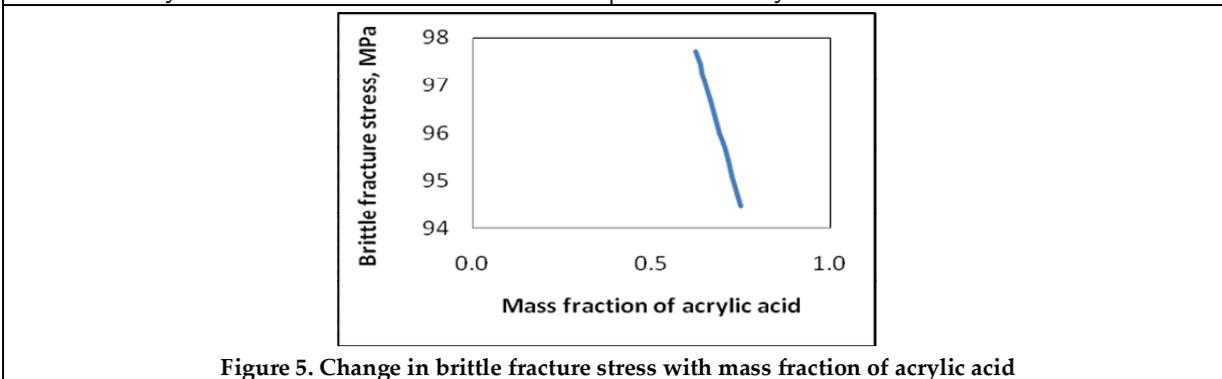


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Polyoxypropylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly oxypropylene composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study will help to determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly oxypropylene composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All of the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly oxypropylene composite.





S. Naik and A Patel

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly oxypropylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 shows that the molar volume of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 shows that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 shows that the permeability of oxygen through the composite decreases with increase in mass fraction of acrylic acid.

Figure 4 shows that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Figure 5 shows that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly oxypropylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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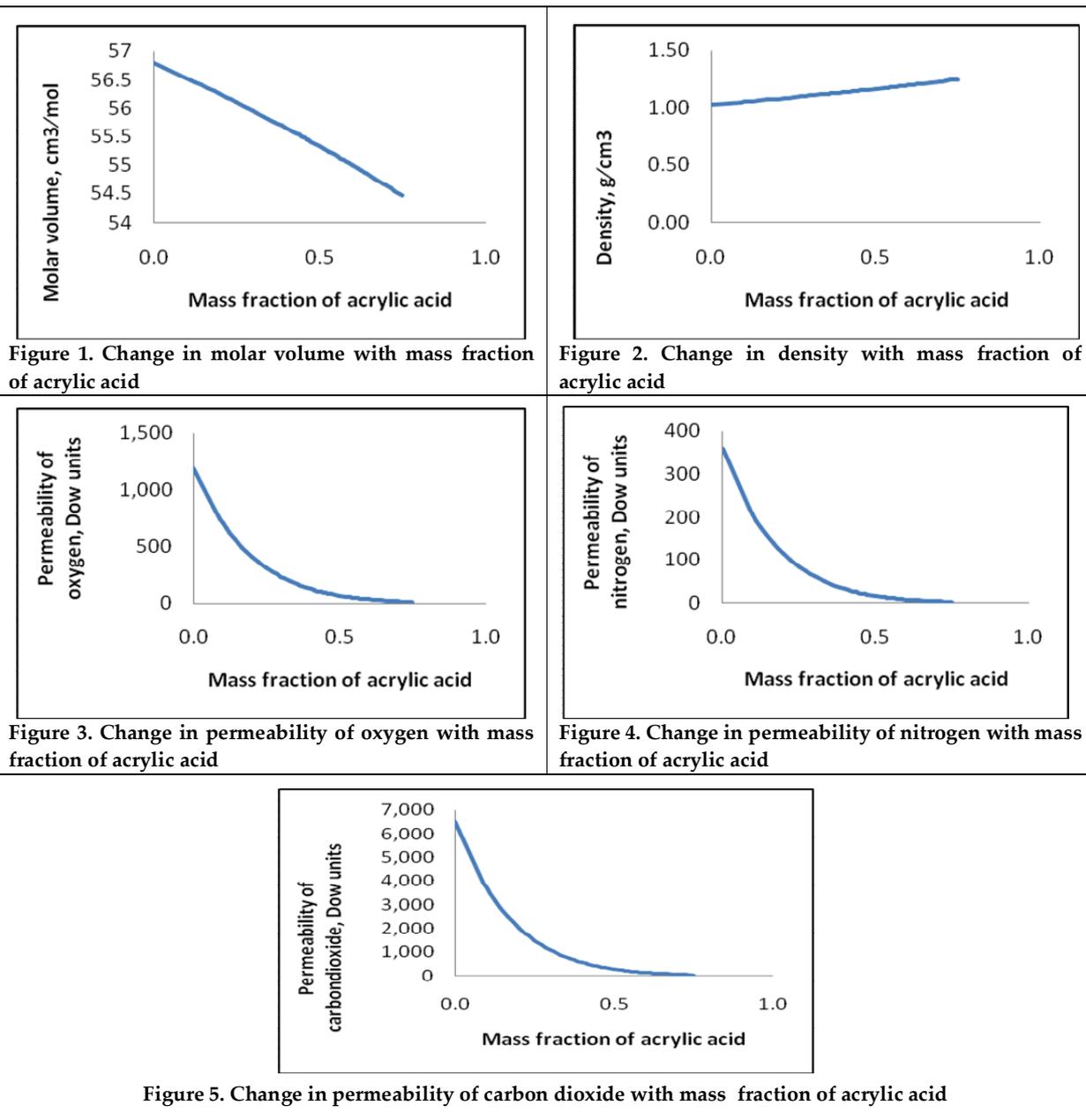
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## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Poly -T Isoprene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly t<sub>2</sub>isoprene composite were studied. The composition of the blend was analyzed with respect to the heat capacity, thermal conductivity and dielectric constant. The results indicated that all the parameters increased with increase in mass fraction of acrylic acid. This study will help to determine the pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly t<sub>2</sub>isoprene composite

## **INTRODUCTION**

Blends or composites are materials that containing more than one components. The components do not lose their identity in the mixture. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly t<sub>2</sub>isoprene composite.





Satyabrata Sadangi

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly t\_isoprene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 shows that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 shows that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and polyacrylic\_acid-t\_isoprene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the three parameters increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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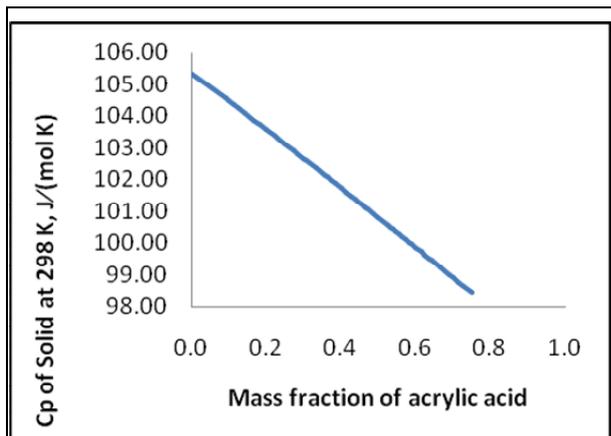


Figure 1. Change in heat capacity with mass fraction of acrylic acid

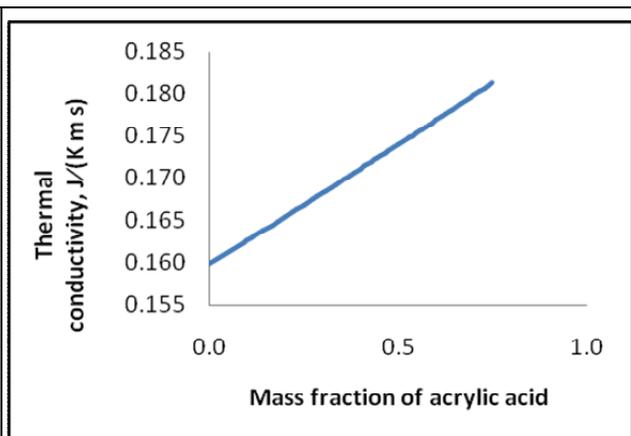


Figure 2. Change in thermal conductivity with mass fraction of acrylic acid

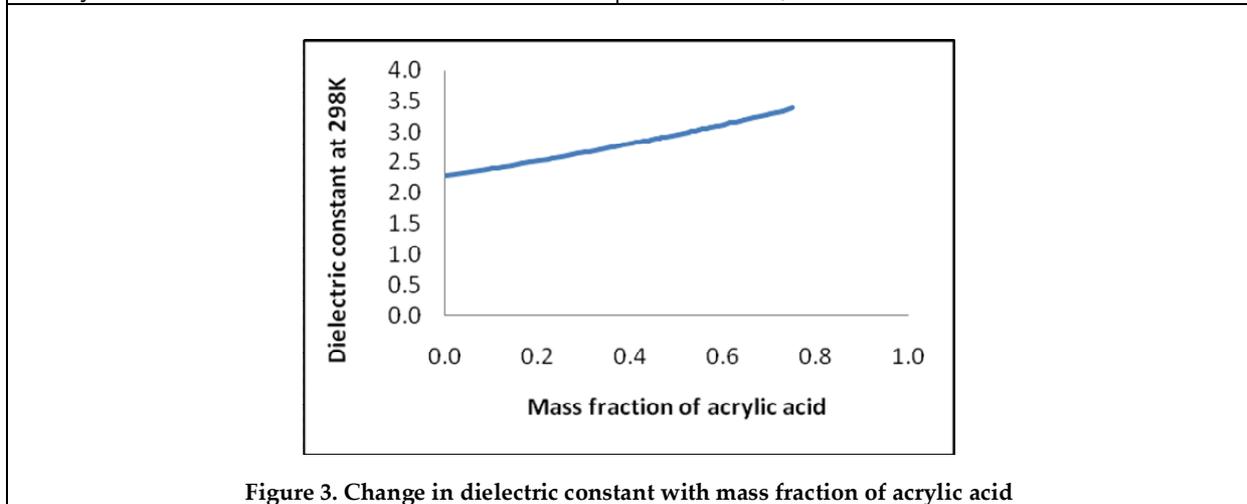


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Poly T\_Isoprene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and polyacrylic\_acid-t\_isoprene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties increased with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyacrylic\_acid-t\_isoprene composite

## **INTRODUCTION**

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and polyacrylic\_acid-t\_isoprene composite.





## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyacrylic\_acid-t\_isoprene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” Figure 2 shows that the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Figure 3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Figure 4 shows that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Figure 5 shows that the brittle fracture stress of the composite increases linearly with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and polyacrylic\_acid-t\_isoprene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

## REFERENCES

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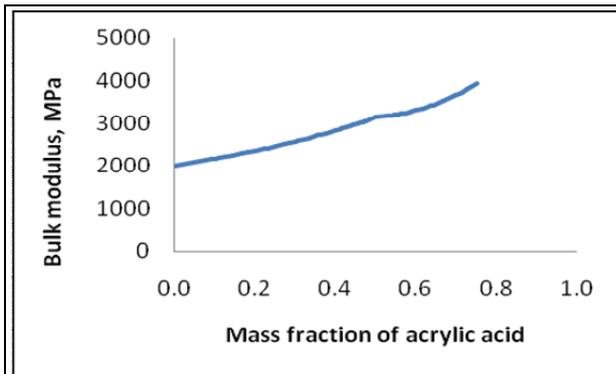


Figure 1. Change in bulk modulus with mass fraction of acrylic acid

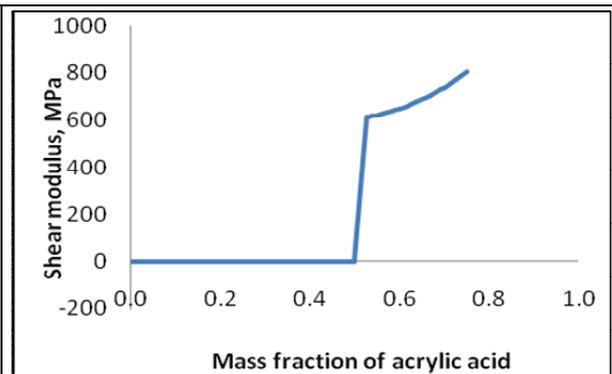


Figure 2. Change in shear modulus with mass fraction of acrylic acid

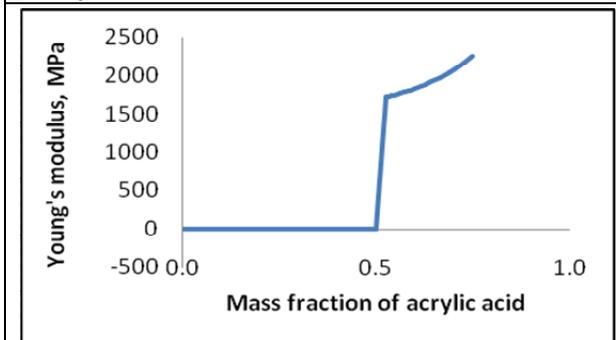


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

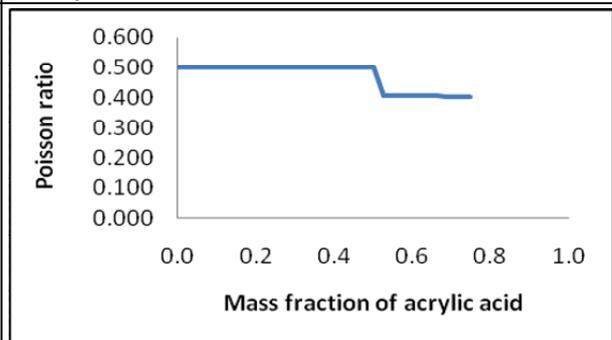


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

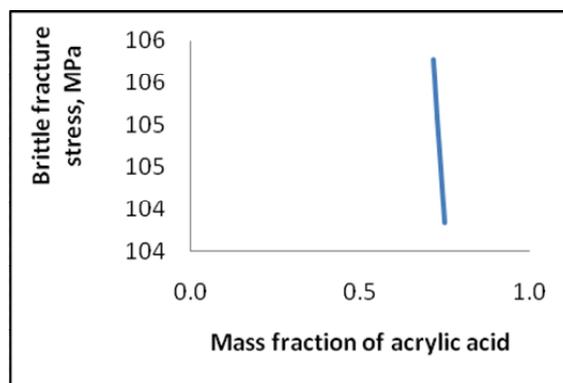


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## *In silico* Analysis of Permeability Properties of Polyacrylic Acid and Poly T\_Isoprene Composite

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### ABSTRACT

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly t\_isoprene composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study will help determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly t\_isoprene composite

## INTRODUCTION

Blends or composites are materials containing more than one component. The components do not lose their identity in the mixture. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and t\_isoprene composite.





Satyabrata Sadangi

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly t-isoprene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 shows that the molar volume of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 shows that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 shows that the permeability of oxygen through the composite decreases with increase in mass fraction of acrylic acid.

Figure 4 shows that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Figure 5 shows that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and acrylic\_acid-t\_isoprene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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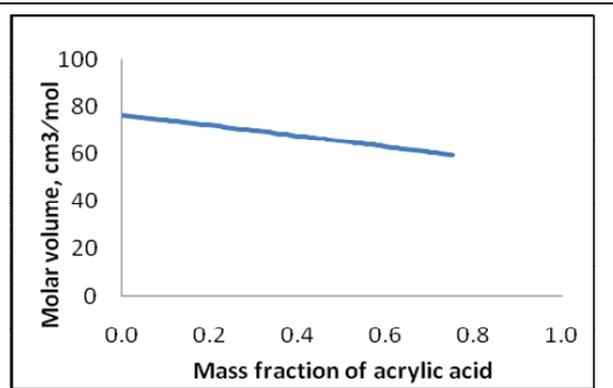


Figure 1. Change in molar volume with mass fraction of acrylic acid

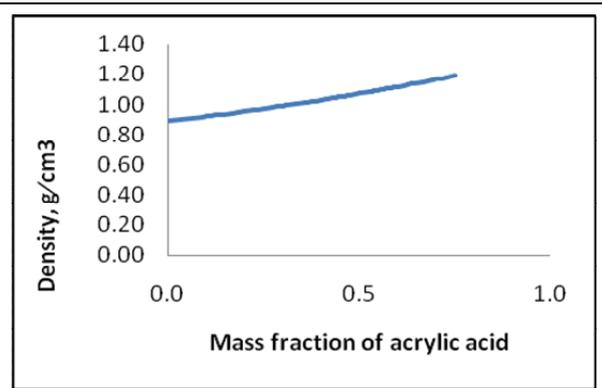


Figure 2. Change in density with mass fraction of acrylic acid

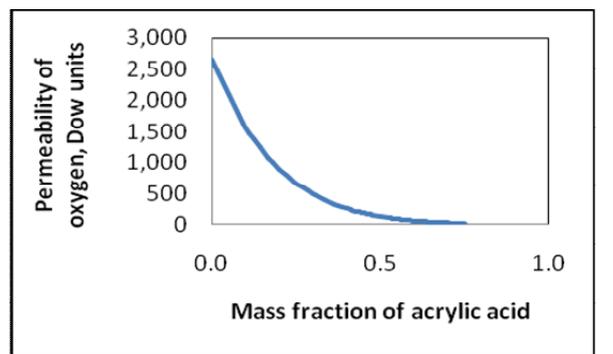


Figure 3. Change in permeability of oxygen with mass fraction of acrylic acid

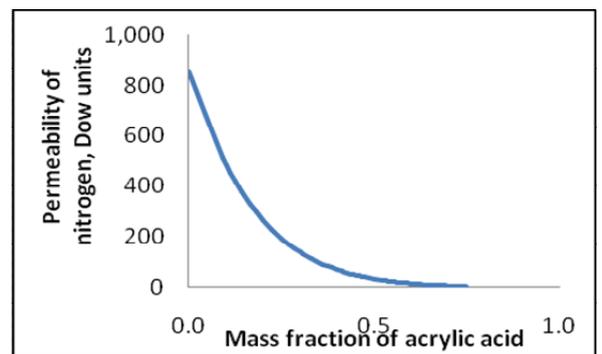


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid

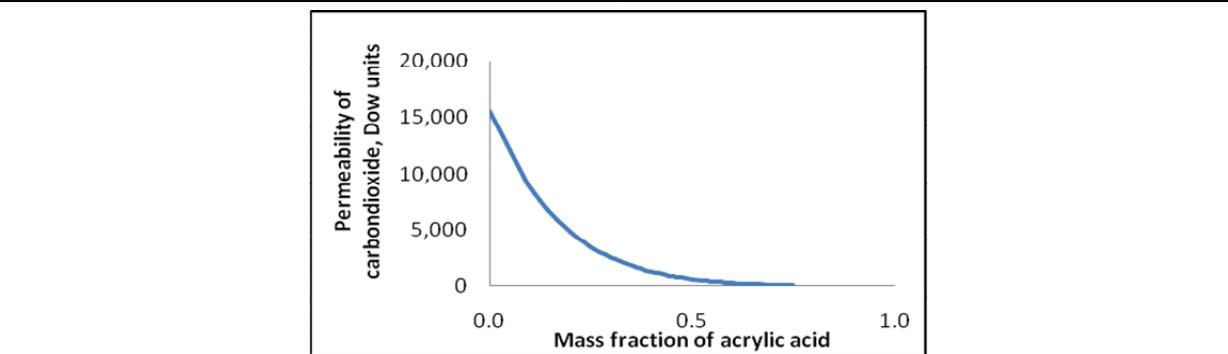


Figure 5. Change in permeability of carbon dioxide with mass fraction of acrylic acid





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Poly Vinyl Alcohol Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly vinyl alcohol composite were studied. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all those parameters increased with increase in mass fraction of acrylic acid. This study has been taken to attempt an in-silico study which will help to determine pairs in a blend without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly vinyl alcohol composite

### **INTRODUCTION**

Blends or composites can be defined as materials consisting more than one component. The components in the mixture do not lose their identity. The components in the mixture combine and contribute to the property of the blend hence improving the quality of the material. Development of a single material with the desired property involves rigorous and extensive research and time. Thus it can be said that a blend, saves time to develop a new material with desired properties reducing the cost of development of products. There are varieties of polymer blends. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above polymer blends mentioned examples are based on experiments done in laboratory. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly vinyl alcohol composite.



**Bhattacharya S et al.**

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly vinyl alcohol were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 shows that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 shows that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly vinyl alcohol to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the three parameters increased with increase in mass fraction of acrylic acid. This *in silico* study will help determine components of a blend without laboratory experiments with less resources, cost and time.

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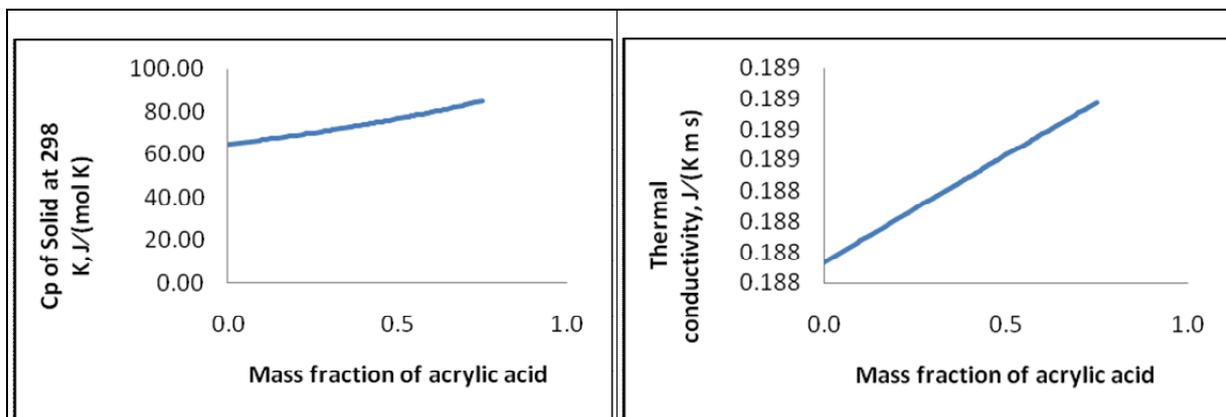


Figure 1. Change in heat capacity with mass fraction of acrylic acid

Figure 2. Change in thermal conductivity with mass fraction of acrylic acid

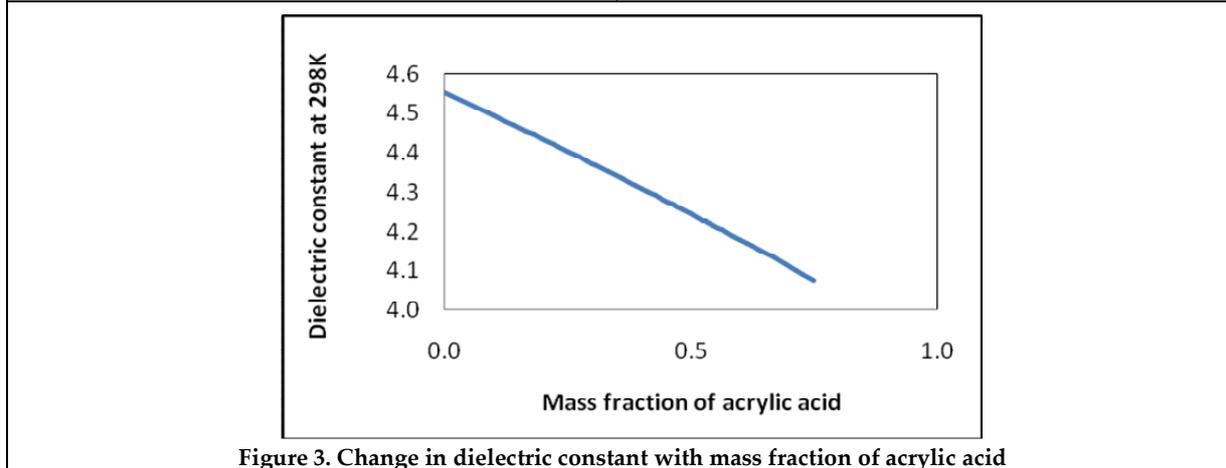


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Poly Vinyl Alcohol Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and polyvinyl alcohol composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties increased with increase in mass fraction of acrylic acid. This insilico study will help determine pairs without performing in vivo experiments reducing requirements for materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyvinyl alcohol composite

## **INTRODUCTION**

Blends or composites are well defined as materials containing more than one component. The components in the mixture do not lose their identity. The components in the mixture combine and contribute to the property of the blend thereby improving its quality. A single material with the desired property is developed with significant research and time. A blend whereas saves time reducing the cost of development of products with desired properties to develop a new material. Blends specially Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above polymer blends examples are based on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and poly vinyl alcohol composite.





## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly vinyl alcohol were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

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**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

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## CONCLUSIONS

The possibility of use of polyacrylic acid and poly vinyl alcohol to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without laboratory experiments without wastage of materials, money and time.

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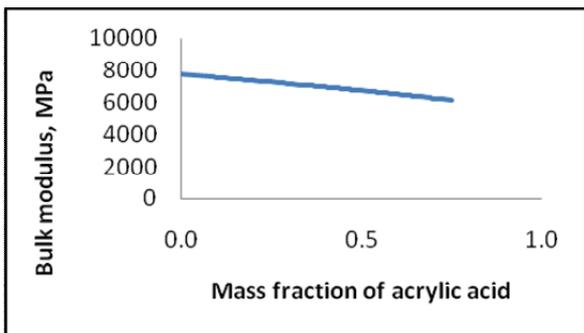


Figure 1. Change in bulk modulus with mass fraction of acrylic acid

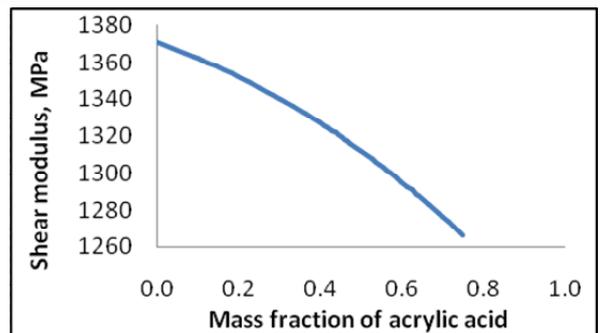


Figure 2. Change in shear modulus with mass fraction of acrylic acid

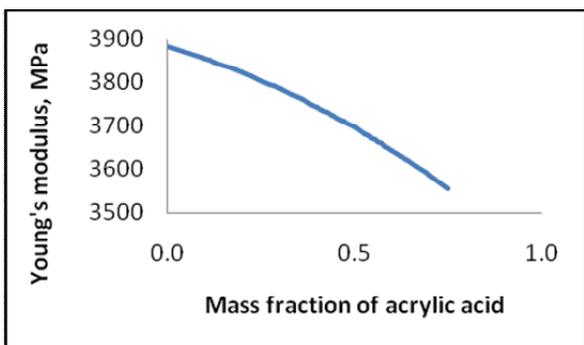


Figure 3. Change in Young's modulus with mass fraction of acrylic acid

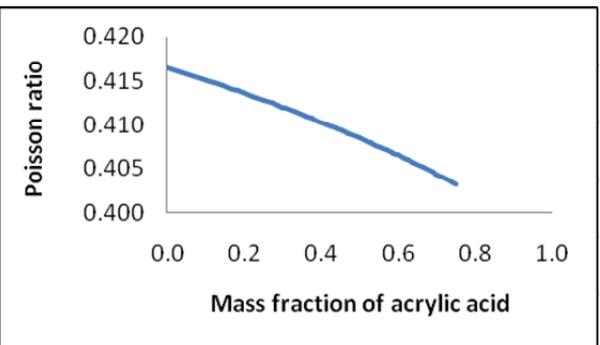


Figure 4. Change in Poisson modulus with mass fraction of acrylic acid

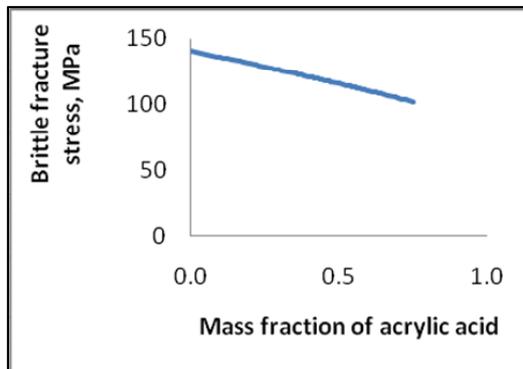


Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid





## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Poly Vinyl Alcohol Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and polyvinyl alcohol composite were studied. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This in silico study was taken to prove that it will help to determine pairs without experimental data of laboratory cutting back materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyvinyl alcohol composite

## **INTRODUCTION**

Blends or composites are defined as materials containing more than one component. The components in the blend do not lose their identity. They combine and contribute to the property of the blend improving the quality of the material thereby. To develop a single material with the desired property includes extensive research and time. Therefore a blend is a great option which saves time to develop a new material with desired properties reducing the cost of development of products. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above examples are based on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly vinyl alcohol composite.



**Bhattacharya S et al.**

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly vinyl alcohol were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 shows that the molar volume of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 shows that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 shows that the permeability of oxygen through the composite decreases with increase in mass fraction of acrylic acid.

Figure 4 shows that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. Figure 5 shows that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly vinyl alcohol to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. From this study it can be concluded that in silico study will help determine components of a blend without performing laboratory experiments reducing materials, cost and time.

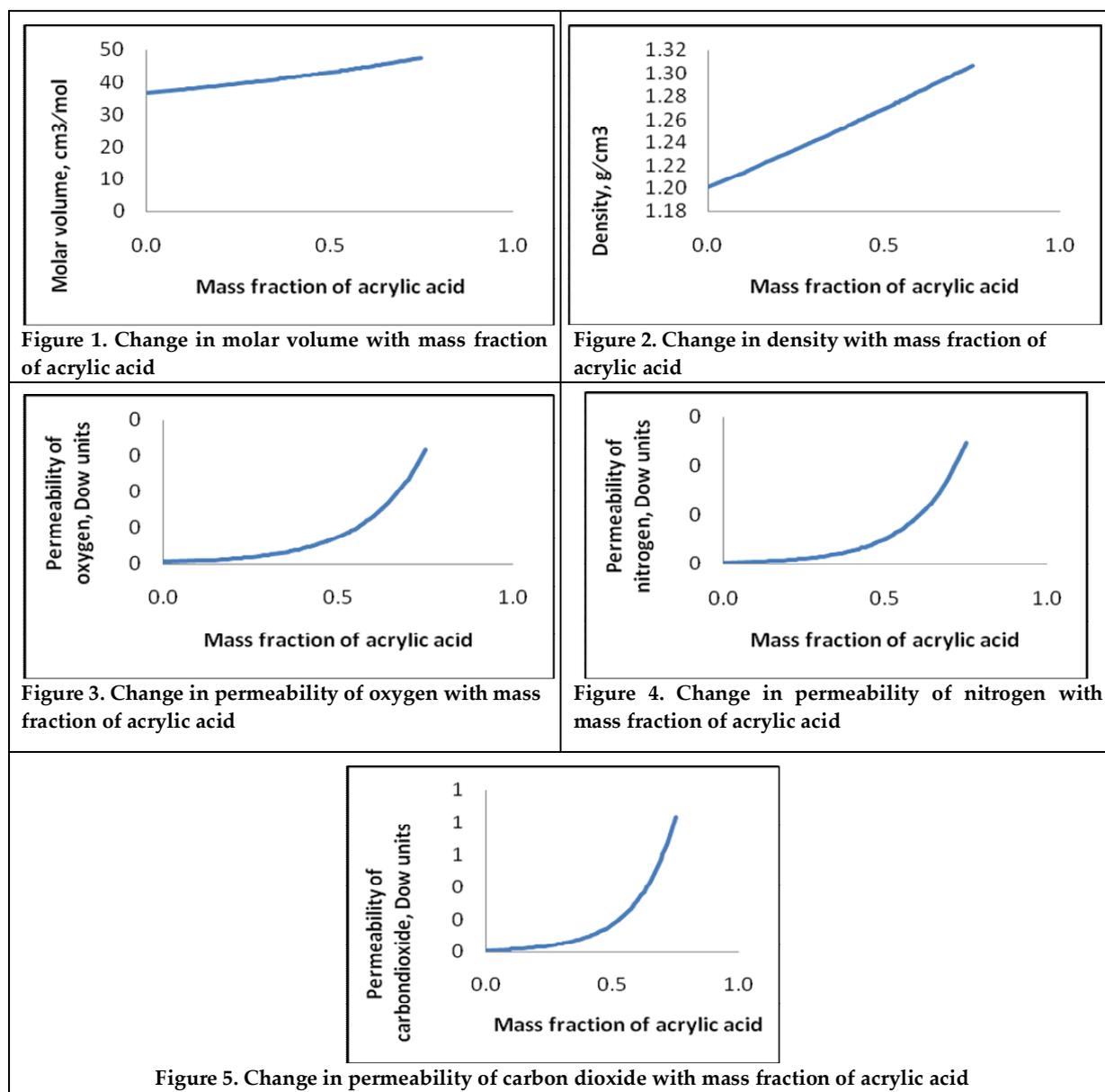
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## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Difluoroethylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and difluoroethylene composite were studied. The composition of the blend was examined with respect to the heat capacity, thermal conductivity and the dielectric constant. The result indicates that those entire frameworks increased with increase in mass fraction of acrylic acid. This study will help to determine pairs without performing laboratory experiments saving the materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and difluoroethylene composite

## **INTRODUCTION**

Blends or composites are materials which contain more than one component. The components don't lose their identity in the mixture. They collaborate and contribute to the property of the blend thus improving the quality of the material. Development of a single material with the craving property involves remarkable research and time. A blend lay aside time to be born a new material thereby decreasing the cost of generation of the products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire-resistant materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementations composites [6] etc. All the above mentioned examples figure on the laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and difluoroethylene composite.





Srabani mishra and Lokanath Meher

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and difluoroethylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. Figure 1 confirms that the heat capacity (Cp) of the composite boost linearly with raise in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 reveals that the thermal conductivity of the composite expands linearly with rise in mass fraction of acrylic acid.

**Dielectric Constant:** “It is describe as the ratio of the electric permeability of the material to the electric permeability of free space”. Figure 3 reveals that the dielectric constant of the composite rise with the growth in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and difluoroethylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The outcome indicated that all the three framework increased with rise in mass fraction of acrylic acid. This silico study will help to determine components of a blend without doing any laboratory experiments saving materials, money and time.

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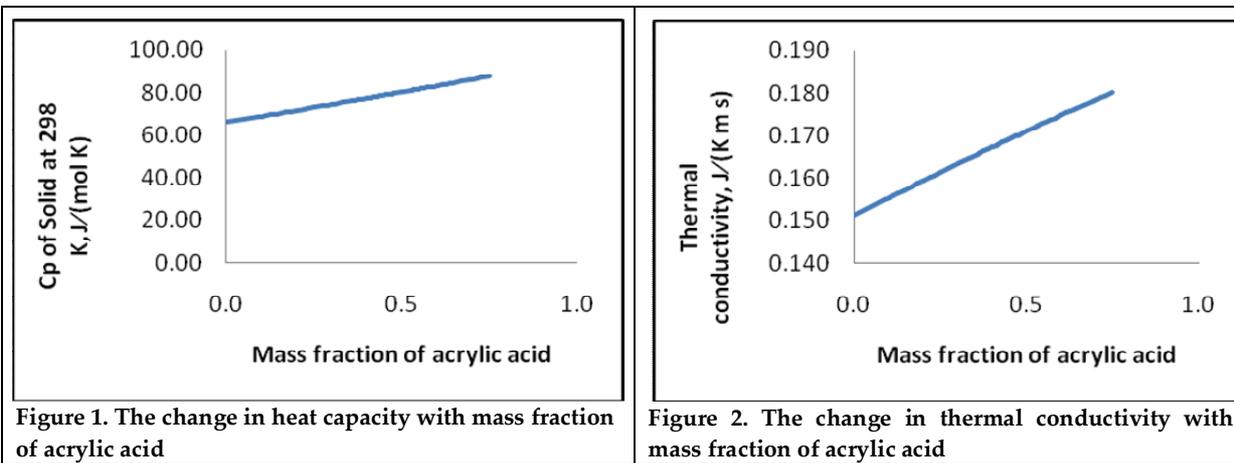


Figure 1. The change in heat capacity with mass fraction of acrylic acid

Figure 2. The change in thermal conductivity with mass fraction of acrylic acid

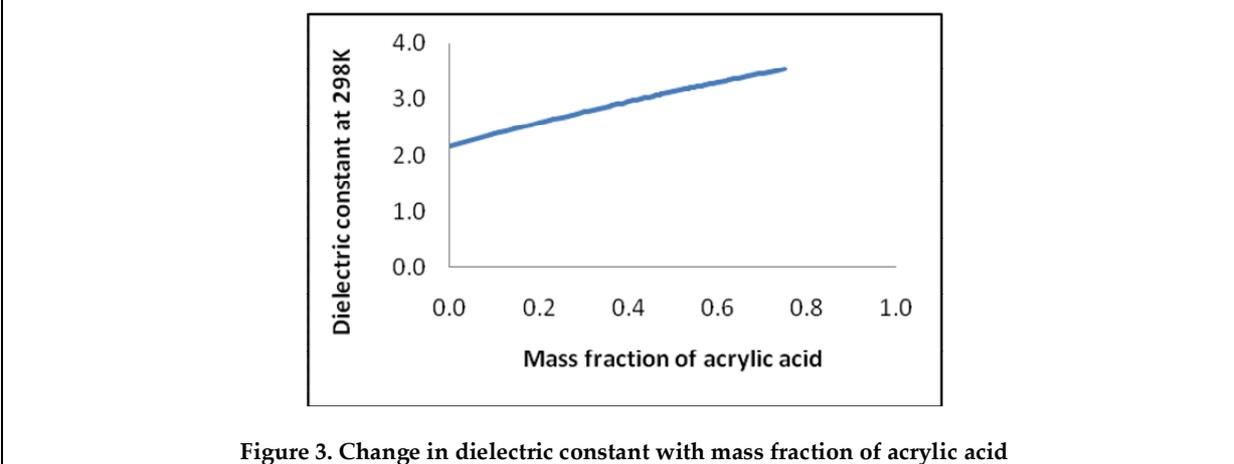


Figure 3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Difluoroethylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and difluoroethylene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The outcome shows that the values of all the properties rise with increase in mass fraction of acrylic acid. This study will help to conclude pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and difluoroethylene composite

## **INTRODUCTION**

Blends or composites are the materials which contain more than one component. The components don't lose their identification in the mixture. They come together and contribute to the property of the blend thereby improving the quality of the material. Improvement of a single material with the preferred property involves important research and time. A blend reduces the time to develop a new material thereby reducing the cost of development of products with preferred properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers-natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and difluoroethylene composite.





Srabani mishra and Lokanath Meher

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and difluoroethylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. Figure 1 shows that the bulk modulus of the composite grows linearly with rise in mass fraction of acrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” Figure 2 reveals that the shear modulus of the composite rise linearly with rise in mass fraction of acrylic acid.

**Young's Modulus:** “It is explain as the ratio of stress and strain and compares relative stiffness”. Figure 3 reveals that the Young's modulus of the composite grows linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. Figure 4 reveals that the Poisson ratio of the composite rise linearly with increase in mass fraction of acrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. Figure 5 indicates that the brittle fracture stress of the composite increases linearly with rise in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and difluoroethylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The outcome indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) grow with increase in mass fraction of acrylic acid. This silico study will help to determine components of a blend without having any kind of laboratory experiments and it saves materials, money and time.

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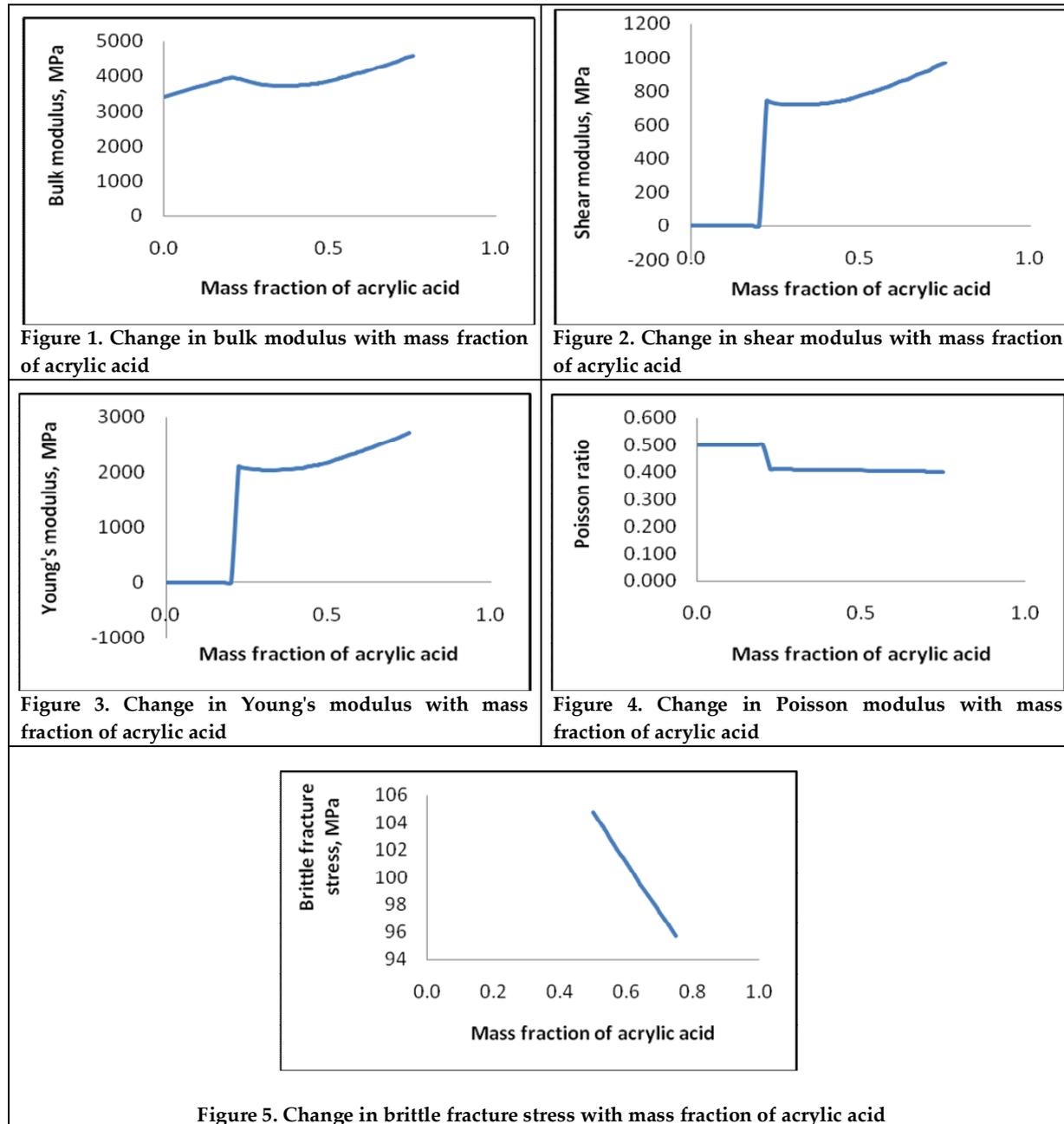
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## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Difluoroethylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and difluoroethylene composite were studied. The molar volume and density decreased with rise in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The outcome showed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study will help to determine the pairs without having any laboratory experiments that will save materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and difluoroethylene composite

## **INTRODUCTION**

Blends or composites are materials which will contain more than one component. The components do not lose their identity in the mixture. They come together and contribute to the property of the blend for improving the quality of the material. Improvement of a single material with the preferred property involves major research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with preferred properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples based on laboratory experiments.

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## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and difluoroethylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. Figure 1 reveals that the molar volume of the composite decreases linearly with rise in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. Figure 2 indicates that the density of the composite decreases linearly with rise in mass fraction of acrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. Figure 3 reveals that the permeability of oxygen through the composite decreases with rise in mass fraction of acrylic acid.

Figure 4 indicates that the permeability of nitrogen through the composite decreases with rise in mass fraction of acrylic acid.

Figure 5 reveals that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and difluoroethylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with rise in acrylic acid fraction. The permeability properties of the composite were studied lies on permeability of oxygen, nitrogen and carbon dioxide. The outcome indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This in silico study will help to determine the components of a blend without having any laboratory experiments and it saves materials, money and time.

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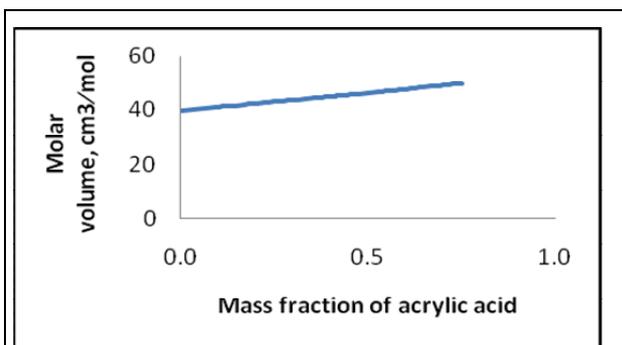


Figure 1. Change in molar volume with mass fraction of acrylic acid

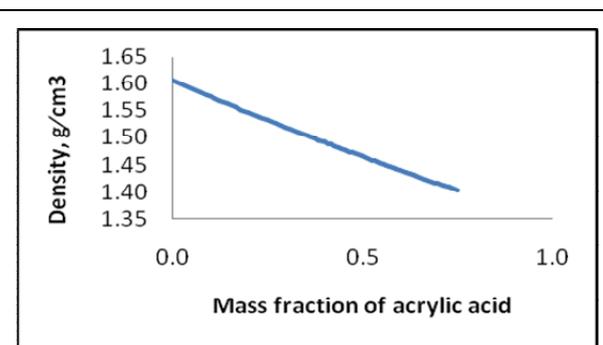


Figure 2. Change in density with mass fraction of acrylic acid

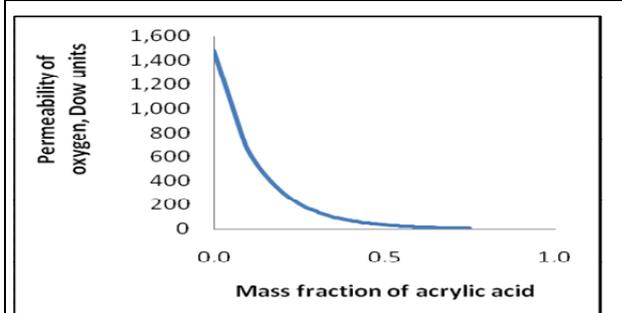


Figure 3. The Change in permeability of oxygen with mass fraction of acrylic acid

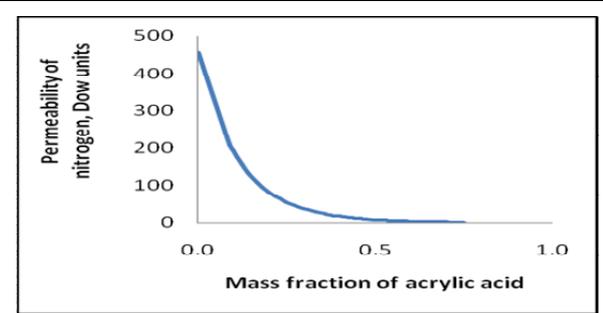


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid.

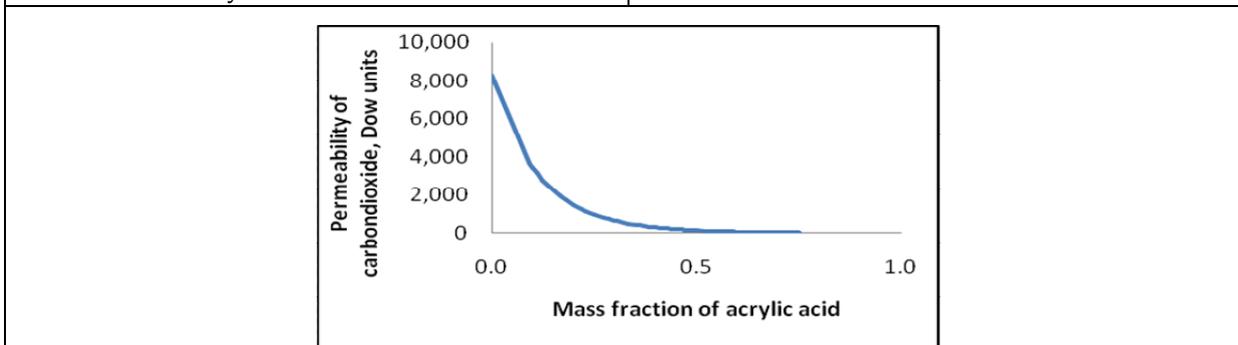


Figure 5. Change in permeability of carbon dioxide with mass fraction of acrylic acid





## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Poly12butadiene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly12butadiene composite were studied. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all those parameters increased with increase in mass fraction of acrylic acid. This study will help us to determine pairs without performing any laboratory experiments it saves our materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly12butadiene composite

## **INTRODUCTION**

Blends or composites are mixture which containing more than one component. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time and as well as to reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples depend on laboratory experiments.

Usually blends are prepared by hit and trial method. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly12butadiene composite.





Sujata Acharya

## MATERIALS AND METHODS

“Materials studio module of Biovia software (DassaultSystemesof France)” was used for analysis. The structures of polyacrylic acid and poly12butadiene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. In the given Fig1 it can be shows that the heat capacity ( $C_p$ ) of the composite increases linearly when mass fraction of acrylic acid increase.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. In the given Fig2 it can be shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. In the given Fig3 it can be shows that the dielectric constant of the composite increases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly12butadiene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results clearly indicated that when the mass fractions of acrylic acid increase then all the three parameters were also increased with increase in mass fraction of acrylic acid. In silico study it will help to determine components of a blend without performing laboratory experiments saving materials, money and time.

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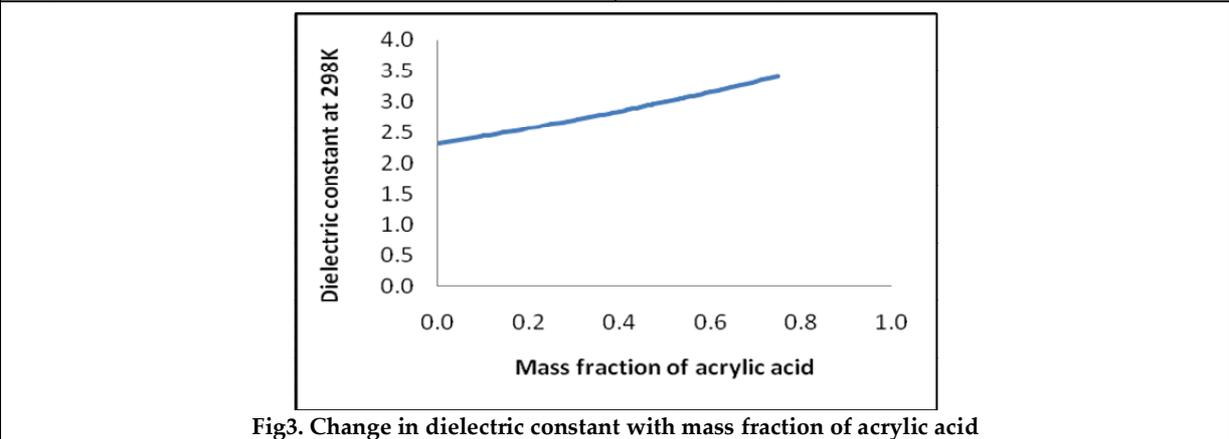
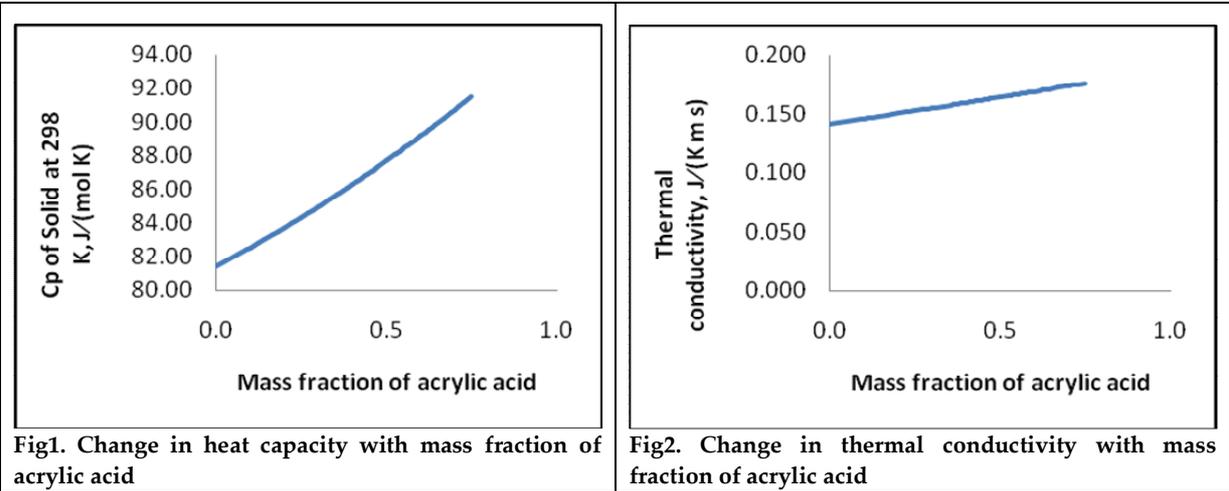


Fig3. Change in dielectric constant with mass fraction of acrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Poly12butadiene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and poly12butadiene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that all those parameters increased with increase in mass fraction of acrylic acid. This study will help us to determine pairs without performing any laboratory experiments it saves our materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly12butadiene composite

## **INTRODUCTION**

Blends or composites are mixture which containing more than one component. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by hit and trial method. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and poly12butadiene composite.





A. Saraf and Sujata Acharya

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polybutadiene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. In the below Fig1 it can be clearly shows that when the mass fraction of acrylic acid increases the bulk modulus of the composite increases linearly.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain”. In the below Fig2 it can be clearly shows that when the mass fraction of acrylic acid increases the shear modulus of the composite increases linearly.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. In the below Fig3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. In the below Fig4 it can be clearly shows that when the mass fraction of acrylic acid increases the Poisson ratio of the composite decreases linearly.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. In the below Fig5 it can be clearly shows that when the mass fraction of acrylic acid increases the brittle fracture stress of the composite increases linearly.

## CONCLUSIONS

The possibility of use of polyacrylic acid and polybutadiene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results indicated that the values of all the properties (bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture) increased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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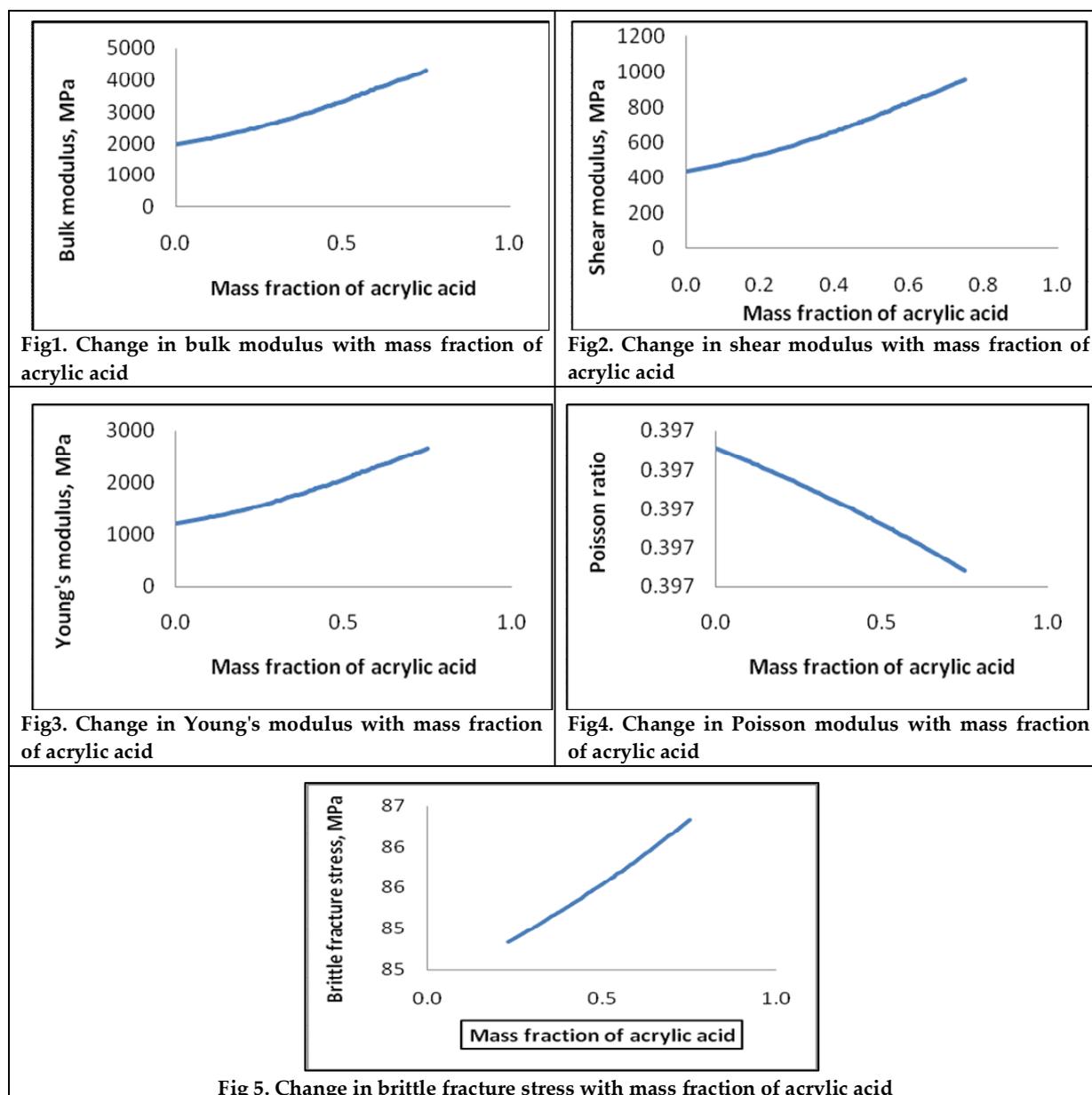
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## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Poly12butadiene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. Different properties of the polyacrylic acid and poly12butadiene composite were studied. When the acrylic acid fraction increases the molar volume and density decreased. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The result clearly shows that when the mass fraction of acrylic acid increases the permeability for all the gases was decreased. This study will help to determine pairs without performing laboratory experiments saving materials, money and time.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and poly12butadiene

## **INTRODUCTION**

Blends or composites are mixture which containing more than one component. They combine and contribute to the property of the blend thereby improving the quality of the material. Development of a single material with the desired property involves significant research and time. A blend saves time to develop a new material thereby reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by hit and trial method. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and poly12butadiene composite.





A. Saraf and Sujata Acharya

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and poly12butadiene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. In the below Fig1 it can be clearly shows that when the mass fraction of acrylic acid increases the molar volume of the composite decreases linearly.

**Density:** “Density is mass per unit volume”. In the below Fig2 it can be clearly shows that when the mass fraction of acrylic acid increases that the density of the composite increases linearly.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. In the below Fig3 it can be clearly shows that when the mass fraction of acrylic acid increases, the permeability of oxygen through the composite decreases.

In the below Fig4 it can be clearly shows that when the mass fraction of acrylic acid increases the permeability of nitrogen through the composite decreases. In the below Fig5 it can be clearly shows that when the mass fraction of acrylic acid increases the permeability of carbon dioxide through the composite decreases.

## CONCLUSIONS

The possibility of use of polyacrylic acid and poly12 butadiene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The molar volume and density decreased with increase in acrylic acid fraction. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. The results indicated that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This in silico study will help determine components of a blend without performing laboratory experiments saving materials, money and time.

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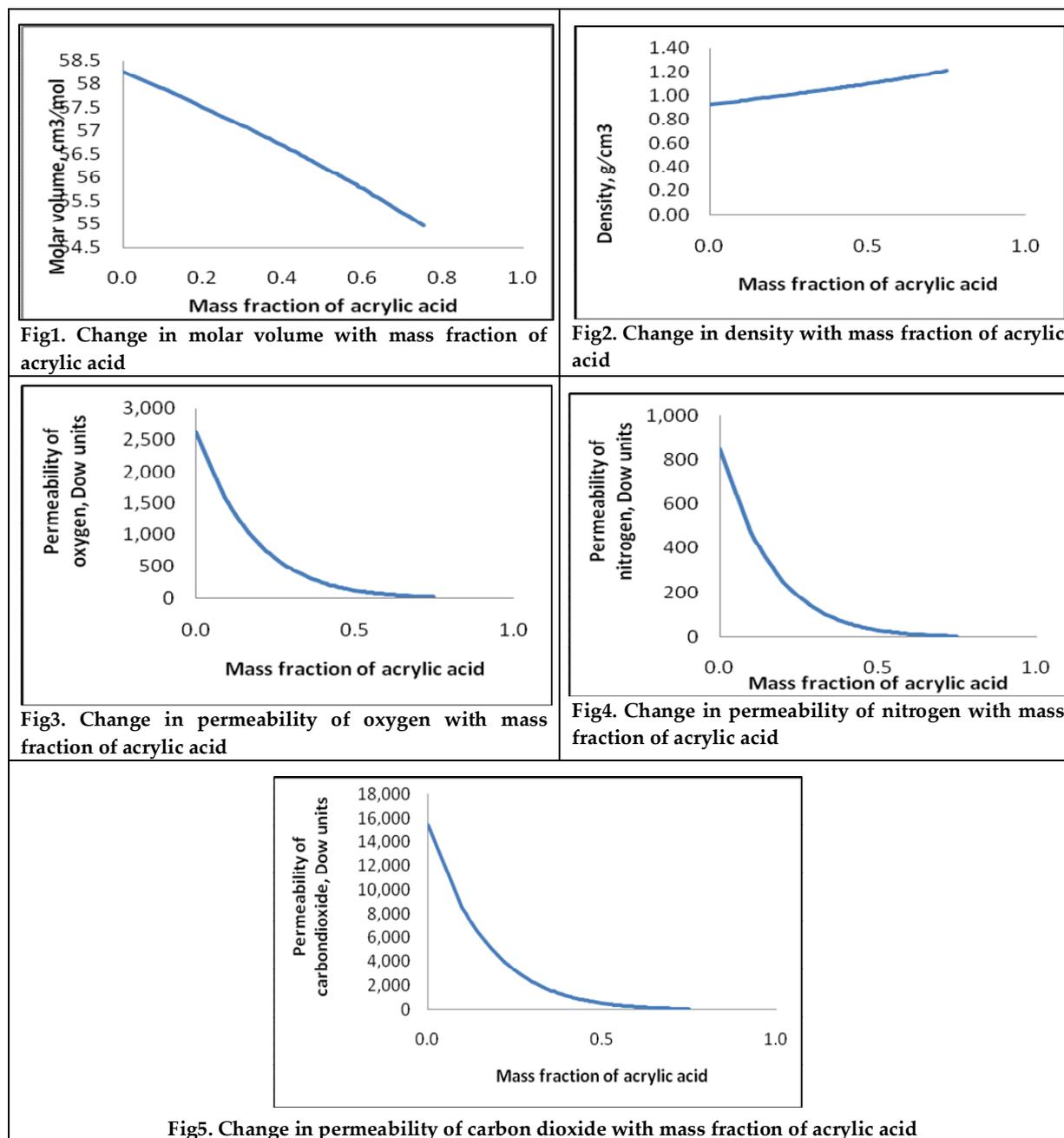
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## ***In silico* Analysis of Thermal and Dielectric Properties of Polyacrylic Acid and Polyoxyphenyl Composite**

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### **ABSTRACT**

A blend or composite is a mixture of more than one component. Homogeneity is a very unique property of a blend polyacrylic acid and polyoxyphenyl composite having many different properties, which can be studied. With respect to heat capacity, thermal conductivity and dielectric constant, the composition of the blend was analyzed. From this result it is clearly indicated that all those parameters increased with increase in mass fraction of acrylic acid. Without performing laboratory experiments, We can determine the pairs using this study. Since a laboratory experiment is not required hence we can save materials, money and time money and time.

**Keywords:** Blend, silico, Biovia, Polyacrylic acid and polyoxyphenyl composite

## **INTRODUCTION**

There are more than one components are present in blends or composites. In the mixture the components do not lose their identity. The components are combined and contribute to the property of the blend which improving the quality of the material. Development of a single material with the desired property involves significant research and time. A new material develops by blend which save time and reducing the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of *in silico* approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and polyoxyphenyl composite.



**Tikina Mishra**

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyoxyphenyl were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Heat Capacity:** “It is the amount of heat required to raise the temperature of one unit weight of a substance by 1°C without change of phase”. From Figure 1 it is clearly observed that shows that the heat capacity ( $C_p$ ) of the composite increases linearly with increase in mass fraction of acrylic acid.

**Thermal Conductivity:** “It indicates the correlation between heat flux per unit area and temperature gradient”. Figure 2 shows that the thermal conductivity of the composite increases linearly with increase in mass fraction of acrylic acid.

**Dielectric Constant:** “It is defined as the ratio of the electric permeability of the material to the electric permeability of free space”. From Figure 3 it is clearly observed that the dielectric constant of the composite increases with increase in mass fraction of polyacrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and polyoxyphenyl to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to permeability properties. The composition of the blend was analyzed with respect to heat capacity, thermal conductivity and dielectric constant. The results indicated that all the above three parameters increased with increase in mass fraction of polyacrylic acid. Without performing laboratory experiments, We can determine the pairs using this study. Since laboratory experiments are not required hence we can save materials, money and time.

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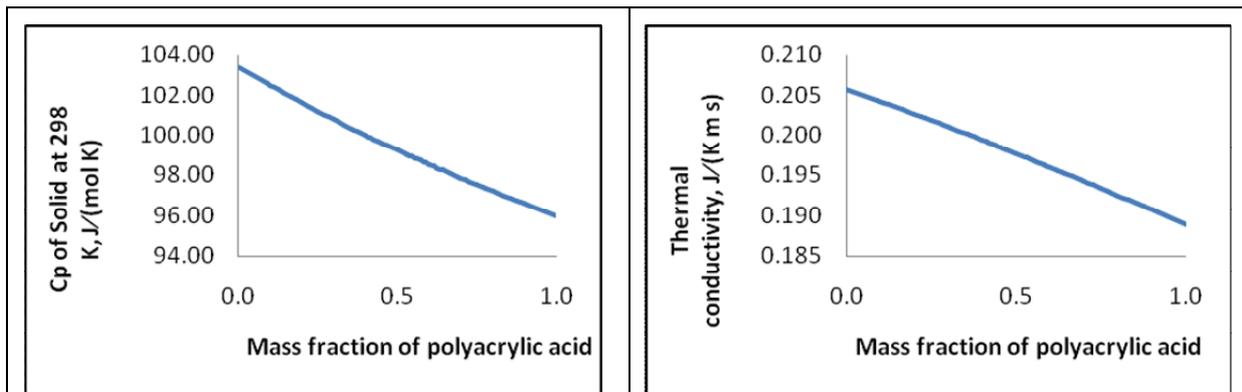


Figure 1. Change in heat capacity with mass fraction of polyacrylic acid

Figure 2. Change in thermal conductivity with mass fraction of polyacrylic acid

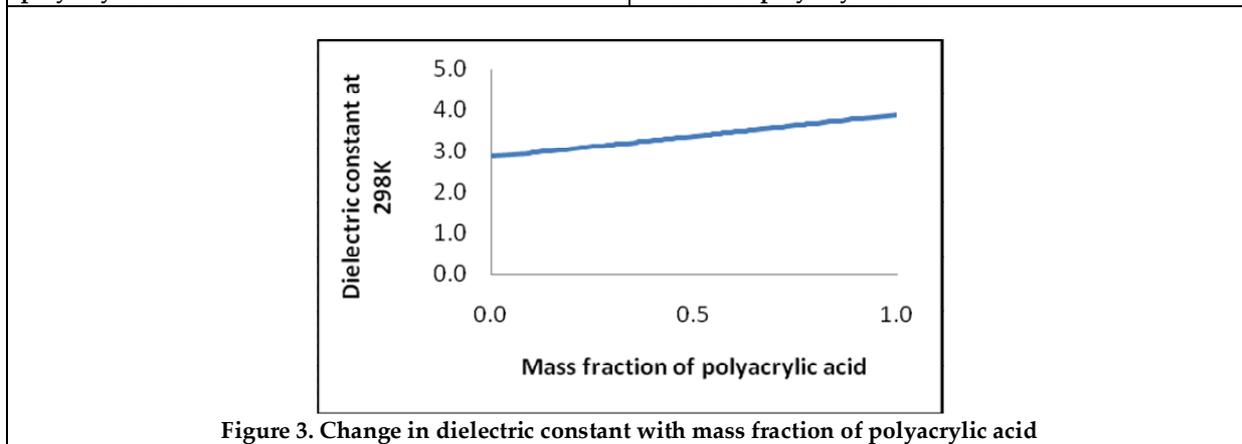


Figure 3. Change in dielectric constant with mass fraction of polyacrylic acid





## ***In silico* Analysis of Mechanical Properties of Polyacrylic Acid and Polyoxphenyl Composite**

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### **ABSTRACT**

A blend is a mixture of more than one component. The desired property of a blend is its homogeneity. The mechanical properties of the polyacrylic acid and polyoxphenyl composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results show that all the above mentioned three parameters increases with increase in mass fraction of acrylic acid. This study saves our valuable time, money and material since it does not require performing laboratory experiments to determine pairs.

**Keywords:** Blend, silico, Biovia, polyacrylic acid and polyoxphenyl composite

## **INTRODUCTION**

Blends or composites are materials in which more than one component are present. In blends the components do not lose their identity. The components combine and contribute to the property of the blend which improves the quality of the material. To develop a single material with the desired property it requires time and significant. A new material with desired properties can be develop by blend which reducing the cost of development and save time. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of polyacrylic acid and polyoxphenyl composite.





Swapna Meher and Tikina Mishra

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyoxyphenyl were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk Modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”. From Figure 1 it is observed that the bulk modulus of the composite increases linearly with increase in mass fraction of polyacrylic acid.

**Shear Modulus:** “It is defined as the ratio of shear stress and shear strain.” From figure 2 it is clearly observed that the shear modulus of the composite increases linearly with increase in mass fraction of polyacrylic acid.

**Young's Modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”. Figure 3 shows that the Young's modulus of the composite increases linearly with increase in mass fraction of polyacrylic acid.

**Poisson Ratio:** “It is the ratio of lateral strain to longitudinal strain”. From figure 4 it is clearly observed that the Poisson ratio of the composite increases linearly with increase in mass fraction of polyacrylic acid.

**Brittle Fracture Stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”. From figure 5 it is observed that the brittle fracture stress of the composite increases linearly with increase in mass fraction of polyacrylic acid.

## CONCLUSIONS

The possibility of use of polyacrylic acid and polyoxyphenyl to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results show that all the above mentioned three parameters increases with increase in mass fraction of acrylic acid. This study saves our valuable time, money and material since it does not require to perform laboratory experiments to determine pairs.. This study saves our valuable time, money and material since it does not require to perform laboratory experiments to determine pairs.

## REFERENCES

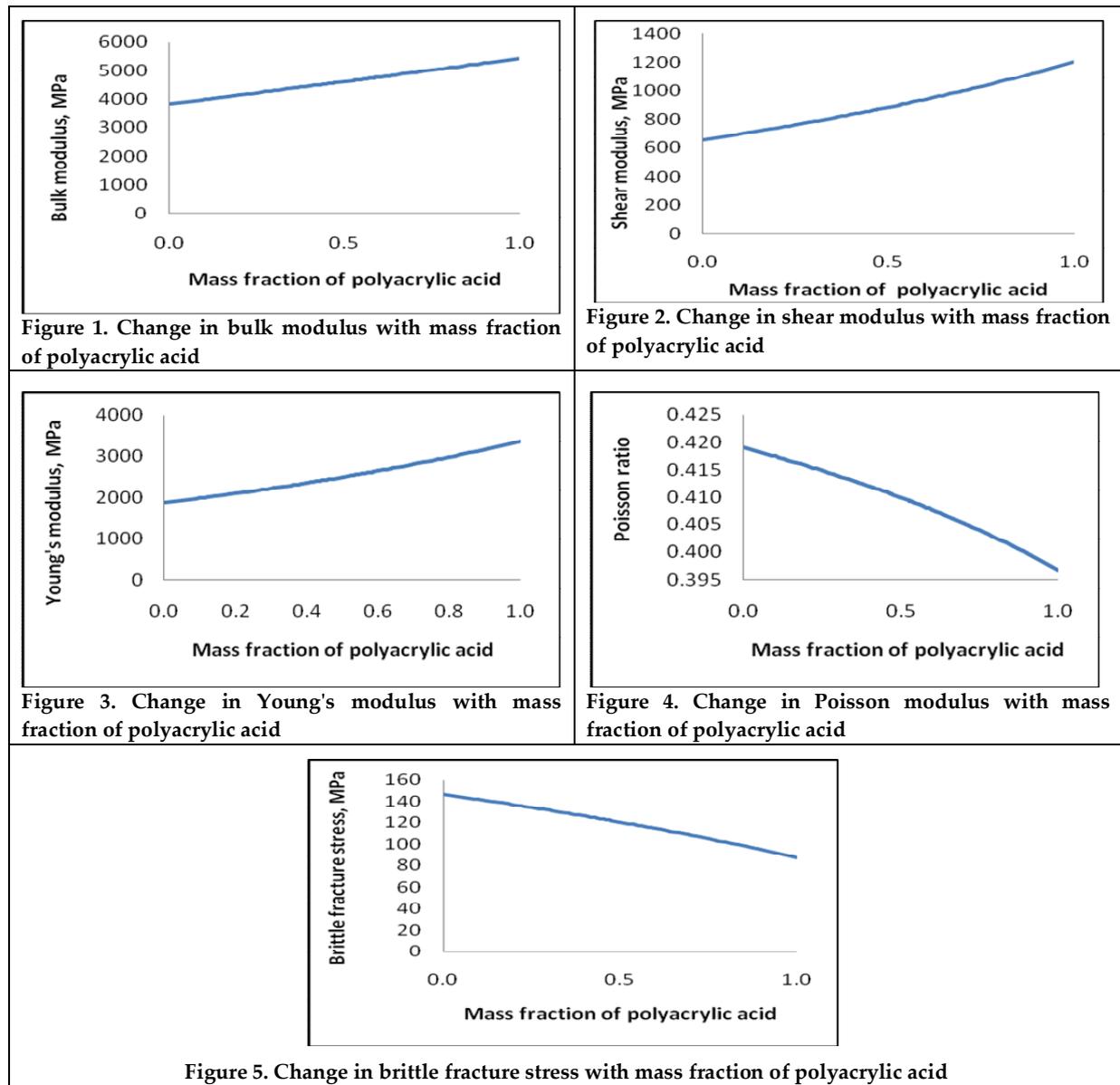
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**Swapna Meher and Tikina Mishra**

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## ***In silico* Analysis of Permeability Properties of Polyacrylic Acid and Polyoxyphenyl Composite**

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### **ABSTRACT**

More than one component gives a mixture which is known as blend. Homogeneity is a very well known property of a blend. Polyacrylic acid and polyoxyphenyl composite have a lot of different properties which were studied. It is observed that the molar volume and density decreased with increase in acrylic acid mole fraction. The permeability is properties of the composite which were studied based on permeability of oxygen, carbon dioxide and nitrogen. From the results it is observed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study saves our valuable time, money and material since it does not require performing laboratory experiments to determine pairs

**Keywords:** Blend, silico, Biovia, Polyacrylic acid and polyoxyphenyl composite

### **INTRODUCTION**

More than one component containing materials are usually known as blend or composite. In the mixture components are do not loss their identity. The components are combine and contribute to the property of the blend which improve the quality of the material. For the development of a single material which have some desired property involves both significant research and time. A blend is a mixture which used to saves time and to develop a new material .Which can reduce the cost of development of products with desired properties. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples relied on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of polyacrylic acid and polyoxyphenyl composite.

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## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of polyacrylic acid and polyoxyphenyl were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar Volume:** “It is the volume occupied by one mole of a substance”. From figure 1 it is clearly observed that the molar volume of the composite decreases linearly with increase in mass fraction of polyacrylic acid.

**Density:** “Density is mass per unit volume”. From Figure 2 it is clearly observed that the density of the composite decreases linearly with increase in mass fraction of polyacrylic acid.

**Permeability of Gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium” From .figure 3 it is observed that the permeability of oxygen through the composite decreases with increase in mass fraction of polyacrylic acid.

From Figure 4 it is observed that the permeability of nitrogen through the composite decreases with increase in mass fraction of polyacrylic acid. From Figure 5 it is observed that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of polyacrylic acid.

## CONCLUSIONS

By using Biovia Materials Studio the possibility use of blend of polyacrylic acid and polyoxyphenyl was explored. Permeability is a properties which is use to analyzed the composition of the blend. When acrylic acid mass fraction increases the molar volume and density decreased. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. From this result it is clearly indicate that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study saves our valuable time, money and material since it does not require performing laboratory experiments to determine pairs.

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**Anju kumara Behera and Tikina Mishra**

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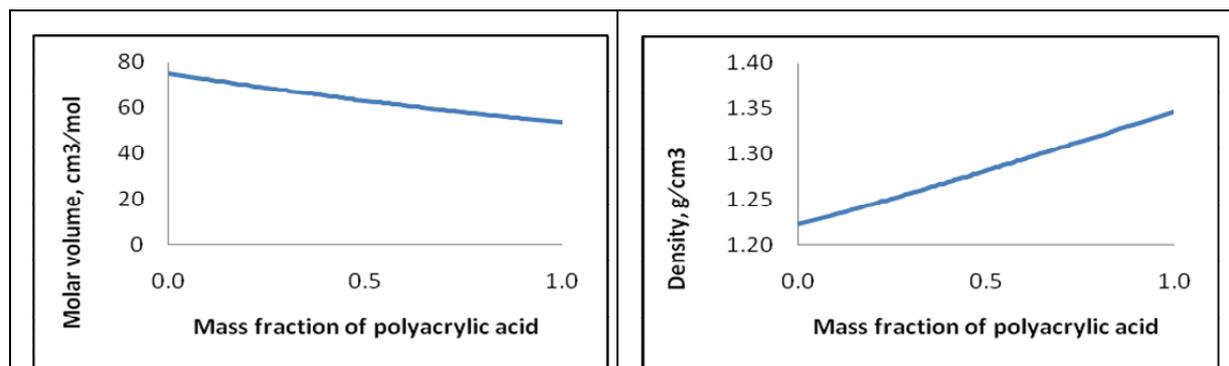


Figure 1. Change in molar volume with mass fraction of polyacrylic acid

Figure 2. Change in density with mass fraction of polyacrylic acid

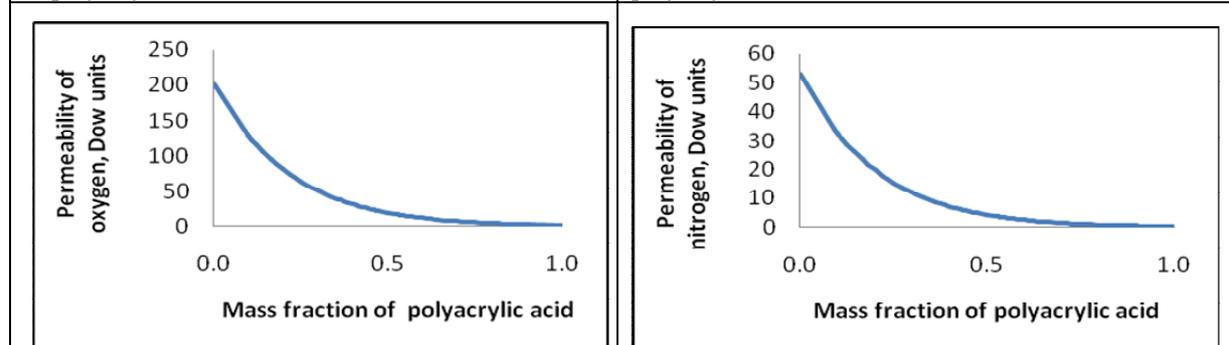


Figure 3. Change in permeability of oxygen with mass fraction of polyacrylic acid

Figure 4. Change in permeability of nitrogen with mass fraction of polyacrylic acid

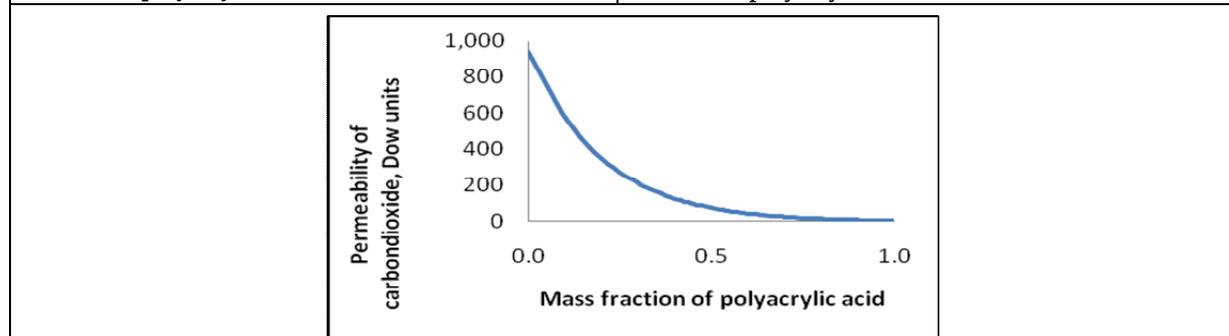


Figure 5. Change in permeability of carbon dioxide with mass fraction of polyacrylic acid





## ***In silico* Analysis of Mechanical Properties of Acrylic Acid and Acetylene Composite**

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### **ABSTRACT**

A blend is a mixture of more than one components. The desired property of a blend is its homogeneity. The mechanical properties of the acrylic acid and acetylene composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results shows that all the above mentioned three parameters increases with increase in mass fraction of acrylic acid. This study saves our valuable time, money and material since it does not require to perform laboratory experiments to determine.

**Keywords:** homogeneity, laboratory, time, acetylene

## **INTRODUCTION**

Blends or composites are materials in which more than one components are present . In blends the components do not lose their identity. The component combine and contribute to the property of the blend which improve the quality of the material. To develop a single material with the desired property it requires time and significant. A new material with desired properties can be develop by blend which reducing the cost of development and save time. Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples based on laboratory experiments. Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money. Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the mechanical properties of acrylic acid and acetylene composite.





Somyasmita Purohit and Tikina Mishra

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of acrylic acid and acetylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Bulk modulus:** “Bulk modulus is the measure of the decrease in volume with an increase in pressure”.From Figure 1 it is observed that the bulk modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Shear modulus:** “It is defined as the ratio of shear stress and shear strain.” From Figure 2 it is observed that the shear modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Young's modulus:** “It is defined as the ratio of stress and strain and compares relative stiffness”From Figure 3 it is observed that the Young's modulus of the composite increases linearly with increase in mass fraction of acrylic acid.

**Poisson ratio:** “It is the ratio of lateral strain to longitudinal strain”.From Figure 4 it is observed that the Poisson ratio of the composite increases linearly with increase in mass fraction of acrylic acid.

**Brittle fracture stress:** “Brittle Fracture is the sudden, rapid cracking of a material under stress”.From Figure 5 it is observed that the brittle fracture stress of the composite increases linearly with increase in mass fraction of acrylic acid.

## CONCLUSIONS

The possibility of use of acrylic acid and acetylene to form a blend was explored using Biovia Materials Studio. The composition of the blend was analyzed with respect to mechanical properties. The results shows that all the above mentioned three parameters increases with increase in mass fraction of acrylic acid. This study saves our valuable time, money and material since it does not require to perform laboratory experiments to determine pairs.. This study saves our valuable time, money and material since it does not require to perform laboratory experiments to determine pairs.

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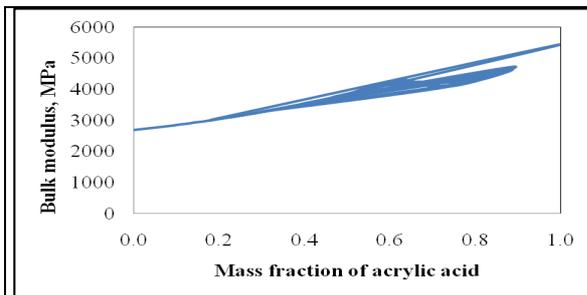
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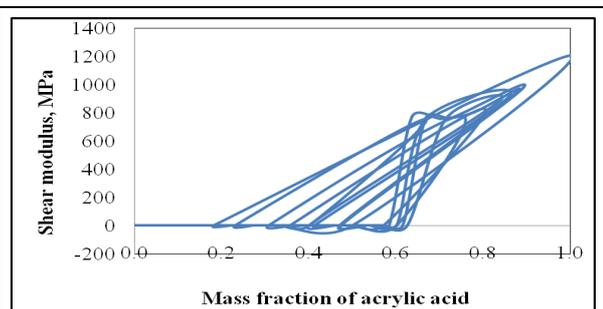


**Somyasmita Purohit and Tikina Mishra**

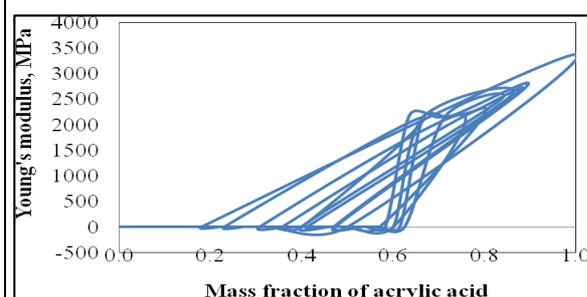
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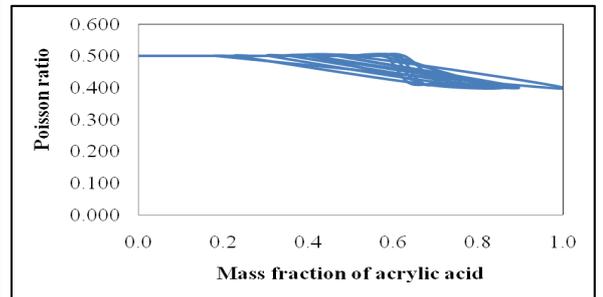
**Figure 1. Change in bulk modulus with mass fraction of acrylic acid**



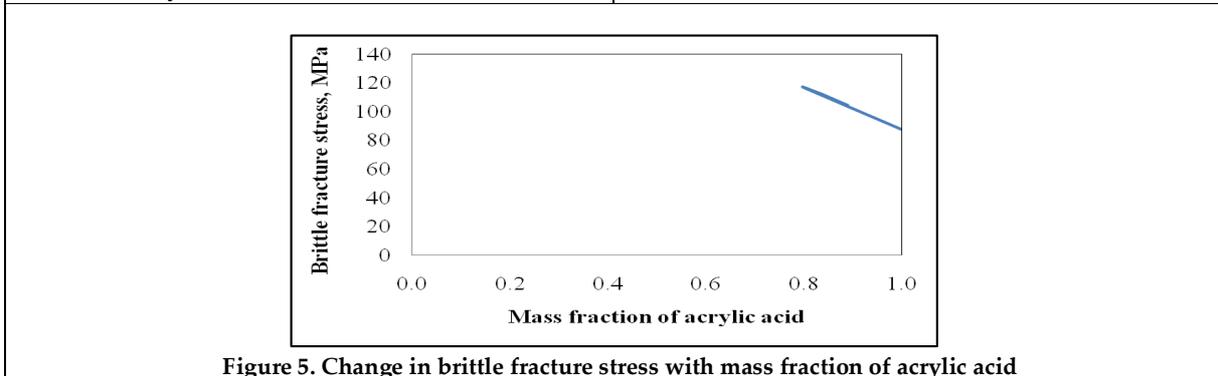
**Figure 2. Change in shear modulus with mass fraction of acrylic acid**



**Figure 3. Change in Young's modulus with mass fraction of acrylic acid**



**Figure 4. Change in Poisson modulus with mass fraction of acrylic acid**



**Figure 5. Change in brittle fracture stress with mass fraction of acrylic acid**





## ***In silico* Analysis of Permeability Properties of Acrylic Acid and Acetylene Composite**

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### **ABSTRACT**

More than one component give a mixture which is known as blend. Homogeneity is a very well known property of a blend. Acrylic acid and acetylene composite have a lot of different properties which were studied. It is observed that the molar volume and density decreased with increase in acrylic acid mole fraction. The permeability is properties of the composite which were studied based on permeability of oxygen, carbon dioxide and nitrogen. From the results it is observed that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study saves our valuable time, money and material since it does not require performing laboratory experiments to determine pairs.

**Keywords:** volume, composite, pairs, acid.

### **INTRODUCTION**

More than one components containing materials are usually known as blend or composite. In the mixture components are do not loss their identity. The components are combine and contribute to the property of the blend which improve the quality of the material. For the development of a single material which have some desired property involves both significant research and time. A blend is a mixture which used to saves time and to develop a new material .Which can reduce the cost of development of products with desired properties.Polymer blends can be nano material modified polymers [1], biodegradable polymers- natural fiber composites [2], fire retardant/fire proof materials [3,4], lightweight composite materials having high strength for transportation industries [5], glass fiber reinforced polymers, latex polymer cementitious composites [6] etc. All the above mentioned examples based on laboratory experiments.

Usually blends are prepared by trial and error method. Thus it involves wastage of materials, time and money.Thus, researchers have focused on the use of in silico approach [7] to develop new blends. This study intends to predict the permeability related properties of acrylic acid and acetylene composite.





Lipsa singh and Tikina Mishra

## MATERIALS AND METHODS

“Materials studio module of Biovia software (Dassault Systemes of France)” was used for analysis. The structures of acrylic acid and acetylene were fed to the synthia menu of Materials Studio and run for different weight fractions of the components.

## RESULTS AND DISCUSSION

**Molar volume:** “it is the volume occupied by one mole of a substance”. From Figure 1 it is observed that the molar volume of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Density:** “Density is mass per unit volume”. From Figure 2 it is observed that the density of the composite decreases linearly with increase in mass fraction of acrylic acid.

**Permeability of gas:** “Permeability is the rate at which the gas can pass through the polymer membrane after the gas has come to equilibrium”. From Figure 3 it is observed that the permeability of oxygen through the composite decreases with increase in mass fraction of acrylic acid.

From Figure 4 it is cleared that the permeability of nitrogen through the composite decreases with increase in mass fraction of acrylic acid. From Figure 5 it is clearly observed that the permeability of carbon dioxide through the composite decreases with increase in mass fraction of acrylic acid.

## CONCLUSIONS

By using Biovia Materials Studio the possibility use of blend of acrylic acid and acetylene was explored. Permeability is a properties which is use to analyzed the composition of the blend. When acrylic acid mass fraction increases the molar volume and density decreased. The permeability properties of the composite were studied based on permeability of oxygen, nitrogen and carbon dioxide. From this results it is clearly indicate that the permeability for all the gases decreased with increase in mass fraction of acrylic acid. This study saves our valuable time, money and material since it does not require to perform laboratory experiments to determine pairs.

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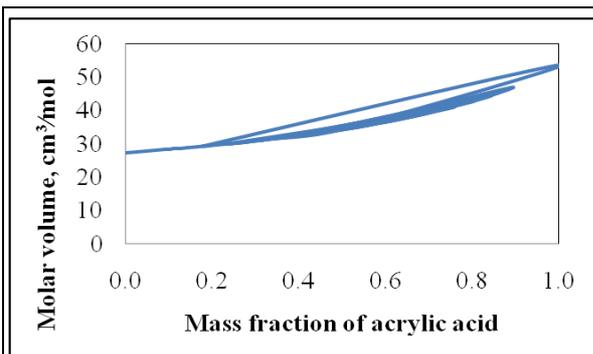


Figure 1. Change in molar volume with mass fraction of acrylic acid

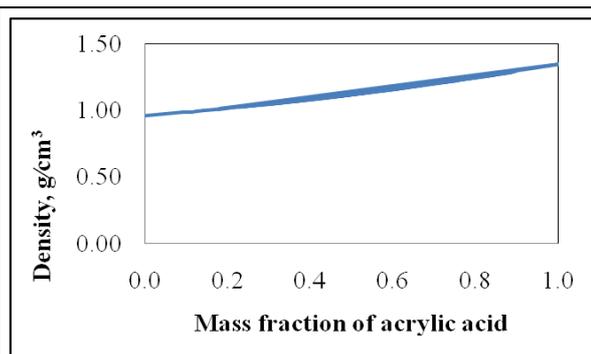


Figure 2. Change in density with mass fraction of acrylic acid

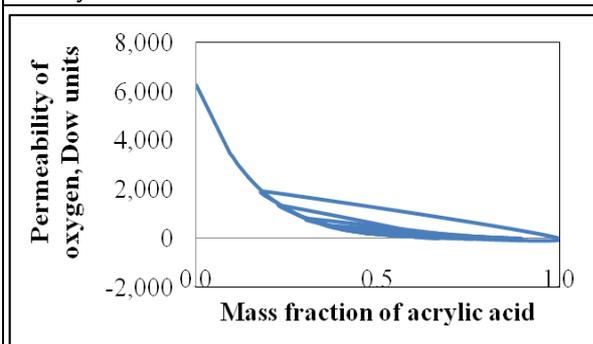


Figure 3. Change in permeability of oxygen with mass fraction of acrylic acid

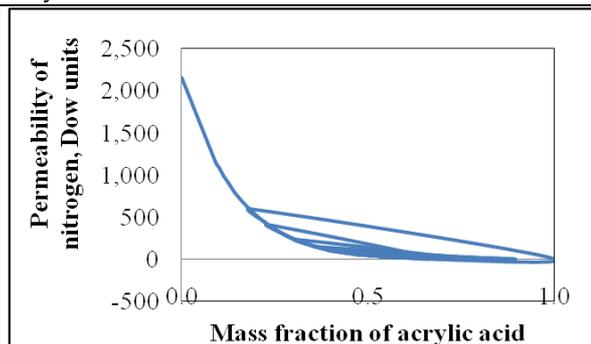


Figure 4. Change in permeability of nitrogen with mass fraction of acrylic acid

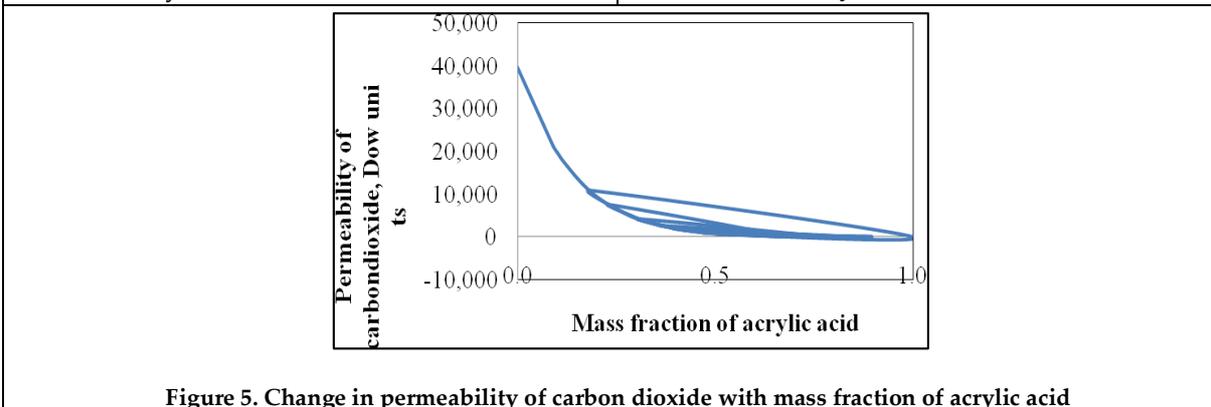


Figure 5. Change in permeability of carbon dioxide with mass fraction of acrylic acid





## Analysis of High Stock Price of Bank of Baroda by Correlation Matrix

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### ABSTRACT

The stock markets play a significant role in the economic development of India. The focus of this work is to identify the statistically significant parameters related to share prices for Bank of Baroda. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that six number of parameters were statistically significant and varied directly while two number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Bank of Baroda, r value, p value, correlation matrix

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Bank of Baroda.

## METHODOLOGY

Data from Bombay Stock Exchange was downloaded on 24 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Bank of Baroda. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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KVD Prakash

## RESULTS AND DISCUSSION

Table 1 shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter. All the values have been taken with the precision upto two places of the decimal.

## CONCLUSIONS

In this study the statistically significant parameters related to share prices for Bank of Baroda were identified. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that six number of parameters were statistically significant and varied directly while two number of parameters were statistically significant and varied inversely.

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Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.07	-0.63	0.23	-0.38	-0.51	0.27	0.07	0.99
No.of Shares			0.47	0.95	0.69	-0.09	0.72	0.37	0.02
No. of Trades				0.26	0.56	0.29	0.02	0.03	-0.60
Total Turnover (Rs.)					0.54	-0.25	0.81	0.37	0.32
Deliverable Quantity						0.61	0.19	-0.16	-0.34
% Deli. Qty to Traded Qty							-0.37	-0.48	-0.52
Spread High-Low								0.51	0.39
Spread Close-Open									0.10
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.70	0.00	0.18	0.03	0.00	0.12	0.71	0.00
No.of Shares			0.00	0.00	0.00	0.61	0.00	0.03	0.91





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No. of Trades				0.13	0.00	0.10	0.92	0.87	0.00
Total Turnover (Rs.)					0.00	0.16	0.00	0.03	0.06
Deliverable Quantity						0.00	0.29	0.36	0.05
% Deli. Qty to Traded Qty							0.03	0.00	0.00
Spread High-Low								0.00	0.02
Spread Close-Open									0.57
High Price									

**Table 2. Summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	WAP-No. of Shares
No. of Trades	
WAP-high price	
No.of shares-Total turnover	
Deliverable Quantity	
% Deli. Qty to Traded Qty	
	Spread High-Low
Spread Close-Open	





## Analysis of High Stock Price of Bank of India by Correlation Matrix

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### ABSTRACT

The stock markets contribute a large scope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Bank of India. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that six number of parameters were statistically significant and varied directly while two number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Bank of India, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focuses on the effect of some BSE parameters on high stock price of Bank of India.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Bank of India. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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## RESULTS AND DISCUSSION

Table 1 shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter. All the values have been taken with the precision upto two places of the decimal.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for Bank of India. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that five number of parameters were statistically significant and varied directly while two number of parameters were statistically significant and varied inversely.

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 [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

Table 1. r and p value matrices

r value matrix	WAP	No. of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.02	0.20	0.10	0.31	-0.29	0.26	-0.38	0.99
No. of Shares			0.85	1.00	0.66	-0.73	0.10	-0.04	0.03
No. of Trades				0.87	0.86	-0.77	0.50	0.04	0.25
Total Turnover (Rs.)					0.68	-0.75	0.13	-0.08	0.11
Deliverable Quantity						-0.55	0.69	0.00	0.37
% Deli. Qty to Traded Qty							-0.29	0.10	-0.31
Spread High-Low								-0.06	0.36
Spread Close-Open									-0.41
High Price									
p value matrix	WAP	No. of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.89	0.26	0.56	0.08	0.09	0.15	0.03	0.00
No. of Shares			0.00	0.00	0.00	0.00	0.56	0.83	0.85
No. of Trades				0.00	0.00	0.00	0.00	0.82	0.16
Total Turnover (Rs.)					0.00	0.00	0.46	0.66	0.53
Deliverable Quantity						0.00	0.00	0.99	0.03
% Deli. Qty to Traded Qty							0.10	0.56	0.08
Spread High-Low								0.75	0.03
Spread Close-Open									0.02
High Price									





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**Table 2. Summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No. of Shares
	WAP-No. of trades
Total turnover	
	Deliverable quantity
% Deli. Qty to Traded Qty	
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of IndusInd Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for IndusInd Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that zeronumber of parameters were statistically significant and varied directly while seven number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, IndusInd Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of IndusInd Bank.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for IndusInd Bank. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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**RESULTS AND DISCUSSION**

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter. All the values have been taken with the precision upto two places of the decimal.

**CONCLUSIONS**

This study focussed on identifying the statistically significant parameters related to share prices for IndusInd Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that zeronumber of parameters were statistically significant and varied directly while seven number of parameters were statistically significant and varied inversely.

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[1] M. Savsani, U. Rathod, “Comparative Risk Return Analysis of Bombay Stock Market with Selected Banking Stocks in India”. International Journal of Scientific Research in Science and Technology, (2018) 4 (5), pp. 908-916.  
 [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.70	-0.65	-0.38	-0.41	0.30	0.07	-0.05	0.99
No.of Shares			0.95	0.88	0.66	-0.24	0.28	-0.04	-0.66
No. of Trades				0.86	0.53	-0.29	0.37	-0.15	-0.60
Total Turnover (Rs.)					0.64	-0.08	0.51	-0.09	-0.32
Deliverable Quantity						0.46	0.10	0.08	-0.40
% Deli. Qty to Traded Qty							-0.06	-0.05	0.29
Spread High-Low								-0.16	0.17
Spread Close-Open									-0.10
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.70	-0.65	-0.38	-0.41	0.30	0.07	-0.05	0.99
No.of Shares			0.95	0.88	0.66	-0.24	0.28	-0.04	-0.66
No. of Trades				0.86	0.53	-0.29	0.37	-0.15	-0.60
Total Turnover (Rs.)					0.64	-0.08	0.51	-0.09	-0.32
Deliverable Quantity						0.46	0.10	0.08	-0.40
% Deli. Qty to Traded Qty							-0.06	-0.05	0.29
Spread High-Low								-0.16	0.17
Spread Close-Open									-0.10
High Price									





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**Table 2. summarizes the trend for the statistically significant parameters, Statistically significant parameters**

<b>Statistically Significant and direct relationship</b>	<b>Statistically Significant and inverse relationship</b>
	No. of Shares
	WAP-No. of trades
	No.of shares-Total turnover
	Deliverable Quantity
	% Deli Qty to Traded Qty
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of Punjab National Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Punjab National Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that threenumber of parameters were statistically significant and varied directly while four number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Punjab National Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Punjab National Bank.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Punjab National Bank. For each of the available dates “weighted average price (WAP), number of shares,

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number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted.

The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter. All the values have been taken with the precision upto two places of the decimal.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for Punjab National Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that threenumber of parameters were statistically significant and varied directly while four number of parameters were statistically significant and varied inversely.

## REFERENCES

- [1] M. Savsani, U. Rathod, “Comparative Risk Return Analysis of Bombay Stock Market with Selected Banking Stocks in India”. International Journal of Scientific Research in Science and Technology, (2018) 4 (5), pp. 908-916.
- [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.02	0.37	0.17	-0.30	-0.48	0.26	-0.02	0.99
No.of Shares			0.48	0.99	0.66	-0.47	0.69	0.48	0.13
No. of Trades				0.53	0.26	-0.29	0.63	0.26	0.42
Total Turnover (Rs.)					0.60	-0.54	0.72	0.47	0.28
Deliverable Quantity						0.28	0.31	0.08	-0.24
% Deli. Qty to Traded Qty							-0.39	-0.38	-0.51
Spread High-Low								0.57	0.40
Spread Close-Open									0.04
High Price									





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<b>p value matrix</b>	<b>WAP</b>	<b>No.of Shares</b>	<b>No. of Trades</b>	<b>Total Turnover (Rs.)</b>	<b>Deliverable Quantity</b>	<b>% Deli. Qty to Traded Qty</b>	<b>Spread High-Low</b>	<b>Spread Close-Open</b>	<b>High Price</b>
WAP		0.89	0.03	0.33	0.08	0.00	0.14	0.92	0.00
No.of Shares			0.00	0.00	0.00	0.00	0.00	0.00	0.46
No. of Trades				0.00	0.14	0.10	0.00	0.14	0.01
Total Turnover (Rs.)					0.00	0.00	0.00	0.01	0.11
Deliverable Quantity						0.10	0.07	0.64	0.17
% Deli. Qty to Traded Qty							0.02	0.03	0.00
Spread High-Low								0.00	0.02
Spread Close-Open									0.80
High Price									

**Table 2. summarizes the trend for the statistically significant parameters, Statistically significant parameters**

<b>Statistically Significant and direct relationship</b>	<b>Statistically Significant and inverse relationship</b>
	No. of Shares
WAP-No. of trades	
No.of shares-Total turnover	
	Deliverable Quantity
	% Deli. Qty to Traded Qty
Spread High - Low	
	Spread Close – Open





## Analysis of High Stock Price of Yes Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Yes Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that zeronumber of parameters were statistically significant and varied directly while seven number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Yes Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Yes Bank.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Yes Bank. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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## RESULTS AND DISCUSSION

Table 1 shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter. All the values have been taken with the precision upto two places of the decimal.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for Yes Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that zero number of parameters were statistically significant and varied directly while seven number of parameters were statistically significant and varied inversely.

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- [1] M. Savsani, U. Rathod, “Comparative Risk Return Analysis of Bombay Stock Market with Selected Banking Stocks in India”. International Journal of Scientific Research in Science and Technology, (2018) 4 (5), pp. 908-916.  
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Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.03	0.33	0.53	-0.21	-0.50	0.70	0.09	0.97
No.of Shares			0.80	0.77	0.97	-0.33	0.59	-0.14	0.17
No. of Trades				0.90	0.67	-0.44	0.70	0.01	0.47
Total Turnover (Rs.)					0.62	-0.52	0.85	0.05	0.66
Deliverable Quantity						-0.17	0.45	-0.17	0.00
% Deli. Qty to Traded Qty							-0.47	-0.09	-0.51
Spread High-Low								-0.10	0.85
Spread Close-Open									-0.05
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.03	0.33	0.53	-0.21	-0.50	0.70	0.09	0.97
No.of Shares			0.80	0.77	0.97	-0.33	0.59	-0.14	0.17
No. of Trades				0.90	0.67	-0.44	0.70	0.01	0.47
Total Turnover (Rs.)					0.62	-0.52	0.85	0.05	0.66
Deliverable Quantity						-0.17	0.45	-0.17	0.00
% Deli. Qty to Traded Qty							-0.47	-0.09	-0.51
Spread High-Low								-0.10	0.85
Spread Close-Open									-0.05
High Price									





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**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No. of Shares
	WAP-No. of trades
	Total turnover
	Deliverable Quantity
	% Deli Qty to Traded Qty
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of ACC Cement by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for ACC Cement. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that fournumber of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, ACC Cement, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of ACC Cement.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for ACC Cement. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for ACC Cement. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that four number of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

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Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.06	-0.14	0.12	0.11	0.14	0.09	-0.09	0.99
No.of Shares			0.45	1.00	0.93	0.61	0.16	0.03	0.10
No. of Trades				0.41	0.11	-0.10	0.46	0.42	-0.08
Total Turnover (Rs.)					0.94	0.63	0.15	0.02	0.15
Deliverable Quantity						0.78	0.00	-0.13	0.13
% Deli. Qty to Traded Qty							0.07	-0.26	0.18
Spread High-Low								0.20	0.20
Spread Close-Open									-0.11
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.72	0.44	0.51	0.55	0.42	0.63	0.62	0.00
No.of Shares			0.01	0.00	0.00	0.00	0.37	0.86	0.57
No. of Trades				0.01	0.53	0.59	0.01	0.01	0.64
Total Turnover (Rs.)					0.00	0.00	0.40	0.91	0.39
Deliverable Quantity						0.00	0.99	0.47	0.46
% Deli. Qty to Traded Qty							0.69	0.14	0.30
Spread High-Low								0.26	0.25
Spread Close-Open									0.52





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No. of Shares
No. of Trades	
WAP – Total Turnover	
Deliverable Quantity	
% Deli Qty to Traded Qty	
	Spread High – Low
	Spread Close – Open





## Analysis of High Stock Price of Allahabad Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Allahabad Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that zeronumber of parameters were statistically significant and varied directly while seven number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Allahabad Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Allahabad Bank.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 1Feb 2020 to 19Mar 2020 for Allahabad Bank. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high





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and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

**RESULTS AND DISCUSSION**

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

**CONCLUSIONS**

This study focussed on identifying the statistically significant parameters related to share prices for Allahabad Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that zeronumber of parameters were statistically significant and varied directly while seven number of parameters were statistically significant and varied inversely.

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**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.70	-0.60	-0.48	-0.76	-0.15	-0.38	-0.03	1.00
No.of Shares			0.90	0.95	0.98	-0.09	0.60	-0.15	-0.67
No. of Trades				0.85	0.87	-0.16	0.61	-0.15	-0.57
Total Turnover (Rs.)					0.90	-0.20	0.59	-0.18	-0.45
Deliverable Quantity						0.06	0.55	-0.13	-0.73
% Deli. Qty to Traded Qty							-0.29	0.07	-0.18
Spread High-Low								-0.18	-0.31
Spread Close-Open									-0.08
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.70	-0.60	-0.48	-0.76	-0.15	-0.38	-0.03	1.00
No.of Shares			0.90	0.95	0.98	-0.09	0.60	-0.15	-0.67
No. of Trades				0.85	0.87	-0.16	0.61	-0.15	-0.57
Total Turnover (Rs.)					0.90	-0.20	0.59	-0.18	-0.45
Deliverable Quantity						0.06	0.55	-0.13	-0.73
% Deli. Qty to Traded Qty							-0.29	0.07	-0.18
Spread High-Low								-0.18	-0.31
Spread Close-Open									-0.08





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**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
	No of Trades
	WAP – Total Turnover
	Deliverable Quantity
	% Deli Qty to Traded Qty
	Spread High – Low
	Spread Close – Open





## Analysis of High Stock Price of Andhra Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Andhra Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that two number of parameters were statistically significant and varied directly while five number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Andhra Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Andhra Bank.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 1Feb 2020 to 19Mar 2020 for Andhra Bank. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for Andhra Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that twonumber of parameters were statistically significant and varied directly while five number of parameters were statistically significant and varied inversely.

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 [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.28	-0.61	-0.23	-0.18	0.22	-0.27	0.03	0.98
No.of Shares			0.11	1.00	0.99	0.52	0.42	0.44	-0.19
No. of Trades				0.10	-0.02	-0.24	0.44	-0.12	-0.56
Total Turnover (Rs.)					0.99	0.55	0.43	0.44	-0.13
Deliverable Quantity						0.59	0.34	0.44	-0.09
% Deli. Qty to Traded Qty							0.01	0.12	0.24
Spread High-Low								0.32	-0.13
Spread Close-Open									0.06
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.11	0.00	0.19	0.31	0.21	0.13	0.87	0.00
No.of Shares			0.52	0.00	0.00	0.00	0.01	0.01	0.29
No. of Trades				0.58	0.89	0.18	0.01	0.51	0.00
Total Turnover (Rs.)					0.00	0.00	0.01	0.01	0.45
Deliverable Quantity						0.00	0.05	0.01	0.60
% Deli. Qty to Traded Qty							0.95	0.51	0.17
Spread High-Low								0.07	0.48
Spread Close-Open									0.74
High Price									





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
	No. of Trades
	WAP – Total Turnover
Deliverable Quantity	
% Deli Qty to Traded Qty	
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of Axis Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Axis Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that fournumber of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Axis Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Axis Bank.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Axis Bank. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for Axis Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that four number of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

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Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.64	-0.78	-0.51	-0.29	0.32	-0.25	-0.03	0.99
No.of Shares			0.92	0.97	0.76	0.01	0.20	0.18	-0.63
No. of Trades				0.84	0.63	-0.08	0.34	0.09	-0.76
Total Turnover (Rs.)					0.76	0.08	0.18	0.19	-0.51
Deliverable Quantity						0.57	0.21	-0.08	-0.28
% Deli. Qty to Traded Qty							0.10	-0.44	0.35
Spread High-Low								-0.02	-0.14
Spread Close-Open									-0.06
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.00	0.00	0.00	0.09	0.06	0.16	0.86	0.00
No.of Shares			0.00	0.00	0.00	0.97	0.25	0.31	0.00
No. of Trades				0.00	0.00	0.66	0.05	0.63	0.00
Total Turnover (Rs.)					0.00	0.67	0.30	0.27	0.00
Deliverable Quantity						0.00	0.23	0.65	0.11
% Deli. Qty to Traded Qty							0.57	0.01	0.04
Spread High-Low								0.91	0.44
Spread Close-Open									0.72





**KVD Prakash**

Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
No of Trades	
WAP – Total Turnover	
Deliverable Quantity	
% Deli Qty to Traded Qty	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of Bank of Maharashtra by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Bank of Maharashtra. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that zeronumber of parameters were statistically significant and varied directly while seven number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Bank of Maharashtra, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Bank of Maharashtra.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Bank of Maharashtra. For each of the available dates “weighted average price (WAP), number of shares,

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number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

**RESULTS AND DISCUSSION**

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

**CONCLUSIONS**

This study focussed on identifying the statistically significant parameters related to share prices for Bank of Maharashtra. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that zeronumber of parameters were statistically significant and varied directly while seven number of parameters were statistically significant and varied inversely.

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**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverabl e Quantity	% Deli. Qty to Traded Qty	Sprea d High-Low	Sprea d Close-Open	High Price
WAP		0.39	0.31	0.48	0.32	-0.21	0.03	0.19	0.92
No.of Shares			0.56	0.99	0.94	-0.08	0.52	0.31	0.49
No. of Trades				0.59	0.45	-0.22	0.32	0.42	0.36
Total Turnover (Rs.)					0.92	-0.10	0.50	0.33	0.57
Deliverable Quantity						0.23	0.36	0.19	0.36
% Deli. Qty to Traded Qty							-0.24	-0.28	-0.28
Spread High-Low								0.42	0.38
Spread Close-Open									0.28
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverabl e Quantity	% Deli. Qty to Traded Qty	Sprea d High-Low	Sprea d Close-Open	High Price
WAP		0.39	0.31	0.48	0.32	-0.21	0.03	0.19	0.92
No.of Shares			0.56	0.99	0.94	-0.08	0.52	0.31	0.49
No. of Trades				0.59	0.45	-0.22	0.32	0.42	0.36
Total Turnover (Rs.)					0.92	-0.10	0.50	0.33	0.57
Deliverable Quantity						0.23	0.36	0.19	0.36
% Deli. Qty to Traded Qty							-0.24	-0.28	-0.28
Spread High-Low								0.42	0.38
Spread Close-Open									0.28





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
	No. of Trades
	WAP – Total Turnover
	Deliverable Quantity
	% Deli Qty to Traded Qty
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of HDFC Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for HDFC Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that threenumber of parameters were statistically significant and varied directly while four number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, HDFC Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of HDFC Bank.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for HDFC Bank. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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**RESULTS AND DISCUSSION**

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

**CONCLUSIONS**

This study focussed on identifying the statistically significant parameters related to share prices for HDFC Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that threenumber of parameters were statistically significant and varied directly while four number of parameters were statistically significant and varied inversely.

**REFERENCES**

[1] M. Savsani, U. Rathod, “Comparative Risk Return Analysis of Bombay Stock Market with Selected Banking Stocks in India”. International Journal of Scientific Research in Science and Technology, (2018) 4 (5), pp. 908-916.  
 [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverabl e Quantity	% Deli. Qty to Traded Qty	Sprea d High-Low	Sprea d Close-Open	High Price
WAP		-0.07	-0.48	0.11	0.18	0.66	-0.37	0.00	0.99
No.of Shares			0.44	0.98	0.91	0.30	0.24	0.33	-0.04
No. of Trades				0.31	0.25	-0.13	0.78	0.08	-0.37
Total Turnover (Rs.)					0.92	0.38	0.16	0.31	0.13
Deliverable Quantity						0.62	0.12	0.29	0.20
% Deli. Qty to Traded Qty							-0.15	-0.03	0.68
Spread High-Low								0.13	-0.22
Spread Close-Open									0.01
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverabl e Quantity	% Deli. Qty to Traded Qty	Sprea d High-Low	Sprea d Close-Open	High Price
WAP		0.69	0.00	0.54	0.32	0.00	0.03	0.99	0.00
No.of Shares			0.01	0.00	0.00	0.08	0.18	0.06	0.81
No. of Trades				0.07	0.15	0.48	0.00	0.66	0.03
Total Turnover (Rs.)					0.00	0.03	0.38	0.07	0.46
Deliverable Quantity						0.00	0.49	0.10	0.26
% Deli. Qty to Traded Qty							0.40	0.89	0.00
Spread High-Low								0.46	0.21
Spread Close-Open									0.98





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

<b>Statistically Significant and direct relationship</b>	<b>Statistically Significant and inverse relationship</b>
	No of Shares
No of Trades	
	WAP – Total Turnover
Deliverable Quantity	
% Deli Qty to Traded Qty	
	Spread High – Low
	Spread Close - Open





## Analysis of High Stock Price of ICICI Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for ICICI Bank. The parameters studied “were weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that three number of parameters were statistically significant and varied directly while four number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, ICICI Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of ICICI Bank.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for ICICI Bank. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and





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low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

**RESULTS AND DISCUSSION**

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

**CONCLUSIONS**

This study focussed on identifying the statistically significant parameters related to share prices for ICICI Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that threenumber of parameters were statistically significant and varied directly while four number of parameters were statistically significant and varied inversely.

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**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.73	-0.70	-0.52	-0.27	0.51	-0.25	-0.01	1.00
No.of Shares			0.85	0.95	0.62	-0.28	0.37	0.11	-0.73
No. of Trades				0.79	0.36	-0.41	0.58	-0.01	-0.70
Total Turnover (Rs.)					0.64	-0.19	0.41	0.14	-0.52
Deliverable Quantity						0.53	0.07	-0.30	-0.27
% Deli. Qty to Traded Qty							-0.22	-0.47	0.51
Spread High-Low								0.27	-0.25
Spread Close-Open									-0.01
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.00	0.00	0.00	0.12	0.00	0.15	0.93	0.00
No.of Shares			0.00	0.00	0.00	0.10	0.03	0.55	0.00
No. of Trades				0.00	0.04	0.02	0.00	0.94	0.00
Total Turnover (Rs.)					0.00	0.29	0.02	0.43	0.00
Deliverable Quantity						0.00	0.69	0.09	0.12
% Deli. Qty to Traded Qty							0.22	0.01	0.00
Spread High-Low								0.12	0.15
Spread Close-Open									0.93





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
No. of Trades	
WAP – Total Turnover	
Deliverable Quantity	
% Deli Qty to Traded Qty	
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of Indian Overseas Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Indian Overseas Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that two numbers of parameters were statistically significant and varied directly while five numbers of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Indian Overseas Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Indian Overseas Bank.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Indian Overseas Bank. For each of the available dates “weighted average price (WAP), number of shares,

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### KVD Prakash

number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for Indian Overseas Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that twonumber of parameters were statistically significant and varied directly while fivenumber of parameters were statistically significant and varied inversely.

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**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverabl e Quantity	% Deli. Qty to Traded Qty	Sprea d High-Low	Sprea d Close-Open	High Price
WAP		0.10	-0.14	0.19	-0.01	-0.47	-0.21	0.03	0.96
No.of Shares			0.66	0.99	0.90	-0.46	0.41	0.21	0.14
No. of Trades				0.65	0.80	0.14	0.36	0.16	-0.10
Total Turnover (Rs.)					0.90	-0.47	0.37	0.21	0.23
Deliverable Quantity						-0.07	0.37	0.31	0.02
% Deli. Qty to Traded Qty							-0.02	0.12	-0.46
Spread High-Low								-0.06	0.02
Spread Close-Open									-0.13
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverabl e Quantity	% Deli. Qty to Traded Qty	Sprea d High-Low	Sprea d Close-Open	High Price
WAP		0.57	0.41	0.28	0.96	0.01	0.24	0.88	0.00
No.of Shares			0.00	0.00	0.00	0.01	0.02	0.24	0.43
No. of Trades				0.00	0.00	0.44	0.04	0.37	0.58
Total Turnover (Rs.)					0.00	0.00	0.03	0.24	0.20
Deliverable Quantity						0.71	0.03	0.07	0.90
% Deli. Qty to Traded Qty							0.89	0.51	0.01
Spread High-Low								0.73	0.89
Spread Close-Open									0.46





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
No of Trades	
WAP – Total Turnover	
	Deliverable Quantity
	%Deli Qty to Traded Qty
	Spread High – Low
	Spread Close – Open





## Analysis of High Stock Price of JSW Steel by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for JSW Steel. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that two number of parameters were statistically significant and varied directly while five number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, JSW Steel, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affect significantly common people. There are studied to understand the effect of various factors controlling the stock price. In most countries the stock exchange has two important functions..Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of JSW Steel.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for JSW Steel. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and





### KVD Prakash

low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for JSW Steel. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that twonumber of parameters were statistically significant and varied directly while five number of parameters were statistically significant and varied inversely.

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Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.12	0.12	-0.09	-0.11	0.44	-0.02	0.04	0.99
No.of Shares			0.16	1.00	1.00	0.69	-0.04	0.00	-0.14
No. of Trades				0.16	0.14	0.25	0.12	0.13	0.14
Total Turnover (Rs.)					1.00	0.70	-0.04	0.00	-0.12
Deliverable Quantity						0.70	-0.04	-0.01	-0.14
% Deli. Qty to Traded Qty							-0.08	-0.14	0.43
Spread High-Low								-0.09	0.10
Spread Close-Open									-0.01
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.49	0.49	0.60	0.52	0.01	0.91	0.84	0.00
No.of Shares			0.37	0.00	0.00	0.00	0.82	0.99	0.41
No. of Trades				0.36	0.44	0.16	0.50	0.45	0.43
Total Turnover (Rs.)					0.00	0.00	0.82	1.00	0.51
Deliverable Quantity						0.00	0.81	0.94	0.44
% Deli. Qty to Traded Qty							0.66	0.41	0.01
Spread High-Low								0.62	0.58
Spread Close-Open									0.95





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No. of Shares
	No. of Trades
	WAP – Total Turnover
Deliverable Quantity	
% Deli Qty to Traded Qty	
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of Steel Authority of India Ltd by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for SAIL. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that five number of parameters were statistically significant and varied directly while two number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, SAIL, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the key drivers to the Indian economy. Thus, there is a need to analyze the factors affecting their share prices. This study focuses on the effect of some BSE parameters on high stock price of SAIL.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for SAIL. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and





### KVD Prakash

low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red show an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for SAIL. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that five numbers of parameters were statistically significant and varied directly while two numbers of parameters were statistically significant and varied inversely.

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**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.19	-0.16	0.08	-0.59	-0.68	0.05	-0.02	0.99
No.of Shares			0.43	0.96	0.63	-0.19	0.64	0.44	-0.09
No. of Trades				0.41	0.24	-0.11	0.20	0.20	-0.13
Total Turnover (Rs.)					0.44	-0.40	0.68	0.43	0.17
Deliverable Quantity						0.58	0.26	0.22	-0.54
% Deli. Qty to Traded Qty							-0.24	-0.17	-0.69
Spread High-Low								0.47	0.20
Spread Close-Open									0.01
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.28	0.37	0.67	0.00	0.00	0.80	0.92	0.00
No.of Shares			0.01	0.00	0.00	0.27	0.00	0.01	0.60
No. of Trades				0.02	0.17	0.55	0.25	0.26	0.48
Total Turnover (Rs.)					0.01	0.02	0.00	0.01	0.33
Deliverable Quantity						0.00	0.14	0.21	0.00
% Deli. Qty to Traded Qty							0.18	0.33	0.00
Spread High-Low								0.01	0.25
Spread Close-Open									0.97





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No. of Shares
No. of Trades	
WAP – Total Turnover	
Deliverable Quantity	
% Deli Qty to Traded Qty	
	Spread High - Low
Spread Close – Open	





## Analysis of High Stock Price of State Bank of India by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for State Bank of India. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that threenumber of parameters were statistically significant and varied directly while four number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, State Bank of India, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of State Bank of India.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for State Bank of India. For each of the available dates “weighted average price (WAP), number of shares,





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number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for State Bank of India. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that threenumber of parameters were statistically significant and varied directly while four number of parameters were statistically significant and varied inversely.

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 [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverabl e Quantity	% Dell. Qty to Traded Qty	Sprea d High-Low	Sprea d Close-Open	High Price
WAP		0.01	0.10	0.40	-0.22	-0.22	0.34	-0.17	0.99
No.of Shares			0.86	0.91	0.39	-0.27	0.71	0.39	0.09
No. of Trades				0.82	0.51	-0.06	0.75	0.22	0.19
Total Turnover (Rs.)					0.24	-0.34	0.79	0.30	0.47
Deliverable Quantity						0.76	0.22	-0.23	-0.17
% Dell. Qty to Traded Qty							-0.21	-0.44	-0.22
Spread High-Low								0.44	0.43
Spread Close-Open									-0.14
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverabl e Quantity	% Dell. Qty to Traded Qty	Sprea d High-Low	Sprea d Close-Open	High Price
WAP		0.95	0.56	0.02	0.21	0.20	0.05	0.33	0.00
No.of Shares			0.00	0.00	0.02	0.12	0.00	0.02	0.62
No. of Trades				0.00	0.00	0.75	0.00	0.22	0.28
Total Turnover (Rs.)					0.16	0.05	0.00	0.08	0.00
Deliverable Quantity						0.00	0.21	0.20	0.34
% Dell. Qty to Traded Qty							0.23	0.01	0.22
Spread High-Low								0.01	0.01
Spread Close-Open									0.42





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
	No of Trades
WAP – Total Turnover	
	Deliverable Quantity
% Deli Qty to Traded Qty	
	Spread High - Low
Spread Close – Open	





## Analysis of High Stock Price of Shree Cement by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Shree Cement. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that fournumber of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Shree Cement, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Shree Cement.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Shree Cement. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for Shree Cement. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that four number of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

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- [1] M. Savsani, U. Rathod, “Comparative Risk Return Analysis of Bombay Stock Market with Selected Banking Stocks in India”. International Journal of Scientific Research in Science and Technology, (2018) 4 (5), pp. 908-916.  
 [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.01	-0.25	0.04	0.02	0.09	-0.20	0.05	0.98
No.of Shares			0.69	1.00	0.97	0.47	0.71	0.30	0.10
No. of Trades				0.66	0.52	0.31	0.67	0.02	-0.19
Total Turnover (Rs.)					0.97	0.48	0.70	0.30	0.15
Deliverable Quantity						0.55	0.62	0.35	0.13
% Deli. Qty to Traded Qty							0.19	0.05	0.13
Spread High-Low								-0.02	-0.05
Spread Close-Open									0.01
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.96	0.15	0.82	0.90	0.60	0.25	0.80	0.00
No.of Shares			0.00	0.00	0.00	0.00	0.00	0.09	0.59
No. of Trades				0.00	0.00	0.07	0.00	0.90	0.29
Total Turnover (Rs.)					0.00	0.00	0.00	0.08	0.41
Deliverable Quantity						0.00	0.00	0.04	0.47
% Deli. Qty to Traded Qty							0.28	0.77	0.46
Spread High-Low								0.92	0.79
Spread Close-Open									0.96





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
No. of Trades	
WAP – Total Turnover	
Deliverable Quantity	
% Deli Qty to Traded Qty	
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of Syndicate Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Syndicate Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that fournumber of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Syndicate Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Syndicate Bank.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 1Feb 2020 to 19 Mar 2020 for Syndicate Bank. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high





**KVD Prakash**

and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

**RESULTS AND DISCUSSION**

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

**CONCLUSIONS**

This study focussed on identifying the statistically significant parameters related to share prices for Syndicate Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that four number of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

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- [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.43	-0.48	-0.30	-0.27	0.18	-0.57	0.07	0.99
No.of Shares			0.51	0.99	0.89	0.08	0.45	0.14	-0.41
No. of Trades				0.48	0.21	-0.36	0.69	0.18	-0.43
Total Turnover (Rs.)					0.89	0.09	0.41	0.14	-0.28
Deliverable Quantity						0.43	0.15	-0.06	-0.28
% Deli. Qty to Traded Qty							-0.47	-0.31	0.13
Spread High-Low								0.15	-0.47
Spread Close-Open									0.03
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.01	0.00	0.08	0.13	0.32	0.00	0.71	0.00
No.of Shares			0.00	0.00	0.00	0.65	0.01	0.45	0.02
No. of Trades				0.00	0.25	0.04	0.00	0.31	0.01
Total Turnover (Rs.)					0.00	0.61	0.02	0.44	0.11
Deliverable Quantity						0.01	0.40	0.75	0.12
% Deli. Qty to Traded Qty							0.01	0.08	0.49
Spread High-Low								0.41	0.01
Spread Close-Open									0.85
High Price									





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No. of Shares
No. of Trades	
WAP – Total Turnover	
Deliverable Quantity	
% Deli Qty to Traded Qty	
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of TATA Steel by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for TATA Steel. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that fournumber of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, TATA Steel, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of TATA Steel.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for TATA Steel. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

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## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for TATA Steel. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that four number of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

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- [1] M. Savsani, U. Rathod, “Comparative Risk Return Analysis of Bombay Stock Market with Selected Banking Stocks in India”. International Journal of Scientific Research in Science and Technology, (2018) 4 (5), pp. 908-916.  
 [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.02	-0.14	0.31	-0.38	-0.48	0.16	-0.14	0.99
No.of Shares			0.90	0.96	0.44	-0.15	0.71	0.38	0.10
No. of Trades				0.82	0.50	0.02	0.74	0.28	-0.04
Total Turnover (Rs.)					0.29	-0.29	0.75	0.32	0.38
Deliverable Quantity						0.79	0.09	-0.12	-0.35
% Deli. Qty to Traded Qty							-0.28	-0.32	-0.49
Spread High-Low								0.43	0.27
Spread Close-Open									-0.12
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.89	0.43	0.08	0.02	0.00	0.36	0.42	0.00
No.of Shares			0.00	0.00	0.01	0.39	0.00	0.03	0.56
No. of Trades				0.00	0.00	0.93	0.00	0.11	0.81
Total Turnover (Rs.)					0.09	0.10	0.00	0.07	0.02
Deliverable Quantity						0.00	0.60	0.50	0.04
% Deli. Qty to Traded Qty							0.11	0.06	0.00
Spread High-Low								0.01	0.12
Spread Close-Open									0.52





**KVD Prakash**

**Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters**

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
	No. of Trades
WAP – Total Turnover	
	Deliverable Quantity
% Deli Qty to Traded Qty	
	Spread High - Low
Spread Close - Open	





## Analysis of High Stock Price of Ultratech Cement by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Ultratech Cement. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that two number of parameters were statistically significant and varied directly while five number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Ultratech Cement, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a requirement to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Ultratech Cement.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Ultratech Cement. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity,





### KVD Prakash

spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for Ultratech Cement. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that twonumber of parameters were statistically significant and varied directly while five number of parameters were statistically significant and varied inversely.

## REFERENCES

- [1] M. Savsani, U. Rathod, “Comparative Risk Return Analysis of Bombay Stock Market with Selected Banking Stocks in India”. International Journal of Scientific Research in Science and Technology, (2018) 4 (5), pp. 908-916.  
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**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.04	-0.32	0.01	-0.01	-0.03	-0.23	0.02	0.97
No. of Shares			0.14	1.00	0.98	0.73	0.04	-0.07	-0.03
No. of Trades				0.11	0.02	0.20	0.61	0.08	-0.17
Total Turnover (Rs.)					0.99	0.73	0.02	-0.06	0.02
Deliverable Quantity						0.75	-0.10	-0.08	-0.03
% Deli. Qty to Traded Qty							-0.10	-0.36	-0.03
Spread High-Low								0.24	0.00
Spread Close-Open									0.01
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.80	0.07	0.97	0.94	0.84	0.20	0.92	0.00
No. of Shares			0.44	0.00	0.00	0.00	0.84	0.68	0.89
No. of Trades				0.53	0.92	0.26	0.00	0.66	0.34
Total Turnover (Rs.)					0.00	0.00	0.93	0.72	0.91
Deliverable Quantity						0.00	0.57	0.67	0.86
% Deli. Qty to Traded Qty							0.59	0.04	0.84
Spread High-Low								0.17	0.98
Spread Close-Open									0.97





**KVD Prakash**

Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No. of Shares
	No. of Trades
	WAP – Total Turnover
Deliverable Quantity	
% Deli Qty to Traded Qty	
	Spread High – Low
	Spread Close – Open





## Analysis of High Stock Price of VISA Steel by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for VISA Steel. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that fournumber of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, VISA Steel, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are studies to understand the effect of various factors controlling the share price. In most countries the stock exchange has two important functions. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of VISA.

## METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for VISA Steel. For each of the available dates “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and





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low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

## RESULTS AND DISCUSSION

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter.

## CONCLUSIONS

This study focussed on identifying the statistically significant parameters related to share prices for VISA Steel. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that four number of parameters were statistically significant and varied directly while three number of parameters were statistically significant and varied inversely.

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 [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016) 1(1), pp. 117-130.

Table 1. r and p value matrices

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.39	0.07	0.55	0.37	-0.32	0.59	0.14	0.98
No.of Shares			0.64	0.97	0.89	-0.58	0.50	-0.07	0.42
No. of Trades				0.53	0.39	-0.51	0.28	0.43	0.10
Total Turnover (Rs.)					0.87	-0.58	0.55	-0.06	0.58
Deliverable Quantity						-0.24	0.45	-0.19	0.41
% Deli. Qty to Traded Qty							-0.52	-0.17	-0.34
Spread High-Low								0.20	0.67
Spread Close-Open									0.16
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.03	0.71	0.00	0.04	0.08	0.00	0.47	0.00
No.of Shares			0.00	0.00	0.00	0.00	0.00	0.71	0.02
No. of Trades				0.00	0.03	0.00	0.13	0.02	0.61
Total Turnover (Rs.)					0.00	0.00	0.00	0.76	0.00
Deliverable Quantity						0.19	0.01	0.31	0.02
% Deli. Qty to Traded Qty							0.00	0.35	0.06
Spread High-Low								0.28	0.00
Spread Close-Open									0.40





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Table 2 summarizes the trend for the statistically significant parameters, Statistically significant parameters

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
No of Shares	
No. of Trades	
WAP – Total Turnover	
Deliverable Quantity	
	% Deli Qty to Traded Qty
	Spread High - Low
	Spread Close - Open





## Analysis of High Stock Price of Kotak Mahindra Bank by Correlation Matrix

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### ABSTRACT

The stock markets contribute a largescope in economic development of India. The objective of this study was to identify the statistically significant parameters related to share prices for Kotak Mahindra Bank. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” and the effects were studied using correlation matrix. The results showed that two number of parameters were statistically significant and varied directly while five number of parameters were statistically significant and varied inversely.

**Keywords:** Bombay Stock Market, Kotak Mahindra Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Share market plays a major role in Indian economy. A significant number of people invest in the share market. However, the ups and downs of the share market affects significantly common people. There are some studies [1,2] to understand the effect of various factors controlling the share price. Most of the trading in Indian stock market takes place through two major stock exchanges namely, Bombay stock exchange (BSE) and National stock exchange (NSE). The banks are the major pillars of the economy. Thus, there is a need to analyze the factors affecting their share prices. This study focusses on the effect of some BSE parameters on high stock price of Kotak Mahindra Bank.

### METHODOLOGY

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 10 PM for the period 2 Mar 2020 to 23 Apr 2020 for Kotak Mahindra Bank. For each of the available dates “weighted average price (WAP), number of shares,





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number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. The data were used to develop a correlation matrix using Mat lab 2014. The r values and p values were noted.

**RESULTS AND DISCUSSION**

Table 1. shows the r values and p values obtained from the correlation matrix. In the r value matrix, the parameters in red shows an inverse relationship while the ones in green shows a direct relationship. In the p value matrix, the parameters in green indicates p value less than 0.05 indicating statistically significant parameter. All the values have been taken with the precision upto two places of the decimal.

**CONCLUSIONS**

This study focussed on identifying the statistically significant parameters related to share prices for Kotak Mahindra Bank. Correlation matrix was used for the analysis. The parameters studied were “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization”. The results showed that twonumber of parameters were statistically significant and varied directly while five number of parameters were statistically significant and varied inversely.

**REFERENCES**

- [1] M. Savsani, U. Rathod, “Comparative Risk Return Analysis of Bombay Stock Market with Selected Banking Stocks in India”. International Journal of Scientific Research in Science and Technology, (2018) 4 (5), pp. 908-916.
- [2] J. Singh, P. Yadav, “A Study on the Factors Influencing Investors Decision in Investing in Equity Shares in Jaipur and Moradabad with Special Reference to Gender”. Amity Journal of Finance, (2016)1(1), pp. 117-130.

**Table 1. r and p value matrices**

r value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		-0.28	-0.61	-0.23	-0.18	0.22	-0.27	0.03	0.98
No.of Shares			0.11	1.00	0.99	0.52	0.42	0.44	-0.19
No. of Trades				0.10	-0.02	-0.24	0.44	-0.12	-0.56
Total Turnover (Rs.)					0.99	0.55	0.43	0.44	-0.13
Deliverable Quantity						0.59	0.34	0.44	-0.09
% Deli. Qty to Traded Qty							0.01	0.12	0.24
Spread High-Low								0.32	-0.13
Spread Close-Open									0.06
High Price									
p value matrix	WAP	No.of Shares	No. of Trades	Total Turnover (Rs.)	Deliverable Quantity	% Deli. Qty to Traded Qty	Spread High-Low	Spread Close-Open	High Price
WAP		0.11	0.00	0.19	0.31	0.21	0.13	0.87	0.00
No.of Shares			0.52	0.00	0.00	0.00	0.01	0.01	0.29
No. of Trades				0.58	0.89	0.18	0.01	0.51	0.00
Total Turnover (Rs.)					0.00	0.00	0.01	0.01	0.45
Deliverable Quantity						0.00	0.05	0.01	0.60
% Deli. Qty to Traded Qty							0.95	0.51	0.17
Spread High-Low								0.07	0.48
Spread Close-Open									0.74
High Price									





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Table 2. summarizes the trend for the statistically significant parameters, Statistically significant parameters

Statistically Significant and direct relationship	Statistically Significant and inverse relationship
	No of Shares
	WAP-No. of trades
No.of shares-Total turnover	`
Deliverable Quantity	
	%Deli Qty to Traded Qty
	Spread High – Low
	Spread Close – Open





## Effect of Amino Groups at Specific Sites of *Curcumin* to Deactivate 6M3M Protein of Corona Virus

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### ABSTRACT

It is known that phytochemicals of different plants have antiviral property. *Curcumin* is one of the major phytochemical capable of fighting against virus. The effect of functional modification of *curcumin* molecule by amino group on deactivation of 6M3M protein of Corona virus has been studied. It was observed that the addition of functional groups at specific sites influence the activity of the ligand.

**Keywords:** antiviral, protein, amino group, *curcumin*

## INTRODUCTION

Corona virus has infected many people around the globe resulting in a pandemic situation [1]. Till date no drugs or vaccines has been developed. Medicinal plants are rich source of bioactive compounds which can be effectively used against this infection [2]. Efforts are going on to use medicinal plants due to their less harmful nature compared to the chemical formulations. Turmeric has medicinal properties and this can be used to prepare medicines. One of the major components of turmeric is curcumin. Usually curcumin is used directly. This study intends effect of modification of curcumin at various sites by amino group on a vital protein of corona virus.

## METHODOLOGY

Simulation module of Biovia Discovery studio was used to add amino groups to specific locations of curcumin thereby modifying the molecule. The list of molecules created through the functional modifications are presented in Table 1. A vital protein for corona virus is 6M3M. Molecular docking has been performed using CDock menu following Charmm algorithm.





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## RESULTS AND DISCUSSION

Table1 shows the effect of amino group at 3 sites of curcumin. The molecules have been represented using SMILES code. The results presented in the table shows that the interaction of the compound with the 6M3M protein is influenced by the nature, size and position of the functional group.

## CONCLUSIONS

A study has been done to identify the effect of amino groups at specific sites of curcumin and evaluate the effectivity of the modified molecules. The results show that curcumin is the maximum effective formulation. COC1=C\C=C\C=C(/O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OCN)\O)\C=CC1=O and COC1=C\C=C\C=C(/O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OCN)\O)\C=CC1=O have effectivity against 6M3M protein of corona virus to some extent. Other formulation is not active.

## REFERENCES

- [1] X. Gu, B. Cao, J. Wang, "Full spectrum of COVID-19 severity still being depicted – Authors' reply", The Lancet, (2020) 395(10228), pp. 948-949.
- [2] D. Das, Sunanya Das, M. Pandey, D. Bhattacharyay. "In silico Analysis of Phytochemicals from Mucunapuriensis (L.) DC against Mycobacterium tuberculosis Causing Tuberculosis" , European Journal of Medicinal Plants, (2020), 31(4), 19-24.

**Table 1. Effect of amino group**

COMPOUND	SMILES CODE	-CDOCKER ENERGY	-CDOCKER INTERACTION ENERGY	REMARKS
Curcumin	<chem>COC1=C\C=C\C=C(/O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O</chem>	10.6273	35.7242	Maximum effective
Modified molecules	<chem>COC1=C\C=C\C=C(/O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OCN)\O)\C=CC1=O</chem>	2.89895	30.4131	Less effective
	<chem>COC1=C\C=C\C=C(/O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OCN)\O)\C=CC1=O</chem>	4.96061	33.7713	Effective to some extent
	<chem>COC1=C\C=C\C=C(\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)/ON)\C=CC1=O</chem>	-7.55469	22.821	Not effective





## Effect of Chloro Groups at Specific Sites of *Curcumin* to Deactivate 6M3M Protein of Corona Virus

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### ABSTRACT

It is known that phytochemicals of different plants have antiviral property. *Curcumin* is one of the major phytochemical capable of fighting against virus. The effect of functional modification of curcumin molecule by chloro group on deactivation of 6M3M protein of Corona virus has been studied. It was observed that the addition of functional groups at specific sites influence the activity of the ligand.

**Keywords:** ligand, phytochemical, chloro group,

## INTRODUCTION

Corona virus has caused serious illness among people around the globe [1] Specific drug for this infection is yet to be identified. Thus, researchers are trying to design and formulate drugs against corona infection. Medicinal plants are rich in phytochemicals which can be effectively used to fight against different diseases [2]. Efforts are going on to use medicinal plants due to their less harmful nature compared to the chemical formulations. Turmeric is well known due to its medicinal values. Curcumin is one of the major components of turmeric. Usually it is taken directly. This study intends effect of modification of curcumin at various sites by chloro group on a vital protein of corona virus.

## METHODOLOGY

Simulation module of Biovia Discovery studio was used to add chloro groups to specific locations of curcumin thereby modifying the molecule. The list of molecules created through the functional modifications are presented in Table 1. A vital protein for corona virus is 6M3M. Molecular docking has been performed using CDOCK menu following Charmm algorithm.





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## RESULTS AND DISCUSSION

Table1 shows the effect of chloro group at 3 sites of curcumin. The molecules have been represented using SMILES code. The results presented in the table shows that the interaction of the compound with the 6M3M protein is influenced by the nature, size and position of the functional group.

## CONCLUSIONS

A study has been done to identify the effect of chloro groups at specific sites of curcumin and evaluate the effectivity of the modified molecules. The results show that curcumin is the maximum effective formulation. COC1=C\C=C\C=C(\[CH-] \ C(=C\C=C\ 2/C=CC(=O)C(=C2)OC)\ O)/OCl)\ C=CC1=O and COC1=C\C=C\C=C(/O)\[CH-] \ C(=C\C=C\ 2/C=CC(=O)C(=C2)OCCl)\ O)\ C=CC1=O have effectivity against 6M3M protein of corona virus. Other formulation is not active.

## REFERENCES

1. X. Gu, B. Cao, J. Wang, "Full spectrum of COVID-19 severity still being depicted – Authors' reply", The Lancet, (2020) 395(10228), pp. 948-949.
2. D. Das, Sunanya Das, M. Pandey, D. Bhattacharyay. "In silico Analysis of Phytochemicals from Mucunapuriensis (L.) DC against Mycobacterium tuberculosis Causing Tuberculosis" , European Journal of Medicinal Plants, (2020), 31(4), 19-24.

**Table 1. Effect of chloro group**

COMPOUND	SMILES CODE	-CDOCKER ENERGY	-CDOCKER INTERACTION ENERGY	REMARKS
Curcumin	<chem>COC1=C\C=C\C=C(/O)\[CH-] \ C(=C\C=C\ 2/C=CC(=O)C(=C2)OC)\ O)\ C=CC1=O</chem>	10.6273	35.7242	Maximum effective
Modified molecules	<chem>COC1=C\C=C\C=C(/O)\[CH-] \ C(=C\C=C\ 2/C=CC(=O)C(=C2)OCCl)\ O)\ C=CC1=O</chem>	3.56741	27.5488	Effective to some extent
	<chem>COC1=C\C=C\C=C(/O)\[CH-] \ C(=C\C=C\ 2/C=CC(=O)C(=C2)OCCl)\ O)\ C=CC1=O</chem>	-1.29667	29.4132	Not effective
	<chem>COC1=C\C=C\C=C(\[CH-] \ C(=C\C=C\ 2/C=CC(=O)C(=C2)OC)\ O)/OCl)\ C=CC1=O</chem>	7.79821	33.8098	Effective





## Effect of Hydroxyl Groups at Specific Sites of *Curcumin* to Deactivate 6M3M Protein of Corona Virus

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### ABSTRACT

It is known that phytochemicals of different plants have antiviral property. Curcumin is one of the major phytochemical capable of fighting against virus. The effect of functional modification of curcumin molecule by hydroxyl group on deactivation of 6M3M protein of Corona virus has been studied. It was observed that the addition of functional groups at specific sites influence the activity of the ligand.

**Keywords:** molecule, virus, phytochemicals.

## INTRODUCTION

Corona virus has infected millions of people worldwide and has been declared as a pandemic [1]. However, there is no treatment for the disease yet. Thus, researchers are trying to design and formulate medicines against corona. Medicinal plants are used to fight against different diseases [2]. Traditional medicines are comparatively reliable and safe. Turmeric plant has enormous medicinal properties. One of the major components of turmeric is curcumin. Usually curcumin is used directly. This study intends effect of modification of curcumin at various sites by hydroxyl group on a vital protein of corona virus.

## METHODOLOGY

Simulation module of Biovia Discovery studio was used to add hydroxyl groups to specific locations of curcumin thereby modifying the molecule. The list of molecules created through the functional modifications are presented in Table 1. A vital protein for corona virus is 6M3M. Molecular docking has been performed using CDock menu following Charmm algorithm.





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## RESULTS AND DISCUSSION

Table1 shows the effect of hydroxyl group at 3 sites of curcumin. The molecules have been represented using SMILES code. The results presented in the table shows that the interaction of the compound with the 6M3M protein is influenced by the nature, size and position of the functional group.

## CONCLUSIONS

A study has been done to identify the effect of hydroxyl groups at specific sites of curcumin and evaluate the effectivity of the modified molecules. The results show that curcumin is the maximum effective formulation. COC1=C\C(=C\C=C(\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)/OO)\C=CC1=O has effectivity against 6M3M protein of corona virus to some extent. Other formulations are less active.

## REFERENCES

1. X. Gu, B. Cao, J. Wang, "Full spectrum of COVID-19 severity still being depicted – Authors' reply", *The Lancet*, (2020) 395(10228), pp. 948-949.
2. D. Das, Sunanya Das, M. Pandey, D. Bhattacharyay. "In silico Analysis of Phytochemicals from *Mucunapruriens* (L.) DC against *Mycobacterium tuberculosis* Causing Tuberculosis", *European Journal of Medicinal Plants*, (2020), 31(4), 19-24.

**Table 1. Effect of hydroxyl group**

COMPOUND	SMILES CODE	-CDOCKER ENERGY	-CDOCKER INTERACTION ENERGY	REMARKS
Curcumin	<chem>COC1=C\C(=C\C=C(/O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O</chem>	10.6273	35.7242	Maximum effective
Modified molecules	<chem>COC1=C\C(=C\C=C(/O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OCO)\O)\C=CC1=O</chem>	4.50365	30.4746	Effective to some extent
	<chem>COC1=C\C(=C\C=C(/O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OCO)\O)\C=CC1=O</chem>	2.31067	37.3287	Effective to some extent
	<chem>COC1=C\C(=C\C=C(\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)/OO)\C=CC1=O</chem>	9.73282	35.9811	Effective





## Effect of Methoxy Groups at Specific Sites of *Curcumin* to Deactivate 6M3M Protein of Corona Virus

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### ABSTRACT

It is known that phytochemicals of different plants have antiviral property. *Curcumin* is one of the major phytochemical capable of fighting against virus. The effect of functional modification of *curcumin* molecule by methoxy group on deactivation of 6M3M protein of Corona virus has been studied. It was observed that the addition of functional groups at specific sites influence the activity of the ligand.

**Keywords:** protein, methoxy, molecule, plants.

## INTRODUCTION

Corona virus has created a worldwide threat killing many people [1]. Till date no treatment has been developed. Thus, researchers are trying to design and formulate medicines against corona. Medicinal plants are used to fight against different diseases [2]. Efforts are going on to use medicinal plants due to their less harmful nature compared to the chemical formulations. Turmeric is well known due to its medicinal values. One of the major components of turmeric is curcumin. Usually curcumin is used directly. This study intends effect of modification of curcumin at various sites by methoxy group on a vital protein of corona virus.

## METHODOLOGY

Simulation module of Biovia Discovery studio was used to add methoxy groups to specific locations of curcumin thereby modifying the molecule. The list of molecules created through the functional modifications are presented in Table 1. A vital protein for corona virus is 6M3M. Molecular docking has been performed using CDOCK menu following Charmm algorithm.





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## RESULTS AND DISCUSSION

Table1 shows the effect of methoxy group at 3 sites of curcumin. The molecules have been represented using SMILES code. The results presented in the table shows that the interaction of the compound with the 6M3M protein is influenced by the nature, size and position of the functional group.

## CONCLUSIONS

A study has been done to identify the effect of methoxy groups at specific sites of curcumin and evaluate the effectivity of the modified molecules. The results show that curcumin is the maximum effective formulation. COCOC1=C\C=C\C=C(O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O has effectivity against 6M3M protein of corona virus. Other formulation are less active.

## REFERENCES

1. X. Gu, B. Cao, J. Wang, "Full spectrum of COVID-19 severity still being depicted – Authors' reply", The Lancet, (2020) 395(10228), pp. 948-949.
2. D. Das, Sunanya Das, M. Pandey, D. Bhattacharyay. "In silico Analysis of Phytochemicals from Mucunapuriens (L.) DC against Mycobacterium tuberculosis Causing Tuberculosis" , European Journal of Medicinal Plants, (2020), 31(4), 19-24.

**Table 1. Effect of methoxy group**

COMPOUND	SMILES CODE	-CDOCKER ENERGY	-CDOCKER INTERACTION ENERGY	REMARKS
Curcumin	<chem>COC1=C\C=C\C=C(O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O</chem>	10.6273	35.7242	Maximum effective
Modified molecules	<chem>COCOC1=C\C=C\C=C(O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O</chem>	8.68375	39.389	Effective
	<chem>COCOC1=C\C=C\C=C(O)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O</chem>	3.3027	35.6272	Effective to some extent
	<chem>COO\C=C/C=C/1\C=CC(=O)C(=C1)OC)\[CH-]\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O</chem>	2.4941	33.0838	Effective to some extent





## Effect of Methyl Groups at Specific Sites of Curcumin to Deactivate 6M3M Protein of Corona Virus

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### ABSTRACT

It is known that phytochemicals of different plants have antiviral property. Curcumin is one of the major phytochemical capable of fighting against virus. The effect of functional modification of curcumin molecule by methyl group on deactivation of 6M3M protein of Corona virus has been studied. It was observed that the addition of functional groups at specific sites influence the activity of the ligand.

**Keywords:** antiviral, ligand, methyl group, protein

## INTRODUCTION

Corona virus is a deadly virus and has threatened global health [1]. Till date there is no specific drug available for it. Thus, researchers are trying to formulate drugs using plant extracts from medicinal plants [2]. Medicinal plants are rich in bioactive compounds. Turmeric is well known due to its medicinal values. One of the major components of turmeric is curcumin. Usually curcumin is used directly. This study intends effect of modification of curcumin at various sites by methyl group on a vital protein of corona virus.

## METHODOLOGY

Simulation module of Biovia Discovery studio was used to add methyl groups to specific locations of curcumin thereby modifying the molecule. The list of molecules created through the functional modifications are presented in Table 1. A vital protein for corona virus is 6M3M. Molecular docking has been performed using CDock menu following Charmm algorithm.





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## RESULTS AND DISCUSSION

Table 1 shows the effect of methyl group at 3 sites of curcumin. The molecules have been represented using SMILES code. The results presented in the table show that the interaction of the compound with the 6M3M protein is influenced by the nature, size and position of the functional group.

## CONCLUSIONS

A study has been done to identify the effect of methyl groups at specific sites of curcumin and evaluate the effectivity of the modified molecules. The results show that curcumin is the maximum effective formulation. CCOC1=C\C(=C\C=C(/O)\[CH-])\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O has effectivity against 6M3M protein of corona virus to some extent. Other formulations are not active.

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Table 1. Effect of methyl group

COMPOUND	SMILES CODE	-CDOCKER ENERGY	-CDOCKER INTERACTION ENERGY	REMARKS
Curcumin	<chem>COC1=C\C(=C\C=C(/O)\[CH-])\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O</chem>	10.6273	35.7242	Maximum effective
Modified molecules	<chem>CCOC1=C\C(=C\C=C(/O)\[CH-])\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O</chem>	1.85571	31.0718	Effective to some extent
	<chem>CCOC1=C\C(=C\C=C(/O)\[CH-])\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O)\C=CC1=O</chem>	-4.55206	29.949	Not effective
	<chem>CO\C(=C/C=C/1\C=CC(=O)C(=C1)OC)\[CH-])\C(=C\C=C\2/C=CC(=O)C(=C2)OC)\O</chem>	-4.60068	31.4513	Not effective





## Marine Bio Active Compounds: Bioprospecting and Its Strategies

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### ABSTRACT

Marine microorganisms continue to be a rich repository of structural and biologically active novel compounds with potential use in the Pharmabiotech industry. The unique physiochemical properties of the marine environment (such as pH, pressure, temperature, osmolarity) and uncommon functional groups (such as isonitrile, dichloroimine, isocyanate, and halogenated functional groups) are frequently found in marine metabolites. These facts have resulted in the production of bioactive substances with different properties than those found in terrestrial habitats. In fact, the marine environment contains a relatively untapped reservoir of bioactivity. Recent advances in genomics, metagenomics, proteomics, combinatorial biosynthesis, synthetic biology, screening methods, expression systems, bioinformatics, and the ever increasing availability of sequenced genomes provides us with more opportunities than ever in the discovery of novel bioactive compounds and biocatalysts. The combination of these advanced techniques with traditional techniques, together with the use of dereplication strategies to eliminate known compounds, provides a powerful tool in the discovery of novel marine bioactive compounds. This review outlines and discusses the emerging strategies of these bioactive compounds

**Keywords:** Biocatalyst discovery, Dereplication, Marine bioactive compounds, Metaproteomic, Omic approaches, Synthetic biology.



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## INTRODUCTION

### Marine bio active compounds: Bioprospecting and its strategies

The advent of biotechnology has prompted researchers to attempt the synthesis of pharmaceutical compounds. Some success has been achieved with synthetic combinatorial chemistry and biosynthetic gene cluster manipulations. However, natural product discovery still proves to be one of the best sources for new bioactive chemicals. Nature's superiority in bioactive chemical production and the unknown number of undiscovered compounds provide poignant motivation to protect the aquatic environment from human alteration. The alteration of the delicate aquatic environment due to human pollution has unknown consequences for the undiscovered life forms. The vast diversity of undiscovered life in the aquatic environment affords many opportunities for increasing the arsenal of therapeutic chemicals used to treat human disease. With each new finding we can continue to marvel at nature's ability to produce such complex and beneficial structures.

French bacteriologist Vuillemin used the term antibiosis for the first time that means "against the life," in the year 1877, later Louis Pasteur and Robert Koch observations came in to light and the word antibiosis renamed as antibiotics by an American microbiologist Selman Waksman, in the year 1942. The idea of microorganisms as a new source of novel pharmaceuticals spurred an extensive search for microbial metabolites of medicinal value. Early efforts led to the discovery and development of several diverse classes of antibiotics which are believed to have added over a decade to man's life span. A majority of the antimicrobials in clinical use today are microbial products, products of microbial origin or are their synthetic/semi-synthetic analogs. However the last three decades have been disappointing as new classes of microbial metabolites worthy of commercialization as antibiotics have not been found. The main focus has been on the semi-synthetic, "me-too" compounds and on synthetic classes the fluoroquinolones and oxazolidinones. The widespread use of these various antimicrobial agents has resulted in the gradual emergence of multi-resistant pathogens. In response to the threat that these organisms now pose a search for novel agents lacking cross-resistance with the older compounds and perhaps possessing new modes-of-action has begun. Microorganisms from unique ecological niches are being explored, libraries of historical compounds are being reevaluated in the light of current needs and new sub-cellular targets discovered through bacterial genomics are being used for screening. These efforts may result to the discovery of new, more effective antibiotics that will meet current formidable challenges in the concerned field.

The effect of microbes in the environment has been recognized for centuries but until the accidental discovery of penicillin by Alexander Fleming in 1928 their true beneficial potential was not recognized. This fortuitous event seemingly provided the first scientific clue that microorganisms could be an enormous source of novel pharmaceuticals. Since then microbial products have been proven to be a rich source of novel compounds with diverse biological activities, (Davies 1999; Demain 1998 and 1999; Imada and Hotta, 1992; Berman et al.,) 1997. Although synthetic compounds have continued to play important role in our fight against various diseases (Table.1) The antibacterial and anticancer therapeutic agents currently in clinical use are dominated by either microbial products or one of their analogs, (Singh and Greenstein, 2000; Cragg et al., 1997). The Physicians' Desk Reference of 1999 lists a total of 403 antimicrobial formulations of which 211 are listed as antibacterial (Physicians' desk reference, 1999). This list includes 19 penicillins, 26 cephalosporins, 1 monobactam, 2 carbapenems, 6 aminoglycosides, 5 tetracyclines, 7 macrolides, 6 fluoroquinolones, etc.

Most of these new antibiotics were discovered through extensive screening of microbial fermentations from the year 1940 - 1960 which is also referred to as the 'golden' period of antibiotics. There after conventional screening became less productive and an upsurge in semi-synthetic and synthetic chemistry efforts expanded the number and quality of antibiotics derived from the known classes (Lawrence et al., 1999; Lee et al., 1999). In the year 1970's the discovery of the monobactams, carbapenems and clavulanic acid by three different microbial screening efforts re established the importance of microorganisms in the discovery of new antibacterial compounds (Christopher et al., 1991).



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Continued chemical and microbiological efforts provided several superior analogs of various antibiotic classes for the antibacterial market and semi-synthetic approaches are still being pursued to further improve the activities of old compounds. In nature all organisms need to compete in order to survive in their habitats and this Biological task can only be achieved by the development of competitive mechanisms such as the production of toxins, enzymes and antimicrobial agents like antibiotics. The search for antibiotics began in the late 18<sup>th</sup> century with the growing acceptance of the germ theory of disease, a theory which linked bacteria and other microbes to the causation of a variety of ailments as a result scientists started to devote more time to search for drugs that would kill these disease-causing bacteria without causing any side or adverse effect to the host.

An antibiotic is a drug that kills or slows down the growth of bacteria. Antibiotics are one class of "antimicrobials" a larger group which also includes anti-viral, anti-fungal, and anti-parasitic drugs. They are relatively harmless to the host and therefore can be used to treat infection. The term originally described only those formulations derived from living organisms but now applied also to synthetic antimicrobials such as the sulfonamides. Antibiotics are labeled (magic bullets) drugs which target disease without harming the host. Antibiotics are not effective in viral, fungal and other non-bacterial infections and individual antibiotics vary widely in their effectiveness on various types of bacteria. Some specific antibiotics target either gram-negative or gram-positive bacteria and others are more wide-spectrum antibiotics. The effectiveness of individual antibiotics varies with the location of the infection and the ability of the antibiotic to reach the site. Oral antibiotics are the simplest approach when effective with intravenous antibiotics reserved for more serious cases. Antibiotics may sometime be administered topically as with eye drops or ointments.

The first widely used antibiotic compounds used in modern medicine were produced and isolated from living organisms such as the penicillin class produced by fungi *Penicillium*, streptomycin from *Streptomyces* but the actinomycetes are the group of prokaryotic filamentous soil microorganisms which are known as the top producers of antimicrobial agents especially *Streptomyces* (Osborne et al., 2000; Rondon M., et al 2000). Some of the antibiotics produced by *Streptomyces* are erythromycin, amphotericin, neomycin, streptomycin and rifamycin. Advances in organic chemistry led to contribute many synthetic antibiotics. Many antibiotics are relatively small molecules with a molecular weight less than 2000 Dalton, with different modes of action. Generally they interfere with biological processes such as replication, translation and cell wall synthesis. Some antibiotics like tetracycline interfere with protein synthesis by associating with the 30S ribosomal sub-unit penicillin, produced by *Penicillium notatum* prevent transpeptidation of N-acetyl-muramic acid resulting in a weakened peptidoglycan structure. The search for new natural products from aquatic microorganisms has already shown promising results by discovering compounds with possibly useful as anticancer and cardiovascular agents (Lei and Zhou 2002). With the worldwide sale of 45 billion dollars, anti-infective compounds represent the third largest therapeutics on commercial sale and is expected to increase by folds.

During the last three decades pharmaceutical companies have been searching for new antibiotics to counter the problem of increasing bacterial resistance. During this period use of new chemical derivatives of pre-existing antibiotics has been the only method available because no novel chemical class of antibiotics has been discovered. The oceans covers over the 70% of the earth's surface and roughly half of the biodiversity found on this planet is by the aquatic environment with 34 of the 36 phyla of life as represented by (Donia and Hamann 2003). Over the last 40 years aquatic natural product research has become a multi-disciplinary field touching on subjects within biology, chemistry, chemical ecology and pharmacology. During this brief period bacterial secondary metabolites with pharmacodynamic properties encompassing such diverse biological activities as antibiotics, antivirals, antimitotic and antineoplastics have already been documented. Other aquatic organisms such as blue green algae, seaweeds, horse shoe crabs, marine fungi and sponge metabolites have also yielded substantial natural products such as steroids, cytotoxic and antimicrobial agents as well as novel and biologically active peptides (Blunt et al., 2004).



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The bacteria have long been the subject of scientific study due to their ability to cause disease in humans (Lederberg, 2000). One of the major advances in the health and well-being of human civilizations was the development of antibiotics. Although the introduction of antibiotics has had an enormous impact on the ability to treat bacterial infections bacteria continues to be the leading cause of deaths worldwide. Moreover the effectiveness of antibiotics has been eroded by the appearance of pathogenic strains that are resistant to nearly all classes of antibiotics coupled with the fact that only one new class of antibiotics has been introduced by the pharmaceutical industry since 1970 (Binder et al., 1999).

Soil microbial communities are among the most complex, diverse and important assemblages of organisms in the biosphere. They participate in various biological activities such as mineralization and decomposition of organic matter, biocontrol and antagonism (Hackl et al., 2004). It is said that bacteria that are found colonizing soil are ubiquitous since the chemical, physical and biotic characteristics present in such medium vary immensely. Recently Horner et al., 2003 postulated that microbial population can be various in a particle of soil due to oxygen concentration (Sprusansky et al., 2005). Postulated that soil bacteria display amazing versatility in their ability to use relatively poor sources of carbon, nitrogen and thrive on a mixture of complex carbohydrates and proteins that result from the degradation of organic material which demonstrates that soil microorganisms are an important source for the search of novel antimicrobial agents and molecules with various biotechnological importance. Some of the cultivable microbes that most commonly are isolated from soil samples belong to the genera of *Bacillus*, *Streptomyces* and *Pseudomonas*, (Belma et al., 2002; Stabb et al., 1994). *Streptomyces* are responsible for the production of over 70% of the antibiotics that have been isolated and reported (Dairi 1999, Lo C., 2002). The genus *Pseudomonas* is comprised of a gram-negative bacteria and is vastly involved in biological control of many plant pathogens.

Soil is a diverse medium composed of many minerals and substrates essential for metabolic pathways of prokaryotic and eukaryotic inhabitants (Dakora et al., 2002). The abiotic and biotic diversity present in this medium makes it difficult for the isolation of all the microbial community present therefore not even 1% of the entire soil microbial community has been identified (Courtis et al., 2003; Hackl et al., 2004; Rondon et al., 2000). There is great opportunity for discovering new microorganisms of industrial and clinical importance in soil. It is not possible to recreate all of the specific requirements that every soil microorganism needs. That is why standard microbiological techniques and innovative molecular and genetic technologies are being designed (Satoshi et al., 2004; Sprusansky et al., 2005; Zhou et al., 1996). Applying these techniques to a given environment one can obtain large quantities of genomic material and study a vast part of a given microbial community. Scientists have developed a new molecular strategies in the field of functional genomics which involves the construction of soil metagenomic libraries for the better understanding of microbial diversity and its possible applications in medical research (Rondon et al., 1999; Satoshi et al., 2004).

The irrational use of antibiotics has caused an increase in number of multiple drug resistant strains (MDR) of bacteria, fungi and many MDR strains are being reported from the genera *Pseudomonas*, *Streptococcus* and *Staphylococcus* (Chitnis et al., 2000). Some of these strains are resistant to most used antibiotics including methicillin, cephalosporins, and other beta-lactams that target peptidoglycan synthesis. Others have gained resistance toward neomycin and streptomycin which attack the bacterial ribosome. Antibiotic resistance got lot of attention in many forms including the recent developments in which the superbug NDM made lot of noise in news at global level there fore the hunt for the novel antibiotics from nature is the need of the day. NDM-1 is a newly-identified enzyme that makes bacteria resistant to a broad range of beta-lactam antibiotics. United Kingdom Health Protection Agency has stated that "most isolates with NDM-1 enzyme are resistant to all standard intravenous antibiotics for treatment of severe infections NDM-1 is known as New Delhi Metallo-Beta-Lactamase. This bacterium which was found recently is called the Superbug because of its efficiency to resist almost all antibiotics invented. NDM 1 has high resistance to survive against antibiotics such as carbapenems and beta-lactams which is its dangerous side. Though the investigations are on it has already effected India's medical tourism. Infact US President Obama has issued an advisory to US nationals not to go to the cheaper treatment in India to avoid the MDR. It is well understood that



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antibiotic resistance is an evolutionary process that is based on selection for organisms that have enhanced ability to survive doses of antibiotics that would have previously been lethal; the underlying molecular mechanisms leading to antibiotic resistance can vary. Intrinsic resistance may naturally occur as a result of the bacterial genetic makeup. At the molecular level it is assumed that the bacterial chromosome may fail to encode a protein that the antibiotic targets or an acquired resistance may result from a mutation in the bacterial chromosome or the acquisition of extra-chromosomal DNA. The spread of antibiotic resistance mechanisms occurs through vertical transmission of inherited mutations from previous generations and genetic recombination of DNA by horizontal genetic exchange.

**Antagonism**

Antagonism may occur for space or for a common resource. (Nair and Simidu, 1987) hypothesized that antagonistic properties are linked to the trophic status of the habitats. Studies by the authors (Burgess et al., 1991) show that in shallow areas such as Tokyo Bay, organic nutrients derived from metabolic processes or death and decay of massive phytoplankton population and constant nutritional inputs from external sources assuage the necessity for bacterial populations to produce antibacterial substances to survive competition. Auto-inhibition acts as a controlling factor in maintaining species diversity by allowing the population to partially limit itself and co-exist with competitors. Many marine free-living and sediment-inhabiting marine bacteria have been shown to produce secondary metabolites that display antibacterial properties (Burgess et al., 1991).

Antibacterial activity has been widely exploited for the past 50 years and antibiotics have revolutionized Medical science by providing cure for formerly life-threatening diseases. Microbial populations have a resilient dynamic stability produced by biological buffering from competition. Microorganisms compete for nutrients, oxygen and favorable ecological niches and are selective for their tolerance towards ambient conditions i.e. pH, carbon dioxide, water and microbial toxins (Baker 1980). Microorganisms secrete metabolites some of which inhibit other microorganisms (antibiotics) while others stimulate other microorganisms to form essential stages of their life cycle.

A negative interaction can therefore directly inhibit a pathogen or inhibit a stimulatory microorganism there by indirectly inhibiting the pathogen. The aquatic environment harbors a wide range of microbes capable of exhibiting bacteriolytic and antibiotic activity. Bacteriolytic activities were found to be higher in the zooplankton than in sea water and the major group isolated were the gram negative bacteria in particularly the *Vibrio parahaemolyticus* followed by the gram positive strain, *Staphylococcus aureus* (Nair et al., 1985). There are reports on such bacteria from nutrient-rich algal surfaces (Jensen and Fenical, 1994; Bernan et al., 1997).

The bacteriolytic bacteria are mainly inhabitants of the places where the organic matter is high and contribute to its decomposition (Nair et al., 1985). A number of surface-associated marine bacteria have been found to produce antibiotics. (Trischman et al. 1994) isolated a species of *Streptomyces* from the surface of a jellyfish. Though the property of production of antimicrobial compounds is constitutive, (Patterson and Bolis 1997) observed that chemical signals received from potential competitor strains elicit an antagonistic response. However, this aspect still remains a little studied phenomenon (Mearns-Spragg et al., 1997; Mearns-Spragg et al., 1998). In contrast to antibiotics which promote interspecies antagonism, bacteriocins are responsible for intra specific antagonism. Colicin produced by *Eschereshia coli* has been studied extensively and similarly there are brevicin, nisin, pediocin produced by various groups.

Bacteriocin produced by *Halobacterium mediterranei* ATCC 33500 has been shown active against many other halobacteria (Meseguer et al., 1985). Bacteriocin -producing bacteria can change their strategy from anti- to pro-biotic depending on the environment. Therefore a brevicin producer could be skillfully used as probiotic to ward off unwanted microbes or to mitigate pathogenesis. A deep sea pigmented *Brevibacterium* sp has been shown to produce linocin-like compound that can be used as probiotic in aquaculture feeds. The extracts of this bacteria have not only been suggested to be useful in prolonging shelf-life of dairy products but the culture *per se* could be used as probiotics and also as feed additives in aquaculture (Loka Bharathi et al., 2003).



**Ravikiran Regeti et al.****16s rRNA sequencing & Metagenomics**

There are various methods to identify, characterize and exploit the microbes and the most accepted and popular technique of bacterial identification and classification is 16s rRNA gene sequencing in bacterial systematics. The rRNA is the most conserved (least variable) gene in all cells. Portions of the rDNA sequence from distantly-related organisms are remarkably similar. This means that the sequences from the distantly related organisms can be precisely aligned making the true differences required for easy measurements, therefore the genes that encode the rRNA (rDNA) have been used extensively to determine taxonomy, phylogeny and to estimate rates of species divergence amongst the bacteria. The comparison of 16s rDNA sequence can show evolutionary relatedness amongst microorganisms. This work was pioneered by (Carl Woese 1977) who proposed the three Domain system of classification - Archaea, Bacteria and Eucarya - based on such sequence information.

Prokaryotic microorganisms comprise the largest part of the earth's total biomass. This group contains a vast array of species, with enormous genetic, metabolic, physiological and behavioral diversity. However less than 1% of them have been cultured. Despite their ubiquity very little is known about their fundamental properties, range of diversity, interaction with the environment, evolution and the role they play in global biogeochemical cycles (Rodriguez-Valera, 2004). It is believed that progress towards filling these knowledge gaps will advance significantly when more whole genome sequences become available for the investigations. The current availability of bacterial genome information originated from molecular biology accomplishments and made available hundreds of protein-protein interactions based solely on sequence comparisons. Moreover genome sequence information can now be coupled with other experimental data (structures, domain shuffling, expression patterns, and gene adjacency in genomes) to allow new approaches to determine gene function. Nowadays genomics and especially metagenomic approaches contributing advancement in knowledge and understanding of microbiology, since it is not possible to transform a bacterial strain, delete gene information or manipulate any level of protein expression of non-culturable bacteria using traditional classical genetics techniques.

The information derived from whole-genome sequences following their comparative analysis can be used to study the novel aspects of biochemistry, physiology and metabolism of these organisms to investigate the role of microorganisms played in complex ecosystems and in global geochemical cycles, study their diversity and to predict the impact of microorganisms on the productivity and sustainability of agriculture, forestry and safety and quality of food supply. Simultaneously new genome sequences can be used to infer phylogenetic relationships among prokaryotes that deal with the organization and evolution of microbial genomes, mechanisms of transmission, exchange and reshuffling of genetic information (Koonin, 1997). The ability to culture a microbe certainly assists the sequencing of genomes. Some laboratories have already developed techniques to sequence organisms without ever culturing them (Kemmer and Fraser, 2002). This technique is important for those organisms that are not well understood or those live in very complex environments like extreme habitats, deep sea, rocks etc. (Nelson, 2003).

This technique allows scientists to discover new enzymes, antibiotics and other microbial products useful in various biotechnological applications including medicine and industry. Another application of sequencing directly from environment gives better understanding of the soil metagenome, metagenome of a healthy vs. diseased individuals (Nelson, 2003). The gene pools present in a prokaryotic species can be order of magnitude larger than that of the genome of a single strain. Contrasting with eukaryotic genomes the repertoire of genes present in a prokaryotic cell does not correlate stringently with its taxonomic identity. Therefore the gene catalogues from a particular environment may provide more meaningful information than the classical species catalogues. The industrial sector and researchers have employed great efforts searching for novel antimicrobial agents. They have screened many types of soils in order to culture antimicrobial agent producing microbes. One of the biggest problem that groups encountered is the rediscovery of the same antimicrobial agents. (Zachner and Fiedler 1995) stated that there is 99% of redundancy when searching for antimicrobial agents. The problem observed can be vastly related with the fact that 99% of the entire soil microbial population cannot be cultivated by conventional microbiological techniques.



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Different approaches such as culture modification techniques in which culture media are prepared with ecological extracts and the use of density gradients for the separation of microbes based on cellular density are being used in order to culture the uncultivable, as mentioned above a limitation is that most of the time these methods render the same group of cultivable microbes resulting in the isolation of similar antimicrobial agents. In order to fulfill the need for novel antimicrobial screening methods significant contributions had been made by (DeLong 2002; Gillespie et al., 2002; Handelsman and Wackett. 2004, Martinez et al., 2004; Streit and Schmitz. 2004; Stevenson et al., 2004; Rondon et al., 2000) using metagenomic tools and techniques leading to the construction of many metagenomic libraries.

**Strategies for Marine Natural Compounds Discovery from Marine Microbial Communities**

Several screening approaches have been exploited in the discovery of novel natural compounds including conventional screening, genomics, metagenomics, combinatorial biosynthesis and synthetic biology. The repeated discovery of known compounds is a major limitation of existing assay methods, hence it is necessary not only to increase the availability of novel techniques to maximize the discovery of new compounds, but also to utilize dereplication strategies to avoid the discovery of known compounds. These strategies include the generation of antibiotic resistance markers and chemical profile analysis based on LC-NMR, LC-MS and HPLC-UV (Liu et al., 2012)

**Genome-Guided Bioprospecting**

Genomic sequencing of microorganisms in recent years has unveiled unprecedented insights into the biosynthetic potential of microorganisms, and thus the discovery of bioactive compounds has entered into the new postgenomic era. In recent years, the sequence data of microorganisms has been compiled into online databases such as Genomes on Line Database. The development of the Microbial Genome Sequencing Project resulted in the sequence, assembly and annotation of 182 marine bacterial genomes, which are available at CAMERA: Community CyberInfrastructure for Advanced Marine Microbial Ecology Research and Analysis. Available online: <https://portal.camera.calit2.net/gridsphere/gridsphere?cid=microgenome> (accessed on 22 January 2014). Due to these advances in bioinformatics, it is now possible to rapidly identify the gene clusters of bioactive compounds and predict their chemical structure *in silico* based on genomic information.

Along with advances in bioinformatics, genome sequencing has made it possible to rapidly identify the gene cluster of bioactive compounds and *in silico* predict their chemical structure based on genomics information. Development of software such as Antibiotics & Secondary Metabolite Analysis SHell (antiSMASH) (Figure 2), which allows the user to efficiently detect secondary metabolite gene clusters in the genomes of bacteria and fungi, has been a significant help to researchers (Medema et al., 2011; Blin et al., 2013). AntiSMASH allows for the detection of biosynthetic gene clusters of secondary metabolites such as type I, II and III PolyKetides (PKs), Non-Ribosomal Peptides (NRPs), phosphoglycolipids, oligosaccharide antibiotics, phenazines, thiopeptides, homoserine lactones, phosphanates, furans, terpenes, ectoines, bacteriocins, lantibiotics, nucleosides, aminoglycosides, aminocumarins amongst others. AntiSMASH also has the ability to partially predict types of compounds that can be produced if the gene cluster is completely functional (Blin et al., 2013).

**Gene-Guided Bioprospecting**

Gene-guided screening has been developed towards target genes associated with the biosynthetic pathways of bioactive compounds, such as those associated with the production of PKS (Engelhardt et al., 2010; Graça et al., 2013), NRPS (Engelhardt et al., 2010; Graça et al., 2013, bacteriocins Prieto et al., 2012) and dTDP-glucose-4,6-dehydratase (Wu et al., 2013). The combined strategy of gene and bioactivity based screens creates a more powerful tool which allows us to obtain valuable strains with the potential to synthesize new bioactive compounds. Marine sponge associated bacteria have been shown to produce a cocktail of secondary metabolites (Bhatnagar and Kim, 2010; Mondol et al., 2013).



**Ravikiran Regeti et al.****Metagenomics**

Metagenomics is the study of DNA from a mixed population of organisms and initially involves the cloning of either total or enriched DNA directly from the environment (eDNA) into a host that can be easily cultivated. Currently, function driven analysis and sequence-driven analysis are the two main approaches used for eDNA library screening (Figure 3) (Kennedy et al., 2010; Lee et al., 2010). More recently, advances in NGS technologies have allowed isolated eDNA to be sequenced and analyzed directly from environmental samples (via direct eDNA sequencing or shotgun metagenomics) (Figure 3) (Shokralla et al., 2012; Schofield et al., 2013). This is an effective strategy to access bioactive compounds encoded by the genomes of previously uncultured microbes through introduction of eDNA into a suitable host, bypassing the laborious step of library construction. This strategy has been used in human genome project and has also aided in the identification of novel biomass-degrading enzymes from cow rumen and compost (Schofield et al., 2013).

**Metagenomics: Functional Screening**

Functional screening has allowed for the identification of a large number of bioactive compounds and biosynthetic pathways including industrially important enzymes such as cellulases (Zhao et al., 2012), proteases (Biver et al., 2013; Waschowitz et al., 2009), lipases (Selvin et al., 2012; Hårdeman and Sjöling 2007), esterases (Jiang et al., 2012; Chu et al., 2008), glycoside hydrolases (Wierzbicka-Wos et al., 2013). For example, the isolation of clone-specific metabolites produced by eDNA clones identified from bacterial top agar overlay assays has led to the characterization of a wide variety of bioactive compounds. Among these compounds can be found long-chain *N*-acyl amino acid antibiotics, a novel isonitrile functionalized indole antibiotic, antibacterial active pigments such as violacein, indigo and turbomycin (Gillespie et al., 2002), terragines (Wang et al., 2000), fatty acid derivatives (Brady and Clardy 2002), and aromatic poliketides (Feng et al., 2011, all of which have been recovered from soil libraries. The cyclic peptides nocamide and patellamide D have also been isolated in this manner from soil and marine sponge libraries, respectively (Brady et al., 2009; Banik et al., 2010).

**Metagenomics: Sequenced-Based Screening**

Sequenced-based screening using homologous PCR or clone hybridization allows the identification of essential genetic components for cluster assembly. Sequenced-based screening has been used together with NGS technologies in the identification of PKS and NRPS clusters from a number of cultured strains (Johnston et al., 2012). Further to this, sequence-based analysis of marine metagenomic libraries has to date revealed the presence of a number of enzymes including peptidases (Cottrell et al., 2005), alkane hydroxylases (Xu et al., 2008, laccase Fang et al., 2011, and a fumarase Jiang et al., 2010).

**Novel Metagenomics Approaches**

In contrast with the conventional metagenomic approach, single cell genomics (Figure 6) begins with the isolation of the microbial cell fraction from an environmental sample and the separation of an individual prokaryotic cell through microfluidics, cytometry, or micromanipulation. Single cell genomics is dependent on multiple displacement amplification (MDA), which allows the generation of genomic DNA suitable for shotgun sequencing from unique microbial cells. Thereby, the entire biochemical potential of a single uncultured microbe can be evaluated from within a complex microbial community Stepanauskas and Sieracki 2007. Using this approach, microbial cells are firstly singularized by FACS, sorted, and individual microbial cells are then subjected to Whole Genomic Amplification (WGA). The amplified genome can then be sequenced, and the catalytic and metabolic potential of the genome analyzed. This approach has recently been employed by the Hentschel group, who used single cell genomics to characterize Poribacteria that form part of the microbial consortia of the Mediterranean sponge *Aplysina aerophoba* (Siegl et al., 2011). Using this approach, nearly 1.6 Mb of DNA sequence was obtained from the poribacterial genome that, following the annotation, allowed the identification of several enzymes, including several sulfatases and peptidases.



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Substrate-Induced Gene-Expression screening (SIGEX), metabolite-regulated screening (METREX) and a technique based on subtractive hybridization magnetic bead capture. METREX involves the introduction of metagenomic DNA into a suitable host cell containing a biosensor plasmid to detect compounds of interest, for example, compounds that induce bacterial quorum sensing. Thereby, a sensor such as green fluorescent protein (GFP) is expressed by the cell either when gene (or genes) is introduced into the cell or when an exogenous quorum-sensing inducer is applied leading to the synthesis of an inducer. This can be identified using FACS or by fluorescence microscopy (Williamson et al., 2005). SIGEX has been developed to isolate novel catabolic genes from metagenomes which are particularly difficult to obtain using traditional gene cloning methods (Uchiyama and Miyazaki 2010). In SIGEX, digested metagenome fragments are ligated into an operon-trap vector containing a reporter protein such as GFP, and a metagenomic library is constructed in a liquid medium by transforming a suitable cloning host. This library is screened by a SIGEX assay, and positive clones are selected by detecting the activity of a co-expressed marker, in this case, the GFP fluorescence. (Uchiyama and Watanabe 2008). Another interesting approach that has been described is based on substrate hybridization capture involving the use of magnetic beads (Meiring et al., 2010). This involves the amplification of the internal portion of the gene of interest using degenerate primers, and the subsequent immobilization of the partial gene amplicons on streptavidin-covered magnetic beads. These beads are then used as hybridization probes to target full-length genes from metagenomic DNA. This method has been used to clone novel bacterial multicopper oxidases from soil but would clearly also have use in marine metagenomic samples (Meyer et al., 2007).

**Combinatorial Biosynthesis**

Combinatorial biosynthesis is a technology based on the genetic manipulation of biosynthetic clusters encoding bioactive compounds. Genetic manipulation techniques used include amino acid substitution, deletion or inactivation, swapping or borrowing of genes within a module, gene fusions, and assembly of these components, with the aim of producing novel structures in order to obtain new or altered structures that would be difficult to synthesize using other methods (Manzella and Reeves 2007). This approach has been used mainly in multi-modular enzymes such as PKS, NRPS and hybrid PKS-NRPS. The rapid advances in microbial genome analysis have not only enabled the identification of these gene clusters, but have also provided the necessary tools for engineering the biosynthesis of novel compounds by combinatorial biosynthesis (Walsh 2004; Manzella and Reeves 2007; Wong and Khosla 2012; Fisch 2013).

**Synthetic Biology**

Synthetic biology is a promising strategy to improve the production of known marine compounds or activate silent gene clusters by genetic manipulation of the biosynthetic machinery (natural or artificial) involved in the assembly of bioactive compounds. This approach is based on the development of genome manipulation techniques such as hierarchical Conjugative Assembly Genome Engineering (CAGE) (Isaacs et al., 2011) and Multiplex Automated Genome Engineering (MAGE) (Wang et al., 2009), as well as functional characterization of abundant genetic materials (e.g., controllable regulatory elements, synthetic RNA/protein scaffolds) (Khalil and Collins 2010). In addition to the efficient genome handling and transfer technologies, compatibilities between microbial hosts and all the necessary machinery to obtain the targeted product are very important for the choice of the most suitable host. This includes the proper expression of the genes responsible for the production of the target compound, compatibility with the enzyme activity and the availability of precursors. Nowadays, synthetic biology is used for the development of microbial cell factories for bioactive compound production (Keasling 2010) or to synthesize gene clusters enabling *in situ* therapeutic delivery (Khalil and Collins 2010). In recent years, many successful examples of bioactive compounds production with therapeutic interest through synthetic biology have been reported. Antibiotics such as aminoglycosides derivatives, which include neomycin, kanamycin and gentamicin (Park et al., 2013), as well as other natural products like PKS (Yuzawa et al., 2012; Gao et al., 2010; Zakeri 2013) and NRPS (Zakeri and Lu 2013) have been produced. In addition, the enzymes responsible for the production of these chemical compounds can be isolated and used as biocatalysts to synthesize bioactive compounds, their intermediates, and derivative compounds.





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### Heterologous Production of Bioactive Compounds

In order to achieve the heterologous production of novel bioactive compounds, the development of marine-derived hosts such as cyanobacteria, actinomycete, and symbiotic fungi is key. Moreover, heterologous expression of genes or entire biosynthetic gene clusters involved in the synthesis of bioactive compounds is an important strategy in the identification of the function of these genes or genes clusters (Gomez-Escribano and Bibb 2014). Techniques such as natural product screening, compound chemical characterization, host isolation, gene cluster identification, sequencing analysis or synthesis, and metabolic and process engineering are necessary in the optimization of heterologous production (Zhang *et al.*, 2011).

### Omic" Integrated Approaches to Characterize Bioactive Compounds Biosynthetic Gene Clusters and Pathways:

Omics approaches utilize genomic, proteomic, metabolomic, and transcriptomic tools to bypass cultivation limitations by studying the collective material of organisms from environmental samples, thus enabling powerful new approaches to gene, genome, protein and metabolic pathway discovery (Schofield and Sherman 2013). Access to NGS and the development of bioinformatics tools is essential for the resolution of the tremendous databases generated from these technology applications.

### Dereplication Strategies

It is of the utmost importance that studies in the discovery of novel marine bioactive compounds, such as antimicrobial compounds, should be performed in parallel with a defined dereplication strategy to screen for previously known bioactive compounds. Dereplication itself is the process of screening samples for the presence of active compounds which have already been studied, thereby eliminating them from consideration. The identification of known molecules early in the marine bioactive compound discovery process minimizes time, effort and cost (Figure 6) (Liu *et al.*, 2013; Yang *et al.*, 2013).

## CONCLUSIONS

The discovery of novel bioactive compounds and biocatalysts is thereby hugely important and is still presenting a major challenge to researchers. Though metagenomic approaches have identified a number of novel genes encoding cellulolytic, pectinolytic, proteolytic, lipolytic enzymes, and so forth and many interesting novel enzymes have been discovered, the fact remains that the majority of biocatalysts are still uncharacterized. Further, since the functional heterologous expression of genes from unculturable microbes is not always successful, approaches like metatranscriptomics and stable isotope probing (SIP) could be adapted for the high resolution identification in the hunt for novel biocatalysts. Considering the wealth of opportunities offered by the ever-increasing sequencing power that allows studies ranging from community mining to elucidating expression circuitries and protein functional analyses, we can only expect an ever-increasing pile of information on known and novel antimicrobials. The interplay of bacteria with their environment, with other organisms and with hosts (e.g. gut microbiota, plant microbiota) will certainly involve antimicrobials of all sorts, and assessing their role in population dynamics will be an important area of research in the coming decade. Moreover, synthetic biology and novel chemistry approaches will enable the production of new-to-nature compounds to fight the increasing and important problem of antibiotic resistance in major human pathogens. A combination of mining approaches at all levels, followed by biochemical and pharmaceutical studies, will be greatly beneficial to find the solutions for major societal problems ahead.





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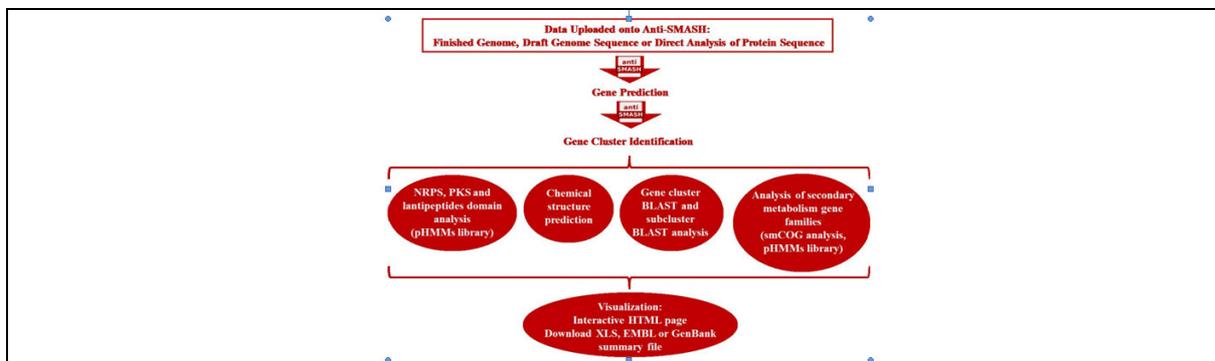


Figure 5. How AntiSMASH works. AntiSMASH is used for the detection of secondary metabolites. Abbreviations: pHMMs library: profile hidden Markov models composed of protein sequences of experimentally characterized biosynthetic enzymes; smCOGs: secondary metabolite-specific clusters of orthologous groups.

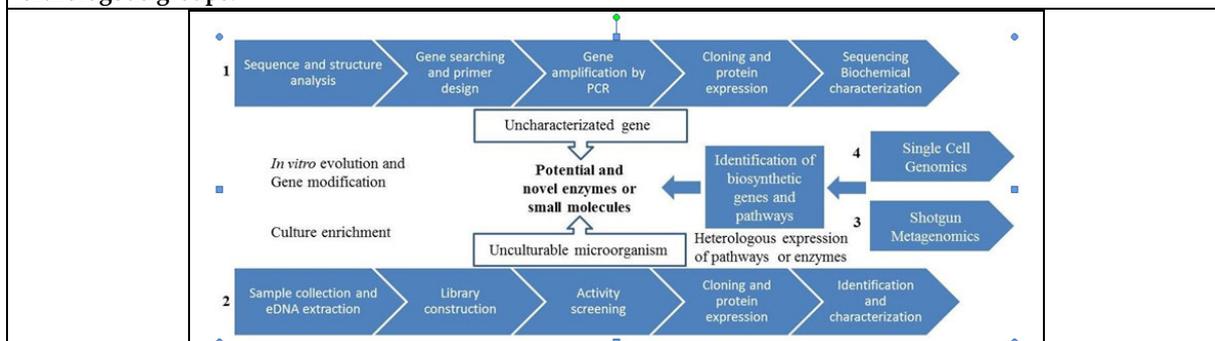


Figure 6. Metagenomic approaches for the discovery of novel biocatalysts or small molecules. (1) Sequence-based screening; (2) Functional-based screening; (3) Shotgun metagenomics and (4) Single cell genomics.





## Prediction of Cataract from Retinal Fundus Images using Gradient Boosting Algorithm

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### ABSTRACT

Early detection of cataract is considered as an important solution to prevent the vision loss. An automatic detection of cataract is proposed in this work with the help of machine learning algorithm such as Gradient Boosting algorithm and Support Vector Machine (SVM). The main aim is to examine the fundus images to detect whether an eye is healthy or affect with cataract. Histogram of gradient makes the job easy as it directly identify the white layer present in an eye, which is responsible for cataract. The cataract identification is carried out with image processing using python machine learning libraries. The classification of the input image verify the percentage of cataract affected area of an eye. This proposed system is modeled and tested with a dataset of 800 images with a ratio of 80:20 and has achieved an average accuracy of 95% using gradient boosting algorithm, this verify the usage of the system in real world scenario.

**Keywords:** Image processing; Augmenting; Pre-processing; classification; Gradient Boosting; Support Vector Machine (SVM).

### INTRODUCTION

A Cataract is a clouding of eye' lens that affects vision, blurry vision, trouble seeing at night and double vision in the affected eye. Most of the cataract is related to aging. A Cataract can affect either in one or both the eyes [1]. The current observation tests & cures are really high [2]. Cataract is detected by looking at the lens of the human eye, Computer processing of a Fundus image provide us with necessary detail such as affected areas & the overall percentage of affection [3]. There are a lot of causes of cataracts-smoking, an overproduction of oxidants, long-term use of medications & steroids, ultraviolet radiation & certain diseases, such as diabetes. Cataract can be divided mainly into 3 types- Nuclear cataracts, Cortical cataracts & Posterior capsular cataracts as shown in [figure-1]. Out of these Posterior capsular cataracts is the faster and affect the back of eye' lens.



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Nuclear cataracts form in middle of the lens. It colors the Centre (nucleus) of the eye. It affect vision leading to blurring of vision. A cortical cataract is wedge-like opacities that start to grow in the periphery of the lens and work its way to the center. This occurs in the lens cortex, which is the part of the lens that surrounds the central nucleus. Posterior capsular cataracts (PSC) are located in the most posterior cortical layer, back of the eye, under the lens capsule. This occurs to younger patients and affect vision and can live permanently. In this literature, An Automatic model is developed for detection of Cataract using machine learning and image processing techniques. To build the model a set of retinal images captured through a fundus image are taken as inputs. The classifier building procedure includes three parts pre-processing, feature extraction, and classifier construction. Preprocessing step, the RGB image is converted into green channel image and by applying image processing techniques, the contrast is enhanced and noise is removed. Then from the resultant image, features of retina are extracted by means of various operators and algorithms. Based on extracted features, classification step is carried out. Based on the degree of the image, the patient is classified into normal or affected. These set of extracted features are used to define the classifier by using 2 machine learning technique Support vector machine (SVM) & Gradient Boosting. This paper has been organized into five sections. Section-2 gives details about the related works that has been done in past, Section-3 demonstrates the proposed system and its methodology. Section-4 provides analysis of results. Finally, Section-5 concludes this study.

**Related Work**

Many works of literature have been done in the past, for the detection of cataract using diverse methodologies and techniques. Many model has been also done for not only just cataract but also for other eye diseases such as glaucoma [4]. Welfer D, Scharcanski J had written an article on A two-stage approach for automated optic disk detection for fundus image .The approach is very simple and is an easy to understanding of cataract detection as it only verify the presence of cataract and not the level of it [5]. J Nayak had developed an image processing model using SVM for normal and final stage of cataract detection [6]. Almost 180 images were taken for this experiment. Then used different machine learning methods to reduce mean intensity of the images. Features like small ring area were extracted and then provided to SVM model for classification.

They found an accuracy of 91%. M.Yang created a model for the cataract classification using back propagation neural network. A total of 504 images were obtained from real life patient and was used in this experiment. The green channel from the combination RGB was used for the clear contrast between regions of interest. The author used top-bottom hat transformation for more clear view of blood vessel and foreground .Author used a method known as trilateral filter to reduce noise in fundus images. The final categorization was done on the basis of severity. F.Wan developed a classification model having 4 Techniques for the best possible result. The paper was focus on PCA .Approx. 445 images were used. Here also top down hat transformation was used for the better extraction expectance He use SVM, Gradient boosting, Random forest and Logistic regression for the best outcome possible. Final classification was done into 2 category-, normal or Cataract [7].The best accuracy came from Gradient Boosting and SVM which was more than 90% [8]. J.J. Yang et al. presented a model .A total of 1239 images were used for this model. IN initial preprocessing stage all images were resized & green channel of RGB was consider for this model. Histogram equalization was used for the model. SET sketch, Wavelet and texture features were the consideration for the feature extraction they used trilateral filter for noise reduction [9].The author used SVM as well as back propagation for the model. The final accuracy came to be 93.2% [10].

**METHODOLOGY**

The Defined Model has four different phases.

**Assemblage and Selection of images:**

Total of 800 images were collected from various sources containing 500 cataract affected image and 300 normal images .Most of them were collected from kaggle and GitHub repository. The images are in JPG and PNG format.





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### Preprocessing of retina image using Open cv

Conversion of digital image into multiple segments pixels set, Image segmentation sorts pixels into larger components, eliminating the need to consider individual pixels as units of observation. Here we have used a histogram to group pixels based on “gray levels”. Simple images consist of an object and a background. The background is usually one gray level and is the larger entity. The RGB format is transformed to HSI (Hue, Saturation and Intensity). HIS conversion is based on set of parallel and sequential partially automated methods.

### Feature Extraction

In this stage, we have to extract some features from retinal fundus images to describe or detect the cataract diseases. A cataract condition consists of a whitish color that appears inside the pupil. This condition can be distinguished from normal condition that has not a whitish color inside the pupil, the feature extraction method uses statistical texture analysis from the extracted image will be distinguished normal and cataract condition affected by the exhibit of the whitish color inside the pupil. Extraction method that is proposed in this research uses GLCM (Gray Level Co-occurrence Matrix) method in getting the features.

### Building the Model

Finally the model is trained and tested with two well-known machine learning techniques.

### Gradient boosting

Gradient boosted trees utilize a *boosting* approach. Decision trees are usually used as that of random forest algorithm when doing gradient boosting. It uses a unit of models (decision trees) to reduce variance, boosting starts off with a high-bias, weak learner, and then uses the remaining from a defined objective function to repeating build trees which improve upon the loss of previous trees [11]. It can build a model on all of its input features. It is effective at classifying complex datasets having a lot of features to keep track on.

### SVM

SVM grant a high accuracy compared to other classifiers as decision trees. It is famous for the way it handle nonlinear input spaces using its kernel tricks. It is used in face detection, intrusion detection, classification of genes, and handwriting recognition. The classifier separates data points using a largest amount of margin by hyper plane. SVM finds an optimal hyper plane for the classifying new data points. It is able to easily handle multiple continuous and categorical variables. SVM generates optimal hyper plane in an iterative manner to minimize an error. The idea of SVM is to find a maximum marginal hyper plane (MMH) that best divides the provided dataset into different categories [12]. Classification is a final step of cataract identification process. After features selection process, we have to classify the obtained features as the degrees of affected areas [13].

## RESULT AND DISCUSSION

The two different models are tested with 200 test images out of which 150 are cataract affected and 50 are normal. The performance of the classifiers evaluated in terms of sensitivity, specificity, overall accuracy and F1 score as shown in [table-1]. The ROC curve shown in [Figure-7, 8] presenting the tradeoff between sensitivity and specificity. X-axis of the graph shows Specificity also known as False Positive rate and Y-axis shows the sensitivity known as True Positive Rate

## CONCLUSION

From the observed results generated by different models it is concluded that, Gradient boosting algorithm is fitting better with the underlying dataset in comparison SVM for detection of cataract with a high accuracy value 95%. In future this work can be extended to detect cataract along with its state using a multi class classifier.





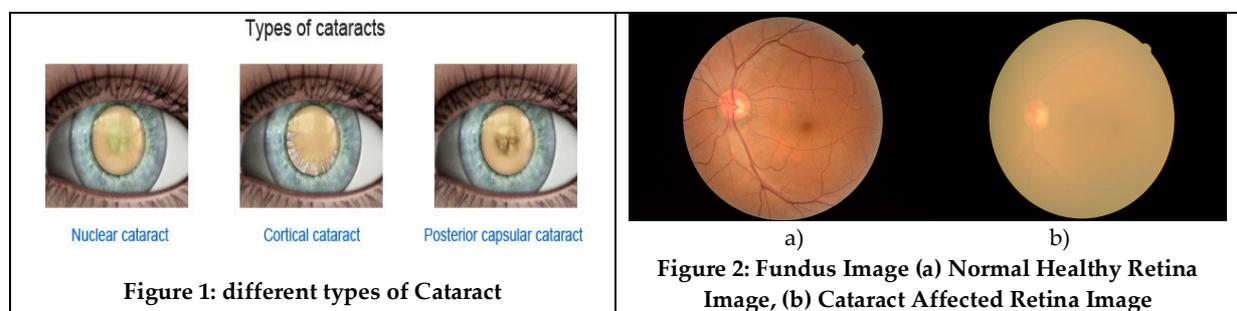
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**Table 1: Accuracy Comparison matrix**

Performance/Techniques	SVM	Gradient Boosting
Accuracy	85.6%	95 %
Sensitivity	95%	100%
Specificity	91.66%	90.33%
F1 score	90%	95%





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Figure3: a) Original Retinal image, b) gray Image, c) HIS image



Figure4: Gray level Feature extraction

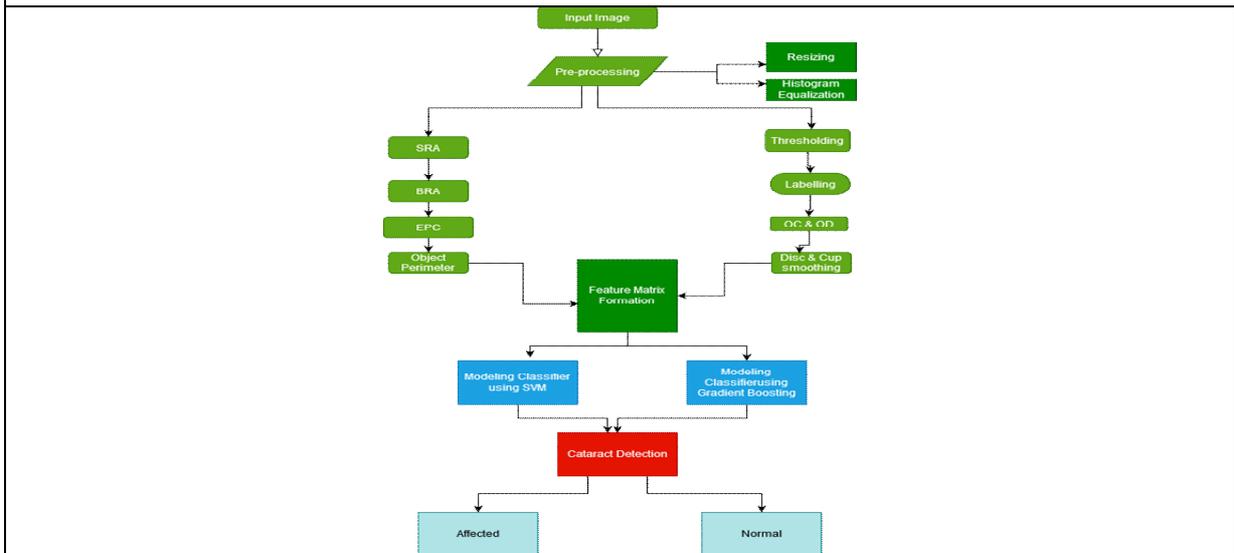


Figure 5: Flow Diagram of the Model

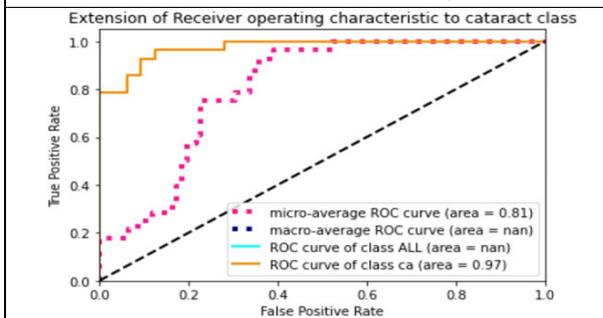


Figure-6: ROC Curvefor SVM

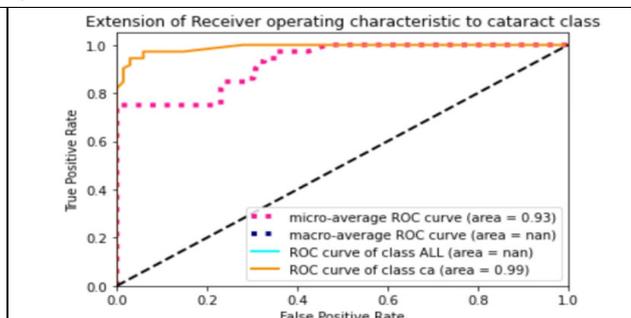


Figure-7: ROC Curvefor Gradient Boosting





## Fly Ash as a Possible Source of Silicon and Potassium to Mitigate Incidence of Brown Plant Hopper in Rice under Flooded Condition

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### ABSTRACT

Experiment was carried out under induced flood stress to analyse the effect of fly ash on certain major pests of rice *viz.*, Brown plant hopper. The population of BPH were assessed at regular intervals on plants imposed with treatments including fly ash, Silicate Solubilizing Bacteria (SSB), Farm yard manure (FYM), and graded levels of soil test based potassium. The results revealed that the combination of Fly ash, SSB, FYM, with graded level of soil test based potassium significantly reduced the incidence of Brown plant hopper as compared to untreated plots. The silicon content was analysed in the leaf blade and leaf sheath cum stem and it was negatively correlated with the insect population. As the age of the plant increased, silicon content proportionately increased in the plants at different growth stages. The main cause for the death of insects due to fly ash application was wearing of mandibles and main feeding organs of insects which resulted in functionless mandibles so that the insects of paddy die without food. Further, the incidence of major insects was negatively correlated with yield. Application of fly ash as a source of silica and potassium with SSB, FYM with STBK reduced the incidence of Brown plant hopper, Green leaf hopper, Stem borer and increased the yield in rice.

**Key words:** fly ash, silica, Brown plant hopper, Green leaf hopper, Stem borer





## INTRODUCTION

Rice is known as Si accumulator, the plants benefit from Si nutrition thereby mitigate biotic (pests and diseases) and abiotic stress (flood) in rice. It is estimated that the rice crop producing a grain yield of 5 t ha<sup>-1</sup> will normally remove from soil of 230 to 470 kg Si ha<sup>-1</sup>. Salim and Saxena (1992) found that at higher levels of silicon, metamorphosis of plant hopper to nymphs to adult was reduced and there was a decrease in adult longevity a female fecundity. It has been reported that silicon suppresses insect pests such as the stem borer, brown plant hopper, green leafhopper, white backed plant hopper, and non-insect pests such as spider mites (Ma and Takahashi, 2002). Silica content in the plant is reported to play an important role in strengthening the cell walls of the plants and enhances resistance to both pests and diseases in the field (Qin and Tian, 2004). Chandramani *et al.* (2009) reported that the combination of FYM, biofertilizers, lignite fly ash and neem cake applied in splits reduced gall midge, stem borer and leaf folder and increased the content of Si and potassium in plants which induced resistance to pests in plants. Hence silicon content in rice plant was found to be negatively correlated with the incidence of brown plant hopper, green leaf hopper, and stem borer.

Fly ash is a major industrial waste in India. It is a by-product of thermal power station where electricity is produced by burning finely powdered coal. In India around 12.21 M t of fly ash is produced every year and for storing one tonne of fly ash, 0.35 m<sup>2</sup> area is required. This huge quantity of fly ash produced is dumped in ash disposal areas which are posing a great threat to the environment. Fly ash contains 0.2 to 3.0 per cent potassium and 15-60% SiO<sub>2</sub>. Silicon and K are considered most important nutrient elements in conferring resistance to biotic stresses *viz.* insect pests, nematodes and diseases and abiotic stresses *viz.* drought, lodging, salinity, water logging, and nutrient imbalances in soil. Potassium is also responsible for improving the quality of produce. In an attempt to effectively solve the disposal problem of the enormous solid industrial waste, some efforts have been made to use it as an amendment to improve soil fertility, reduce pest incidence and increase yield.

## MATERIALS AND METHODS

Field experiment were conducted under induced flood condition in split plot design with two replications. The plot size was 5x4 m<sup>2</sup> with 4 main plot treatments and 5 sub plot treatments. The main plot treatments, M<sub>1</sub> – Control (0 fly ash), M<sub>2</sub> – fly ash @ 25 t ha<sup>-1</sup> + silicate solubilizing bacteria (SSB) @ 2 kg ha<sup>-1</sup>, M<sub>3</sub> - fly ash @ 25 t ha<sup>-1</sup> + Farm yard manure (FYM) @ 12.5 t ha<sup>-1</sup>, M<sub>4</sub> - fly ash @ 25 t ha<sup>-1</sup> + (SSB) @ 2 kg ha<sup>-1</sup> + FYM @ 12.5 t ha<sup>-1</sup> were followed and subplot treatments were graded level of soil test based Potassium (STBK), S<sub>1</sub> - Control, S<sub>2</sub> - 25 % STBK, S<sub>3</sub> - 50 % STBK, S<sub>4</sub> - 75 % STBK, S<sub>5</sub> - 100 % STBK. The fly ash was applied before transplanting followed by incorporation of silicate solubilizing bacteria and farm yard manure. The rice variety BPT 5204 was selected for field experiment. The observations of pests were observed under natural condition. The incidence of brown plant hopper was recorded in 10 hills selected at random in each plots at 15 days interval and stem borers are measured as percentage of dead heart before flowering and percentage of white ear after flowering as below.

$$\text{Stem borer damage as dead heart/ white ear (\%)} = \frac{\text{Number of affected tillers/meter}^2}{\text{Total number of tillers/meter}^2} \times 100$$

The rice plant samples are randomly selected from each experimental plot and analysed for silicon content in different parts *viz.*, leaf blade, leaf sheath cum stem and ear head at tillering, panicle initiation and flowering stage.

### Estimation of Silicon in plant samples

The powdered samples of different parts of rice plant *viz.*, leaf blade, leaf sheath cum stem, ear head, were dried in an oven at 70 °C for 2-3 hrs prior to analysis. A 0.1 g sample was digested in a mixture of 7 ml of HNO<sub>3</sub> (62 per cent), 2 ml of hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) (30 per cent) and 1ml of hydrofluoric acid (46 per cent) kept in for 10-15 min for pre-digestion.



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The samples were digested using microwave digester (Microwave reaction system Antonpaar Multiwave 3000 solv) with following program 500 watt for 17 minutes with a ramp at 10 °C per minute to reach the temperature of 150 °C, 500 watt for 10 minutes for holding the temperature of 150 °C and venting for 10 minutes. The digested samples were diluted to 50ml with 4 % boric acid (Ma et al., 2002).

The Si concentration in the digested solution was determined by transferring 0.1 ml of digested aliquot to a plastic centrifuge tube, added with 3.75 ml of 0.2 N HCl, 0.5 ml of 10 per cent ammonium molybdate and 0.5 ml of 20 per cent tartaric acid and 0.5 ml of reducing agent 1- amino -2- naphthol- 4- sulfonic acid (ANSA) and the volume was made up to 12.5 ml with distilled water and kept it for one hour. After one hour, the absorbance was measured at 600 nm with a UV- Visible spectrophotometer. Similarly, standards (0, 0.2, 0.4, 0.8, and 1.2 ppm) were prepared by using 1000 ppm, by following the same procedure. The stock standard of silica was obtained from Merk. The data obtained from field experiments were subjected to statistical scrutiny (Snedecor and Cochran, 1967) and the analysis was carried out in Agres Agdata. Square root transformation was followed for converting the population numbers. The treatment means were compared by Duncan's Multiple Range Test (DMRT) at p=0.05 for their significance (Gomez and Gomez, 1985).

**RESULTS**

The results (Table 1) on the incidence of important pests due to the application of fly ash + SSB +FYM+ STBK were represented below. The mean BPH population was low (0.15/ tiller) in the plots treated with fly ash with SSB and FYM with 100 % STBK which was on par with 75% STBK over control (0.4/ tiller) when compare to other treatments at tillering stage. At panicle initiation stage the plots treated with fly ash with SSB and FYM with 100 % STBK recorded the low mean BPH population of (0.1/ tiller) over control (0.35/ tiller) which was on par with 75% STBK. Similarly in flooded condition no BPH population was observed in the plots treated with fly ash with SSB and FYM with STBK over control (0.4/ tiller) when compare to other treatments. At panicle initiation stage the plots treated with fly ash with SSB and FYM with 100, 75, 50 % STBK recorded no BPH population whereas control recorded (0.45/ tiller).

**Silicon content in rice**

The results revealed that the application of fly ash increased the silicon content in rice. The mean Si content of 1.84 per cent in leaf sheath cum stem was recorded due to the addition of fly ash with SSB and FYM over control which recorded 1.64 per cent in leaf sheath cum stem in drought condition and in flood condition 1.63 per cent in leaf sheath cum stem was registered by the addition of fly ash with SSB and FYM. The control recorded the lowest content of 1.44 in leaf sheath cum stem.

Among the graded levels of STBK, the highest mean silicon content of 1.96 per cent in leaf blade and 1.76 per cent in leaf sheath cum stem was recorded due to the addition of 100 per cent K over control. At panicle initiation stage, the treatment effect of fly ash with SSB and FYM showed significant difference and recorded the mean Si content of 2.51 per cent in leaf blade and 1.96 per cent in leaf sheath cum stem over control which recorded 2.27 per cent in leaf blade and 1.77 per cent in leaf sheath cum stem. Among the graded levels of STBK, the highest mean silicon content of 2.40 per cent in leaf blade and 1.88 per cent in leaf sheath cum stem was recorded due to the addition of 100 per cent K.

**DISCUSSION**

The incidence of brown plant hopper was noticed during tillering, panicle initiation and flowering stage respectively. The treatment effect of fly ash with SSB and FYM with 100 % STBK on incidence of Brown plant hopper showed per cent reduction of 37.5 per cent at tillering and 22.2 per cent at panicle initiation stage in drought condition. (FIG 1 &



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2). The pest incidence was reduced due to the soluble silicic acid present in the fly ash enhanced the Si uptake in plant which inhibits the feeding activity of BPH and also due to the antibiosis mechanism due to defensive chemicals like phenol (Meyer and Keeping, 2005)

The higher levels of silicon and phenolic compounds play important role in the metamorphosis of plant hopper to nymphs to adult was reduced and there was a decrease in adult longevity and female fecundity (Rajeshwari, 2000). The results of the present study revealed that the combination of fly ash with SSB and FYM with 100 % STBK significantly reduced the incidence of stem borer (46.7%) at flowering stage compared to control under drought condition whereas, under flooded condition stem borer incidence of 70 per cent at flowering stage was observed. This was due to the application of fly ash that enhances Si and K content results in the damage of mandibles of larvae of the rice stem borer. The results were in consonance with the findings of Djamin and Pathak (1967). Chandramani et al. (2009) reported that the main cause for the death of insects due to fly ash application was wearing of mandibles and main feeding organs of insects which resulted in functionless mandibles so that insect like leaf folder, stem borer die without food. Hence the application of fly ash with SSB and FYM significantly increased the silicon content at different growth stages and deposition of silicon in the leaf sheath cum stem reduced the incidence of brown plant hopper, green leaf hopper, and stem borer. In conclusion silicon is beneficial to plant growth and helps plants to overcome abiotic and biotic stresses and increasing resistance to pests and diseases, as well as other stresses.

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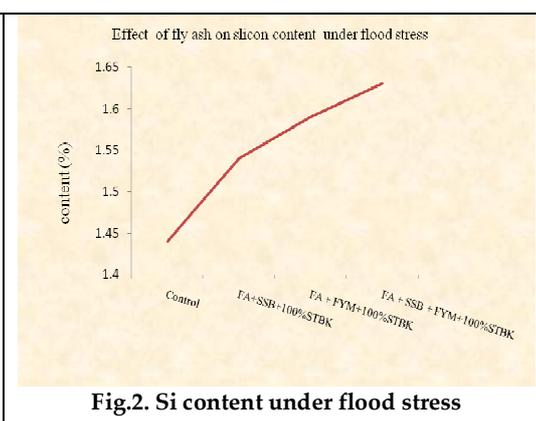
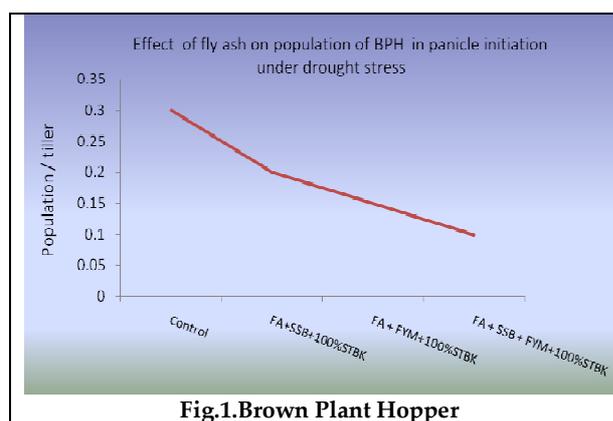
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**Table 1. Effect of fly ash with SSB + FYM with soil test based K on incidence of BPH in different growth stages of rice\* under drought stress**

Treatments	Incidence of BPH				
	Tillering		BPH Panicle initiation		
	Drought	Flooded		Drought	Flooded
Control	0.4 (0.63)	0.4 (0.63)		0.45 (0.66)	0.45 (0.67)
FA@25 t ha <sup>-1</sup> + SSB + FYM +0 % STBK	0.2 (0.447)	0		0.35 (0.59)	0.1 (0.32)
FA@25 t ha <sup>-1</sup> + SSB + FYM +25% STBK	0.2 (0.447)	0		0.2 (0.447)	0.1 (0.32)
FA@25 t ha <sup>-1</sup> + SSB + FYM +50% STBK	0.2 (0.447)	0		0.15 (0.381)	0
FA@25 t ha <sup>-1</sup> + SSB + FYM +75% STBK	0.15 (0.381)	0		0.2 (0.447)	0
FA@25 t ha <sup>-1</sup> + SSB +FYM+100% STBK	0.15 (0.381)	0		0.1(0.316)	0
SEd	0.032	0.05		0.047	0.02
CD(P=0.05)	0.096	NS		NS	0.06

\*Mean of two replications @ Values in parentheses are square root transformation





## Air Quality Prediction by Machine Learning Technique

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### ABSTRACT

Air pollution refers to harmful toxins into the atmosphere that are very much dangerous to human beings. Many living beings as well as non-living beings also get suffered due to this pollutant like it causes severe damage to crops, forests also. To take precautions of this problem, it is very much important to predict quality of air using machine learning techniques. Subsequently, assessment of air quality and prediction is most significant in research fields. Air quality dataset is preprocessed with respect to univariate, bivariate and multivariate analysis. Take care of missing values, data validation and data cleansing are also done. The performance of various machine learning algorithms is analyzed by comparing with Precision, Recall and F1 Score respectively. Decision Tree algorithm works very well and giving very good result for predicting air quality. This paper can be beneficial for the meteorological Department.

**Keywords:** Linear; Lasso; Decision Tree Regression

### INTRODUCTION

With economic development, population also increase in cities. Environmental pollution problems include air pollution, noise pollution and water pollution required a great attention. By these air pollutions, it directly impacts on human health through exposure to pollutants and has resulted to severe issues. So, public awareness should be increased all over the world regarding reduction of air pollution. Air pollution caused by power plants, residential heating, various manufacturing industries, fuel running vehicles, and also natural disasters. Human health suffered due to air pollution which is one of the major effects of air pollution, especially in urban areas. Anthropogenic greenhouse gas emissions lead to global warming which is a long-term consequence of air pollution. Perfect air quality forecasting can reduce the effect of rise in pollution in this ecosystem. Hence improving air quality prediction is a crucial goal.





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“Air quality” in our surrounding means the quality of the air present our surrounding. Good air quality refers to cleanliness of air, free from pollutants such as smoke, dust and other gaseous impurities in the air. Air quality is determined by assessing a variety of pollution indicators. Good air quality is a requirement for preserving the exquisite balance of life on earth for humans, plants, animals and natural resources. Human health, plants, animals and natural resources are getting threatened when pollution in the air reach high concentrations. Poor air quality can affect and harm human health and to the environment. Air quality can be degraded by natural or man-made sources. Natural sources include volcanic eruption, windstorm dust. Man-made source include pollution from moving vehicles, toxic gases from industries, coal powered plants, burning wood or other material in open air. Both these sources can seriously affect the overall air quality and can lead to severe health problems for humans.

An air quality model is a numerical tool used to describe the causal relationship between emissions, meteorology, atmospheric concentration, deposition and other factors. It can give a complete deterministic description of the air quality problem. The most commonly used air quality models built upon regression. In this section, different models and their applications will be introduced. This paper is divided into five sub section i.e. 1. Introduction, 2. Related work, 3. Methodology, 4. Result Analysis for Model Evaluation and last section is 5. Conclusion.

### Related Work

Related Work is an import part to get referral from various existing paper. So, Some researched paper is studied and analyzed for this respective paper. [1] Air quality prediction in Milan: feed-forward neural networks, pruned neural networks and lazy learning by Corani and Giorgio. [2] Identifying pollution sources and predicting urban air quality using ensemble learning methods by Kunwar P. Singh, Shikha Gupta and Premanjali Rai. [3] Deep learning architecture for air quality predictions by X Li, L Peng, Y Hu, J Shao and T Chi. [4] Big data and machine learning approaches by GK Kang, JZ Gao, S Chiao and S Lu. [5] Applying machine learning techniques on air quality data for real-time decision support by IN Athanasiadis, VG Kaburlasos and PA Mitkas. [6] A deep learning model for air quality prediction in smart cities by I Kok, MU Simsek and S Ozdemir. [7] Short-term air quality prediction using a case-based classifier by E Kalapanidas and N Avouris. [8] Data classification for air quality on wireless sensor network monitoring system using decision tree algorithm by B Sugiarto and R sustika.

### METHODOLOGY

There are four important stages that are proposed in this model: Data acquisition, Data processing and Model Building using Different ML Techniques like Linear Regression, Lasso Regression and Decision Tree Regression and at last Model Evaluation is done as shown in [Fig-2].

### Data Collection

For this respective model building data is acquired from Github repository which has a great collection of datasets for performing many machine learning analysis and model building. The dataset contains 9358 instances of hourly averaged responses from an array of 5 metal oxide chemical sensors embedded in an Air Quality Chemical Multisensor Device. The device was located on the field in a significantly polluted area, at road level, within an Italian city. Data were recorded from March 2004 to February 2005 (one year) representing the longest freely available recordings of on field deployed air quality chemical sensor devices responses. Ground Truth hourly averaged concentrations for CO, Non Methanic Hydrocarbons, Benzene, Total Nitrogen Oxides (NO<sub>x</sub>) and Nitrogen Dioxide (NO<sub>2</sub>) and were provided by a co-located reference certified analyzer. Evidences of cross-sensitivities as well as both concept and sensor drifts are present as described in De Vito et al., Sens. And Act. B, Vol. 129,2,2008 (citation required) eventually affecting sensors concentration estimation capabilities. Missing values are tagged with -200 value. This dataset can be used exclusively for research purposes. Commercial purposes are fully excluded.





### Preprocessing

The acquired data contain missing values, inconsistent data and repeated data. To avoid improper prediction result, data cleansing must be done, missing values must be taken care by filling mean values. Redundant data must be eliminated. Classification and clustering algorithms will work efficiently if all this preprocessing is taken care of.

### Construction of a Predictive Model

For making good predictive model, data pre-processing is most essential. Prediction fails due to raw data in the dataset. So, data cleansing is required before training and model is tuned with different parameters for better accuracy. Here are three types of algorithms used for different predictive models for comparison purpose and resultant in getting a better predictive model for air quality. These are

- Linear Regression
- Lasso Regression
- Decision Tree Regression

### Linear Regression

Linear equation takes combination of specific input values ( $x$ ) and the solution ( $y$ ) for the set of input values ( $x$ ) to predict output. As such, both the input values ( $x$ ) and the output value ( $y$ ) are numeric. One scale factor is assigned to each input value or column of linear equation, called a coefficient and represented by the capital Greek letter Beta ( $B$ ). Another coefficient is also added, giving the line an additional degree of freedom and is often called as the intercept or the bias coefficient. For example, in a simple regression problem (a single  $x$  and a single  $y$ ), the form of the model would be:

$$y = B_0 + B_1 * x \quad (1)$$

In higher dimensions when it has more than one input ( $x$ ), the line is called a plane or a hyper-plane. The representation therefore is the form of the equation and the specific values used for the coefficients (e.g.  $B_0$  and  $B_1$  in the above example). It is common to talk about the complexity of a regression model like linear regression. This refers to the number of coefficients used in the model. When a coefficient becomes zero, it effectively removes the influence of the input variable on the model and therefore from the prediction made from the model ( $0 * x = 0$ ). This becomes relevant if you look at regularization methods that change the learning algorithm to reduce the complexity of regression models by putting pressure on the absolute size of the coefficients, driving some to zero.

### Lasso Regression

Lasso regression is an example of regularized regression. Regularization is one approach to tackle the problem of over-fitting by adding additional information, and thereby shrinking the parameter values of the model to induce a penalty against complexity. The 3 most popular approaches to regularized linear regression are the so-called Ridge Regression, Least Absolute Shrinkage and Selection Operator (LASSO) and Elastic Net method. Suppose a regularized regression model on a dataset with  $n$  observations and  $m$  features. Lasso regression is an L1 penalized model where it simply adds the L1 norm of the weights to least-squares cost function:

$$J(w) = \sum_{i=1}^n (y_i - \hat{y}_i)^2 + \alpha \sum_{j=1}^m |w_j| \quad (2)$$

Where

$$\hat{y}_i = w_0 + \sum_{j=1}^m X_{ij} w_j \quad (3)$$





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## Decision Tree Regression

A decision tree is a flowchart-like structure in which each internal node represents a test on a feature (e.g. whether a coin flip comes up heads or tails), each leaf node represents a class label (decision taken after computing all features) and branches represent conjunctions of features that lead to those class labels. The paths from root to leaf represent classification rules. Below Fig.3 is the diagram illustrate the basic flow of decision tree for decision making with labels (Rain(Yes), No Rain(No)). The above three figures Fig. 4, Fig. 5 and Fig. 6 are the representation for comparison between Linear Regression, Lasso Regression and Decision Tree Regression. The linear regression gives 0.9288505701939468 accurate value, Lasso regression gives 0.8424337687413078 accurate value and Decision Tree regression gives 0.9964315525768502 accurate value. Hence Decision Tree Regression gives more accurate result than both Linear and Lasso Regression. The below fig. 7 is the combination of all Linear, Lasso and Decision Tree Regression predictions.

## CONCLUSION

It began with information cleansing, record processing, detailed evaluation and then model construction and prediction is done. The best accuracy for test set is acquired by decision tree method by comparing with accuracy of other two regression methods. The future work is to automate the prediction result in web application or desktop application and also optimization of the work in Artificial Intelligence environment to be done".

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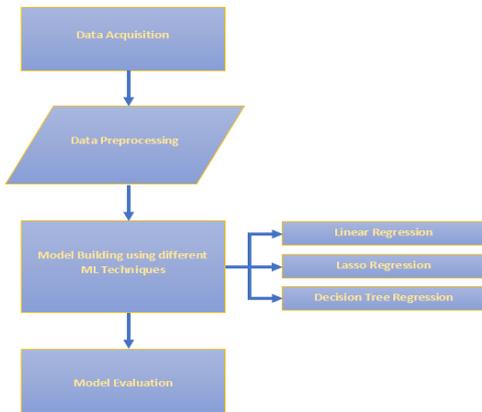


Fig. 1 Flow diagram of the proposed model

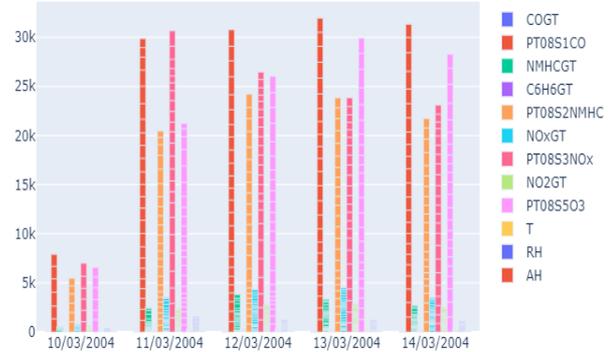


Fig. 2 is representation for 12 categories of gasses in the atmosphere for 5 time lapse of 4 dates.

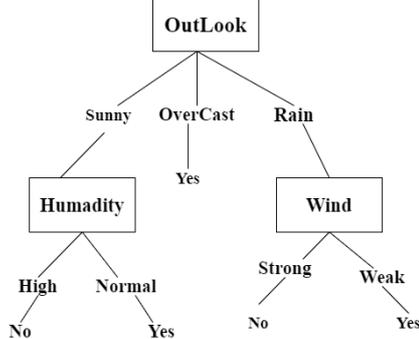


Fig.3 the basic flow of decision tree

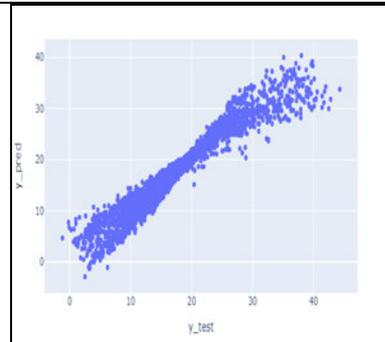


Fig.4 Linear Regression

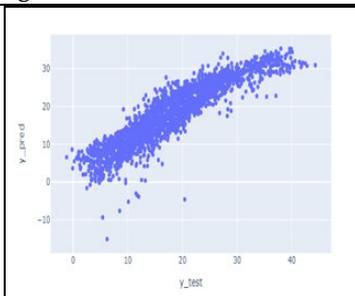


Fig.5 Lasso Regression

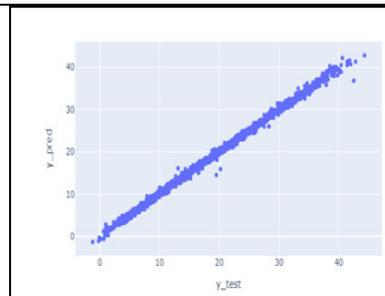


Fig.6 Decision Tree Regression

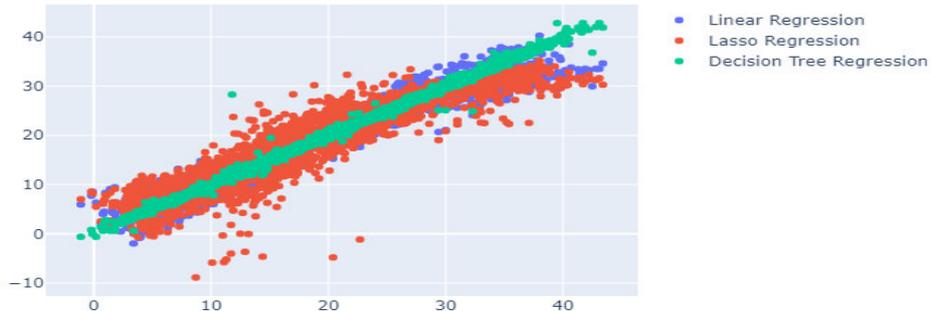


Fig. 7 is the combination of all predictions.





## Status and Delineation of Plant Available Silicon in Soils of Cauvery Delta Zone of Tamil Nadu, South India

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### ABSTRACT

The Cauvery Delta Zone is a rice bowl of Tamil Nadu where the rice is being intensively cultivated season by season. Being silicicolous monocot rice exhausts large quantity of silicon from soil and accumulates in different parts led to decline in soil available Si year after year. Therefore an investigation was carried out to assess the status of plant available soil silicon in Cauvery Delta Zone of Tamil Nadu, South India. The surface soil samples have been collected from different locations of Cauvery Delta Zone using GPS coordinates. The soil properties viz., pH, EC, organic carbon, CEC were analysed and results were correlated with N NaOAc (pH 4.0) extractable Si. The results revealed that availability of Si is positively correlated with the soil reaction. Among the totally analysed samples (82) sample No.9 with pH 9.3 resulted higher availability of soil Si (324 ppm) and vice versa. The linear decreasing trend of plant available soil silicon has been arrived with decreasing soil pH. The soils of Cauvery Delta Zone revealed 62 per cent of samples as low in available soil silicon status and 21 per cent were high in silicon status. The organic carbon status of soils was 32.9 per cent as low, 32.9 per cent as medium and 34.1 per cent as high. The average organic carbon content was 0.68 per cent however no significant correlation was observed with available Si. On an average the soils of Cauvery Delta Zone where rice is a core crop showed N NaOAc (pH 4.0) extractable available silicon of 69.94 ppm (low). Hence depleted soil silicon status should be replenished to maintain the crop yield before the limit of abiotic and biotic stresses exceeds economic threshold level.

**Key words:** plant available soil silicon; Cauvery Delta Zone; intensive rice cultivation

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## INTRODUCTION

Rice is a silicicolous plant that absorbs Si in the form of mono silicic acid ( $H_4SiO_4$ ) through active aerobic respiration and accumulates large amount that several fold greater than those of other macronutrients from the growing medium. Although Si is not an essential nutrient element, it is considered essential for rice, maize, sugarcane and other graminaceous plants. It is estimated that nearly 20 kg of  $SiO_2$  is removed from the soil by the rice for producing 100 kg brown rice. Total Si removed by rice grown in an inceptisol varied from 205–611 kg Si ha<sup>-1</sup> (Prakash 2002). Though the exact role-played by Si in the nutrition of crops remain still obscure, its efficiency for normal growth of rice plants cannot be ruled out. Japanese scientists have carried out intensive research activities on Si nutrition in order to establish its role for the normal growth of rice. Although Si fertilization is not a standard practice in India, the beneficial role for the application of Si in increasing the yield of rice was evident through such studies. In addition, Si depletion can occur in traditional rice soils from the continuous monoculture of high yielding varieties with intensive cultural practice especially if farmers are not replacing the Si removed by rice (Miyake, 1993). The amount of Si available to plants in soil is very small and varies with different soils. However, concentration of Si in the solution increases after flooding as well as with organic matter of the soil. (Ponnamperuma, 1984). Hence investigation has been carried out to delineate the status of plant available soil Silicon in intensively rice growing Cauvery delta zone of Tamil Nadu.

## MATERIALS AND METHODS

The soil samples from 82 locations were collected from different rice growing areas of Cauvery Delta Zone viz. Thanjavur, Thiruvarur, Nagapattinam, Trichy districts of Tamil Nadu using GPS coordinates for easier positioning. The soil samples were processed and analysed for available Si and other soil properties viz. soil texture pH, EC, Organic Carbon and Cation Exchange Capacity for their correlation with available Si. The pH and EC were determined by using Elico pH and EC meter. The soil organic carbon was estimated by Walkley and Black method as outlined by Jackson (1973). The CEC was determined by using  $NH_4OAc$  displacement subsequent distillation as per the procedure given by Jackson (1973). The soil available Si was estimated by using N NaOAc (pH 4.0) extractant colorimetrically.

## RESULTS

As a part of present investigation 82 samples were collected from intensively rice growing areas of Cauvery delta zone. The surface soil samples have been collected from different locations of Cauvery delta zone using GPS to find out the latitude, longitude and altitude of the location and enable to assess the soil available Si after certain year to find out the depleted level. The soil properties viz., pH, EC, organic carbon, CEC and soil texture were analysed and results correlated with N NaOAc (pH 4.0) extractable Si. The results revealed that availability of Si is positively and significantly correlated with the soil reaction. Among the totally analysed samples (82) sample No.9 with pH 9.3 resulted higher availability of soil Si (324 ppm) and vice versa. The linear decreasing trend of plant available soil Si has been arrived with decreasing soil pH. The soils of Cauvery Delta Zone revealed that 62 per cent of samples were low in available soil Si status. Out of 82 samples only 21 % were high in Si status. Significant correlation was found between soluble salts concentration ( $dSm^{-1}$ ) and N NaOAc (pH 4.0) extractable Si. The organic carbon status of soils revealed 32.9 per cent as low, 32.9 per cent as medium and 34.1 per cent as high. The average organic carbon status was 0.68 per cent. The maximum soil CEC of 37 meq lit<sup>-1</sup> was observed in sample No. 42 in which soil Si was low and vice versa. The soil exchange capacity was negatively correlated with soil Si status, however the correlation was statistically not significant (Tables 1, 2, 3, & 4).



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Among investigated locations silty clay loam was prominent soil texture and occupied 52.5 per cent of soils followed by 18.3 per cent loamy sand, 15.8 per cent sandy loam and 13.4 per cent clay loam. The soil Si status was depleted in Cauvery Delta Zone due to intensive rice cultivation and long span of submergence in which sandy loam soils lies in first position with 69.2 per cent of low Si soils. Among silty clay loam, clay loam, loamy sand 67.4, 54.5 and 46.6 per cent soils were low soil Si status respectively. Among loamy sand soils 6.6 per cent registered the highest soil Si status followed by silty clay loam with 16.3 per cent. Irrespective of soil texture Si depletion was observed in Cauvery Delta Zone soils. On an average, soil in Cauvery delta zone showed N NaOAc (pH 4.0) extractable available Si of 69.94 ppm (low).

**DISCUSSION**

Delineation of soil silicon status in intensively rice growing areas of Cauvery delta zone revealed 62 per cent soil low in Si status which may be due to intensive rice cultivation (Lee, 2006). Among the totally analysed samples (82) sample No.9 with pH 9.3 resulted higher availability of soil Si (324 ppm) and vice versa. The linear decreasing trend of plant available soil silicon has been arrived with decreasing soil pH. Similar results were obtained by Korndorfer (2009). The pH was significantly correlated with N NaOAc (pH 4.0) extractable Si which may be due to rapid solubilisation of monosilicic acid at pH 8.0-9.0 from 2:1 clay as noticed by Goldberg and Glaubig (1986). Soils with pH range of 5.8-6.4 revealed low Si status which may due to additive impact of acidity and anions on Si release as showed by Wang (2004). As an exceptional case, sample No.2 though acidic in soil reaction showed medium soil Si status (108 ppm) which satisfies the results of Cheong (1982) and Jones and Handreck (1963) which may be due to decomposition of organic matter and production of mineral acids for solubilization of silica (Money, 1961).

Significant correlation was found between soluble salts concentration ( $dSm^{-1}$ ) and N NaOAc (pH 4.0) extractable Si which satisfies the results of Wickramasinghe and Rowell (2005) and Lin (1978). The average organic carbon status was 0.68 per cent which was slightly increased the soil Si status; however no significant correlation with soil Si was observed which satisfies the results of Money (1961). The soil exchange capacity was correlated with soil Si status, however the correlation was statistically not significant may be due to inherent soil Si has no significant effect on soil CEC but Si fertilization has been reported to induce soil exchange capacity (Matichenko, 2001). Soil texture greatly influenced the soil Si status (Mckeague and Cline, 1963). Among investigated locations silty clay loam was prominent in soil texture followed by loamy sand, sandy loam and clay loam. The silty clay loam, sandy loam, loamy sand soils were 69.7, 69.2 and 46.6 per cent low status of Si respectively which may be due to increase in sand content (Gontijo, 2000). Among loamy sand soils 26.6 per cent registered the highest soil Si status followed by silty clay loam with 16.27 per cent (Chinnaswamy and Chandrasekaran, 1978) which may be due to higher clay content with increase in pH improved the soil Si status (Meyer, 2001). Irrespective of soil texture Si depletion was observed in Cauvery Delta Zone soils. On an average, soil in Cauvery delta zone showed N NaOAc (pH 4.0) extractable available Si of 69.94 ppm (low) which coping with the results of low Si status in intensively rice growing soils (Lee, 2006).

**CONCLUSION**

The soils of Cauvery Delta Zone of Tamil Nadu, south India reveals 62 per cent of soil samples were low in plant available soil silicon status.





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**Table 1: Characterization of Soils collected from Cauvery Delta Zone of Tamil Nadu, South India**

Sl.No.	properties	No. of samples analyzed	Minimum	Maximum	Average
1	pH	82	5.1	9.3	6.71
2	Electrical conductivity (dS m <sup>-1</sup> )	82	0.08	1.22	0.41
3	Available Si (ppm)	82	4	324	69.94
4	Organic Carbon (%)	82	0.025	1.31	0.68
5	Cation Exchange Capacity (meq lit <sup>-1</sup> )	82	2.6	37	16.29





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**Table 2: Status of soil organic carbon in Cauvery Delta Zone of Tamil Nadu, South India**

GPS details of the location where sample has been collected						No. of samples analyzed	Status of organic carbon					
Latitude		Longitude		MSL(m)			< 0.5% (low)		0.5-0.75% (medium)		> 0.75 (high)	
Min.	Max.	Min.	Max.	Min.	Max.		No. of samples	%	No. of samples	%	No. of samples	%
10.2774 N	11.19 03N	78.58102 E	79.838 46E	-1	+89	82	27	32.9	27	32.9	28	34.2

**Table3: Status of available Si in soils of Cauvery Delta Zone of Tamil Nadu, South India**

GPS details of sampled location						Status of plant available Si					
Latitude (decimal)		Longitude (decimal)		MSL (m)		< 7 5ppm (low)		75-105 ppm (medium)		> 105 ppm (high)	
Min.	Max.	Min.	Max.	Min.	Max.	No. of samples	%	No. of samples	%	No. of samples	%
10.2774 N	11.1903 N	78.58102 E	79.83846 E	-1	+89	51	62	14	17	17	21

**Table 4: Status of texture wise plant available Si in soils of Cauvery Delta Zone of Tamil Nadu, South India**

S.No	Texture	No. of samples	%	< 7 5ppm (low)		75-105 ppm (medium)		> 105 ppm (high)	
				No. of samples	%	No. of samples	%	No. of samples	%
1	Silty clay loam	43	52.5	29	67.4	7	16.3	7	16.3
2	Sandy loam	13	15.8	9	69.2	2	15.4	2	15.4
3	Loamy sand	15	13.4	7	46.6	3	20.0	1	6.6
4	Clay loam	11	18.3	6	54.5	2	18.2	7	63.6





## An Image based Glaucoma Detection Technique using Support Vector Machine

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### ABSTRACT

Glaucoma is an incurable vision impairment disease and the vision loss due to this can't be restored in any case, early detection is the only way to prevent it. There are several automatic screening techniques exist for the determination of the disease still there is a scope for the improvement in accuracy of prediction. One of the way to improve the accuracy is by considering important artifacts present in the retina; those play a vital role in disease prediction. In case of glaucoma the important artifacts are Optic disc and blood vessels. In this literature, An Automatic model is developed for detection of glaucoma using image processing and machine learning techniques. To build the model a set of retinal images captured through a fundus camera are taken as inputs, which consists of the images of two types of retina healthy and glaucoma affected. From each input retinal image a set essential features are extracted like Optic disc and blood vessels, using two well-known predefined feature extraction techniques scale-invariant feature transform (SIFT) and speeded up robust features (SURF). These set of extracted features are used by Support vector machine (SVM) classifier for prediction of glaucoma. For a 210 set of test images the overall accuracy of the model is 96%.

**Keywords:** Optic disc; blood vessels; scale-invariant feature transform (SIFT); speeded up robust features (SURF); Support Vector Machine (SVM).

### INTRODUCTION

Glaucoma is the second most leading eye disease which causes irreversible vision loss. According to a survey conducted in 2019, 70 million people are affected by glaucoma [1]. It is a group of heterogeneous eye disease in which loss of retinal ganglion cells occurs. It's started with no pain and slowly from peripheral vision loss to permanent blindness. Glaucoma is the cause of 85% blindness all over the world [2]. Among the retinal diseases 13% of cases are affected by glaucoma. 0.5% of people aged 40 and 10% of people who are above 80 are affected by

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glaucoma. In a healthy eye, a liquid called the aqueous humor is continuously produced by epithelium of the ciliary body to nourish the cornea and lens and drain out through a mess like a channel called canal of Schlemm. In glaucoma this fluid builds up which results in an increase in IOP (Intraocular Pressure) restricting the blood flow and severely damaging the optic nerve. IOP of normal eye range between 12 to 22 mmHg, but in glaucoma condition IOP is higher than normal [3].

Glaucoma mainly affects the optic nerve, major branches of the retinal vein, artery, ciliary body, and angle of the anterior chamber. It has been suggested that the diagnosis of glaucoma can't be certain until the progression has been demonstrated. Hence the correct diagnosis is required only at initial visits. There are different parameters to confirm that a patient has been correctly diagnosed with glaucoma or not [4] like Increase in IOP (Intraocular Pressure), definite visual field progression in at least one eye, Optic disc hemorrhage and Abnormal CDR. Many works of literature have been done in the past, for the detection of Glaucoma using diverse methodologies and techniques. The variation in model accuracy and average specificity depends upon the design of the algorithm and dataset. To classify the disorder related to the retina, different data mining, image processing, and Machine Learning algorithms have been suggested for feature extraction and classification. For automated Glaucoma detection, mostly used features are Intraocular Pressure (IOP) [5], Retinal Blood Vessel [6], papillary rim [6], and CDR and ISNT ratio [7]. Similarly different ML techniques such as, Neural Network is used for detection of glaucoma in article [5]. Decision tree algorithm was able to achieve 85% accuracy in glaucoma prediction, in article [8]. Naive Bayes classifier and k-nearest neighbor used and resulting an accuracy of 86%, in article [9]. In article [10], an automated Diagnosis of glaucoma using texture and higher-order spectra Features was developed, which produces an accuracy of 91%. In another article [11], the model is using the neuro retinal cup detection model and getting an average sensitivity and specificity of 97.2% and 98% respectively. But the dataset used for defining the model is very small (71 images).

In this literature, An Automatic model is developed for detection of glaucoma using machine learning and image processing techniques. to build the model a set of retinal images captured through a fundus camera are taken as inputs, which consists of the images of two types of retina healthy and glaucoma affected as shown in [Figure-1]. [Figure-2] shows the block diagram of the model, where each input image went through a preprocessing stage for getting more qualitative features. After the pre-processing, feature extraction is done using (SIFT) and (SURF) to capture the essential feature present in the retina. These extracted features are passed through the SVM classifier to predict the disease. This paper has been organized into four sections. Section-2 demonstrates the proposed system and its methodology. Section-3 provides analysis of results. Finally, Section-4 concludes this study.

## METHODOLOGY

### Assemblage and Selection Of images

The dataset for this paper is collected from deep blue data library [12]. The dataset consists of 3 different files: 1) MESSIDOR dataset file contains 460 Glaucomatous Retinal Images .2) Bin Rushed files contain 195 images 3) Magrabi Eye center file and contains 95 images. The total number of collected data from the above source is 750 which is of Glaucoma. The images are in JPG and TIFF format. 300 normal non-glaucomatous retina images are collected from different sources in JPG and PNG format.

### Preprocessing of retina image

Image processing is a method to perform different operations on an image, to get an enhanced image, or to extract some useful information from it. It takes the image as input however the output may be image or characteristics/features related to that input image. As we have Fundus retinal images as input, the accuracy of the model exclusively depends upon however we tend to preprocess the data. The supervised machine learning is employed for building the model that the RGB image dataset must undergo some basic image processing operations like compression to create it labelled for additional processes. The collected retinal images are of upper resolution





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that will have an effect on the ultimate model accuracy. Consequently, all images are resized to a resolution of 512\*512. Then retinal images are filtered through layer separation techniques e.g. channel separation, image smoothing/blurring (Gaussian blurring, bilateral filtering) by convolving the image with a low-pass filter kernel that removes high-frequency content like extra noise and detecting required edges needed for further procedure. Contrast-Limited Adaptive Histogram Equalization (CLAHE) is employed to boost the contrast. Through this adjustment, the intensities are often higher distributed on the histogram [13]. This method allows a lower contrast region to achieve higher contrast.

#### Feature Extraction

There are many features involved for the detection of glaucoma as shown in [Figure-3], in this paper, two well-known predefined feature extraction techniques scale-invariant feature transform (SIFT) and speeded up robust features (SURF). Retinal Blood Vessels.

#### SIFT

The following steps are involved in SIFT.

- A. Scale-space Extrema Detection
- B. Key point Localization
- C. Orientation Assignment
- D. Key point Matching

#### SURF

SURF uses Wavelet responses in both parallel as well as perpendicular direction. A locality of size  $20s \times 20s$  is considered around the key point where  $s$  is the scope. Then it is distributed into  $4 \times 4$  sub-sections. For every sub-section, both parallel and perpendicular wavelet responses are considered and as a result a vector is made as equation ii,

$$V = (\sum dx, \sum dy, \sum |dx|, \sum |dy|) \dots\dots\dots(i)$$

This characterized as one vector that produces SURF features with total 64 dimensions. Lesser the dimension, higher the matching rate with better computational speed. This phenomenon provides better uniqueness of features.

#### Designing the Classifier

After feature extraction, we have two different feature sets one for SIFT and the other for SURF. The pixel matrix of both the features is flattened, and stacked horizontally. We keep track of the length of all the pictures taken to ensure a perfect feature matrix. The all above action is performed for the Normal and affected images. 1D Arrays for each sample are created and stacked vertically after grouping. This process yields a feature matrix of all the images. Now we create the target vector for the affected with the help of np.ones and for the unaffected np.zeros. The target vector is stacked horizontally with the feature matrix. Now we got the pixel values and label, which makes the dataset. Which is now ready to feed into the model. In this paper, the SVM classifier is used for the classification purpose.

SVM (linear) is a type of classifier that finds a hyper plane which, distinctly classify the given data into two chunks, positive and negative. The beauty of SVM is its powerful mathematical background. It classify the data more accurately as compared to other techniques in real-life applications. It immensely does well in case of high dimensional data like image. For example, Let the set  $D$  be  $\{(a_1, b_1), (a_2, b_2), \dots, (a_r, b_r)\}$ , is an input vector in  $A \subseteq R^n$  and  $b_i$  is its output value (class label),  $b_i \in \{1, 0\}$ . Where 1: positive class and 0: negative class. Then SVM finds a linear function in the form ( $w$ : weight vector)  $f(a) = \langle w \cdot a \rangle + k$





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$$b_i = \begin{cases} 1 & \text{if } \langle \mathbf{w} \cdot \mathbf{a}_i \rangle + k \geq 0 \\ 0 & \text{if } \langle \mathbf{w} \cdot \mathbf{a}_i \rangle + k < 0 \end{cases} \dots\dots(ii)$$

### Algorithm

#### MODEL FLOW

**STEP I:** Every input RGB image from the dataset goes through the following pre-processing techniques, such as (Resizing 512x512, Green Channel Extraction, Adaptive Histogram Equalization and Edge Enhancement).

**STEP II:** Two feature extraction techniques SIFT and SURF are implemented on each image simultaneously to capture the features present in it. The result of both techniques are appended and preserved in a single row of the feature table.

**STEP III:** After the completion of Step II each row in the feature matrix representing the features of individual input image is labeled with '0' or '1' depending on the type of image i.e. normal or affected.

**STEP IV:** This feature matrix generated in Step III used to train the Classifier.

**STEP V:** The Trained classifier applied on the test data set i.e. generated by a set of retinal images using Step I and II for generating the resultant matrix.

**STEP VI:** The generated result is compared with the actual to calculate the accuracy of the model.

### RESULT AND DISCUSSION

[Figure-4] shows the intermediate results produced after completion of each stage, in the proposed model. Where (a) and (b) indicates the original input image of Normal and Glaucoma affected eye. Figure (c) and (d) indicates the respective outputs after completion of preprocessing phase and finally figure (e) and (f) indicates the features captured using SIFT and SURF operator. Finally the model is evaluated using 210 test images out of which 150 are Glaucoma affected and 60 are normal images. The performance of the classifier evaluated in terms of sensitivity, specificity, overall accuracy are shown in [table-1].

### CONCLUSION

Glaucoma is an irredeemable disease, if it remains untreated may lead to permanent vision loss. This paper expresses effort concerning the automatic detection of Glaucoma disease using image processing and Machine Learning techniques. The well-known feature extraction techniques like SIFT and SURF are used for capturing the features and for modeling the classifier a very popular machine learning technique SVM is employed. The proposed model achieved an overall accuracy of 96% over 210 test images and has the potential to be additional sensitive for prediction of Glaucoma at its early stage. In future this work can be extended for detection of glaucoma at its various stages using a multiclass classifier.

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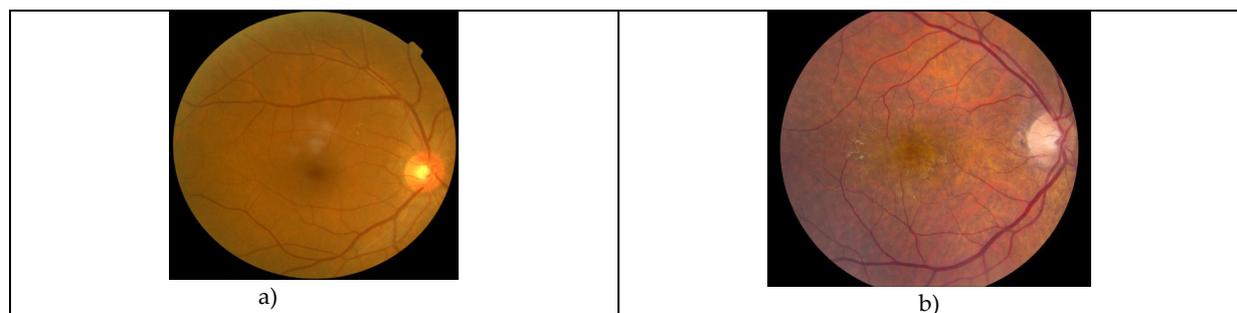


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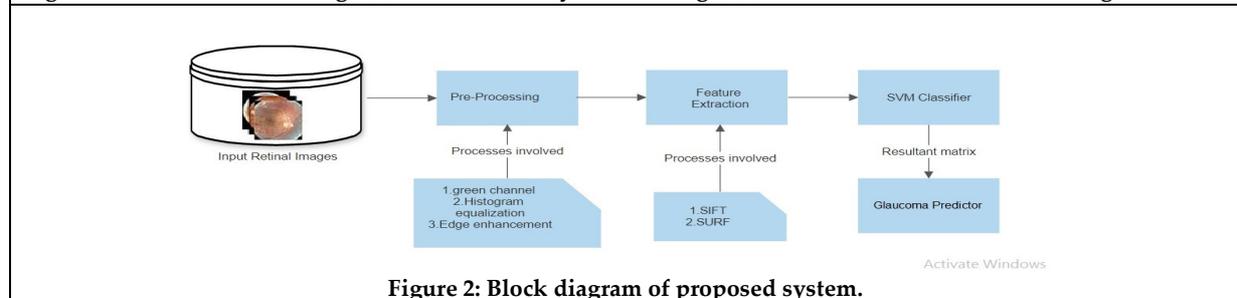
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**Table 1: Performance measure of the model**

Accuracy	96%
Sensitivity	100%
Specificity	91.69%



**Figure 1: Retinal Fundus Image (a) Normal Healthy Retina Image, (b) Glaucoma Affected Retina Image**



**Figure 2: Block diagram of proposed system.**





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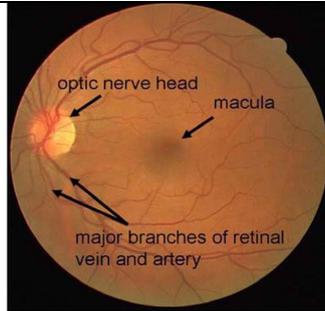


Figure.3: Important features for detecting Glaucoma in retina image.

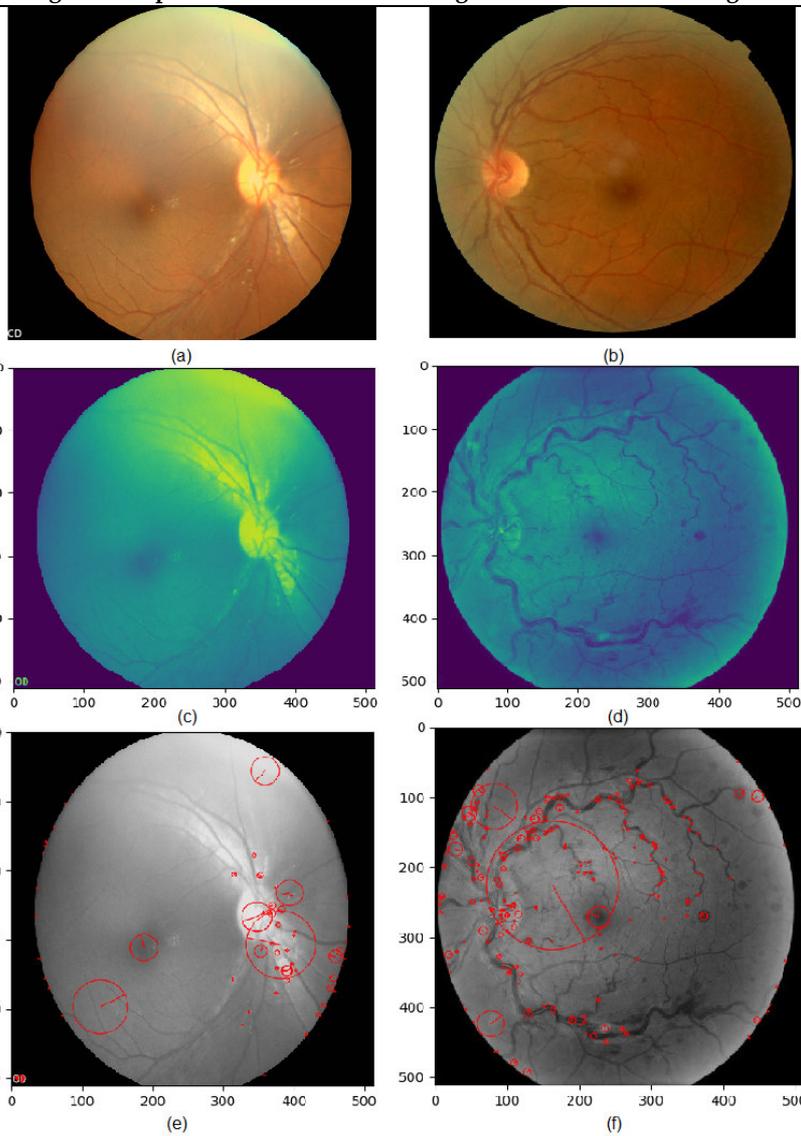


Figure-4: Intermediate Results produced after each phase using the Proposed Model





## Comparative Studies on Antimicrobial Activity of Silver and Chitosan Nanoparticle-A Review

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### ABSTRACT

Agriculture production and productivity is constantly suffering from of threats created by various classes of plant pathogens leading to huge economic losses. To control the plant disease a huge amount of pesticide used for many year lead to the warning to environment and at the same time it is contribute the development of resistant pathogen races. So to maintain sustainability nano technology (Nanopesticide, Nanofertilizer etc.) introduced in modern agriculture. Among all the nano formulation tested for antimicrobial activity against plant pathogen silver and chitosan nano particle show significant effect.

**Keywords:** Nano-particle,Chitosan,Silver,Pesticide

### INTRODUCTION

Agriculture is the primary source of livelihood for about 58 per cent of India's population. The production and productivity is constantly suffering from of threats created by various classes of plant pathogens leading to huge economic losses. Among the total crop losses caused by different sources, 14.1 % are lost due to plant diseases alone and the total annual worldwide crop loss from plant diseases is about \$220 billion. (Agrios ,2005). To minimize loss caused due to the pathogen pesticides are used in huge amount for many years since mid-1950s.Due to the potential use of pesticide it start damage the environment and food as they are spread over the crop plant several times each year, at the same time it has contributed to the development of resistant pathogens (Lamsal *et al.*, 2011).

So for the maintain equilibrium between environment and food production innovative technologies are being introduced in modern agriculture to minimise such losses. Among such technological innovations, nanotechnology (nanopesticide, nanofertilizer etc.) is gathering noteworthy considerations due to its robust applications in agriculture (R nair 2010) ( Ghormade V *et al.*, 2011). In general, nanoparticles have attracted considerable attention in



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the fields of medicine, pharmaceuticals, cosmetics and electronics due to unique physical, chemical and biological properties (Bakshi M *et al.*, 2014). In present day, the development and application of biosynthesized nanoparticles has opened new avenues in agricultural research oriented to developing ecofriendly and effective means of controlling plant diseases. Most importantly, biological synthesis of silver nanoparticles (AgNPs), Chitosan has offered a consistent, non toxic and ecofriendly approach for plant disease management due to their strong antimicrobial properties (Navrotsky A, 2000). This review evaluates the current literature on the effect of nanoformulation to inhibit the growth of plant pathogenic microorganism in *in-vitro* condition.

**Antimicrobial efficacy of Chitosan**

Chitosan is a naturally-occurring, linear polysaccharide produced from chitin by deacetylation in the solid state under alkaline conditions, or by enzymatic hydrolysis of chitin deacetylase. It is considered to be the second largest renewable biomaterial after cellulose in terms of utilization and distribution (Elgadir *et al.*, 2015). Now a days chitosan and its derivative biomaterials have a significant attention in the biomedical field, owing to their unique biological properties. Some of the most noted properties of chitosan are its non-toxicity, biodegradability, biocompatibility, and immunoenhancing, antibacterial and antimicrobial activity. Sudarshan *et al.* (1992) suggested that chitosan could penetrate fungal cell wall and bind to its DNA and inhibit the synthesis of mRNA and, in turn, affect the production of essential proteins and enzymes required for the infection. Rabea *et al.* (2003) explained chitosan chelates with metal ions, which has been implicated as a possible mode of antimicrobial action. Phaechamud and Ritthidej (2008) reported chitosan nanoparticles have got various applications in biology due to its biodegradable and nontoxic properties.

In acidic condition the free amino groups of chitosan protonates and contributes to its positive charge the inhibition mode of chitosan against fungi. García-Rincón *et al.* (2010) explained that positive charge of chitosan interacts with negatively charged phospholipid components of fungi membrane, which in turn alter the cell permeability of plasma membrane and causes the leakage of cellular contents, which consequently leads to death of the cell. Soleimani *et al.* (2011) reported that host resistance was an efficient and effective component in integrated management of plant diseases. The aim of this study was to test whether Acibenzolar-S-methyl (ASM), Chitosan, Heads-up and Acetyl Salicylic Acid (ASA), known to induce resistance against various diseases, can help protect potato crop against brown leaf spot. The effect of these inducers, on two potato cultivars, Goldrush and FL1879 against *Alternaria alternata*, causal agent of brown leaf spot at two different field sites were evaluated. To determine the effects of the application of inducers on disease resistance, the foliage of the potato cultivars was sprayed with appropriate concentrations of ASA, chitosan, and ASM. Heads-up was also applied as a pre-plant treatment on potato tubers. The results obtained from the both field experiments indicated the highest yield performance was achieved in plots treated with ASM, followed by Heads-up and chitosan treatments. However, no significant difference in terms of tuber yield production has been noted between ASA treated potato foliage, and the untreated control plants.

Results of experiments with detached leaves showed that there was a significant difference regarding disease index reduction between plots which been treated with defense inducers and untreated, inoculated plots. It was clear that on both potato cultivars, application of chitosan and ASM encouraged enhancement of the disease resistance compared to the ASA and Heads-up treatments. In the laboratory experiment, disease progress was recorded on leaves from three different heights of the crop canopy. The results indicated that disease severity was low in the apex, moderate in the middle and high in the lower parts of the crop, in both potato cultivars. These results suggest that chitosan and ASM may offer alternative methods for controlling brown leaf spot of potato. M. Sathiyabama *et al.* (2015) found that chitosan at the concentration of 1mg/ml inhibit the radial growth of *Alternaria solani* and protect the tomato plant from blight pathogen by enhancing the chitinase activity. Yadi Suryadi *et al.* (2017) explained that nano chitosan had an inhibitory activity to *Colletotrichum gloeosporioides in vitro* up to 85.7%.



**Abhinandita sahoo and Ria Mukhopadhyay****Antimicrobial efficacy of silver nanoparticle**

Silver was known as one kind of efficient disinfectors in the early 19th century. From then on, it was widely applied in the fields of bacteria inhibition, wound dressing, mildew preservation, etc. In the recent year, it was found that silver nanoparticle (AgNPs) were checked the growth of fungi, bacteria and virus. Becker *et al.* (1999) showed a nanosilver particle may or may not be charged on its surface or generate silver ions.

Like ionic silver, nano silver is a very potent killer of bacteria and has been shown to kill fungi, algae, and some viruses, including HIV. Park *et al.* (2006) explained that Silver in ionic or nanoparticle forms had a high antimicrobial activity and was therefore widely used for various sterilization purposes including materials of medical devices and water sanitization. Relatively few studies were reported on the applicability of silver in controlling various plant pathogens in a relatively safer way compared to synthetic fungicides. Min *et al.* (2009) observed in microscope that hyphae exposed to silver nanoparticles showed severe damage and resulted in the separation of layers of hyphal wall and collapse of fungal hyphae. Wei *et al.* (2009) reported that Silver has been used as an antimicrobial agent since ancient civilizations; it has been used extensively due to its broad spectrum and multiple modes of antimicrobial activity.

Young-ki Jo *et al.* (2009) examined the antifungal activity of silver ions and nanoparticles against two plant-pathogenic fungi, *Bipolaris sorokiniana* and *Magnaporthe grisea*. In vitro petri dish assays indicated that silver ions and nanoparticles had a significant effect on the colony formation of these two pathogens. Effective concentrations of the silver compounds inhibiting colony formation by 50% (EC50) were higher for *B. Sorokiniana* than for *M. grisea*. The inhibitory effect on colony formation significantly diminished after silver cations were neutralized with chloride ions. Growth chamber inoculation assays further confirmed that both ionic and nanoparticle silver significantly reduced these two fungal diseases on perennial rye grass (*Lolium perenne*). Particularly, silver ions and nanoparticles effectively reduced disease severity with an application at 3 h before spore inoculation, but their efficacy significantly diminished when applied at 24 h after inoculation. The in vitro and in planta evaluations of silver indicated that both silver ions and nanoparticles influence colony formation of spores and disease progress of plant-pathogenic fungi. In planta efficacy of silver ions and nanoparticles is much greater with preventative application, which may promote the direct contact of silver with spores and germ tubes, and inhibit their viability. Kumar *et al.* (2010) described that Metallic nanoparticles possess unique chemical and physical properties, small size, huge surface to volume ratio, structural stability and strong affinity to their targets. Lamsal *et al.* (2011a) showed the effective usage of silver nanoparticles instead of commercial fungicides.

They evaluated the effect of silver nanoparticles against six *Colletotrichum sp.* associated with pepper anthracnose under different culture conditions and found that, application of 100 ppm concentration of silver nanoparticles inhibited the growth of fungal hyphae as well as conidial germination in vitro when compared to the control. Silver nanoparticles showed significantly high inhibition of fungi in field conditions when applied on the plants before disease outbreak. Lamsal *et al.* (2011b) studied on *in vitro* and *in vivo* efficacy of silver nanoparticles against powdery mildew before and after disease outbreak in plants under different cultivation conditions, showed maximum inhibition of fungal hyphae and conidial germination with less concentration of nanoparticle on cucumbers and pumpkins. Hameed *et al.* (2012) studied that the secondary metabolites in plants have been used in the formulation of nanoparticles through increase the effectiveness of therapeutic compounds used to reduce the spread of plant diseases, while minimizing side effects for being: rich source of bioactive chemicals, biodegradable in nature and non-polluting (eco-friendly).

Particulate systems like Nanoparticles have been used a physical approach to alter and improve the effective properties of some types of synthetic chemical pesticides or in the production of bio-pesticides directly. Ing *et al.* (2012) explained that chitosan therefore could be formulated and applied as a natural antifungal agent in nanoparticles form to enhance its antifungal activity. Kim *et al.* (2012) reported the inhibitory effect of three different silver nanoparticles (WA-CV-WA13B, WA-AT-WB13R, and WA-PR-WB13R) against eighteen different commercially





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important plant pathogenic fungi on potato dextrose agar (PDA), malt extract agar, and corn meal agar. They found that inhibition of fungal pathogens with silver nanoparticles was concentration dependent and also on type of silver nanoparticles used. Most fungi showed a good inhibitory effect at 100 ppm concentration of silver nanoparticles on PDA, compared with others. WA-CV-WA13B showed the highest inhibition effect compared to other silver nanoparticles. Effect of silver nanoparticles on the growth of sclerotium-forming species *Rhizoctonia solani* and *Sclerotinia sclerotiorum*, revealed that silver nanoparticles effectively inhibit the hyphal growth in a dose-dependent manner.

## CONCLUSION

In the review cited above it observed that silver and chitosan nanoparticle is significant properties like its non-toxicity, biodegradability, biocompatibility, and immunoenhancing, antibacterial and antimicrobial activity. It potentially inhibit the mycellial growth, spore germination .

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## COVID-19 Outbreak Prediction using Machine Learning Techniques

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### ABSTRACT

A number of Epidemic diseases has been coming since a past years and a huge number of people and animals are coming in the clench of these deadly disease. More than 19 epidemic diseases have been reported by the WHO (World Health Organization). Those are Chikungunya, Cholera, Crimean-Congo hemorrhagic fever, Ebola virus disease, Hendra virus infection, Influenza, Lassa fever, Marburg virus disease, Meningitis, MERS CoV, Mokeypox, Nipah virus infection, Plague, Rift Valley fever, SARS, Smallpox, Tularaemia, Yellow Fever, Zika virus disease and now Novel Coronavirus. Before in the past years somehow spread of diseases were limited to affected countries only. But in this current era there are a certain reason which are responsible for the spread of disease globally like global trade, exchange of capital among the people of different geographic boundaries. It's becoming crucial to know the affected Coronavirus cases for future actions. Thus, machine learning techniques are applied to predict total number of cases affected by Coronavirus. In this Study, Data has been collected and interpreted for a number of analysis, how COVID-19 cases are reaching at a peak level, how death rates are increasing rapidly, the percentage of recovery cases and the mortality rate analyzed across the globe. Among all machine learning algorithm, linear regression is giving promising accuracy rate and suitable results in this proposed model. Therefore, this algorithm is chosen to prepare the model which will get trained by the previous cases and will predict the future cases.

**Keywords:** Coronavirus; Graph Visualization; Linear Regression

### INTRODUCTION

A perilous novel Coronavirus (COVID-19) which is pandemic all over the world emerged from a 'wet market' of Wuhan City in China in the year Dec, 2019. This contagious disease is caused by severe acute respiratory syndrome

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Coronavirus 2 (SARS-CoV-2). More than 108 countries are in the grasp of this deadly disease. Therefore, economy of these affected countries is drifting into troubles. Many initiative measures have been taken place such as informed the residents not to come outside of their mansion, wear masks and maintain social distance among people. Every day the cases are booming up and since it is a herculean task to control it and it's becoming significantly necessary to predict the total number of Corona affected people in coming days. So, that government can make future decisions and make arrangements such as to keep max units of ventilators, more number of doctors to be available, and be prepared to cope with the adverse situations.

The epidemic disease Novel Coronavirus which is since active in the date of writing this paper, need to be controlled. The disease is spread among people by indirect contact or direct close contact through coughing or sneezing by the affected persons. Symptoms such as cold, cough, tiredness, shortness of breath and fever develop in all these patients. People having these symptoms are required to be in quarantine and must do covid test in their respective testing centre. All countries should be ready to fight with this harsh situation. Before that, it is always required to predict the total number of Corona cases. For that quick prediction of total cases, a Machine Learning Technique is proposed which will predict the total Corona cases in near future and it will be helpful for great decision making by the countries to grapple this repugnant situation.

In this proposed model, at first confirmed cases of all the COVID-19 affected countries are visualized and analyzed by the trend line and growth rate. Country India is also analyzed. Future cases of India are predicted using machine learning algorithms. Total case of the world is analyzed and future case is predicted using machine learning model. Active cases, Death cases and Recovery cases are represented in a single scatter graph to interpret the highest growth trend. Mortality rate and recovery rate is interpreted. Top 10 affected Countries having highest percentage is evaluated and visualized in a pie chart. This paper is divided into five section i.e. 1. Introduction, 2. literature Survey, 3. Material and Methods, 4. Simulation Results and Discussion and 5. Conclusion.

## LITERATURE SURVEY

From existing machine learning models of Linear regression, some thoughts, understanding, ideas are acquired. [1] Regression analysis for prediction of residential energy consumption by Nelson Fumo and Mantosh Biswas. [2] Estimating Warehouse Rental Price using price using Machine Learning Techniques by Yixuan Ma, Zhenji Zhang, Alenxanderlhler and Baoxiang Pan. [3] Stock price prediction using linear regression based on sentiment analysis by YahyaEru Chakra and BayuDistiawanTrisedya. [4] Electricity consumption forecasting in Italy using linear regression models by Vincenzo Bianco, OronzioManca and Sergio Nardini. [5] Linear and nonlinear modeling approach for urban air quality prediction by Kunwar P. Singh, Shikha Gupta, Atulest Kumar and Sheo Prasad Shukla. [6] A Comparative Study of Performances of Various Classification Algorithms for Predicting Salary Classes of Employees by SwapnajitChakraborti. [7] Prediction of GDP in Henan Province Based on Grey Linear Regression Combined Model. [8] Forecast of Railway Passenger Traffic Based on a Grey Regression Combined Model. [9] Temperature and latitude analysis to predict potential spread and seasonality for COVID-19. [10]

Emerging COVID-19 coronavirus: glycan shield and structure prediction of spike glycoprotein and its interaction with human CD26. [11] Why is it difficult to accurately predict the COVID-19 epidemic? [12] Corona Tracker: world-wide COVID-19 outbreak data analysis and prediction. [13] Modified SEIR and AI prediction of the epidemics trend of COVID-19 in China under public health interventions. [14] Prediction models for diagnosis and prognosis of COVID-19 infection: systematic review and critical appraisal. [15] Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. From all of the above existing papers, knowledge is acquired from the analysis and predictions, how Linear Regression is used effectively and know different approach for the prediction of COVID-19 in various sector of medical field of science and technology.





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## MATERIAL AND METHODS

### Data Acquisition

The main motive is to predict the total number of affected cases in upcoming dates. So, data is acquired from the popular GitHub repository. It contains a huge collection of datasets. i.e. [https://raw.githubusercontent.com / datasets/covid-19/master/data/time-series-19-covid-combined.csv](https://raw.githubusercontent.com/datasets/covid-19/master/data/time-series-19-covid-combined.csv).

### Data Preparation

The datasets describe about affected cases, number of recovery cases and number of death cases with respect to date. To eliminate any rise of error in quality of performance, the null values are replaced with mean values. But in this model of future prediction of affected cases, null values are replaced with 0, if no cases happened on that date. Active cases are calculated by subtracting the sum of death and recovery cases from the affected total cases.

### Feature and Target

Date is serialized by transforming it to numerical values. Then it is taken as input and total cases are taken as output before building the model. It's crucial to align the total cases with its respective dates.

### Linear Regression (LR)

Linear Regression is one of the machine learning algorithms comes under supervised learning approach. It is basically used for performing regression task. The main goal of linear regression is to find the variation in one variable (called dependent variable), based on the variation in one or more other variables (called independent variables). This means linear regression to find out relationship between variables and forecast data i.e. relationship between dependent and independent variables. The three major uses for linear regression analysis are

- (1) To determining the strength of predictors
- (2) To forecasting an effect
- (3) And to find the trend of forecasting.

Linear regression has many practical uses. Most applications fall into one of the following two broad categories [16]:

- i. If the aim is to make the prediction, forecasting or error reduction then the linear regression can be used to fit a predictive model.
- ii. If the goal is to find out the variation or error, the linear regression can be more skillful used to quantify the strength between the dependent and the independent variables. And to determine whether some independent variables may have no linear relationship with the dependent variables at all, or to identify which subsets of independent variables may contain redundant information about the dependent variables.

$$Y = B_0 + B_1 * X \quad (1)$$

The above equation (1) is of Simple Linear Regression. Y is dependent variable which represents the total cases of COVID-19 and X is independent variable which represents the dates as per respective total cases.  $B_0$  is constant or intercept term and  $B_1$  is coefficient for independent variable.

During training model, the process includes insertion of all training data(X) and labels to training data(Y). It finds the best fit line to predict the value for the given input data. Model finds the best regression by updating the intercept and coefficient of the input value by updating the intercept and coefficient of input value. With minimization of error, difference between the true value and the predicted value by using cost function best fit line is obtained.

### Proposed Algorithm

Now the normalize data is ready for modelling after the data cleansing phase is over. Splitting of the normalize data into training and testing data is a crucial part before model building. From the whole clean data, 80% percentage of



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the data is assigned for training data i.e. signed to  $x_{train}$  and  $y_{train}$  respectively. The remaining 20% is assigned for testing where data i.e.  $x_{test}$  and  $y_{test}$  respectively.

Model is built by fitting the training and testing data by using Linear Regression algorithm. Linear regression is a very efficient algorithm which maps numeric inputs to numeric outputs in machine learning. Linear Regression makes the line which best fits to the data points. In this case, normalize is set to true and fit intercept is set to false of the parameter. Then the  $x_{train}$  and  $y_{train}$  is fitted to the model for training and  $x_{test}$  and  $y_{test}$  is fitted to the model for testing purpose. Score function is used to find the accuracy. The Completion of data fitting, resulting in 97% accuracy.

**SIMULATION RESULTS AND DISCUSSION**

Data is interpreted to predict total cases in upcoming future dates. At the very beginning, after adopting a certain procedure of data cleansing. Data is arranged in a structural manner as per usage model. Total cases of all affected countries are represented with interactive graph visualizations then analyzed and finally used for prediction.

At the time of writing this paper, highly affected countries by COVID-19 are US, Spain, Italy, France, United Kingdom, Germany, Turkey, Russia, Iran and Brazil. US is the most affected country and at the top among all the affected countries by this deadly disease.

Fig. 1 Represents the graph having total confirmed cases of India which has already crossed over 2,40,000 number of cases. Where as Fig. 2 show the graph having total confirmed cases of all over the world which has reached more than 6.5 million cases. The mortality rate is less than half of the global average as per as the information of Govt. Of India. Initially the rate of death is gradually increase up to April 2020 end. After the may 2020 first week the rate of mortality case through out the globe is decrease which shows in Fig.5. Similarly the recovery rate is proportionally increase with death rate across globe in Fig 6. India is a second highest populations after China in the world. Day by day the infection rate is increasing in India as well as all over the world. This model predict to the number of confirmed cases in very near future in India as well as the world by using linear regression algorithm. This model gives the prediction result 97% accuracy. Fig.7 and Fig.8 shows the number of confirmed cases for India and whole world.

**CONCLUSION**

Since past many years, a number of epidemic diseases have emerged in this world and grab a lot of human lives, made huge losses. But somehow, those ended. But now this Novel Coronavirus is booming up every day. Life of people are deceased without vaccine. But regardless of great achievements and developments in the field of medical research, no vaccine has yet prepared. Researchers, scientists of reputed medical organizations of various countries are under continuous research to prepare for antidote. It's a very critical situation for all the people to overcome this obstacle. All human beings have a great hope for proper vaccine to rescue this world. In COVID-19 period, it's very crucial to stay safe and keep all safe.

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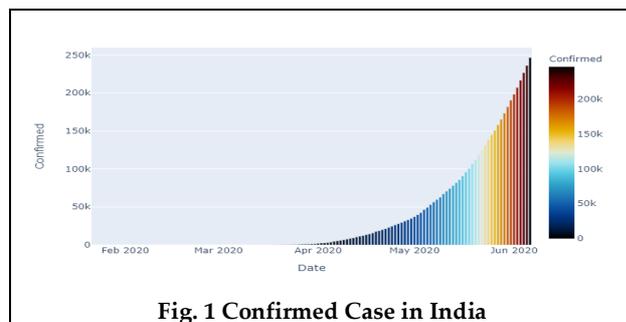
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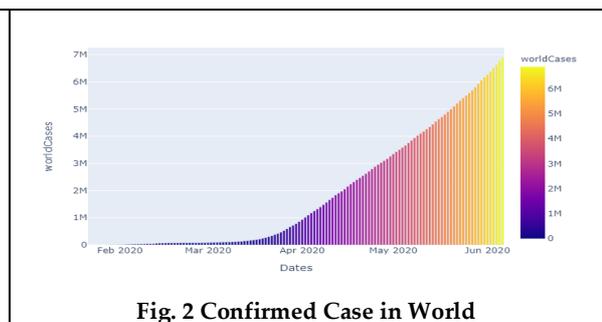


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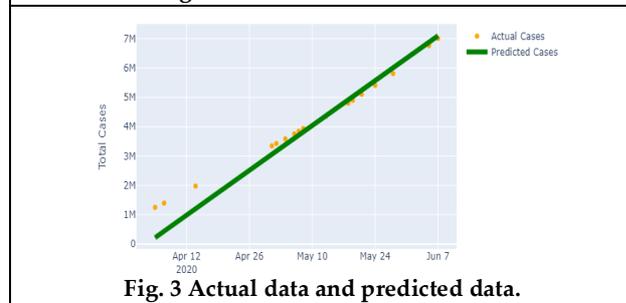
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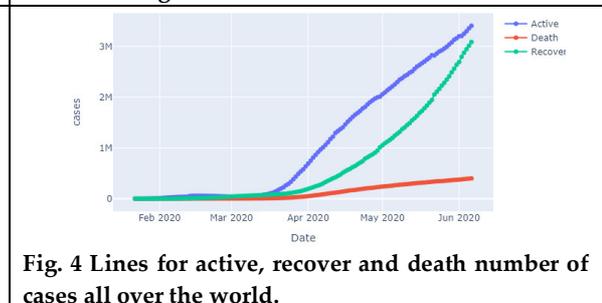
**Fig. 1 Confirmed Case in India**



**Fig. 2 Confirmed Case in World**



**Fig. 3 Actual data and predicted data.**



**Fig. 4 Lines for active, recover and death number of cases all over the world.**





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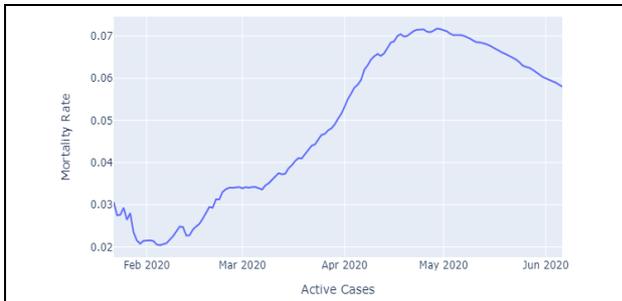


Fig. 5 show the mortality rate with respect to active cases across the globe.

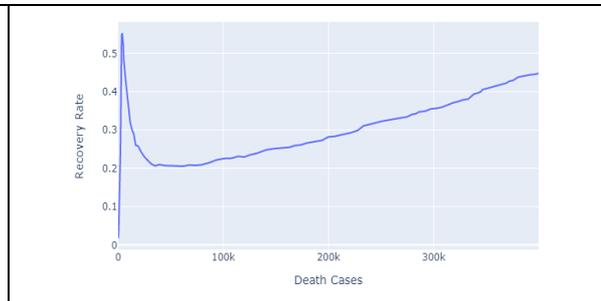


Fig. 6 show the recover rate with respect to death cases across the globe.

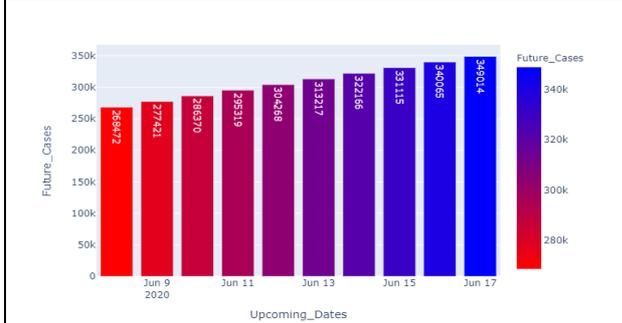


Fig. 7 Prediction of future COVID-19 cases of India



Fig. 8 Prediction of future COVID-19 cases of Globe





## Metal and Drug Transportomes Analysis from *Cyanobacterial* sp.

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### ABSTRACT

Cyanobacteria belong to an ancient group of photosynthetic prokaryotes with pronounced variations in their cellular differentiation strategies, physiological capacities and choice of habitat [9]. The availability of complete genome sequences of some of the cyanobacteria occupying remarkably diverse ecological niches enabled to gain insights into their adaptive properties. The objective of this study was to analyze complete cobalt, nickel, zinc, cadmium, Mg<sup>2+</sup>, Mn<sup>2+</sup>, molybdate, chromate ion metal transporters (metal transportomes) from eleven representative *Cyanobacterial* species and to identify metal transporters which is associated with "Genomic Island".

## INTRODUCTION

Dataset cataloguing has been executed for the transition element metal ion transporters from all the selected eleven *Cyanobacterial* species using TIGR-CMR and Transport DB[5][6]. Metal transporters having "Genomic Island" associated features were identified using Island path analysis.

### Findings

#### Background

Cyanobacteria (also known as blue-green algae) are a group of extraordinarily diverse Gram-negative prokaryotes that originated 3.5 billion years ago. Their diversity ranges from unicellular to multicellular, coccoid to

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branched filaments, nearly colourless to intensely pigmented, autotrophic to heterotrophic, psychrophilic to thermophilic, acidophilic to alkylphilic, planktonic to barophilic, freshwater to marine including hypersaline (salt pans). They are found both free living and as endosymbionts [1].

The transition metal ions including cobalt, copper, manganese, nickel and zinc are essential for the viability of Cyanobacteria as well as many other bacteria [2]. The transition metals like nickel and cobalt, essential components of many enzymes, etc. are taken up by specific transport systems of different types [18]. Biological systems have different types of transporters based on the different types of transport mechanisms, ATP dependent, ion channels, secondary transporters and unclassified transporters [6]. Three ATP-binding cassette (ABC)-superfamily multidrug efflux pumps are known to be responsible for chemoresistance [19]. These multidrug transporters provide resistance to the organism against different types of exogenous drug molecules along with some of the endogenous toxic compounds. Unlike metal ion transporters, multidrug transporters are nonspecific to the substrate, former one is more specific towards its substrate.

Cyanobacterial species are ecologically significant group of bacteria. In the post genomic era complete genome sequence of following eleven cyanobacterial species allowed us to understand the genomic organization of metal transporters (transition metals: Ni<sup>2+</sup>, Cu<sup>2+</sup>, Mn<sup>2+</sup>, Co<sup>2+</sup>, Cr<sup>2+</sup>, Mo<sup>2+</sup>; Poor metals: Zn<sup>2+</sup> and Cd<sup>2+</sup>; Alkali earth metal: Mg<sup>2+</sup> and multidrug transporters from *Prochlorococcus marinus* MED4 (CCMP 1378), *Prochlorococcus marinus* MIT 9313, *Prochlorococcus marinus* SS120 (CCMP 1375), *Synechococcus elongatus* PCC6301, *Synechococcus* sp. CC9311, *Synechococcus* sp. CC9605, *Synechococcus* sp. CC9902, *Synechococcus* sp. RCC307, *Synechococcus* sp. WH7803, *Synechococcus* sp. WH8102 and *Synechocystis* sp. PCC6803. Through analyzing their complete repertoire of metal transporters of cyanobacterial species, variety of metal transporters acquired through Horizontal Gene Transfer (HGT) are reported.

## METHODS

### Compilation of metal and drug transporter inventory

The genomic sequence information of the eleven sequenced Cyanobacterial sps *Scys*PCC6803, *Pmar*MED4 (CCMP1378), *Pmar*MIT9313, *Pmar*SS120 (CCMP1375), *Selo*PCC6301, *Synsp*CC9311, *Synsp*CC9605, *Synsp*CC9902, *Synsp*RCC307, *Synsp*WH7803 and *Synsp*WH8102 employed in this study were selected from TIGR-CMR database. Protein sequences were compiled using TransportDB; a relational database describing the predicted cytoplasmic membrane transport protein complement for organisms was used as a substrate for building the metal and drug transportomes [4]. From the compiled sequences phylogenetic trees were constructed for substrate specific transporters individually and through analyzing the aligned sequences conserved domains for individual metal ion and drug transporter were reported [7]. For some of the specific Nickel secondary transporter (slr 1796) and Cobalt transporters orthologous and paralogous sequences were obtained using KEGG database and phylogenetic trees were generated for them [8]. Transmembrane helix prediction for membrane transporters was performed using TMHMM version 2.0 [3]. Genomic location and gene organization were identified from TransportDB.

### Phylogenetic analysis

CLC main workbench has been employed to construct the phylogenetic tree for the compiled metal ion transporters and also for our intense interested multidrug transporters from *Scys*PCC6803 [7]. For the phylogenetic analysis, multiple sequence alignments (MSA) were produced using progressive alignment algorithm. The generated alignments were used for determining the evolutionary distance between the sequences. Thus the calculated sequence distance was used to create a phylogenetic tree- employing neighbour joining (NJ) algorithm with 1000 bootstrap replicates.





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### Sequence clusters and orthologous sequences

KEGG pathway database has been executed to identify sequence clusters for Ni<sup>2+</sup> transporter (slr0796) [8]. This database aids us to identify the clusters of genes those having the related functional annotation. Orthologous sequences having similar function in different species are also identified using KEGG pathway database for the same Ni<sup>2+</sup> secondary transporter (slr0796) (Fig 1).

### Island path analysis

Cyanobacterial sps are ecologically diversified organisms habituated to grow in different environmental conditions- freshwater ecosystems and marine water ecosystems are some examples to be named. Organisms to get acquainted to specific niche, they need to meet the requirements to survive in that conditions. Horizontal gene transfer mechanism is involved in the achievement of essential needs. Island path analysis was used for the detection of metal transporters acquired through HGT(islandpath). After generating the genomic sequences of eleven Cyanobacterial species with island path software (IPA version 1.0 tool) for the identification of the transporters located in GI's or exhibiting GI associated features like anomalous %G+C, dinucleotide bias above 1 STD DEV, presence of RNA genes (tRNA, rRNA genes) and mobility genes (transposons and insertion sequences).

### Protein sequence analysis

Metal and drug transporter proteins analysis has been carried out using CLC main workbench 6.9. The conserved motif in the ATP dependent transporter's membrane domain" LSGGQ" has been identified. This domain is the signature sequence for the ABC transporter proteins.

## RESULTS AND DISCUSSION

### From genome to metal and multidrug transporters in Cyanobacteria

Based on the global features of the eleven Cyanobacterial genomes we could draw a comparison among the genome size, number of genes, transporter proteins and total number of metal transporters and multidrug transporters from *ScysPCC6803*(Table 1). Among the eleven spp, *ScysPCC6803* has the largest metal transporter inventory (38 metal ion transporters) while *PmarMED4* (CCMP1378) has the lowest (16 metal ion transporters). *Prochlorococcus* spp has the less number of total transporters and metal ion transporters when compared to *Synechococcus*spp, while *Synechocystis PCC6803* has the largest genome size of 3.9mb, the highest total of 168 transporters and 38 metal ion transporters among the other organisms involved in this study [10]

Based on the TransportDB the metal transportomes were compiled for the metal ion complements of transition metals: Ni<sup>2+</sup>, Cu<sup>2+</sup>, Mn<sup>2+</sup>, Co<sup>2+</sup>, Cr<sup>2+</sup>, Mo<sup>2+</sup>; Poor metals: Zn<sup>2+</sup> and Cd<sup>2+</sup>; Alkali earth metal: Mg<sup>2+</sup> and multidrug transporters from *ScynPCC6803*. These transportomes furnish information for class/family/subfamily, protein name, orientation, length of the protein, TMD's substrate and the predicted role of the above metal transporters. A comparative analysis depicting the basic differences in the composition of transporter classes and metal transporter families from the eleven *Cyanobacterial* species is represented in Table 2. From the above analysis we were reported that *ScycPCC6803* has the highest no: of ATP dependent transporters (19 ATP dependent transporters) among the group and secondary transporters are distributed in uniform fashion in all the organisms and also the unclassified transporters are very less in number in all the group members.

### Salient features of Cyanobacterial transporters

Dataset cataloguing and multiple sequence alignment of the sequences helped to find the unique signature sequences in cobalt transporter along with regular signature sequences of ATP dependent transporter proteins (Fig 3). Most of the ion channel transporters contributed to MIT family Mg<sup>2+</sup>/Cobalt transporters. There are no records found related to Mg<sup>2+</sup>/Cobalt ion channel transporters from *Prochlorococcus* species.



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The major finding of our study is that there is only one Nickel transporter from *ScysPCC6803* found among all the organisms from the group and also the reported Nickel export transporter (slr 0796) is secondary transporter belongs to MFS superfamily. Analysis of the complete genome sequence of the cyanobacterium *Synechocystis PCC 6803* (henceforth referred to as *Synechocystis*) [12] led to the identification of a metal-regulated gene cluster involved in resistance against zinc, cobalt and nickel [13]. This 12 kb region consist of 11 open reading frames (ORFs) organized into six putative transcriptional units (Fig. 2): (i) *nrsBACD* operon involved in  $\text{Ni}^{2+}$  and  $\text{Co}^{2+}$  tolerance and regulated by the upstream *nrsSR* operon [14], (ii) *ziaA* encoding a putative  $\text{Zn}^{2+}$  efflux P-type ATPases and regulated by the product of the preceding ORF, *ziaR* [15], and (iii) *coaT* encoding a putative  $\text{Co}^{2+}$  translocating P-type ATPase under the regulation of the upstream *corR* product [16][11].

Various kinds of transporters related to different superfamily transporters were identified in the secondary transporters. CDF family  $\text{Cd}^{2+}/\text{Zn}^{2+}/\text{H}^{+}/\text{K}^{+}$  antiporter (*sync\_0686*), ZIP family Zinc ion (*sync\_0684*), Nramp family manganese/iron ion (*sync\_2773*), RND superfamily cobalt/zinc/cadmium ion efflux (HME subfamily) (*sync\_1510*) from *Synechococcus sp.* CC9311 and RND family cobalt/zinc/cadmium ion efflux (HME subfamily) (*syncRCC307*) from *Synechococcus sp.* RCC307 were reported. ABC transporters contain a specific motif, the consensus signature sequence LSGGQ/R/KQR, which is highly conserved and is specific to the ABC superfamily. This sequence is also known as the linker peptide or C motif and is located N-terminal with respect to the Walker B motif [17].

Multidrug transporters from *ScynPCC6803* were compiled and using CLC main workbench multiple sequence alignment was generated but there are no conserved domains were reported, being a multidrug transporter, substrate binding domain binds to various kinds of compounds Horizontal gene transfer effect plays an important role in the acquisition of the requirements to adapt to specific niche conditions. Island path analysis tool is used to analyze Genomic island associated features of metal ion transporters for 10 cyanobacterial spp and for PmarMED4 (CCMP1378) genomic island features are not available in the island path tool. Thus island path analyzer gave us the clear idea on the no. of metal ion transporters acquired through HGT mechanism in the Cyanobacterial spp. PmarMIT9313 showing 71% of metal ion transporters are acquired through HGT mechanism and SyncsWH7803, syncspWH8102 and PmarSS120 (CCMP1375) has the very less no. of transporters acquired through HGT mechanism.

## CONCLUSION

In this study a dataset cataloguing was performed for 184 transporter proteins including metal ion transporters from eleven *Cyanobacterial spp* and multidrug transporters from *ScynPCC6803*. This is the comprehensive genomic comparison of metal transporters, providing potentially important insights into the fundamental molecular aspects and novel facets of *Cyanobacterial* metal transporters.

## ACKNOWLEDGEMENT

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Table 1: Global features of eleven *Cyanobacterial spp.*

Topology	Genome size (bp)	G+C content (%)	Total no: of genes	Total transporter proteins	Total metal transporters
<i>Scyc</i> PCC6803	3,956,957	48.22	3,725	168	38
<i>Pmar</i> SS120(CCMP1375)	1,751,080	37.01	1,928	53	19
<i>Pmar</i> MED4(CCMP1378)	1,657,990	30.80	1,756	56	16
<i>Pmar</i> MIT9313	2,410,873	51.75	2,326	88	24
<i>Selo</i> PCC6301	2,752,955	55.98	2,326	107	30
<i>Synsp</i> CC9311	2,434,428	52.91	2,944	127	29
<i>Synsp</i> CC9605	2,510,659	59.39	2,692	83	25
<i>Synsp</i> CC9902	2,234,828	54.52	2,355	78	21
<i>Synsp</i> RCC307	2,224,914	60.61	2,583	107	31
<i>Synsp</i> WH7803	2,366,980	60.32	2,586	132	32
<i>Synsp</i> WH8102	2,434,428	60.02	2,579	88	26





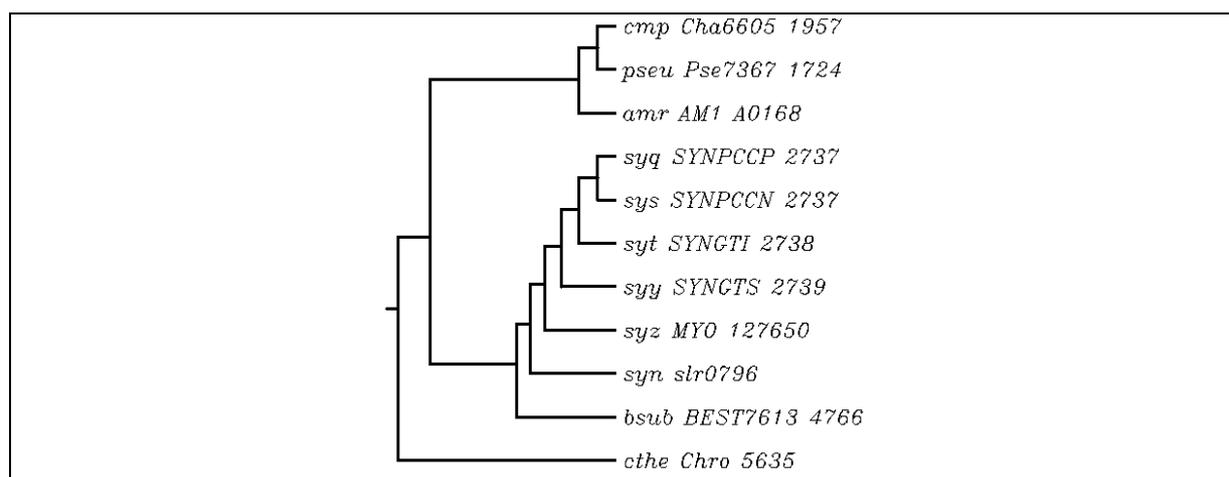
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**Table 2. Comparative Analysis of Metal transporters from *Cyanobacterial spp***

Name of the organism	Metal Transporter Type/Family			
	ATP dependent	Ion channels	Secondary transporters	Unclassified transporters
<i>ScycPCC6803</i>	19	6	12	2
<i>PmarSS120(CCMP1375)</i>	5	2	11	1
<i>PmarMED4(CCMP1378)</i>	5	1	9	1
<i>PmarMIT9313</i>	5	3	15	1
<i>SeloPCC6301</i>	9	5	15	1
<i>SynspCC9311</i>	6	5	19	2
<i>SynspCC9605</i>	6	2	16	1
<i>SynspCC9902</i>	5	1	14	1
<i>SynspRCC307</i>	6	7	16	1
<i>SynspWH7803</i>	7	7	16	1
<i>SynspWH8102</i>	6	4	15	1

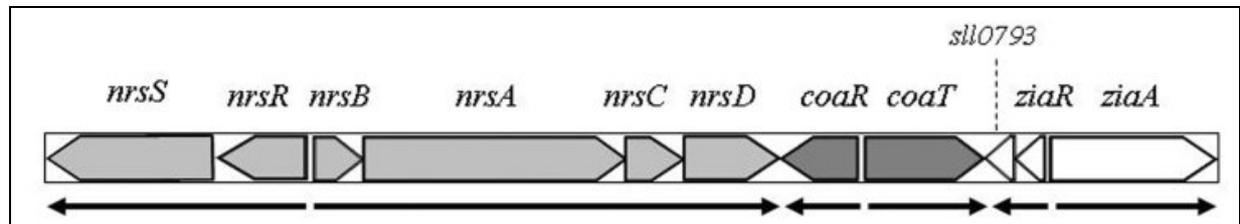
**Table 3. Inventory of multidrug transporters from *ScynPCC6803***

Metal Transporter Type/Family	No. of multi drug transporters
<b>ATP dependent</b>	
ABC family	05
<b>Secondary transporters</b>	
The Major Facilitator Superfamily (MFS)	04
The Multidrug/Oligosaccharidyl-lipid/Polysaccharide (MOP) Flippase Superfamily	02
The Resistance-Nodulation-Cell Division (RND) Superfamily	03



**Figure 1. Phylogenetic tree for MFS family Ni<sup>2+</sup> transporter with its orthologous sequences It depicts the grouping of various orthologous from different species.**





Figur.2. A metal-regulated gene cluster of Synechocystis PCC 6803. The pentagons represent ORFs (open reading frames) and indicate the direction of translation. From left to right: slI0798 (nrsS), slI0797 (nrsR), slr0793 (nrsB), slr0794 (nrsA), slr0795 (nrsC), slr0796 (nrsD), slI0794 (coaR), slr0797 (coaT), slI0793, slI0792 (ziaR), slr0798 (ziaA). Black arrows mark the putative operons.

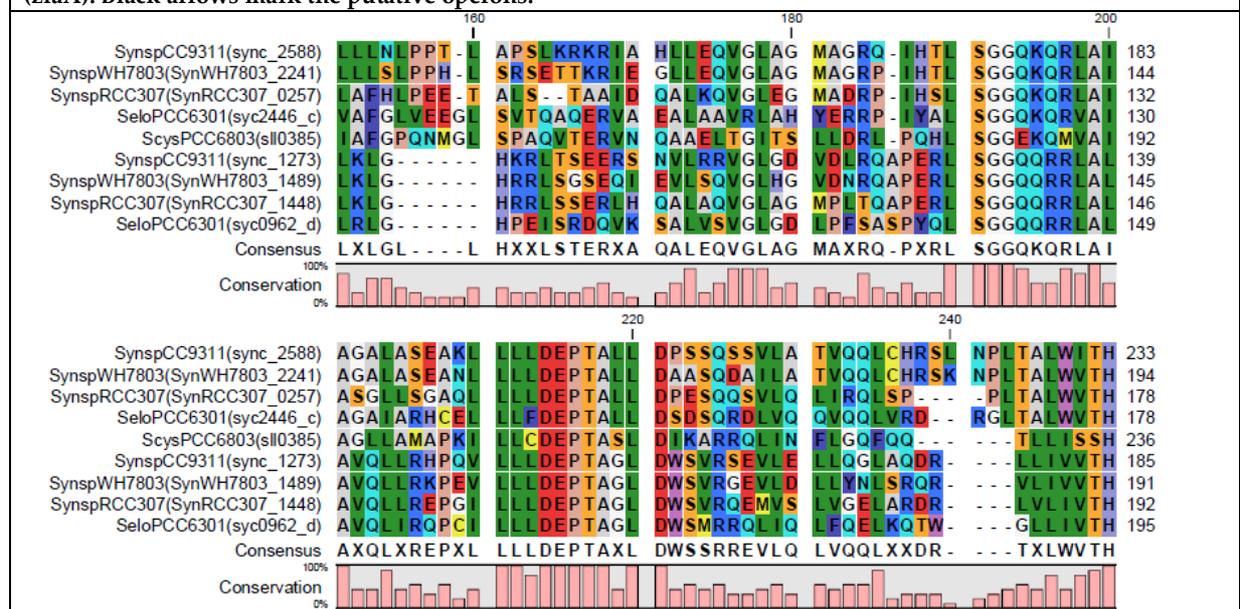


Figure 3. Multiple sequence alignment of cobalt transporters from Cyanobacterial spp LSGGQ is the regular signature sequence of the ATP dependent transporters and LLLDEPTA is the newly reported in the ATP dependent cobalt transporters

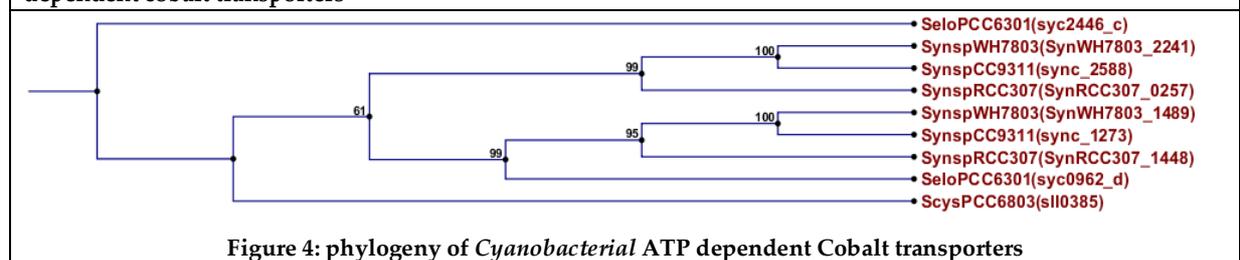


Figure 4: phylogeny of Cyanobacterial ATP dependent Cobalt transporters





## Customer Churn Prediction in Banking using Naïve-Bayes Algorithm

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### ABSTRACT

Churn prediction is a very important aspect in different private and public sectors all over the world. Customer's churn is very harmful for company's revenue and profit. Main step to avoid churn is to detect churn. Prediction of customer's churn helps company to apply various marketing strategies on the basis of whether the customer is about to leave or not. The objective of this paper was to predict the churn of banking sector by supervised classification using well known machine learning techniques like decision tree and Naïve-Bayes algorithm; the classification model to be built on historical data and then the model is used to predict the result for the current customers to identify the churn. The defined model is very effective for prediction of churn with the experimental dataset of an International Bank collected from kaggle repository and produced a prediction accuracy of 94.25%. Other than banking sector the model also can be useful in different sectors like telecommunication, online subscription, and online marketing field.

**Keywords:** Predictive models; Customer churn prediction; Performance metrics; Data sampling decision; Naïve-Bayes algorithm.

### INTRODUCTION

The key aspiration of every business is to build a loyal customer base and maintain that as well. However, the banking sector is characterized by stiff competition and also based on various marketing strategies. For a single dissatisfaction service, a customer does not churn [1]. So, customer churn can be defined as the loss of profit or revenue in the business sector [2]. The customer churn can be defined in other way also, like low switching cost, deregulation motivates a customer to replace the sector. The churn is also classified into two: voluntary and involuntary churn [3]. Voluntary churn is defined as the termination of services by the customer itself, whether involuntary churn is defined as the termination of services by the bank for fraud, non-payment services.





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The customer churn is very risky if it is not managed carefully, it may bring a company to its knees for poor maintain services. Cost of customer churn also includes loss of revenue, profit. Previous case study has shown that the cost of maintaining new customer is higher than the cost of maintaining the old one [4]. There are various banks who are suffering with this customer churn problem. So the most defined way is to deal with this problem is developing predictive model that can reliably and easily identify the possible churning. In the recent past most frequently used technique is data mining to develop such models with satisfactory results [5]. Day by day when this churn prediction problem get importance, much more research efforts generated towards improving churn prediction rates.

Most frequently used features that have been used previously includes credit score, geography, has credit card or not, is active member, estimated salary [6]. Due to business privacy and policy it is difficult to find and use public dataset for churn prediction. Tsai and Lu previously used two different hybrid model which can predict customer churn. To increase the prediction rate Kechadi and Buckley used attribute derivation process [4]. In this paper we present a new subset of features in order to improve the prediction accuracy. We performed experiments using Naïve Bayes classifier [7] and the result compared with decision tree [8], most frequently used algorithm in many classification and prediction work. This paper has been organized into five sections. Section-2 provides details of dataset and evaluation measures, Section-3 demonstrates the proposed system and its methodology. Section-4 provides analysis of results. Finally, Section-5 concludes this study.

### Data set details and Evaluation criteria

In this Study, a bank data is considered where a huge number of customer is leaving the bank. Almost 10000 records of the bank, collected from Kaggle repository is going to help the model to investigate and predict which of the customers are about to leave the bank soon. To test and evaluate the features the total dataset sliced into two subsets, training and testing dataset. Training dataset can be used to define the statistical model and the testing dataset can be used to predict the result and calculation of accuracy metrics for determining the model accuracy.

For validation of the model accuracy of the classifier is calculated on the basis of four output factors:

True positive (TP): correctly predicted positive cases.

False negative (FN): positive cases wrongly predicted as negative.

False positive (FP): negative cases wrongly predicted as positive.

True negative (TN): negative cases correctly predicted.

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + FN + TN}$$

### METHODOLOGY

The defined model contains four different phases: data sampling, data pre-processing [9] and feature extraction, lastly model construction and model evaluation phase.

#### Data sampling

The dataset set containing 10000 costumers data in 24 columns, those are customerid, surname, credit score, gender, age, balance, geography, hasrcard, exited (the value indicates 1 when the customer churned).

#### Preprocessing

In this phase different preprocessing techniques like handling the missing values, data cleaning and feature extraction process has been performed. To identify the missing values in the dataset imputation technique will be used to impute the blank and null values. Noisy data, irrelevant attribute should be removed. Those variables those are not so much important can be removed in case of model building [10]. Finally for determining the performance of predictive model [11], feature extraction plays an important role for correct prediction. Here are some important features with description that can be useful for model construction as shown in [Figure-1].





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- Age: the age of the customer.
- Balance: the total bank balance of the customer.
- Is Active Member: how active the customer is/was in his service period.
- Tenure: defined by the length of service or duration, from the starting date to termination date. Plays an important role for prediction of churn.
- When it comes to the distribution of all data points over mean, box plots are used to identify the median and also respective qualities in well-structured manner.

### Building the Model

In this study, probabilistic algorithm Naïve Bayes algorithm is used on the proposed feature set for defining the model. Then the result is compared with the decision tree algorithm that most widely used algorithm for classification work. The two techniques are briefly discussed.

### Decision tree

Decision tree uses the most common method 'divide and conquer' to construct the model based on tree structure. The decision tree looks something like flowchart. The nodes of the tree represent the features. Main approach of this method is that it searches for the best attribute with the best information gain through the root node, then divide the tree into various sub trees. Similarly, those sub trees follow the same rule and separated recursively. When the leaf node is reached or there is no information gain, then the partitioning will be stopped.

### Naïve-Bayes algorithm

this is based on the Bayesian theorem. The approach instantly analyses the relationship between each feature as well as the class of each instance based on conditional probability. Assume that  $X$  is denoted as the vector of instance and also a random variable  $C$  denoted as the class of an instance. So now decide that  $X$  is a particular instance and  $C$  is a particular class. Now the training process shows that the computation of the probability of each class is defined by the how many times the class occurs in the training dataset. This is known as the prior probability  $P(C=c)$ . As well as the probability of the instance  $x$  given  $c$  is also computed by this algorithm. The advantage of this algorithm is that Naïve Bayes has achieved good result when the assumption and the considered class is violated. So, the Bayes formula is as follows:

$$P(C = c | X = x) = \frac{P(C = c) \prod_i P(x_i | C = c)}{P(X = x)}$$

The probability of an instance ( $x$ ) and a class  $c$  can be computed by the combination of prior probability and attribute density function.

Finally the block diagram of the proposed model is shown in [figure-2]

## RESULT AND DISCUSSION

The model is evaluated using two different machine learning algorithms decision tree and Naïve-Bayes algorithm by using a test data size 2000, which is 20% of the total dataset. The performance of the classifiers evaluated in terms of sensitivity, specificity and overall accuracy as shown in [table-1]. Based on the all pairs of TP and FP the ROC curves [12] were plotted as shown in [Figure-3] where X axis represents the false churn rate and Y axis represents the true churn rate. Each ROC curve represents actual pair of prediction rate (FP, TP). The ROC curve which is closer to the left top corner represent a better prediction rates. The difference between the Naïve Bayes and decision tree has shown from the upper curves. It is also shown that the sampling rate CHURN/ACTIVE decreases the number of ACTIVE increases through the Naïve Bayes model. This study shown that Naïve Bayes probabilistic classifier achieve higher growth that the decision tree.





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The gain of information is measured by the information theory, that also measure the information content on the attribute. The attribute we use to build the model is all about high information gain. Depending on the information gain of the attribute we use the top ranked attribute for model building purpose. It is defined that the selected attribute has the highest prediction rate through the Naïve Bayes model.

## CONCLUSION

Customer churn prediction plays an important role for predicting the churns in different sectors including banking. The defined model fits appropriately in identify the churners, with the underlying experimental dataset. The principal features were selected and evaluated by a powerful ML technique, Naïve Bayes algorithm and then the result is compared with Decision Tree algorithm. In future this work can be extended for prediction of churns in other sectors like sectors like telecommunication, online subscription, and online marketing field.

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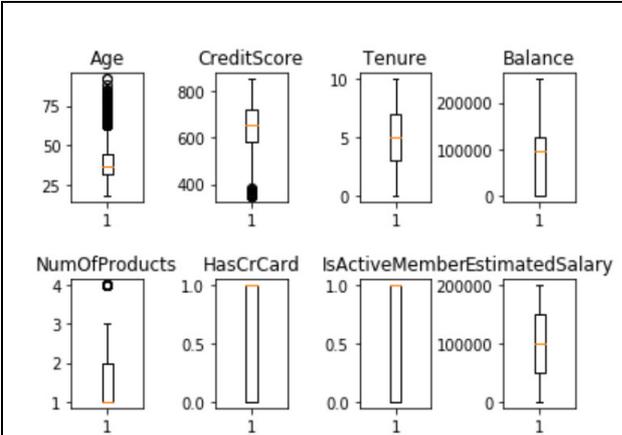
**Table 1 Performance measure and comparison of the model**

Performance measures	Naïve Bayes	Decision Tree
Accuracy	94.63%	92.25%
Sensitivity	97.54%	96%
Specificity	94.25%	92%

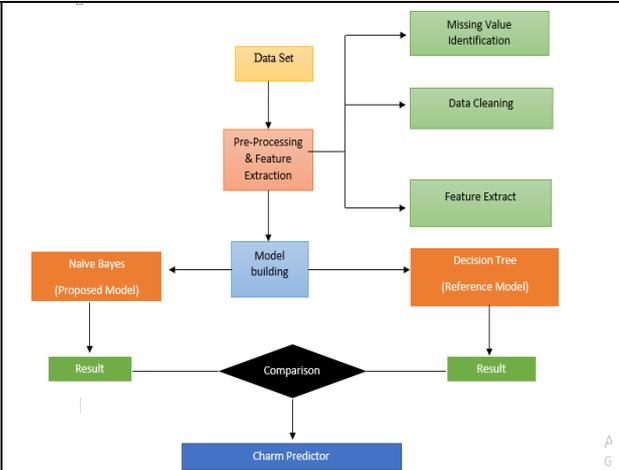




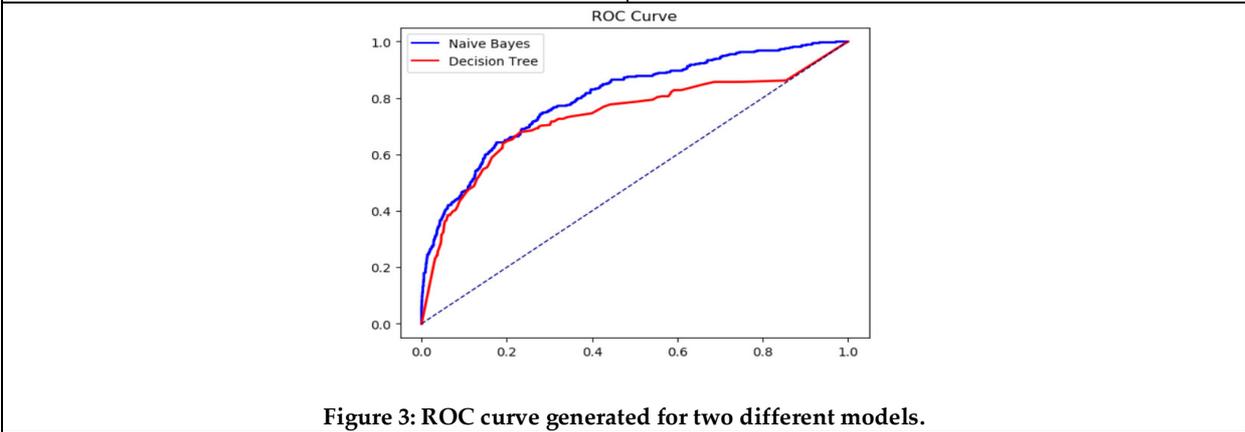
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**Figure- 1: Set of essential Features used to define the model.**



**Figure.2: Flow Diagram of the Model**



**Figure 3: ROC curve generated for two different models.**





## Physiological, Molecular and Genetic methods to assess Cyanobacterial Diversity: A Mini Review

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### ABSTRACT

Cyanobacteria can form dense eutrophic and harmful algal blooms (HAB). It can contribute towards atmospheric nitrogen fixation and influence the global nutrient cycles. Hence the study of their physiology, biochemistry and genetics is of much importance since last few decades. A cyanobacterial population provides an excellent model to identify the underlying molecular mechanisms which allow their success in water columns with higher intensities of light and extreme levels of nutrients. As cyanobacteria are primitive organisms, they provide novel insights into the genetic adaptations to their environmental changes happening due to global warming, high Photosynthetically Active Radiation (PAR) and UV-Radiation along with anthropogenic impacts. Comparing different types of species to different conditions enables better understanding of different physiological pathways linked to toxin production and bloom formations. The complete analysis of cyanotoxin biosynthesis-gene clusters (eg. Nodularin, Anatoxin, Microsporin, Cylindrospermopsin etc.) and the developments of their genetic manipulation techniques are of high importance in this area of research. However, toxin production depends on biological, physical and chemical factors encountered in the ecosystem. Genetic markers rather than traditional methods, presents a tremendous way to understand the interrelations, allelopathic





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influences and these are critical to understand the hidden secrets. In geographical distribution of cyanobacterial species, there is large information still to be explored to reveal the phylogenetic findings. In this review, few attempts were made to show possible solutions towards the above mentioned problems and are discussed in a general way emphasizing on genetic markers along with few other models.

**Keywords:** Cyanobacteria, genetic markers, PAR, UVR, algal blooms

## INTRODUCTION

### Connecting link between bacteria and plant

Cyanobacteria (blue green algae) form a diverse group of autotrophic bacteria, found in both aquatic and terrestrial environments. They evolved around 3 billion years ago (Knoll, 2008) and played an important role in the evolution of present day atmosphere oxygen, carbon, phosphorus, iron and nitrogen cycles - in short evolution of life on earth (Van den Hoek *et al.* 1995). It plays a key role in the functioning of onshore and offshore ecosystems, as they form the major constituent of phytoplankton communities and form dense mats of plankton blooms when favorable conditions prevail. These blooms are stimulated by high temperature, low CO<sub>2</sub> concentrations, high intensities of light, stratification of water body, a high phosphorus concentration and low inorganic N and P concentrations in the water column (Huisman *et al.* 2005). The important factor is, the cyanobacterial bloom once established, influences the internal phosphorus loading, light gradient, temperature, CO<sub>2</sub> depletion, which in turn stabilizes the bloom (Bicudo *et al.* 2007).

There are many species of cyanobacteria that produce hepato-, neuro-, gastrointestinal and cytotoxins along with some irritants i.e., Microcystis, Planktothrix, Anabeana, Aphanizomenon, Cyndrospermopsis that are highly toxic to some eukaryotes (Codd *et al.* 2005), causing health crisis in both fresh and marine ecosystems. Moreover, both global warming and eutrophication of waters have increased the frequency of formation of these blooms worldwide during last decade and it may continue (Jöhnk *et al.* 2008, Huisman *et al.* 2005). All these conditions prompt us to understand biodiversity of the species especially toxin producing ones. Genetic markers' gives us a scope to identify individuals and toxin producing species accurately. In ecological sense, genetic marker acts as a screening tool for ecological risk assessment and analysis. Several studies have shown that 16S rDNA are useful as molecular marker in taxonomic studies of cyanobacteria as in other prokaryotes. Hence, there is a need of thorough study of phylogenetics of cyanobacteria (Giovannoni *et al.* 1988, Otsuka *et al.* 1999).

Cyanobacteria can produce structurally diverse group of compounds called cyanotoxins which are synthesized via a nonribosomal pathway and are a product of the secondary metabolism (Pearson *et al.* 2008). Cyanotoxins have potential impact on aquatic ecosystems as well as on humans and livestock animals (Carmichael, 1992). Cyanotoxins are classified on the basis of their toxic effects and mode of action: hepatotoxins, neurotoxins and dermal toxins (Carmichael and Liu 2006). The production of cyanotoxin is not strain specific, for example, Cyndrospermopsin has been from nine different species (Moreira *et al.* 2012; Glenn *et al.* 2011). A family of multi-enzymatic complexes known as nonribosomal peptide synthetases and polyketide synthases, which are organized into repeated functional units are responsible for biosynthesis of cyanotoxins (Cane *et al.* 1996; Dittmann *et al.* 2011).

### Genetic diversity of cyanobacteria

Genetic markers provide valuable data which enables the detection of differentiation of species at DNA level. The suitability of the genetic marker depends on different characteristics, which include that the marker must be polymorphic, must show co-dominance, must be distributed randomly in the genome, must include simple and cost effective mechanisms and must be reproducible. They are useful in both basic studies like phylogenetic studies, searching of useful genes and applied studies like marker assisted selection, traceability testing.



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There are approaches which rely on DNA sequencing of cyanobacteria. In cyanobacteria, more than 80 genomes have been sequenced (Moreira *et al.* 2013). Genetic markers helped to determine the genetic diversity, population structure, phylogeographic structure and biogeographic pattern of the isolates ( Bittencourt-Oliveira *et al.* 2001; Moreira *et al.* 2011; Bahl *et al.* 2011). However, most phylogenetic analyses of nucleic acids as molecular markers for cyanobacteria have focused on *Synechococcus* and symbiotic filamentous *Anabaena* and *Nostoc* (Brett A. Neilan, 2002). The use of 16S rRNA genetic marker becomes an appropriate marker for cyanobacterial phylogenesis in recent years. The genetic polymorphism using 16S-23S ribosomal RNA transcribed spacer (RNA ITS) is able to define new horizons besides traditional methodology of classification (Brett A. Neilan, 2002). Genetic markers can be used to bring out the causes of hereditary diseases (Giovani, 1988). Procedures involving DNA transfer and probe hybridization have showed delineation of closely related and toxic cyanobacteria (Giovannoni, 1988, Douglas *et al.* 1988, Mazel *et al.* 1990, Wood *et al.* 1988, 1990).

There are many genetic markers identified which have wide application in phylogeny, taxonomy, phylogeography, evolution and biogeography studies of cyanobacteria (Moreira *et al.* 2013). Phycocyanin Intergenic spacer (PC-IGS) can be used as taxonomy, phylogenetic, phylogeography and biogeographical application while *ftsZ*, *glnA*, *glx*, *gyrB*, *pgi*, *recA*, *tpi*, 16S-23S ITS1-L, 16S-23S ITS1-S, *rpoC1*, *nifH*, 16 rRNA, 16S-23S ITS, *psbA*, *rbcL*, *rbcS*, *nifH*, 16 rRNA, 16S-23S ITS, *rbcLX* and *hetR*. From evolutionary point of view *nifH* and *rpoC1*, 16rRNA are important markers that find importance in phylogenetic studies only. Genetic markers which find application in taxonomy are *rpoB*, *rpoC1*, *nifH*, *nifD*, 16S-23S ITS, *rbcLX* and *hetR*. Genetic markers are useful tools to resolve taxonomic issues among genera or at species level, as well as to establish biogeographic patterns. There is a clear agreement between all the applied markers (Ballot *et al.* 2008; Gugger *et al.* 2002; Haande *et al.* 2007) in multi-gene analysis studies, though sometimes controversies may arise about the choice of best phylogenetic markers due to conflicting results (Dyble *et al.* 2002).

Multi-gene analysis requires more PCR reactions and DNA sequencing, which in turn, makes the procedure more expensive than to use a single genetic marker. In global perspective, we should consider different climatic zones tropical to temperate, high to poor levels of nutrients, high and low light gradient zones, all these different conditions influence the cyanobacterial blooms. Molecular markers are one of the proxies for detecting how environmental or biological factors are influencing the physiological and gene patterns of cyanobacteria. Such markers are the main source for indicating stress responses to low or high nutrient concentrations and changes in light intensities which can be detected at the gene transcription or protein level technologies (LaRoche *et al.* 1999), for example, the status of marine *Synechococcus* be assessed using a protocol expression of N regulatory gene *ntcA*. (Lindell *et al.* 2001) These responses may indicate species migrations and succession or suppression conditions. (Scanlan *et al.* 1997, 1999).

**Molecular approaches to study genetic diversity of cyanobacteria**

In early 1990s, research started on cyanotoxins and molecular markers of cyanobacteria. The studies were based on identification, detection, quantification, profiling, assembling of genetic diversity and phylogenetics of a particular taxa. Qualitative and quantitative studies of cyanotoxin were performed by HPLC and ELISA. In recent times, molecular tools DNA bar coding, Phylogenetic tree analysis, PCR, multiplex-PCR, Restriction Fragment Length Polymorphism (RFLP), Amplified Fragment Length Polymorphism (AFLP), Simple Sequence Repeats (SSR) / Microsatellites, Multilocus Sequence Typing (MLST), Random Amplified Polymorphic DNA (RAPD), Denaturing Gradient Gel Electrophoresis (DGGE), Fluorescence *in situ* Hybridization (FISH), Real-time PCR (qPCR) and DNA microarrays, CRISPRi technology are widely used.

All these methods are PCR based and the techniques used follows the same basic steps of using of Restriction Enzymes for digestion, Polymerized Chain Reaction (PCR) and finally Gel Electrophoresis. The methodology of genetic markers includes extracting proteins or chemicals from cells or tissues. Then different laboratory procedures will be applied and later blotting or staining techniques will be applied during which the information is formed in to a set of data. Analyzing these data sets, genetic diversity can be defined, measured and interpreted. The *in vitro*





molecular approaches based on Polymerized Chain Reaction showed significant advantages as screening tools for the identification of toxin releasing species because these systems enable potentially rapid as well as sensitive results. The type of technique selected is determined by the type of sample used and problems to be addressed.

- a) Restriction Fragment Length Polymorphism (RFLP):** The differences in DNA sequence of all organisms are genotypically distinct. This characteristic is the base for RFLP technique. Technique includes digestion of DNA fragment using digestive enzymes, gel electrophoresis and southern blotting. This technique is useful in identifying genetic diversity within and between species (Old *et al.* 1998). It shows a great co-inheritance but it takes long time and large amounts of DNA fragments which are the needs for this technique.
- b) Random Amplified Polymorphic DNA (RAPD):** Polymerized chain reaction (PCR) technique is being used in this technique along with gel-electrophoresis. It yields results in a short time. This technique enables to amplify a desired sequence of a DNA molecule, using a short primer and will be useful in phylogenetics. Its fast, high variability and relatively low cost characteristics made this technique a widely used one, but inability to give reproducible results made this technique replaced by other recent techniques.
- c) Amplified Polymorphic Length Polymorphism (AFLP):** This technique is a combination of both RFLP and RAPD techniques. Its good reproducibility, high levels of polymorphism and speed of analysis made this technique very popular now a day. These abilities enable one to utilize this technique for whole genome fingerprinting (Faccioli *et al.* 1999) and map expansion (Castiglioni *et al.* 1998).
- d) Denaturing Gradient Gel Electrophoresis (DGGE):** Black band disease (BBD) is a pathogenic, sulfide-rich microbial mat dominated by filamentous cyanobacteria that infect corals worldwide. We isolated cyanobacteria from BBD into culture, confirmed their presence in the BBD community by using denaturing gradient gel electrophoresis (DGGE), and demonstrated their ecological significance in terms of physiological sulfide tolerance and photosynthesis-versus-irradiance values. Twenty-nine BBD samples were collected from nine host coral species, four of which have not previously been investigated, from reefs of the Florida Keys, the Bahamas, St. Croix, and the Philippines. From these samples, seven cyanobacteria were isolated into culture. Cloning and sequencing of the 16S rRNA gene using universal primers indicated that four isolates were related to the genus *Geitlerinema* and three to the genus *Leptolyngbya*. DGGE results, obtained using Cyanobacteria-specific 16S rRNA primers, revealed that the most common BBD cyanobacterial sequence, detected in 26 BBD field samples, was related to that of an *Oscillatoria* sp. The next most common sequence, 99% similar to that of the *Geitlerinema* BBD isolate, was present in three samples. One *Leptolyngbya*- and one *Phormidium*-related sequence were also found. Laboratory experiments using isolates of BBD *Geitlerinema* and *Leptolyngbya* revealed that they could carry out sulfide-resistant oxygenic photosynthesis, a relatively rare characteristic among cyanobacteria, and that they are adapted to the sulfide-rich, low-light BBD environment. The presence of the cyanotoxin microcystin in these cultures and in BBD suggests a role in BBD pathogenicity. Our results confirm the presence of *Geitlerinema* in the BBD microbial community and its ecological significance, which have been challenged, and provide evidence of a second ecologically significant BBD cyanobacterium, *Leptolyngbya*.
- e) Microsatellites:** These are also known as Simple Sequence Repeats (SSRs), Short Tandem Repeats (STRs), Single Nucleotide Polymorphism (SNPs), Simple Sequence Length Polymorphism (SSLPs) etc. Generally there are many different microsatellite loci in organisms which are distinct genotypically. This technique is based on these loci. Microsatellites generally consist of less than 5 bp in length and show high variability, co-dominance and reproducibility which make them ideal for genome mapping besides population genetic studies.
- f) DNA microarrays:** Non-PCR based Methods: Non-PCR based approaches to identify and quantify cyanobacteria and cyanotoxin are based on DNA microarrays studies (Li *et al.* 2004). These studies are comparatively new to cyanobacteria field of research and limited to validation of methods related to detection of microcystin (*mcyE*) and





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nodularin (*ndaF*) cyanobacteria producers in both strains and environmental samples (Rantala *et al.* 2008). FISH studies is useful in identification of cyanobacteria in natural samples (Worden *et al.* 2000; Schönhuber *et al.* 1999) as well as for identification of the cyanotoxin microcystin (*mcyA*) in the cyanobacterium *M. aeruginosa* (Metcalf *et al.* 2009). In FISH, cells are made permeable to fluorescent labelled probes by a fixative. Probes are hybridized under stringent condition to rRNA and florescent signal determined by flow cytometry (Sekar *et al.* 2004).

- g) CRISPRi technology: Spatiotemporal Gene Repression System in the Heterocyst-Forming Multicellular Cyanobacterium *Anabaena* sp. PCC 7120:** The heterocyst-forming multicellular cyanobacterium *Anabaena* sp. PCC 7120 is often used as a model organism for prokaryotic cell differentiation. We recently demonstrated that heterocysts are suitable for photosynthetic production of valuable chemicals, such as ethanol, due to their active catabolism and microoxic conditions. We have developed gene regulation systems, including cell type-specific gene induction systems, to broaden this cyanobacterium's use. In the present study, a heterocyst-specific conditional gene repression system was successfully created by combining a cell type-specific gene induction system with CRISPRi technology. We targeted the *glnA* gene that encodes glutamine synthetase, an essential enzyme for nitrogen assimilation, to reconstruct metabolism in the multicellular cyanobacterium. Heterocyst-specific repression of *glnA* enhanced ethanol production. We believe that heterocyst-specific gene repression systems are useful tools for basic research on cell differentiation as well as for metabolic engineering of heterocysts.
- h) Photosynthetic capabilities of cyanobacterial isolates:** Photosynthetic growth rates of cyanobacterial cultures were determined experimentally by measuring the photo incorporation of [<sup>14</sup>C] NaHCO<sub>3</sub> over a 2-h period, using a photosynthetron, which generates a photosynthesis-versus-irradiance curve in a single experiment by using replicate samples over a range of light intensities (26). Light was supplied by a reflective fixture with four cool-white fluorescent bulbs (F40/ CW) and two very-high-output fluorescent bulbs (FR40T12/VHO). In each experiment, three replicate scintillation vials were incubated for each of 15 simultaneous light intensities (45 vials total), which were controlled by using neutraldensity filters to provide light in 7.1% increments from darkness to 100% light (150  $\gamma$ E m<sup>-2</sup> s<sup>-1</sup>). Light was measured using a biospherical Instruments Inc. (San Diego, CA) model QSL-100 averaging quantum meter. Experiments were conducted at a constant temperature of 30°C.
- i)** To measure oxygenic photosynthesis, an equal volume of cell suspension (1 ml) from a culture that was inoculated and incubated overnight was added to each experimental vial by using a sterile self-repeating syringe. This was accomplished by first dispersing the filaments by pumping with the syringe. Each of the 45 scintillation vials contained an equal volume (5 ml) of sterile ASN III medium. After inoculation, [<sup>14</sup>C]NaHCO<sub>3</sub> was added to a specific activity level of 0.05  $\gamma$ Ci m<sup>-1</sup> l. After the 2-h incubation, each sample was killed by the addition of formalin to a final concentration of 1.5%. The samples were filtered onto 934-AH glass fiber filters, washed with sterile ASN III medium, and rinsed with a solution of 2.0% HCl. Each filter was placed in 7 ml of Ecolume scintillation cocktail (MP Biomedicals, Solon, OH) to measure the photo incorporation of <sup>14</sup>C, using a Beckman LS-6500 liquid scintillation counter (Beckman Coulter, Fullerton, CA).
- j)** The amount of <sup>14</sup>C incorporated was expressed as CO<sub>2</sub> fixation per biomass by use of dry weight, which was obtained from three vials containing only ASN III medium (without [<sup>14</sup>C]NaHCO<sub>3</sub>) that were inoculated at the same time as the experimental vials, immediately filtered onto preweighted filters, dried, weighed, and averaged. Each experiment was performed in triplicate and included a dark aerobic control. Photosynthesis in the presence of sulfide was measured using the same experimental procedures as described above, with the following modifications. Anaerobic media were prepared by bubbling ASN III medium with a steady stream of reagent-grade N<sub>2</sub> gas for 30 min to remove the oxygen. In order to maintain anaerobic conditions, 7-ml scintillation vials with Hungate caps and septa were used. Sulfide was added from a stock solution of Na<sub>2</sub>S 9H<sub>2</sub>O through the septum of each vial to a final concentration of 0.5 mM. Each sulfide experiment included the following two controls: anaerobic without the addition of sulfide and anaerobic with sulfide and the addition of



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3-(3,4-dichlorophenyl)-1,1-dimethylurea (DCMU; final concentration of 10  $\mu$ M), which blocks electron transport to photosystem II. These controls were performed in triplicate at the highest experimental light intensity.

- k) **Photomicroscopy:** Photomicrographs were taken using a Leitz DMR microscope (Rockleigh, NJ) equipped with a Leica DC500 digital camera interfaced with a computer equipped with digital imaging software.

**CONCLUSIONS**

Application of genetic markers in combination with DNA amplification techniques into phylogenetic and toxicological studies of cyanobacterial system makes the system more accurate. Results of 16S rRNA genetic markers in cyanobacteria showed that morphological characters themselves are not appropriate for this system (Giovannoni *et al.*, 1988; Wilmotte, 1994). Species relatedness is determined by performing DNA-DNA hybridization procedures. More than 97% of in DNA-DNA homology technique resembles the species relatedness of a specific species. But still the same result always does not show same strain of the species. So we need a specific intraspecific genetic marker for several purposes. Then only we can conclude environmental, physiological, chemical and behavioral responses of different species of cyanobacteria. Along with the above we can conclude the harmful toxin producing abilities of different strains in relation to different nutrients, light gradients, temperatures etc in a global scale to minimize the detrimental effects and accidental effects. There is a great need of techniques to estimate the levels of cyanobacterial harmful toxins on global and regional scale to maintain the stocks, biodiversity of the species. Acquiring all these techniques and methodologies, scientific community must possess a duty to show some sort of solution mechanisms or strategies to the industries like aquaculture and tourism besides biodiversity.

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## Drowsiness Detection System by using Viola Jones and Haar Cascade Algorithm

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### ABSTRACT

Now-a-days the numbers of vehicle accidents are increasing and a large portion of these is going on due to carelessness of driver. Drivers must watch out for the street, so they can respond to abrupt occasions right away. Driver weakness regularly turns into an immediate reason for some vehicle crashes. Consequently, there is a need to build up the frameworks that will identify and tell a driver of her/him terrible psycho-physical condition, which could fundamentally diminish the quantity of exhaustion related auto crashes. In any case, the advancement of such frameworks experiences numerous challenges identified with quick and appropriate acknowledgment of a driver's exhaustion manifestations. One of the specialized prospects to execute driver sluggishness recognition frameworks is to utilize the vision-based methodology. This article presents the as of now utilized driver laziness identification frameworks. Here the system is distinguishing the driver languor by evaluating vision arrangement of him. A convolution activity is performed on these layers utilizing a channel that performs 2D network duplication on the layer and channel.

**Keywords:** Haar Cascade Algorithm; OpenCV; Viola Jones Algorithm

### INTRODUCTION

Driver sleepiness recognition is a vehicle well being innovation which forestalls mishaps when the driver is getting sluggish. Different investigations have recommended that around 20% of all street mishaps are exhaustion related, up to half on specific streets. Driver weariness is a huge factor in an enormous number of vehicle mishaps. Ongoing insights gauge that yearly 1,200 passing and 76,000 wounds can be credited to weariness related accidents. The advancement of advances for recognizing or forestalling sluggishness in the driver's seat is a significant test in the field of mishap evasion frameworks. In view of the risk that sluggishness presents out and about, strategies should





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be created for checking its effects. Driver negligence may be the consequence of an absence of sharpness when driving because of driver languor and interruption.

Driver interruption happens when an article or occasion keeps a person from noticing the driving assignment. In contrast to driver interruption, driver sleepiness includes no activating occasion in any case, rather, is portrayed by a dynamic withdrawal of consideration from the street and traffic requests. Both driver laziness and interruption, nonetheless, might have similar impacts, i.e., diminished driving execution, longer response time, and an expanded danger of crash contribution shows the square chart of by and large framework. In light of Acquisition of video from the camera that is before driver performs constant handling of an approaching video stream so as to construe the driver's degree of weakness on the off chance that the sleepiness is estimated, at that point it will give the alarm by detecting the eyes. The system is used six steps to complete the project. Here this paper is divided into six sections i.e. Face Introduction , Related Work, Methodology , Result Discussion , Conclusion.

### Related Work

A few endeavors have been accounted for in the writing on the improvement of the not-meddlesome checking tiredness frameworks dependent on the vision [1]. build up a light-inhumane framework. They utilized the Haar calculation to recognize objects [2] and face classifier executed by [3] in OpenCV [4] libraries. Eye areas are gotten from the facial district with anthropometric components. At that point, they identify the eyelid to quantify the degree of eye conclusion [5] executes a framework to recognize side effects of driver tiredness dependent on an infrared camera. By abusing the wonder of brilliant students, a calculation for distinguishing and following the driver's eyes has been created. At the point when languor is distinguished, the framework cautions the driver with an alert message. The localization of the eye is done by locating facial landmarks such as eyebrow and possible face center. Morphological operation and K-means is used for accurate eye segmentation. Then a set of shape features are calculated and trained using non-linear SVM to get the status of the eye. This research paper characterizes a framework for recognizing the eye states progressively to recognize the driver sleepiness state.[4] The face area is recognized dependent on the improved Jones and Viola technique [2]. The eye region is acquired by a flat projection. At last, another multifaceted nature work with a powerful limit to recognize the eye state.

### METHODOLOGY

This section describes different aspects of the system considered in its implementation. The used algorithm processes the color information present in the image, First of all the original image is converted to grayscale image. Then to determine the face in the image, the image is divided in sub regions determining whether the sub region is a face or not. The gesture detection is done from the residual error that is modeled considering a linear combination of facial movement models. It includes a system that allows detecting facial gestures in the presence of head movement. Fig. 1 shows the flowchart of the system limitation of the algorithms, which camera content or features are very limited. There are some stages which are shown in flow chart. When the driver enters in to the vehicle and starts the engine at that time the camera is opened and observed the face and eyes. Then it separates and detected the face and eyes of driver. When the driver feels sleepy at the time of driving and his/her eyes closes for some second, then the alarm is rung and a warning is given through the alarm to the driver to stop the vehicle.

### Face Detection

OpenCV libraries use to classification of the images. When the face is in the front of camera it detects the face by making a rectangular on it. It detects the position of the face observe your moment of face.

Here is the equation for face detection:

$$SAD(x, y) = \sum \sum I(X+I, Y+j) - M(i, j) \quad (1)$$





The system is proposed to make a regular update of the reference model M to adjust it every time when light conditions change while driving, by making a tracking test:

$$\text{Tracking} \quad \left\{ \begin{array}{ll} \text{Good} & \text{if } SAD \leq Th \\ \text{Bad} & \text{if } SAD > Th \end{array} \right. \quad (2)$$

### Parameter Detection

At the time detection it make rectangle shape around the face and eyes and separate these.

### Eyes Tracking

It also tracks the eyes and according to the movement of eyes it gives warning to the driver. When the drowsiness level increases, it gives warning. The Hough transform for circles (HTC) is used on the image of the eye to detect the iris. For that, the system is applied the HTC to the edge image of the eye to detect the circles with defined rays, and at the end the circle which has the highest value in the accumulator of Hough for all the rays is taken. Then, the logical 'AND' logic is applied between edges image and complete circle obtained by the HTC by measuring the intersection level between them "S". Finally, the eye state "state eyes" is defined by testing the value "S" by a threshold:

$$\text{State}_{eye} = \text{Open} \quad \left\{ \begin{array}{ll} \text{if } S \geq Th \\ \text{Close} & \text{if } S < Th \end{array} \right. \quad (3)$$

### Driver state

The system is decided the driver state by estimating PERCLOS. In the event that the driver his eyes in any event 5 progressive edges a few times over a time of up to 5 seconds, it is viewed as drowsy.

Our system starts with the initialization phase, which is face and eyes detection to extract both face and eyes regions and take them as templates to track them in the following frames. For each tracking the system is tested if that tracking is good or bad? If the tracking is bad, the system is returned to the initialization step, else it is passed to the following steps which are: eyes states identification and driver state.

### Detection Model

- I. **Viola Jones Algorithm:** The proposed work uses Viola Jones algorithm for detecting the eyes, eyeblink using background subtraction, gradient based corner detection and it is capable of detecting common cases of fatigued behavior linked with prolonged computer use by tracking the eye blink rate.
- II. **Haar Cascade Algorithm:** Haar Cascade Algorithm for Face Detection and for image classification we used OpenCV libraries. To capture driver drowsiness, we use high resolution camera. When the drowsiness is detected the alarm rings and gives a warning to the driver.

### Alarm

The Alarm is used for giving warning to the driver at the time of driving, when drowsiness is detected.

## RESULTS AND DISCUSSION

Implementation of drowsiness detection with Python and OpenCV was done which includes the following steps: Successful runtime capturing of video with camera. Captured video was divided into frames and each frame was





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analyzed. Successful detection of face is followed by detection of eyes. If closure of eye for successive frames were detected, then it is classified as drowsy condition else it is regarded as normal blink and the loop of capturing image and analyzing the state of driver is carried out again and again. In this implementation during the drowsy state the eye is not surrounded by circle or it is not detected, and corresponding message is shown. This section presents the results on the detection of visual indicators of drowsiness. Collecting the data set to properly evaluate the system is a challenge; this is because dangerous drowsiness events are not guaranteed to occur during daily driving for application testing. Haar Cascade Algorithms is used for face and eye detection.

Table. 1 presents the results of the detection of somnolence considering the normal operation of the system in which the responses are obtained from each of the drivers that were submitted to the addresses issued by the co-pilot who recorded the results. The level of total hits on detection represents an average percentage of 92.23%. The above graph [Fig. 4] represents the drowsiness of driver in different condition. Table. 2 present the results obtained by placing additional objects on the clothes of the drivers, which in this case were the caps and glasses. The average percentage of hits is 84.33%. Above graph [Fig. 5] represents number of hits in two condition one is driver with glass and the driver without glass while driving. Table. 3 present the results obtained by considering the hair covering driver's face. The drivers were women and the average percentage of hits was 72%. The presented results indicate the efficiency of the system that is of higher level and even better than other systems referred to in this work. The lower levels of accuracy occur when users include elements that do not allow to correctly identify the face gestures, but despite that, their levels are satisfactory. The graph [Fig. 6] represents the hitting point of position of driver in two condition one is Hair cover by face and another one hairless face.

## CONCLUSION

This research paper represents the Drowsiness of the driver. Harr Cascade Algorithm is used for Face Detection and by it is applied to detect driver face and position of the face. Viola Jones Algorithm is used for detecting the eye and eye blink. By using this algorithm, the eye blink rate has been tracked. IDLE platform and python 3.8 version are used for this project. At the time of working on it, there is one problem has faced by us i.e in low beam of light it is not working properly.

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**Table.1: Detection levels for drowsiness parameter under normal conditions.**

Test	Number of observations	Number of hits	Percentage of hits
Yawn detection	140	133	86.6%
Front nodding	150	140	90%
Assent of the head to the right	150	145	96.66%
Assent of the head to the left	150	146	97.33%
Distraction to the right	150	137	91.33%
Distraction to the left	150	138	92%
Blink detection	150	139	92.66%

**Table. 2: Detection levels for different drowsiness parameter under special conditions.**

Test	Number of Observations	Number of hits	Percentage of hits
Driver with a cap	150	123	82%
Driver with glasses	150	130	86.66%

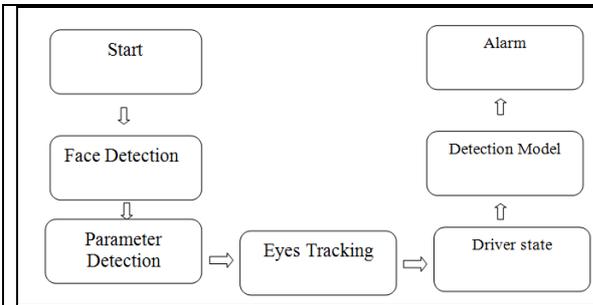
**Table. 3: Detection levels for different drowsiness parameter considering the hair covering face.**

Test	Number of Observation	Number of hits	Percentage of hits
Hair covering driver's face	50	43	86%
Hair not covering driver's face	50	29	58%





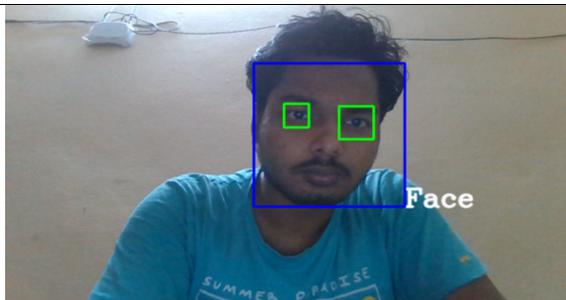
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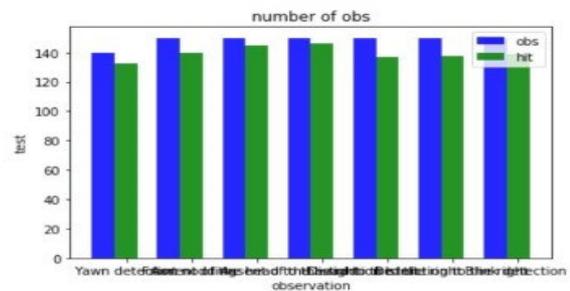
**Fig. 1: Flow chart of the proposed system**



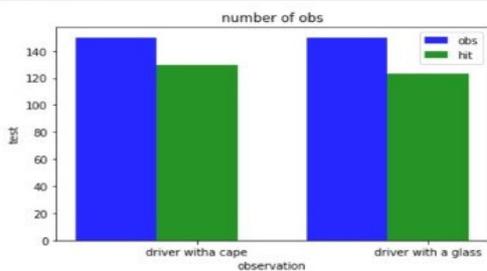
**Fig. 2: Detecting the face**



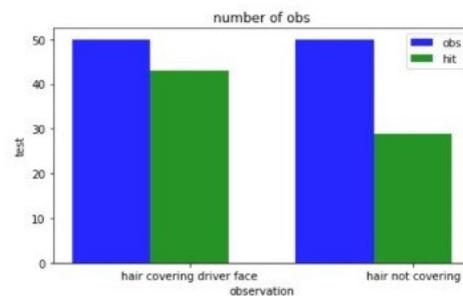
**Fig. 3: Detecting both face, eyes**



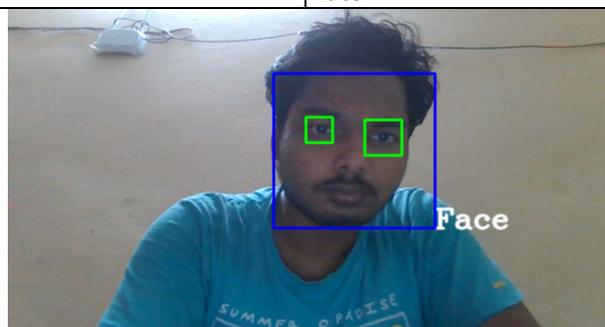
**Fig. 4: Represent the Drowsiness of driver in different condition**



**Fig. 5: Observation with glass and without glass**



**Fig. 6: Observation with hair covering face or hairless face**



**Fig. 7: Detecting face, eye states, giving the warning.**





## Coir Fibres: A Natural Eco-friendly Reinforcing Material for Flexible Pavement Construction

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### ABSTRACT

Transportation Engineering plays a vital role towards the progress of the nation. As the population is growing day by day, the demand for vehicles is also increasing accordingly and simultaneously the condition of the roads is getting deteriorated. It requires heavy maintenance costs and is even costlier if roads are constructed again. Flexible pavements are usually susceptible to rutting and cracking due to repeated application of heavy vehicle loads. Hence, this issue must be addressed in order to improve the life span and performance of the pavements. In this study, coir or coconut fibre is used as an reinforcement in bituminous mixes. Marshall method of bituminous mix design is adopted for the mixes. In this research work the bitumen content is taken is 5% and the percentage of coconut fibre is taken from 0.1% to 0.4%. Effort is made to find out how different percentage of coir fibre added to 5% Bitumen content enhances the durability of the pavement.

**Keywords:** Coconut fibre, bitumen, aggregate, eco-friendly, flexible pavement

### INTRODUCTION

A pavement consists of a mixture of asphaltic or bituminous material and aggregate placed on a good quality and compacted granular material is termed as flexible pavement. The pavement consisting of a Portland cement concrete slab is known as rigid pavement. Flexible pavements are preferred more than rigid pavements as they have self-healing properties, whatever deformation occurs in a flexible pavement due to heavier wheel loads, it is recoverable to some extent after some time but it is not so in case of rigid pavement. Flexible pavements are economical as compared to rigid pavements. Here, in this study, efforts are being made to find out the percentage of coir fibre which when added to bitumen gives satisfactory results. Coir fibre is commonly known as Cocunut tree. Cocunut fibre is mostly taken as a waste material. But According to some researchers in their previous studies, If Grounded cocunut powder is added to Bitumen, It not only proves eco-friendly but reduces the problem of disposal and also strengthens the pavement. It blends with Bitumen Easily. Therefore, In this project work, properties of aggregate and



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Bitumen are studied and an performance analysis is done with 0% addition of coconut fibre in bitumen and with different percentages of coconut fibre content added to 5% Bitumen content. The objective of the present work is to find out the percentage of coir fibre that increases the stability value of the bituminous concrete mix and to reduce the degradation of the environment by reutilizing the agricultural waste materials. Basically there are four types of tests on aggregate to test the quality of aggregates. These tests are required to be done for flexible pavement design. The results of the tests are tabulated below:

**TESTS ON BITUMEN:** Bitumen is a black colour viscous liquid which is obtained as a residue from petroleum distillation. It is used as a road paving material, road surfacing and also roofing. It is black in colour and highly sticky susceptible to climatic changes. The different properties of bitumen are studied and are presented in the following table:

**MARSHALL STABILITY TEST:** The procedure adopted for testing the specimens is Marshall method of Bituminous mix design. Here specimens are made adding bitumen percentage 5% and simultaneously adding the percentage of coconut fibre from 0.1% to 0.4%. Bitumen used here for testing is VG-30. In the Marshall method of Bituminous mix design two tests are done: Density-Void Analysis and Stability Test.

## RESULTS AND DISCUSSION

The Marshall Tests are done for all the specimens and the results obtained are tabulated below along with Graphs.

## CONCLUSION

After Testing all the Marshall samples , we are coming to a conclusion that after addition of 0.30% of coconut fibre content to 5% Bitumen content, observed stability values are increasing but after that point values are found to get decreased. The flow values are also showing an increasing trend at 0.30% fiber content and air content percentages are decreasing. Marshall stability value is maximum at 0.30% and minimum at 0% fibre content. The main reason behind it is excess addition of fibre content cannot bind with Bitumen as a result of which stability values are decreasing simultaneously. As fiber content increases, binding capacity of bitumen decreases as a result of which flow value increased simultaneously. VFB values are increasing as voids are getting filled with bitumen and some voids are filled up with fiber. VMA values are showing a decreasing trend as most of the voids are getting filled with fibres. Overall, from the results, we came up with a conclusion that 0.30% addition of fibre content with 5% Bitumen content increases the stability of the pavement along with other parameters. Definitely it is Sustainable, Eco-friendly, Economical and can be used for Road paving Purposes.

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**Table 1. Aggregate Gradation Chart as per BC mixes**

Sieve size (mm)	Cumulative percentage passing by weight (Range)	Percentage passing by weight (Adopted)
19	100	100
13.2	90-100	95
9.5	70-88	79
4.75	53-71	62
2.36	42-58	50
1.18	34-48	41
0.6	26-38	32
0.3	18-28	23
0.15	12-20	16
0.075	04-10	07

**Table 2. Flexible pavement design**

Property	Test	Requirements as per table 500-16 of mort & h Specifications (fifth revision) , 2013	Observed Value
Strength	LOS Angeles Abrasion Value	Max 30%	21.48%
	Aggregate Impact Value	Max 24%	22.56%
	Crushing Strength	Max 30%	24.33%
Water Absorption	Water Absorption	Max 2%	0.94%
Specific Gravity	Specific Gravity	2.7	2.55
Particle Shape	Combined Flakiness and Elongation Indices	Max 35%	29.82%

**Table 3. Tests on Bitumen**

Characteristics	Requirements as per IS: SP: 73 - 2013	Observed Value
Penetration	50-70	61
Softening point in deg C	47	45.8
Ductility @ 27 deg C (cm)	40	81
Specific gravity	Min 0.99	1.02

**Table 4. Marshall Property**

Marshall properties	Fiber content 0%	Fiber content 0.1%	Fiber content 0.2%	Fiber content 0.3%	Fiber content 0.4%
Marshall stability (KN)	14.08	14.26	14.80	15.12	14.23
Flow value (3-5)	3.9	4.1	4.3	4.5	4.2





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% of Air voids	2.57	2.48	2.33	2.21	2.09
Bulk Density	2.540	2.498	2.520	2.518	2.536
VMA	16.832	16.779	16.413	16.230	16.118
VFB	86.233	86.249	86.371	86.562	85.411

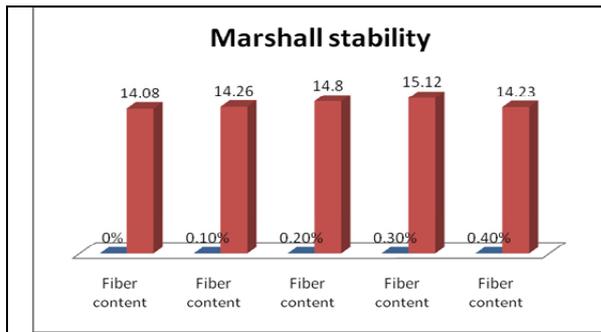


Fig. 1 Marshall stability value

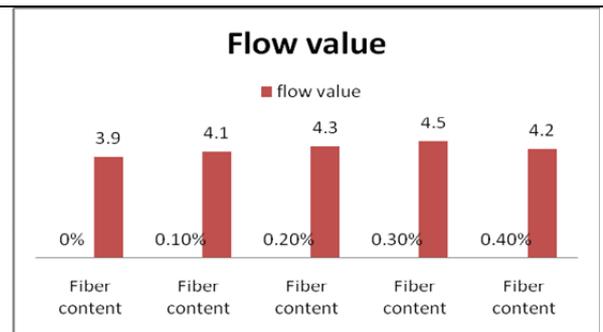


Fig. 2 Flow Value

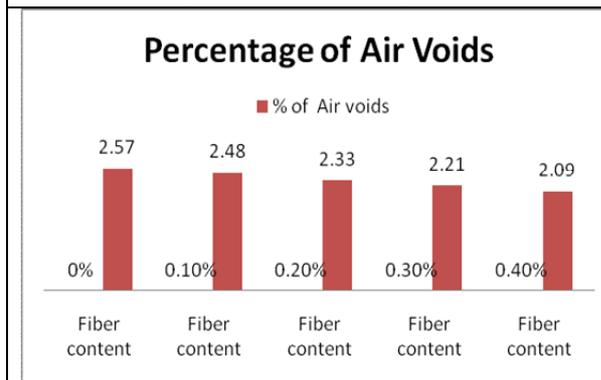


Fig. 3 Percentage of Air Voids

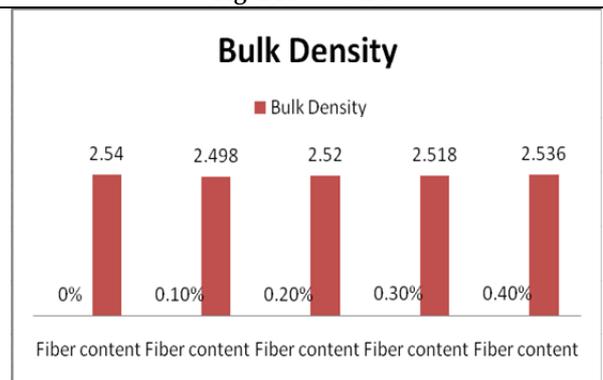


Fig. 4 Bulk Density

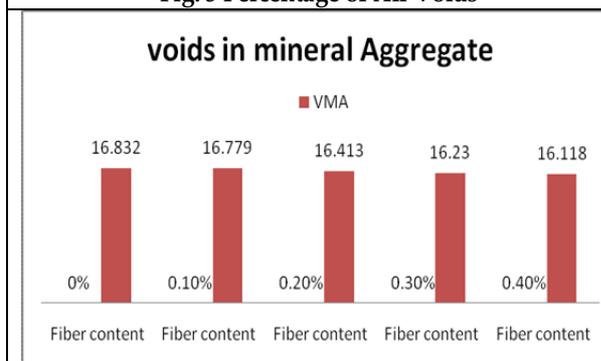


Fig. 5 Voids in mineral aggregates

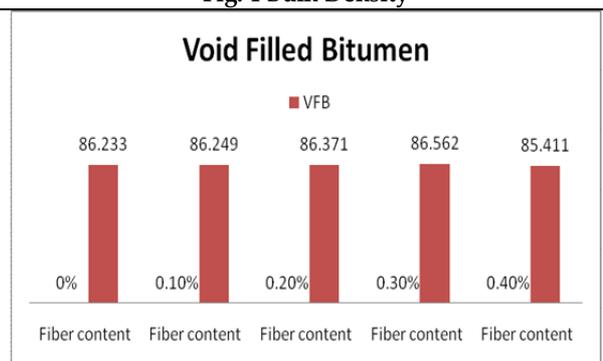


Fig. 6 Void filled bitumen





## Prediction of Breast Cancer using Machine Learning Techniques

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### ABSTRACT

One of the most dreadful disease is breast cancer and it has a potential cause for death in women. Early detection and diagnosis of breast cancer plays a significant role in the welfare of women. The mortality rate due to breast cancer is on an all-time high. As the diagnosis of this disease manually takes long hours and the lesser availability of systems, there is a need to develop the automatic diagnosis system for early detection of cancer. Machine Learning Techniques contribute a lot in the development of such system. For the classification of benign and malignant tumour we have used classification techniques of machine learning in which the machine is learned from the past data and can predict the category of new input. We have also implemented different machine learning algorithms for creating models like decision tree, logistic regression, random forest and gradient boosting which are applied on pre-processed data which gives greater accuracy for prediction.

**Keywords:** Logistic Regression (LR), Decision Tree Classifier (DTC), Random Forest Classifier (RFC), Gradient Boosting Classifier (GBC), Malignant, Benign

### INTRODUCTION

According to World health organization, Breast cancer is the most frequent cancer among women and it is the second dangerous cancer after lung cancer. In 2018, from the research it is estimated that total 627,000 women lost their life due to breast cancer that is 15% of all cancer deaths among women. In case of any sign or symptom, usually people visit doctor immediately, who may refer to an oncologist, if required. The oncologist can easily identify breast cancer by using Breast ultrasound, Diagnostic mammogram, Magnetic resonance imaging (MRI), Biopsy. Based on these test results, doctor may recommend further tests or therapy.





Early detection is very crucial in breast cancer. If cancer is predicted at early stage then the chances of survivability of patient may increase. An alternate way to identify breast cancer is using machine learning algorithms for prediction of abnormal tumour. Thus, the research is carried out for the proper diagnosis and categorization of patients into malignant and benign groups. There are two types of breast cancer tumours: those that are non-cancerous, or 'benign', and those that are cancerous, which are 'malignant'. When a tumour is diagnosed as benign, doctors will usually leave it alone rather than remove it. Even though these tumours are not generally aggressive toward surrounding tissue, occasionally they may continue to grow, pressing on organs and causing pain or other problems. In these situations, the tumour is removed, allowing pain or complications to subside. Malignant tumours are cancerous and aggressive because they invade and damage surrounding tissue. When a tumour is suspected to be malignant, the doctor will perform a biopsy to determine the severity or aggressiveness of the tumour.

Machine Learning, with its advancements in detection of critical features from the complex datasets is largely acknowledged as the method in the prediction of breast cancer. Application of data mining techniques in the medical field can help in prediction of outcomes, minimizing the cost of medicines, aid people's health, upgrade the healthcare value and to rescue lives of people. This process of classifying benign and malignant tumours can be best done by the application of Classification techniques of machine learning. Lot of research is being conducted in this area by the application of various machine learning and data mining techniques for many different datasets on Breast Cancer. Most of them show that classification techniques give a good accuracy in prediction of the type of tumour.

#### RELATED WORK

Lots of breast cancer research has been reported in the literature of medical data analysis, and most of them turn up with good classification accuracies. Some of such works are as follows. Liu Y-Q, Wang C and Zhang L.-2009 [1] used decision table (DT)-based predictive models for breast cancer survivability, concluding that the survival rate of patients was 86.52%. They Employed the under sampling C5 technique and bagging algorithm to deal with the imbalanced problem, thus improving the predictive performance on breast cancer. C.L. Chi, W. N. Street, W. H. Wolberg -2007 [2] used the ANN model for Breast Cancer Prognosis on two dataset. They predicted recurrence and non-recurrence based on probability of breast cancer and grouped patients with bad (<5 years) and good (>5 years) prognoses. Shomona G. Jacob, R. Geetha Ramani-2012 [3] have compared various classifier algorithms on Wisconsin Breast Cancer diagnosis dataset. They came across that Random Tree and SVM classification algorithm produce best result i.e. 100% accuracy. However they mainly worked on 'Time' feature along with other parameters to predict the outcome of non-recurrence or recurrence of breast cancer among patients. In this paper, "Time" feature has not been relied upon for prediction of recurrence of the disease. Here, prediction is based on "Diagnosis" feature of WBCD dataset.

Shajahaan, S.S; Shanthi, S., Chitra, V.M. -2013 [4] worked on the application of data mining techniques to model breast cancer data using decision trees to predict the presence of cancer. Data collected contained 699 instances (patient records) with 10 attributes and the output class as either benign or malignant. Input used contained sample code number, clump thickness, cell size and shape uniformity, cell growth and other results physical examination. The results of the supervised learning algorithm applied showed that the random tree algorithm had the highest accuracy of 100% and error rate of 0 while CART had the lowest accuracy with a value of 92.99% but naïve bayes' had the an accuracy of 97.42% with an error rate of 0.0258. D. Delen, G. Walker, A. Kadam -2005 [5] compared ANN, decision tree and logistic regression techniques for breast cancer prediction analysis. They used the SEER data of twenty variables in the prediction models. From the experiment the author found that the decision tree with 93.6% accuracy and ANN with 91.2% are more superior to logistic regression with 89.2% accuracy.

The study is based on multiple prediction models for breast cancer survivability using large datasets along with 10 fold cross validation method. It provides a relative prediction ability of different data mining methods. In future this work is extended by collecting real dataset in the clinical laboratory. Turgay Ayer, Jagpreet Chhatwal, Oguzhan



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Alagoz, Charles E. Kahn, Jr, Ryan W. Woods, Elizabeth S. Burnside -2010 [6] describes about Two models namely Logistic Regression and ANN which was implemented. They were used to compare prediction accuracy breast cancer in mammography. Their study says logistic regression performed well in prediction. Abdelghani Bellaachia, Erhan Guven-2006 [7] describes about using powerful machine learning classification algorithm Naïve Bayes, C4.5 which is usually used in data mining and ANN a neural network algorithm for the tumour classification of breast cancer in dataset. Their work shows C4.5 did a better job in classification. Diana Dumitru- 2000 [8] describes about Naïve Bayes algorithm which was implemented to test the classification accuracy of breast cancer dataset with specificity, sensitivity and mean accuracy. Cuong Nguyen, Yong Wang, Ha Nam Nguyen-2013[9] describes about Random forest classifier which was implemented in their project to find sensitivity, time consumed and mean accuracy of two data set WBCPD and WBCDD.

Rasool Fakoor, Faisal Ladhak, Azade Nazi, Manfred Huber-2013 [10] describes about Performance criterion of classifiers whose experimental results shows that SVM-RBF kernel produces an accuracy of 96.84% which is higher than other classifiers. Alireza Osarech, Bitu Shadgar-2011 [11] used SVM classification technique on two different benchmark datasets for breast cancer which got 98.80% and 96.63% accuracies. Nidhi Mishra, Naresh Khuriwal-2018 [12] took data from Wisconsin Breast Cancer database and worked on breast cancer diagnosis. The results of their experiments proved that ANN and Logistic Algorithm worked better and provided a good solution. It achieved an accuracy of 98.50%. Mandeep Rana, Pooja Chandorkar, Alishiba Dsouza-2015 [13] worked on the diagnosis and the prediction of recurrence of breast cancer by applying KNN, SVM, Naïve Bayes and Logistic Regression techniques, programmed in MATLAB. The classification techniques are applied on two datasets taken from UCI depository. A dataset of them is used for identification of disease (WDBC) and the next one is used for recurrence prediction (WPBC). Yeh WC, Chang WW, Chung YY-2009 [14] presented an innovative technique for breast cancer detection, by using statistical methods in combination with swarm optimization and reported the accuracy of 98.71%

Kaya Y, Uyar M-2013 [15] presented a hybrid approach for the detecting hepatitis disease by means of rough set and extreme machine learning algorithm. The selected hepatitis disease dataset was from UCI repository. 20 reducts containing three to seven attributes were produced by using rough set theory. The reducts are selected and then the records with missing value are removed from each reduct. Classification is done on selected reducts by using back propagation neural network and obtained the accuracy of 98.6%.

**PROPOSED APPROACH**

The Proposed Model is shown in Figure 1. In the suggested approach, we apply various supervised learning algorithms and classification technique to build a model which comes up with accuracy of Breast Cancer Prediction. The system is organized in following phases such as collection of information sets, pre-processing phases, selection of features and appealing different ML techniques such as Logistic regression (LR), Decision Tree Classifier (DTC), Random Forest Classifier (RFC) and Gradient Boosting Classifier methods.

**Collection of Data Sets**

The Data for the prediction of Breast Cancer is collected from the Wisconsin Breast Cancer diagnosis dataset from UCI repository. This dataset contains characteristics derived from digitized imaging of fine needle aspirates of a breast tumour cell mass. The goal of this analysis is to train a machine learning algorithms to accurately distinguish between a benign and malignant tumour to aid in clinical diagnosis. The data set used in this paper is breast cancer diagnosis data having the attributes like diagnosis, radius mean, texture mean, smoothness mean, compactness mean etc.

**Pre-processing step**

In machine learning, this phase is a very crucial phase. Pre-processing of the five data sets of five different crops consists of loading the missing values, the proper range of the data, and the functionality extraction. In this paper we





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have applied isnull () technique for checking null values and In Diagnosis Attribute, we have used Value labels in place of Numeric Values i.e. Benign Cells are coded as value "0" and malignant Cells are coded as value "1".

### Features Extraction

Feature extraction of breast cancer diagnosis data is about finding the subset of original features and simplifying the amount of data involved to represent a huge data set. The diagnosis data is divided into malignant and benign groups. Ten real-valued features having high entropy value which were computed as main feature for each cell nucleus for accuracy forecast of Breast Cancer Prediction are

- radius (mean of distances from centre to points on the perimeter)
- texture (standard deviation of grey-scale values)
- perimeter
- area
- smoothness (local variation in radius lengths)
- compactness (perimeter<sup>2</sup> / area - 1.0)
- concavity (severity of concave portions of the contour)
- concave points (number of concave portions of the contour)
- symmetry
- fractal dimension ("coastline approximation" - 1)

### Splitting the Dataset into Train Sets and Test Sets

This phase covers training and testing of input data. The loaded data of breast cancer is split into 2 sets, such as train sets data and test sets data, with a division ratio of 80% or 20% (0.8 or 0.2). In the training sets, a classifier is applied to build the obtainable input data. In this phase, we create the classifier's reinforce information. During the testing state, the data are tested and the concluding data are formed during pre-processing and is refined by the machine learning.

### Machine Learning Models

In this paper we have applied several supervised Machine Learning techniques such as Logistic regression (LR), Decision Tree Classifier (DTC), Random Forest Classifier (RFC) and Gradient Boosting Classifier methods for accuracy calculation of Breast Cancer Prediction which are as follows.

#### Logistic Regression (LR)

Logistic regression is a supervised learning classification algorithm used to predict the probability of a target variable. The nature of target or dependent variable is dichotomous, which means there would be only two possible classes. In simple words, the dependent variable is binary in nature having data coded as either 1 (stands for success/yes) or 0 (stands for failure/no). Mathematically, a logistic regression model predicts  $P(Y=1)$  as a function of  $X$ . It is one of the simplest ML algorithms that can be used for various classification problems.

#### Decision Tree Classifier (DTC)

In general, Decision tree analysis is a predictive modelling tool that can be applied across many areas. Decision trees can be constructed by an algorithmic approach that can split the dataset in different ways based on different conditions. Decision trees are the most powerful algorithms that falls under the category of supervised algorithms. They can be used for classification tasks. The Decision trees algorithm consists of two parts: nodes and rules (tests). A Decision tree is like tree structure, where node denotes a test on an attribute, Branch represents an outcome of the test, and each leaf node holds a class label. For detecting breast cancer, its leaf nodes are categorised as benign and malignant. And then certain rules are established to check tumour is benign or malignant





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### **andom Forest Classifier (RFC)**

Random forest algorithm is a supervised classification algorithm. In this classifier, the higher the number of trees in the forest gives the high accuracy results. Random forest algorithm can use for both classification and the regression task and can handle the missing values too. For this dataset, we have already handled missing values of attributes.

Random forest algorithm creates decision trees on data samples and then gets the prediction from each of them and finally selects the best solution by means of voting. It is an ensemble method which is better than a single decision tree because it reduces the over-fitting by averaging the result. It can also work on categorical values too. In this case, we had categorical data as B & M representing benign & malignant which is further converted to value labels as 0 & 1 respectively.

### **Gradient Boosting Classifier (GBC)**

Gradient boosting classifiers are a group of machine learning algorithms that combine many weak learning models together to create a strong predictive model. Decision trees are usually used when doing gradient boosting. Gradient boosting models are becoming popular because of their effectiveness at classifying complex datasets, and have recently been used to win many Kaggle data science competitions.

For detecting breast cancer, the leaf nodes of decision tree are categorised as benign and malignant. And then certain rules are established to check tumour is benign or malignant

## **EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS**

### **Data Exploration**

From the Data Exploration, we came to know that, In Wisconsin Breast Cancer dataset, there are 569 instances in which 357 are benign and 212 are malignant. In addition, there are two classes malignant which contributes to 62.7% of dataset and benign 37.3%. The Heat Map of some of the top Correlation Features extracted from the Feature Extraction of the Wisconsin Breast Cancer diagnosis dataset are

### **Logistic Regression (LR)**

The predicted accuracy of Breast Cancer Prediction using Logistic Regression is shown in Figure 8.

### **Decision Tree Classifier (DTC)**

The predicted accuracy of Breast Cancer Prediction using Decision Tree Classifier is shown in Figure 9.

### **Random Forest Classifier (RFC)**

The predicted accuracy of Breast Cancer Prediction using Random Forest Classifier is shown in Figure 10.

### **Gradient Boosting Classifier (RFC)**

The predicted accuracy of Breast Cancer Prediction using Gradient Boosting Classifier is shown in Figure 11.

### **Performance Analysis**

The Accuracy for Some of the Machine Learning Models for predicting Breast Cancer are as shown in Table 2 and the graphical representation is shown in Figure 12.

## **CONCLUSION**

Medical dataset can not only be classified with the previously mentioned algorithms from machine learning, there are many algorithms and techniques which may perform better than these. Production of accurate classifier which perform efficiently for medicinal application is the main challenge we face in machine learning. In this paper, we





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have implemented different types of models and their accuracies are computed and compared with each other, so that the best cancer prediction model can be used in real life to identify breast cancer relatively faster than previous methods. Random Forest surpasses all the other algorithms with an accuracy of 97.90%. In conclusion, the Random Forest algorithm achieves the highest predicted accuracy which might be the best choice of algorithm for this problem and prediction of disease.

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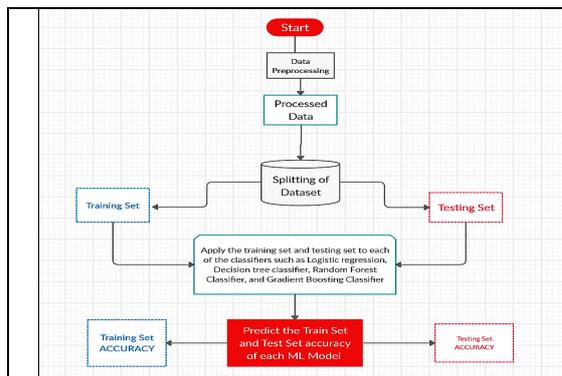
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**Table 1. Diagnosis Frequency**

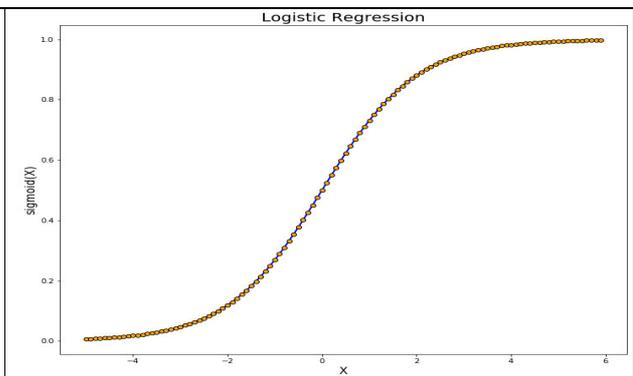
	Diagnosis	Percent
Benign	357	63
Malignant	212	37

**Table 2. Predicted Accuracy of Different ML Models**

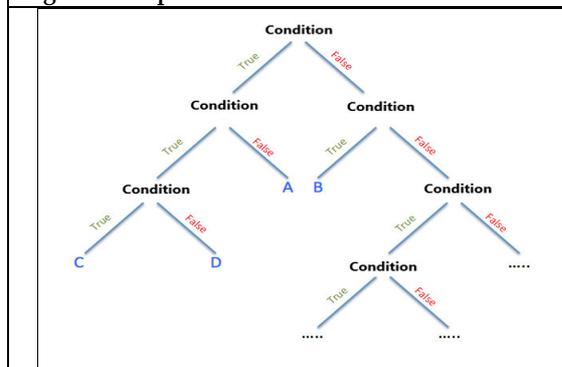
SINo	Machine Learning Models	Train Set Accuracy	Test Set Accuracy	Accuracy
1	Logistic Regression	99.06	95.80	95.80
2	Decision Tree Classifier	97.65	92.31	92.31
3	Random Forest Classifier	100	97.90	97.90
4	Gradient Boosting Classifier	100	96.50	96.50



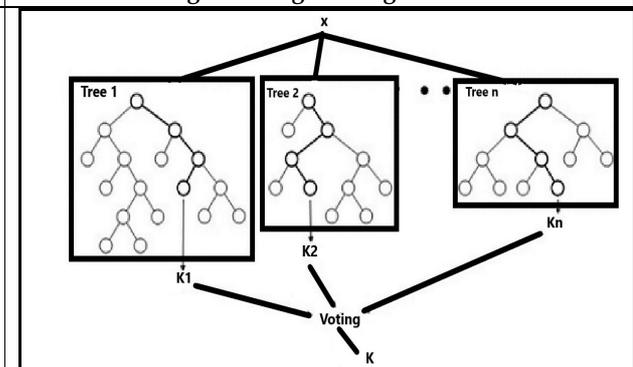
**Figure 1. Proposed Model**



**Figure 2. Logistic Regression**



**Figure 3. Decision Tree Classifier**

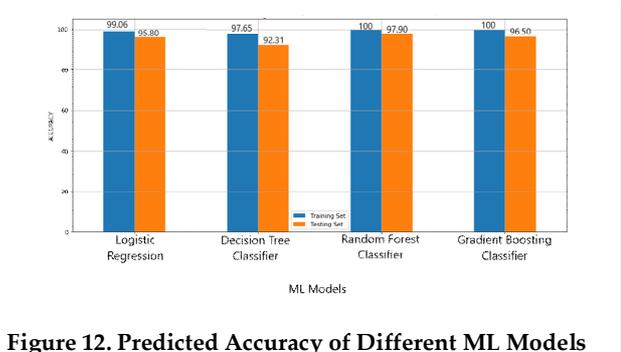
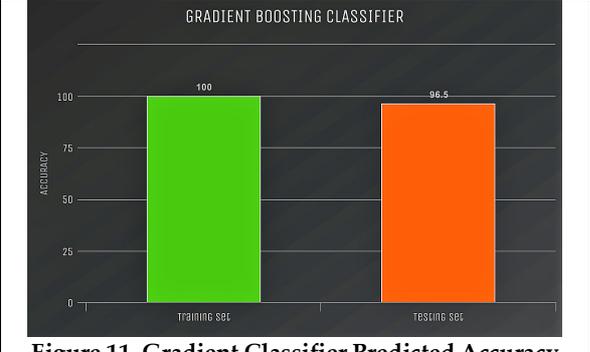
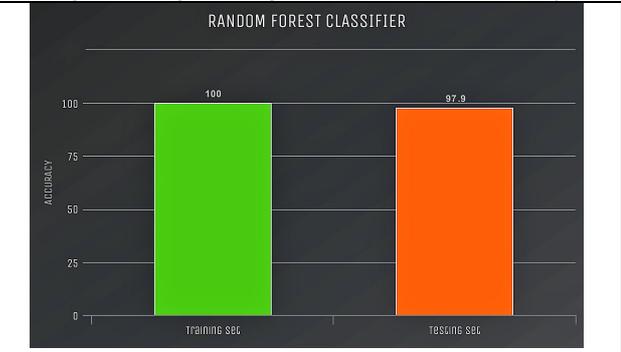
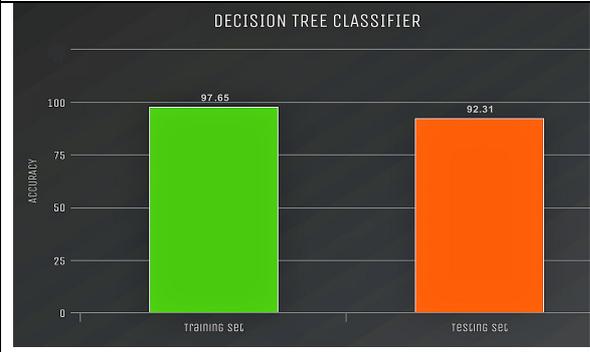
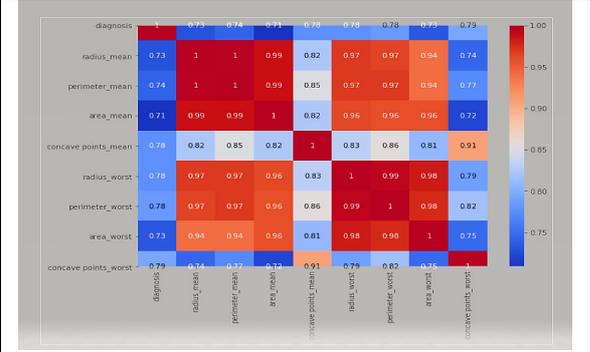
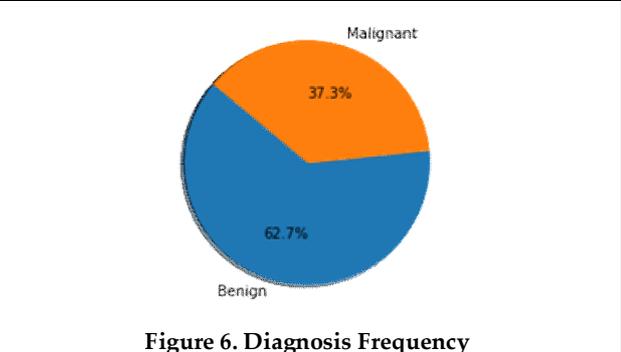
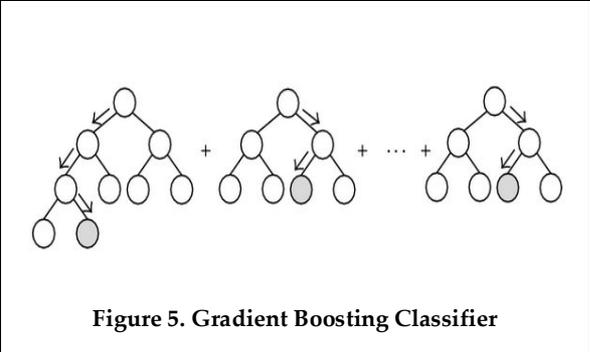


**Figure 4. Random Forest Classifier**





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## Studies of Negative Temperature Coefficient of Resistance Behaviour for Thermistor Application in $\text{Na}_2\text{Ba}_2\text{Eu}_2\text{W}_2\text{Ti}_4\text{Nb}_4\text{O}_{30}$ Ceramics

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### ABSTRACT

Polycrystalline sample of  $\text{Na}_2\text{Ba}_2\text{Eu}_2\text{W}_2\text{Ti}_4\text{Nb}_4\text{O}_{30}$  is synthesized by high temperature solid-state reaction technique. X-ray structural analysis confirms the formation of compound in orthorhombic crystal structure at room temperature. The surface morphology of the sintered sample recorded by scanning electron microscope exhibits a uniform grain distribution. The frequency and temperature dependent impedance spectroscopy was carried out in order to investigate the conduction mechanism. The Cole-Cole plot shows depressed semicircle arc, which confirms the Non-Debye type relaxation in the material. The radius of the semicircle decreases with temperature indicating the reduction of resistance with temperature, which confirms the NTCR behavior in the material. The variation of bulk resistance of the material with temperature was obtained from the fitting of the equivalent circuit. The thermistor parameters with respect to temperature were calculated. The high value of parameters shows that the present compound is very much suitable for high temperature thermistor application.

**Keywords:** temperature, uniform, material, parameters .

### INTRODUCTION

The TB structure compounds belong to an important class of dielectric materials, having various properties [1, 2] at different temperature. The tungsten-bronze (TB) structure stands at intermediate positions between the perovskite and pyrochlore-type structures. The general formula of TB structured compounds is written as  $(\text{A}1)_2(\text{A}2)_4(\text{C})_4[(\text{B}1)_2(\text{B}2)_8]\text{O}_{30}$ , where the A-site is occupied by mono to tri-valence cations, the B-sites occupied by tetra to hexa-valent ions ( $\text{W}^{+6}$ ,  $\text{Ti}^{+4}$ ,  $\text{Nb}^{+5}$ ,  $\text{Ta}^{+5}$ ,  $\text{V}^{+5}$ ) and C site being small often remains empty, giving the general formula  $\text{A}_6\text{B}_{10}\text{O}_{30}$ . In the recent years, some new lead based TB type ferroelectrics of  $\text{A}_2\text{Pb}_2\text{R}_2\text{W}_2\text{Ti}_4\text{X}_4\text{O}_{30}$  (A=Li, Na, K; R= rare earth; X=V, Nb, Ta) have received much scientific attention due to their interesting ferroelectric





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properties [3-6]. However, the lead-based ceramics is eliminated due to the environmental, health and social aspects issues [7-9]. In view of the above, we have studied the structural, dielectric and electrical properties of  $\text{Na}_2\text{Ba}_2\text{Eu}_2\text{W}_2\text{Ti}_4\text{Nb}_4\text{O}_{30}$  [10].

Thermistor is special type of resistor, whose resistance varies more significantly with temperature than in standard resistors. The resistance of the thermistors decreases with the rise in temperature, for which it have been received considerable attention in house appliances, and aerospace as elements for suppression of in-rush current, temperature measurements and controlling, etc. As the resistance of thermistors depends on the temperature, they can be connected in the electrical circuit to measure the temperature of the body. Thermistors are mainly used as temperature sensors, inrush current limiters, self-resetting over-current protectors and self-regulating heating elements. Traditional NTC ceramic thermistors always contain transition-metal compounds with spinel structure such as Mn–Ni–O, Ni–Cu–Mn–O and Ni–Mn–Co–O systems, etc. [11–13]. However, the existence of the structural relaxation in those compounds leads to property degradation such as aging, and limits their applications at elevated temperatures ( $>300^\circ\text{C}$ ) [14]. Much work have reported to improve the electrical properties and ageing resistance of the thermistors with cation doping and microstructure modification [15–16]. The literature survey suggests that no attempt has been made to understand the impedance analysis of the above sample that the resistance of the material decreases with rise in temperature resulting NTCR behavior for the fabrication of highly sensitive thermistor. This factor motivated us to carry out a detailed characterization of the thermistor parameters of the above ceramic.

## EXPERIMENTAL

The Polycrystalline sample of  $\text{Na}_2\text{Ba}_2\text{Eu}_2\text{W}_2\text{Ti}_4\text{Nb}_4\text{O}_{30}$  (abbreviated as NBEWTN) was prepared using solid state reaction technique using high purity ingredients  $\text{Na}_2\text{CO}_3$ ,  $\text{BaCO}_3$ ,  $\text{Eu}_2\text{O}_3$ ,  $\text{WO}_3$ ,  $\text{TiO}_2$ , and  $\text{Nb}_2\text{O}_5$ . These ingredients, taken in suitable stoichiometry, were thoroughly mixed and ground in dry and wet (methanol) medium for 2h each in an agate mortar. Calcination was carried out in an alumina crucible at  $1150^\circ\text{C}$  for 4 h. The quality and formation of the compound were checked using X-ray diffractometer (Rigaku Ultima IV, Japan) with  $\text{CuK}\alpha$ ,  $\lambda = 1.5405 \text{ \AA}$  over a wide range of Bragg angles  $2\theta$  ( $20^\circ \leq 2\theta \leq 80^\circ$ ). The powder was then pelletized under the uniaxial pressure of 3.5 ton with polyvinyl alcohol (PVA) as binder. The pellets were then sintered at  $1200^\circ\text{C}$  for 6 h. The surface morphology of the sintered pellet was studied at room temperature using a scanning electron microscope (HITACHI SU3500). The sintered pellets were polished and electroded with silver paste and then dried at  $150^\circ\text{C}$  for 1 h. The dielectric and impedance parameters of the pellet were recorded as a function of frequency (1 kHz to 1 MHz) using a computer-controlled HIOKI 3532 LCR Hitester over a wide range of temperature.

## RESULTS AND DISCUSSION

### Structural study

Figure 1 shows the room temperature XRD pattern of NBEWTN on powder sample. The diffraction pattern consists of sharp and single diffraction peaks, which confirms the formation of single-phase of the compound [17]. Most of the observed peaks were indexed in different crystal systems with different unit cell configurations using a standard computer program package "POWD" [18]. The orthorhombic crystal system was confirmed on the basis of minimum error between observed and calculated inter planar spacing (d). The refined lattice parameters of the material are found to be very much consistent with those of reported compounds of similar structure. Figure 1(inset) shows the surface morphology of NBEWTN recorded on the bulk pellet sample. The nature and grain size of the sample suggests that the surface is highly dense due to uniformly distribution of grains. The average size of the grain is ranging from 4 to 5  $\mu\text{m}$ . In spite of sintering at high temperature some small voids of irregular shape and dimension are seen which may be due to background effect.





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### Complex Impedance analysis

Impedance spectroscopy is a powerful tool for analyzing the electrical properties of materials and results may be correlated with many complex materials. An equivalent circuit based on impedance spectra provides the physical processes occurring inside the sample. Most of the ceramics contain grains and grain-boundary regions, which individually have different physical properties [19].

Measurements of impedance and related parameters of the materials provide us some important data having both real (resistive) and imaginary (reactive) components. The basic formalism or equations of impedance and electrical modulus resistive and reactive components of the complex parameters have been reported elsewhere [10]. The frequency dependent of  $Z'$  at selected temperatures is shown in Fig. 2. It is observed that  $Z'$  decreases with rise in frequency at different temperature. At high frequency the value of  $Z'$  at the selected temperature coincides, which is due to the disappearance of space charge from the grain boundary. The value of  $Z'$  at lower frequency is high, which indicates the larger effects of polarization in the material. The value of  $Z'$  decreases with rise in temperature in low frequency region shows the negative temperature coefficient of resistance (NTCR) behavior in the material.

Figure 3 shows the complex impedance spectra (Nyquist plot) with fitted data [20] of the compound obtained at different temperatures ( $>200^\circ\text{C}$ ) over a wide frequency range (1 kHz to 1 MHz). At low temperature, (i.e up to  $300^\circ\text{C}$ ) complex impedance plots have single semicircular arc (not shown). The intercept of the semicircular arc along  $Z'$  axis gives the value of the bulk resistance, and it is observed that the value of  $Z'$  decreases with rise in temperature, due to which the dc conductivity in the material increases. However, at higher temperatures it shows two semicircles, where the high frequency semicircle can be attributed to the bulk property of the material arising due to the parallel combination of bulk resistance and bulk capacitance of the material. The low frequency semicircle is due to the grain boundary effect, which also can be confirmed by SEM micrographs in which polycrystalline grains separated by grain boundaries. The presence of two semicircular arcs due to grain interior and grain boundary is consistent with the "brick layer model" for polycrystalline materials [21] and it can be expressed as an equivalent circuit consisting of parallel combination of two resistance and capacitance connected in series. For non-Debye – like response, an equivalent circuit consists of parallel combination of (CQR) and (CR), where Q is known as constant phase element (CPE). The admittance of Q is defined as  $Y(\text{CPE}) = A_0(j\omega)^{-n} = A + jB$  with  $A = A_0 \cos(n/2)$  and  $B = A_0 \sin(n/2)$ , where  $A_0$  and  $n$  are frequency independent and temperature dependent parameters.  $A_0$  determines the magnitude of the dispersion, and  $0 \leq n \leq 1$  (for an ideal capacitor  $n=1$  and for ideal resistor  $n = 0$ ) [22]. From fitting curves, the calculated value of bulk resistance ( $R_b$ ) and grain boundary resistance ( $R_{gb}$ ) at different temperatures are plotted in fig. 3. It clearly shows that both the parameters decrease with rise in temperature, which confirms the negative temperature coefficient of resistance (NTCR) behavior of the material.

The relation between resistance and temperature for a compound exhibiting NTCR behavior is expressed as

$$R_T = R_N \exp [\beta(T_N - T)/TT_N],$$

Where  $R_T$  is the resistance at temperature  $T$ ,  $R_N$  the resistance at temperature  $T_N$  is known, and  $\beta$  is an NTC thermistor characteristic parameter.

The thermistor characteristic parameter can be expressed as

$$\beta = [TT_N / (T_N - T)] \ln R_T / R_N$$

The sensitivity of the thermistor  $\beta$  can also be defined by the temperature coefficient of resistance ( $\alpha$ ), which can be expressed as a function of  $\beta$  parameter according to the following equation

$$\alpha = (1/R)[d(R)/dT] = -\beta/T^2$$



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The various thermistor parameters are plotted against temperature. The observed  $\beta$  values in the ceramic are better compared to the values reported earlier by other researchers [23, 24]. Thus, the high value of  $\beta$  obtained endorsed, the sample as a good quality NTC material for the fabrication of thermistor devices.

## CONCLUSION

The polycrystalline material of  $\text{Na}_2\text{Ba}_2\text{Eu}_2\text{W}_2\text{Ti}_4\text{Nb}_4\text{O}_{30}$  has been prepared by a high-temperature solid-state reaction technique. Preliminary structural analysis confirmed the formation of a single phase material in an orthorhombic system at room temperature. Nyquists plots show both bulk and grain boundary effect and the resistance decreases with rise in temperature, which indicates the NTCR behavior of the sample.

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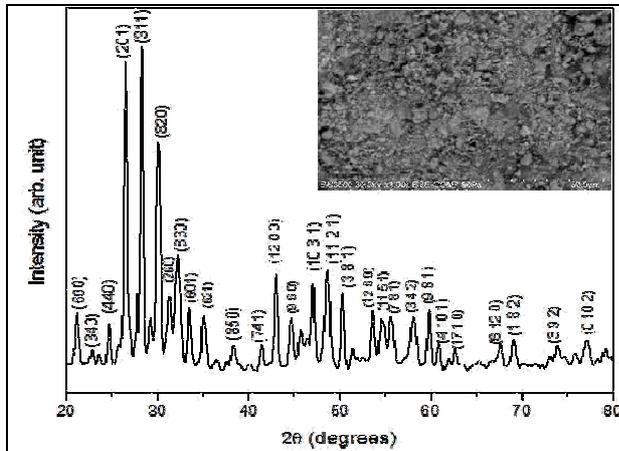


Fig. 1. Indexed XRD pattern & SEM micrograph of NBEWTN.

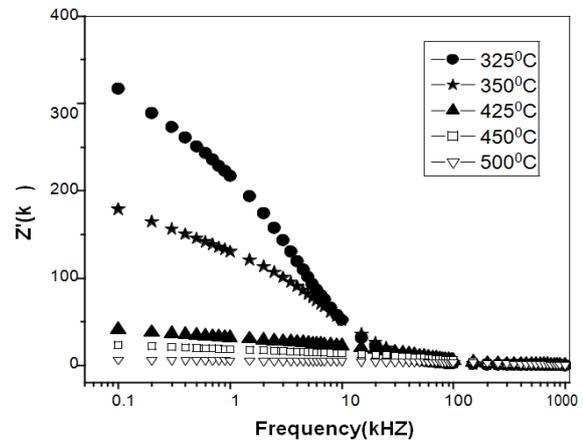


Fig.2. Variation of  $Z'$  with frequency of NBEWTN at different temperatures.

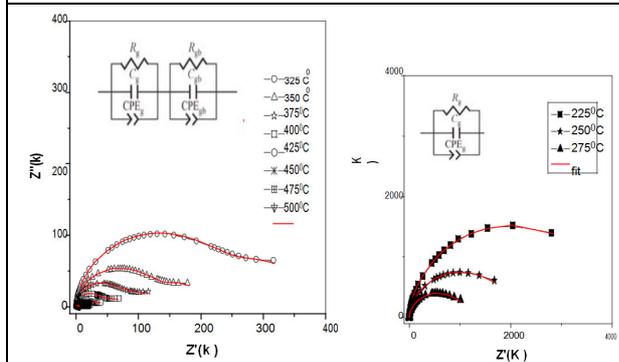


Fig.3. Variation of  $Z''$  with  $Z'$  of NBEWTN at different temperatures

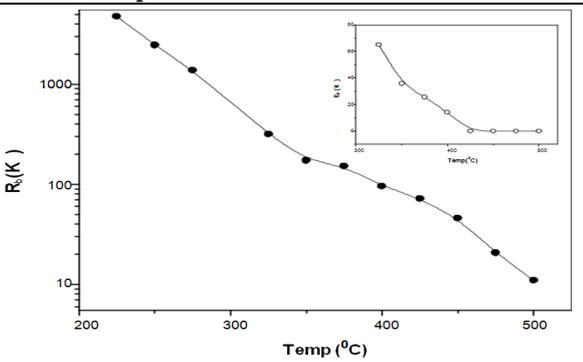


Fig.4. Variation of  $R_b$  and  $R_{gb}$  with different temperatures of NBEWTN

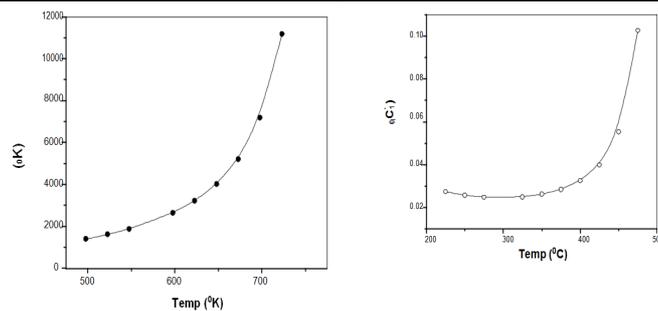


Fig.5. Variation of Thermistor parameter of NBEWTN with temperature.





## Odia Handwriting Recognition: Way to find the Identity

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### ABSTRACT

In the beginning of new millennium, the forensic science has practices to assess the identity of an individual from his handwriting. Character recognition has become one of the most researched work in the world of recognition and identification. Identifying a person through his handwriting is a biggest achievement for the handwriting experts. Handwriting recognition is one of a challenging task for academic circles, text recognition and also for forensic department. Handwriting is considered as the mirror of human character. Handwriting describes the human psychology. Starting from the love letters to the suicide letters the handwriting has explains the emotions of a person. Before we jump to the handwriting, we need to recognize the alphabets first. This research paper explains about the recognition of odia alphabets. The research paper presents the frame work for real time. These technologies are available in the library and methodology to implement them using Python in machine learning and artificial intelligence. For alphabet detection we have used edge histogram, and for alphabet recognition Genetic algorithm, ELM, PSO algorithm were used.

**Keywords:** Alphabet recognition; Machine learning; ELM; PSO; Histogram

### INTRODUCTION

Machine learning is a science that make the computers learn by itself and act like humans do, and improvise in their learning over time in a self-directed way, by collecting the information in the form of observation and real-world communications and feeding them. Technically we can define that machine learning is nothing but to train a model in such a way that in which we can fit our dataset. Alphabet Recognition is the capability of a computer to receive and construe intelligible handwritten input from sources such as paper documents, books, answer sheets, newspaper and other sources. Handwriting recognition traditionally is divided into two parts. One is offline recognition and other is online recognition [1-4].

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Handwriting recognition is nothing but to classify the alphabets according to their features. From a generation point of view, handwriting involves in several works. Handwriting recognition can be viewed as a particular instance of article class recognition. In object-class identification, the errand is to discover the areas and sizes of all articles in a picture that have a place with a given class. Like biometric, handwriting is also a key for all individuals. Handwriting differs from person to person. The main purpose of the step of pre-processing is to remove irrelevant information in the input data, which may affect the recognition accuracies [3]. It is practically equivalent to picture recognition in which the picture of an individual is coordinated a little bit at a time. A lot of variations can be found in alphabets during the recognition. These types of pictures are usually alluded as countenances in nature. A portion of these varieties incorporate head presents, alphabets in different angles, impediments, similarities between alphabets, and outward appearances. Customary techniques depended close by created highlights, for example, edges and surface descriptors, joined with machine. Fig. 1 shows typical variations found in alphabets. (a) Inclination of angle. (b) similarities between alphabets (c) curves in alphabets and (d) straight lines in alphabets. Alphabets representation is arguably the most important component of a handwriting. Recognition system and the focus of the literature review in Section II.

## LITERATURE REVIEW

Earlier researches about handwriting recognition looking for the methods that used image processing techniques to match simple features describing the geometry of the alphabets. Even though these procedures only worked under very constrained settings, they showed that it is possible to use computers to automatically recognize the alphabets. These methods are referred to as *all-inclusive* since they use the entire alphabet as an input. Though English alphabets are not so curved so it is quite difficult to recognize the alphabets of regional language. *Feature-based* approaches to alphabet recognition consist of matching these local features across images of the alphabets [8].

Moreover, whatever the techniques that have been implemented in the past have not yet provided a reliable output. Hence more refine methods need to developed for improved output. With many different types of algorithms present, it gave us an opportunity to study various feature extraction and image classification techniques [11-12]. Holistic and feature-based approaches were further developed and combined into *hybrid* methods. Handwriting recognition systems based on this hybrid approaches remained the up-to-the-minute until recently, when deep learning emerged as the leading approach to most computer vision applications, including the alphabet recognition. Picture of alphabets match with the picture stores in database. Any changes in the database will discredit the coordinating process.

The features like shape, size, colours are used to identify the alphabet first. Input or given alphabets will match with the images of alphabets that present in the datasets. After the identification the next step is to recognize whose handwriting it is. That means we need to reduce the percentage of error. Finding the minimum errors means that our alphabets are matching perfectly with the database. After various cycles, all the applicants with a high wellness esteem are chosen for additional confirmation. At this stage, it estimated and the presence of the distinctive highlights is confirmed for each alphabet images. Methods depended close by created highlights, for example, edges and surface descriptors, joined with machine. The rest of this paper provides a summary of some of the most representative research works on each of the above-mentioned types of methods. Fig. 2 shows alphabet recognition frame work

### Work flow

Alphabets recognition systems are usually composed of the following building blocks:





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### Inputdata

In this research work we have taken datasets from UCI repository (<https://archive.ics.uci.edu/ml/index.php>). We have normalized our data and store in a file to extract a meaningful information from the dataset.

### Pre-Processing

In machine learning the processing of data means to fit our generalized datasets into a model. We have trained our datasets to our model. That stage is also known as train-test-spilt. In this phase model have learnt and given a prediction. This train-test-spilt is a random process. Because the model does not know from the dataset which are going to be trained and tested in every particular execution.

### Feature Extraction

At this stage, the pixel values of an image of an alphabet are transformed into a compact and discriminative feature vector, also known as a template. Ideally, all the alphabets of a same subject should map to similar feature vectors [8,12]. We have used edge histogram for extracting the features. We have predicted the shape of each alphabets. Though odia alphabets have a lot of curves.so, we have taken the shape of the edge.

### Training using ELM

Generally algorithm learns data from the dataset. Then after it will create a relation by understanding the data. It will classify the data and train itself for better performance. Classification is a process to predict that an object or task to which class it belongs to. In this stage the classifier will classify the alphabets according to their features.

### Testing using ELM

In testing data, the model used to test the data to get an expected result. Generally, the classifiers are used to represent the general categories. Here the classifier like ELM will classify the alphabets according to their features [12].

### Optimization using PSO

In this stage the algorithm will optimizes to get the best result. PSO or particle swarm optimization is a machine learning algorithm that helps to optimize the problem iteratively till it finds an optimum result. In handwriting recognition, the accuracy of matching the alphabets with the data set should be maximum. At that time the error should be minimum. This optimization algorithm will help to get the minimum error value.

### Output Results

After being optimized it will give the minimum error value. This research works consists of three major steps.

1. To recognize the alphabets- From the given images, it will recognize the alphabets by extracting the features. It will take the handwritten alphabets or from any source as its input.
2. To generate the labels for the training data- It will generate the labels and then it will train the classifier.
3. To predict the minimum errors- to predict the minimum error is equal to predict the maximum accuracy percentage of the matching of alphabets with the training images. In this step we have to find that how accurate our result is.

### Feature extraction

It is a process to reduce the dimensions of a raw data. Feature extraction is basically a method by which it extracts the important and meaningful information from a large dataset [1-2,5,11]. We have taken edge histogram to extract our features. In our dataset the alphabets are same in color. So, we took the edge histogram to extract the features on the basis of structure or shape of the alphabets. Though we know odia alphabets have a number of curves.





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### Edge Histogram

Basically, Histogram is a graphical representation of repetition of pixels in a particular image or can be defined as histogram is the representation of frequency of pixels in an image. Similarly, the edge histogram is a graphical representation of repetition of pixels of an edge of an image. The figure 3 and 4 are the edge image of 15<sup>th</sup> number alphabet of odia language. Likewise, we have taken the edge histogram of each and every alphabet present in our dataset. Then after we will put all the extracted edge images in a CSV file.

### Multiclass Classification

Generally multi means more than one. So, the classification having more than one classes is known as multi class classification. Multi-class classification makes the assumption that each sample is allotted to one and only one label: By taking an example of English alphabets, an alphabet can be either a "A" or a "B" but not both at the same time. In a multiclass classification, we have trained a classifier using our training data, and use this classifier for classifying new examples. Similarly, the below alphabets are different from each other. The classifier classifies into different classes according to their features. Fig. 5: multiclass classification of different alphabets of different language. (from left "ka" of Hindi alphabets, middle one is "da" of Odia alphabets and the right one is "a" of English alphabets.) Fig. 5 shows multiclass classification of different alphabets of different language.

### ELME

LM is also known as Extreme Learning Machine is basically a machine learning algorithm. It is a single-hidden-layer Forward feed neural network. Generally, it is used for classification, regression etc. It is a rapid learning algorithm and avoids the unnecessary iterations [8,14]. The main advantage of elm is short training time. The number of hidden layer nodes can be randomly selected and analyzed to determine is to reduce the calculation time while learning speed fast [14-15]. However, ELM has some disadvantages such as over-fitting problem. This algorithm depends upon the number of neurons. This classifier because it takes less time to execute or can be said that ELM having the short training time [8]. We know that elm is depend upon the number of neurons. So, the only motive is to check whether it classifies properly or not. In elm the hidden nodes are chosen randomly (i.e. not only they are free of training data; but also independent of each other) and the parameters of the hidden nodes (i.e. input weights, bias for additive hidden nodes) need not be tuned manually. The output weights are calculated analytically.

### Activation Function

The activation function is the non-linear transformation in the weighted input signals and bias. The activation function is important in elm because it transforms the input data to a non-linear feature space which may help in the prediction of accuracy. This paper gives the approximated architecture of five different activation functions in elm.

### No. of Neurons

The number of neurons in the input layers equals to the number of input variables in the data to be processed and, the number of neurons in the output layers equals to the numbers of output associated with each input. This research paper will create a relationship activation function and number of neurons with the error. The only purpose of this paper to match the alphabets with the datasets and, find out the minimum error value. So, here it is going to prove that which activation function is giving the minimum error value. Two graphs have been plotted between the number of neurons and activation functions with the error to check the best activation function by which extreme learning machine is giving the minimum error value with a maximum prediction and also it will check that in how many particular number of neurons it is giving the minimum error. The figure 6 is the graph plotted in between error value and activation functions. Though the errors coming out from the execution is different each time of execution, here we have taken five executions and noted down in a table 1.



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From the above table it is found that in 1<sup>st</sup> execution we found the minimum error .value at rbf\_12 function. In 2<sup>nd</sup> execution we found the minimum value at sigmoid function. In 3<sup>rd</sup> execution tanh has the minimum value. Linear function has the minimum value in 4<sup>th</sup> execution. In 5<sup>th</sup> execution sigmoid has the minimum error value. From this we can concluded that no specific activation function is giving the minimum error value because of randomness and complexity of the datasets. So, this classification algorithm (ELM) is independent of activation function. Fig. 7 depicts a graph between error and number of neurons.

We have plotted a graph between error Vs number of neurons. Though the errors coming out from the execution is different each time of execution, we have taken five iterations or executions and noted down in a table 2. From this table we have concluded that here also the values of the number of neurons also differs from execution to execution because of randomness and complexity of the datasets. So, this classification algorithm (ELM) is dependent of the value of number of neurons. After getting above disadvantages and randomness results ELM we have implemented PSO in this work.

**Optimization Algorithm**

An optimization algorithm is a method which is executed iteratively by comparing various solutions till an optimum or a satisfactory solution is found. Optimization is the procedure of improving a program's performance characteristics such as code size and execution speed. Traditional algorithm is a step by step procedure to follow in order to solve a given problem. We are taking the variable as  $x$  and calculating the  $f(x)$  for find out the global minimum value of a given graph. The purpose of optimization is to achieve the "best" design relative to a set of prioritized criteria or constraints. These include maximizing factors such as productivity, strength, reliability, longevity, efficiency, and utilization.

**Genetic Algorithm**

Genetic algorithm is a type of optimization algorithm that is based on the principle of genetics and natural selection or recombination theory to solve optimization problems. Genetic algorithms are commonly used to generate high-quality solutions to optimization and search problems by relying on bio-inspired operators such as mutation, crossover and selection.

**PSO**

Particle Swarm Optimization a type of optimization algorithm that is based on the examples of fish schooling and a flock of birds in searching their foods. All particles have fitness values which are evaluated by the fitness function to be optimized, and have velocities which direct the flying of the particles. The particles fly through the problem space by following the current optimum particles. It is shown in fig 8. PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. In every iteration, each particle is updated by following two "best" values. The first one is the best solution (fitness) it has achieved so far. (The fitness value is also stored.) This value is called pBest. Another "best" value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the population. This best value is a global best and called gbest. By taking an example of flock of birds in searching their food we can explain the pbest of a bird is that it will compare its velocity and position from the initial point and how far it is from the particle. The gbest is to compare the velocity and position of the bird with every individual who is closer to the particle. In fig 8 example of particle swarm optimization is given. Though PSO is independent of number of neurons and activation function we have implemented in this work to find out the minimum error.





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## SIMULATION RESULTS AND DISCUSSION

Machine learning is a science by which the machine learns by itself without any external help. It is all about to fit our dataset into the model. The model should train properly. Firstly, we have taken the datasets from UCI repository. Later on, we have used the customize datasets (handwritten alphabets). We can take genetic algorithm in this work but we know that genetic algorithm runs on the concept of recombination theory of scientist Charles Darwin. Though it has a number of steps, it will take more time to execute. In genetic algorithm the step size is necessary to find the best solution and these step sizes are not fixed. Every time we have to take a new one to get the optimum result. But in PSO there are no such recombination method is applied and also no need of step size in PSO. By comparing ELM classifier with PSO algorithm we found ELM depends on the number of neurons and activation function. The minimum error value is changing in every execution. No specific activation function is giving the minimum error value. Similarly, the minimum error value also changing if we are going plot against the number of neurons. PSO is independent of this number of neurons and also activation function. It will give result on the basis of gbest and pbest. As a result of testing the model, we got a minimum number of error value for the all activation function, that is 0.1. From this we concluded that no specific activation function is giving the minimum error value because of randomness and complexity of the datasets.

## CONCLUSION

In the beginning we have taken the datasets from UCI repository (<https://archive.ics.uci.edu/ml/index.php>). Later on, we have utilized the redo datasets of our own penmanship. We have taken twenty-six images of each alphabets for training. We got 0.1 of minimum error value. We have seen how handwriting recognition has surveyed the same evolution as many other computer visions applications. This describes the project for forensic science to match the handwriting, and in text recognition module. Next, it explains the technologies used in the project and the methodologies used. Finally, it shows the results, discuss the challenges. Utilizing Histogram calculation in picture preparing for highlights extraction worked amazingly well in any event, when the subjects have worn spectacles. Real time alphabet recognition has done by using ELM algorithm combined with PSO can be executed as a cost effective alphabet recognition platform. The computational models, which were implemented in this paper, were chosen after extensive exploration, and the successful testing results confirm that the choices made by the researcher were consistent.

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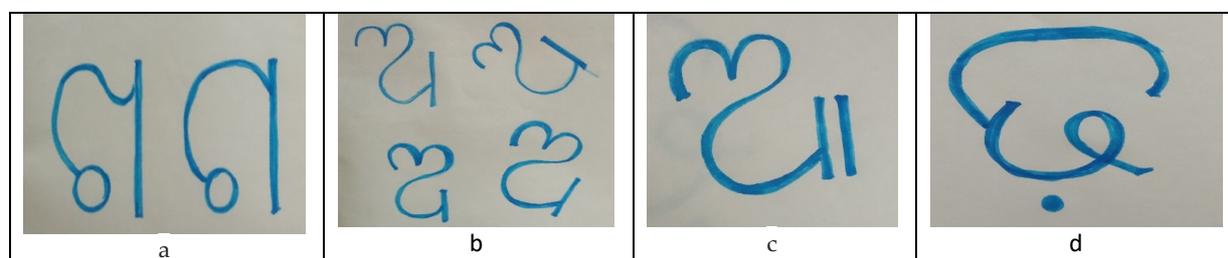
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**Table 1 Tabulation of records of five executions ( No. of execution Vs Activation Function)**

No. of execution Vs Activation Function	1 <sup>st</sup> Execution	2 <sup>nd</sup> Execution	3 <sup>rd</sup> Execution	4 <sup>th</sup> Execution	5 <sup>th</sup> Execution
Linear	0.25	0.166	0.125	0.090	0.25
Sigmoid	0.125	0.2	0.142	0.142	0.1
Tanh	0.142	0.166	0.090	0.1	0.142
Rbf_12	0.111	0.166	0.111	0.166	0.166
Rbf_linf	0.166	0.111	0.111	0.2	0.2

**Table 2 Tabulation of records of five executions (Errors Vs No. of neurons)**

Errors Vs No. of neurons	1 <sup>st</sup> Execution	2 <sup>nd</sup> Execution	3 <sup>rd</sup> Execution	4 <sup>th</sup> Execution	5 <sup>th</sup> Execution
1	0.166	0.25	0.166	0.25	0.2
2	0.142	0.125	0.25	0.142	0.166
3	0.142	0.166	0.125	0.125	0.166
4	0.25	0.125	0.2	0.166	0.25
5	0.125	0.111	0.1	0.142	0.2
6	0.142	0.25	0.125	0.166	0.25
7	0.142	0.2	0.125	0.166	0.25
8	0.166	0.2	0.2	0.333	0.166
9	0.5	0.125	0.1	0.25	0.142
10	0.33	0.2	0.25	0.5	0.333
11	0.166	0.125	0.33	0.142	0.166
12	0.2	0.125	0.2	0.142	0.166
13	0.25	0.2	0.25	0.166	0.2



**Fig. 1: Variations found in alphabets. (a) Inclination of angle. (b) similarities between alphabets (c) curves in alphabets and (d) straight lines in alphabets**





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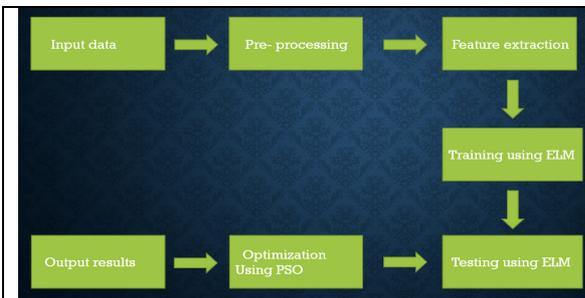


Fig. 2: Alphabet recognition frame work.

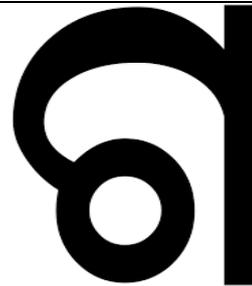


Fig.3. Image of 15<sup>th</sup> alphabet of odia language

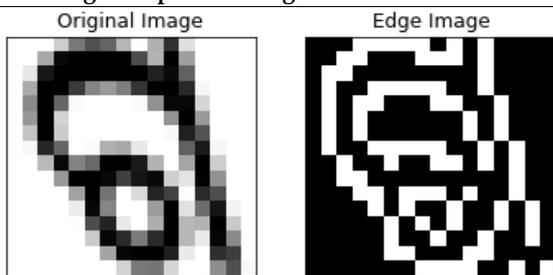


Fig.4(b): The edge histogram of the above image (output of the code).



Fig. 5: multiclass classification of different alphabets of different language

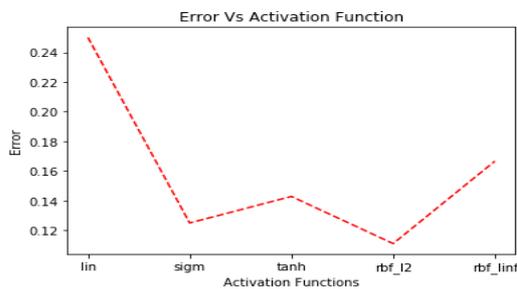


Fig. 6: A graph between error and activation function.

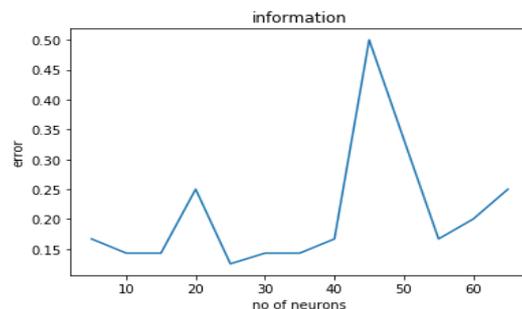


Fig. 7: A graph between error and number of neurons.

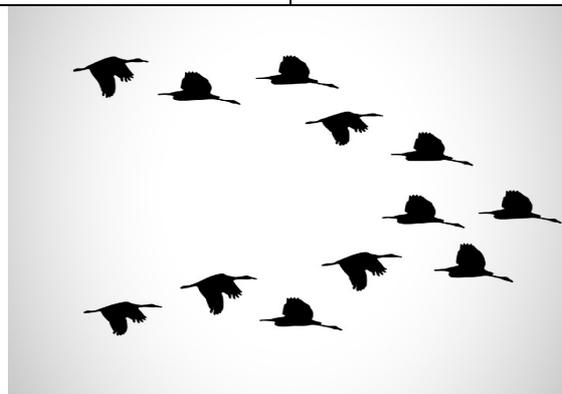


Fig.8: Example of particle swarm optimization.





## Silver Nanoparticles Play Key Role in Silver-Poly (Lactic acid) Nanocomposite Directed Wound Healing

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### ABSTRACT

This study investigated the wound healing efficacy of silver/poly (lactic acid) nanocomposite (Ag/PLA-NC). Here silver nanoparticles (Ag-NPs) were amalgamated into PLA via chemical reduction method. Silver nitrate is used as silver precursor, while sodium borohydride is used as reducing agent. Poly (lactic acid), worked as a polymeric matrix and a stabilizing agent. The wound healing efficacy of the silver/poly (lactic acid) nanocomposite (Ag/PLA-NC) was examined in mice model. The results indicated that Ag/PLA-NC possessed a strong wound healing efficacy. To evaluate the role of poly (lactic acid) in wound healing, the wound healing efficacy of Ag/PLA-NC and silver nanoparticles were compared. The assessment of wound healing parameters showed no significant difference. This further indicated that the wound healing activity of Ag/PLA-NC was due to silver nanoparticles present in the composite and PLA can works as a suitable biocompatible matrix.

**Keywords:** silver, polymeric, method, chemical, healing, wound.

### INTRODUCTION

The limitation with conventional drugs is that it is not that target specific. Moreover, people started disliking conventional drugs because of its ineffective dosage formulations and unintentional side effects. Therefore, there is a surge in demand to design drugs with high specificity and minimal side effects. Nanotechnology addresses these issues amicably. Nanotechnology, engineering and manufacturing at nanometer ( $10^{-9}$  meter) scale is a new technology which is already present in many parts of industry and medicine, and the impact of it is being felt in everyday life. It uses nanoparticles of 1-100 nm and has revolutionized the field of medicine by using these particles for therapeutics and diagnostics. Clinical uses of silver as an antimicrobial agent is time tested and Silver nitrate is a

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handy prescription for treating chronic wounds [1]. The noble metal works effectively killing broad spectrum of microorganisms ranging from viruses, bacteria, yeast and filamentous fungi [1, 6-10]. It targets the cytochromes present in the respiratory chain of microorganisms, thus impeding its function and ceasing the proliferation of microorganisms [2]. People also reported that it binds to DNA inhibiting replication of the master molecule [3-5]. There have been ripe evidences that ionic silver in exact proportion is a suitable agent for wound treatment [11-14]. This is being imperative by the loss of rubor in chronic wounds by colloidal silver. This is suggested to be because of the anti-inflammatory nature of the white metal [7].

Since silver nanoparticles have larger surface area therefore they have started replacing silver sulfadiazine for wound healing purpose [14-15]. The larger surface area of the nanoparticles may provide better bacterial interaction site thus working as a stronger antibacterial agent than metallic silver [16]. Similarly, study are there citing the enhancement of effectiveness of silver nanoparticles as wound healing agent when augmented with other materials. Therefore, several methods have been developed i.e. silver-doped hydroxyapatite [17]; polymer-silver nanoparticles [18]; and silver nanoparticles on TiO<sub>2</sub> [19] for studying the enhancement of antibacterial activity of silver nanoparticles when doped with other materials.

Silver nanoparticles when doped with biopolymers produce new antimicrobials. Several natural polymers like gum acacia, starch, gelatin and sodium alginate are being used to prepare biocompatible polymeric silver nanocomposite [20-22]. Though silver colloid based therapy is available in the market for wound healing. However, the bacteriostatic nature of poly (lactic acid) appeals to look for its utility in enhancing the wound healing efficacy of silver nanoparticles. Poly (lactic acid) (PLA) is a biodegradable thermoplastic polymer. It has got high melting point and better mechanical properties. The biodegradation, biocompatibility, superior thermal and mechanical properties make PLA a material of choice. [23-28]. Importantly, Poly (lactic acid) is an immunologically inert [29-30] and bacteriostatic polymer [31].

The crucial properties of poly (lactic acid) like bacteriostatic property, immunological inertness, biodegradability, and biocompatibility can be exploited in preparing a wound healing nanocomposite along with silver nanoparticle. The enhancement in wound healing efficacy of silver nanoparticles when blended with poly (lactic acid) can then be investigated. This study focussed to evaluate the enhancement of wound healing efficacy of silver nanoparticles when conjugated with PLA. The objective was met in two steps, in the first step silver/poly lactic acid nanocomposites were prepared by chemical reduction method followed by evaluating the wound healing efficacy of the prepared material in mice in second step.

## MATERIALS AND METHODS

### Materials

The reagents used in this work were of analytical grades and were used in their original form without any purification. Poly lactic acid (PLA) was supplied by Sigma-Aldrich, India. Silver nitrate (AgNO<sub>3</sub>) (99.8%) and tri sodium citrate dihydrate (99%) were obtained from RFCL limited, India. sodium borohydride (NaBH<sub>4</sub>) (95%), N, N-dimethyl formamide (DMF) (99%) and dichloromethane (CH<sub>2</sub>Cl<sub>2</sub>) (99%) were obtained from Sisco Research Laboratories, Mumbai, India. Double distilled water (DD-water) was used for making all the aqueous solutions.

### Synthesis of silver/poly (lactic acid) nanocomposites

Poly (lactic acid) was dissolved in a mixed solvent of dimethyl formamide (DMF) and dichloromethane (CH<sub>2</sub>Cl<sub>2</sub>) (1/9 v/v) to achieve a concentration of 10 wt % and certain amounts of silver nitrate (AgNO<sub>3</sub>) (0.08 g) powder was added to the solution. When stirred for 48 hours in an ice water bath a colourless solution of AgNO<sub>3</sub>/PLA was observed. To this 10 mL of sodium borohydride (NaBH<sub>4</sub>) aqueous solution (molar ratio of AgNO<sub>3</sub>/NaBH<sub>4</sub> 1:2) was added drop wise under vigorous stirring at the same temperature for 2 hours. The formation of the Ag-NPs started in the



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aqueous phase, but later the nanoparticles transferred to the organic phase due to the presence of van der Waals interactions between the hydroxyl groups of the PLA and the partial charges surrounded in the surface of the Ag-NPs. The organic phase containing stable Ag-NP colloid was separated from the aqueous phase and shaken with DD-water twice to remove any silver ions. It was then left for drying at room temperature; and form Ag/PLA-NC films [67].

**Synthesis of silver nanoparticles**

Silver nanoparticles were synthesized by chemical reduction method [68] by using sodium borohydride as a reducing agent and trisodium citrate as a capping agent. Here trisodium citrate (0.3 mM, 1 ml) was added to an aqueous solution of AgNO<sub>3</sub> (0.1 mM, 100 ml) and then NaBH<sub>4</sub> solution (50 mM, 1 ml) was subsequently added by drop-wise addition to the solution as a particle stabilizing agent with constant stirring in ice cold condition. This leads to the formation of yellow colour solution, which was the characteristic colour of the silver nanoparticle solution.

**Characterization methods and instrumentation**

The synthesis of silver nanoparticles and Ag/PLA nanocomposites were characterized using UV-visible (UV-vis) spectroscopy and Fourier transform infrared (FT-IR) spectroscopy. The size of the synthesized particles was determined using dynamic light scattering (DLS) technique. The UV-vis spectra were recorded over a range of 200-800 nm with a UV-1800 (SHIMADZU) UV-vis spectrophotometer. FT-IR spectra were recorded over the range of 400-4000 cm<sup>-1</sup> with an ALPHA (Bruker optics), FT-IR spectrophotometer. Particle size was determined using Zetasizer Nano (Malvern).

**Experimental animals**

Fifteen (for three experimental group, five in each group), five-six week old Swiss albino mice of either sex, weighing between 40 and 50 grams obtained from the animal house of CHRI (Chettinad Hospital & Research Institute), kelambakkam, Chennai, India, were used for *in vivo* studies. The experiments were conducted in accordance with the internationally accepted principles for laboratory animal use and approved by Institutional Animal Ethics Committee. The animals were housed in polypropylene cages in proper environmental conditions (20–25 °C), fed with standard rodent diet and water *ad libitum*.

**Excision Wound Model**

Animals were anaesthetized by open mask method with anesthetic ether. The hair on the back of each mouse was shaved and a predetermined area of 100 mm<sup>2</sup> full thickness outer skin was excised behind the neck. Group I (control) mice were left untreated, Group II mice were treated with silver nanoparticles colloid and Group III (test) mice were treated with Ag/PLA nanocomposites colloid. The wounds were applied with the appropriate agents daily.

**Doses of wound healing agents**

Group II mice were treated with 500 µL of 0.02 mg/mL silver nanoparticles and Group III mice were treated with 500 µL of 0.02 mg/mL Ag/PLA nanocomposites colloids daily for twenty days. This corresponds to a daily dose of 0.01 mg of silver nanoparticles and Ag/PLA nanocomposites for Group II and Group III mice respectively.

**Wound healing evaluation parameters****Measurement of wound contraction**

Excision wounds margins were traced following the progressive changes in wound area planimetrically, excluding the day of wounding. The size of wounds was traced on a transparent polythene sheet on day 5, 10, 15 and 20. The tracing were then shifted to a graph paper, from which the wounds surface areas were calculated. The evaluated surface area was then employed to calculate the percentage of wound contraction, taking initial size of wound, 100 mm<sup>2</sup>, as 100 %, by using the following formula:





$$\text{Wound contraction \%} = \frac{\text{Wound area day 0} - \text{Wound area day n}}{\text{Wound area day 0}} \times 100$$

### Epithelialization period

This was assessed by finding the number of days required for the Escher to fall off from the wound surface exclusive of leaving a raw wound behind.

### Statistical analysis

Results obtained from three wound models have been expressed as mean  $\pm$  SEM. Statistical differences were determined using t test. A p value of  $< 0.05$  was taken as statistically significant.

## RESULTS AND DISCUSSION

### UV-visible spectroscopy

The absorption spectrum (figure 1) of the yellow colour synthesized colloid showed a surface plasmon resonance around 400 nm with a plasmon peak at 425 nm indicating the presence of Ag nanoparticles in colloid. Similarly, the absorption spectrum (figure 2) of the dark brown Ag/PLA nanocomposites colloid showed the characteristic of the silver surface plasmon resonance band around 400 nm with a plasmon peak at 420 nm. This clearly indicates the formation of Ag nanoparticles in Ag/PLA nanocomposites.

### Particle size analysis

Dynamic light scattering technique was used to determine the size distribution profile of nanoparticles in colloids. Both in silver nanoparticles and Ag/PLA nanocomposites colloids most of the particles (98 %) were observed under a single peak area i.e. the colloids were almost monodisperse, indicating most of the particles in the colloids were of identical size. The mean hydrodynamic diameters of silver nanoparticles in silver nanoparticles and Ag/PLA nanocomposites colloid were found to be 80 and 109 nm respectively (figure 3, figure 4).

### FT-IR analysis

FT-IR spectroscopy was used to characterize the interaction between the Ag-NPs with PLA. Figure 5 shows FT-IR peaks for PLA and Ag/PLA-NCs. The peaks at 1264 (1091), 3055 (2936), and 3666  $\text{cm}^{-1}$  were assigned to the C–O, C–H (double) and O–H stretching of the –CH (CH<sub>3</sub>)–OH end group of PLA, respectively. The splitting of the C=O carbonyl stretching at 1669  $\text{cm}^{-1}$  might be due to the presence of –CH–CO–O– group. The peaks at 149, and 1387  $\text{cm}^{-1}$  were assigned to –CH<sub>3</sub>, and –CH– bending including symmetric and asymmetric bending. The interactions between PLA chain molecules and Ag-NPs were associated with the peak at 3489  $\text{cm}^{-1}$ . Broad peak was due to the presence of van der Waals interactions between the hydroxyl groups of PLA and the partial positive charge on the surface of the Ag-NPs.

### Evaluation of Wound healing efficacy

The progress of the wound contraction (expressed as percentage wound contraction) by day 5, 10, 15, and 20 in three experimental animal groups were shown in Table 1. It was observed (figure 6) that the wound contraction efficacy of Ag-NPs and Ag/PLA-NCs were significantly greater than that of the untreated group. Again, more than 95 % wound contraction was recorded in the Ag-NPs and Ag/PLA-NCs treated groups, as compared to 82 % wound contraction in the control (untreated) group by 20<sup>th</sup> day (figure 7). Throughout the experiment, the percentage wound contraction rate in the untreated group was significantly lower than those of Ag-NPs and Ag/PLA-NCs treated groups. It was observed that epithelisation has occurred on 20<sup>th</sup> and 19<sup>th</sup> day for Ag-NPs and Ag/PLA-NCs treated groups respectively, whereas no epithelization was observed till 20<sup>th</sup> day in untreated group. This indicates that Ag-NPs and Ag/PLA-NCs have high wound contraction efficacy and reduced epithelization time as compared



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to that of the untreated group. The wound healing efficacy of Ag/PLA-NCs treatment was not significantly different from wound healing efficacy of Ag-NPs treatment alone.

This further indicates that the wound healing activity of Ag/PLA-NCs is due to the antimicrobial and anti-inflammatory activity of silver nanoparticles present in the polylactic acid nanocomposites. Here polylactic acid nanocomposites acts as a matrix support for silver nanoparticles which releases the silver nanoparticles to the area of the wound. Moreover the biocompatible and biodegradable nature of poly (lactic acid) provides a strong support to use it as the matrix material for wound dressing. It is important to note that throughout the period of wound treatment, the nanocomposites did not cause irritation or pain to the animals as the mice neither show any signs of restlessness nor scratching/biting of wound site when the nanocomposites were applied. If animals were treated with silver nanoparticles on daily basis and silver-PLA nanocomposites on alternate day basis the enhancement in wound healing efficacy because of PLA can be better assured. Hence the role of PLA more than the matrix for control release of nanoparticles could have been fully pronounced.

**CONCLUSION**

Silver/poly lactic acid nanocomposite was synthesized. The average diameter of the silver nanoparticles in silver/poly lactic acid nanocomposite was 109 nm. The UV-visible absorption spectra show signature surface plasmon resonance peaks of the silver nanoparticles. FT-IR shows that interactions exist between molecules of poly lactic acid and silver nanoparticles. The wound healing efficacy of silver/poly lactic acid nanocomposite was demonstrated. Further it was confirmed that wound healing activity of silver/poly lactic acid nanocomposite was due to silver nanoparticles in the composite and PLA act as the supporting matrix in controlled release of silver nanoparticles.

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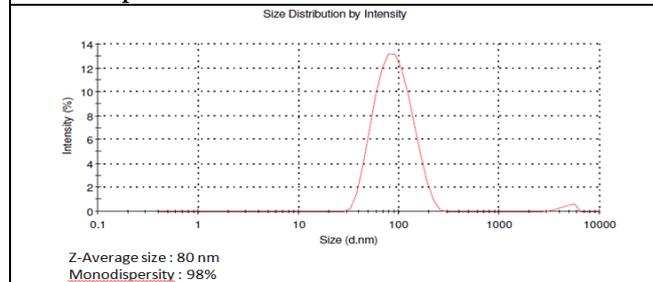
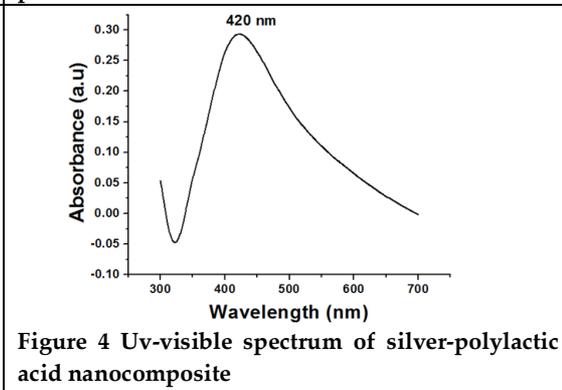
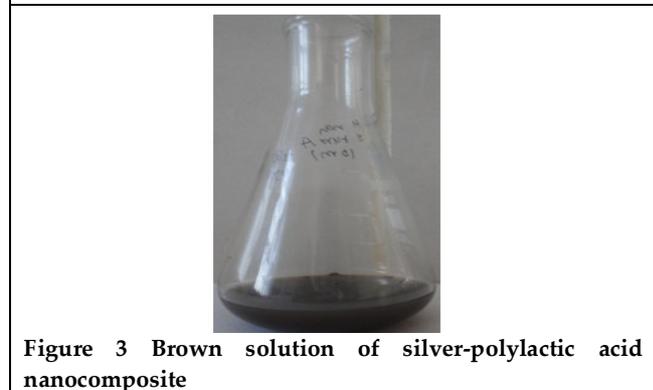
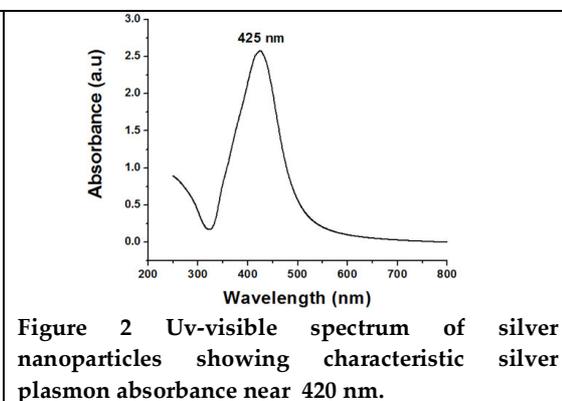
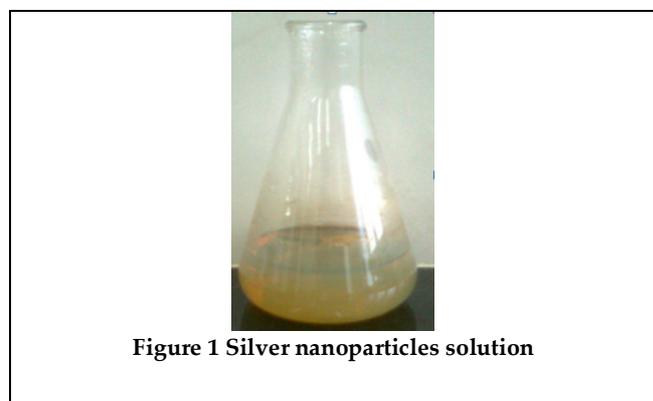




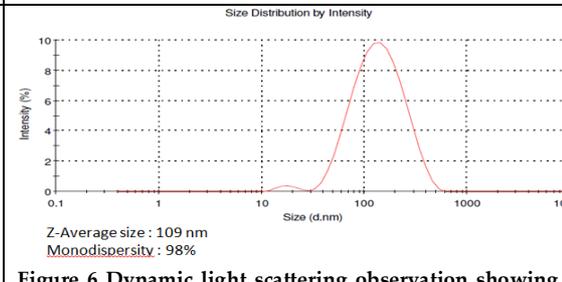
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**Table1: Percentage of wound contraction in mice.**

EXPERIMENTAL ANIMAL GROUPS	PERCENTAGE (%) OF WOUND CONTRACTION			
	BY DAY 5	BY DAY 10	BY DAY 15	BY DAY 20
Group I (Control- Untreated)	21	50	74	82
Group II (Ag-NPs Treated)	49	72	87	98
Group III (Ag/PLA-NCs treated)	54	75	85	97



**Figure 5 Dynamic light scattering observation showing almost monomodal distribution of silver nanoparticles.**

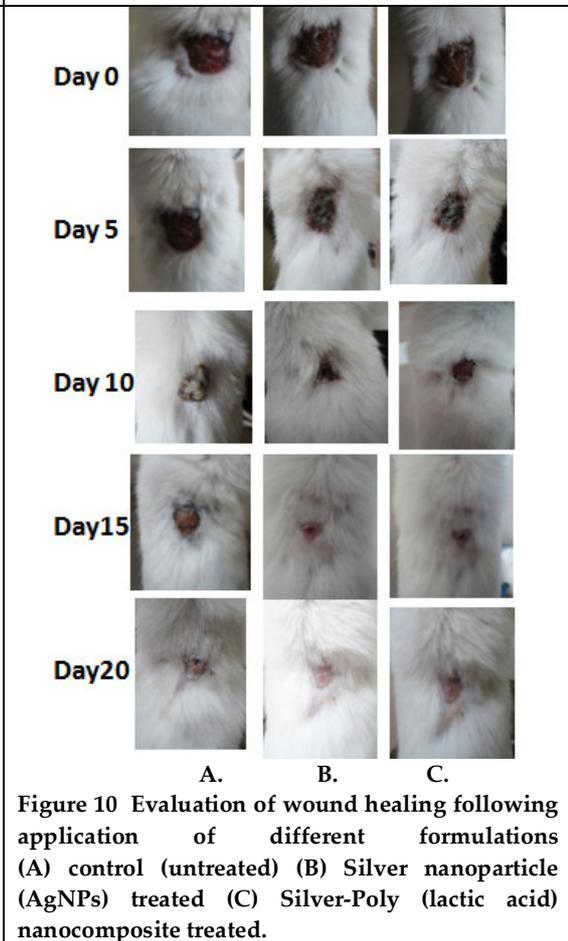
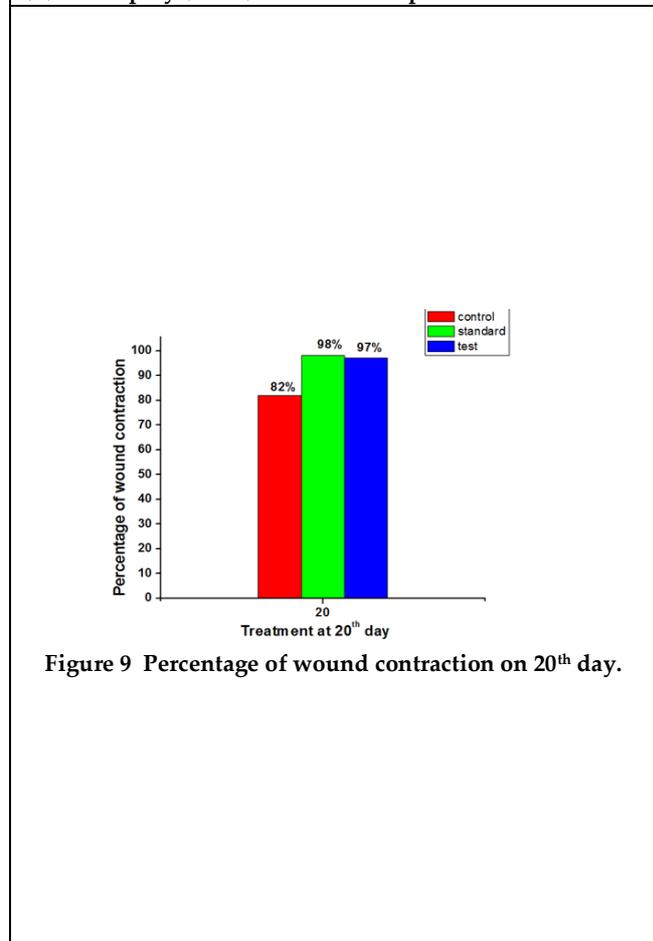
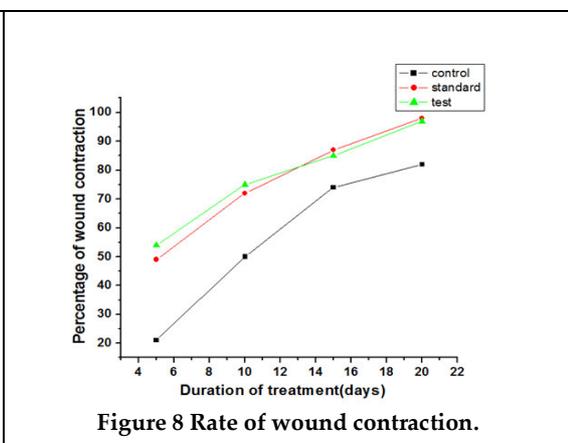
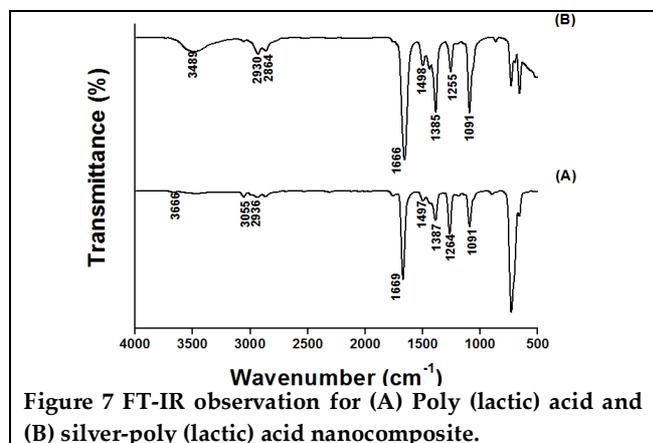


**Figure 6 Dynamic light scattering observation showing almost monomodal distribution of silver-PLA nanocomposites.**





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## Rainfall Prediction Using Multiple Linear Regression

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### ABSTRACT

The present paper analyses the monthly rainfall data of various regions of India between 1901-2015. Multiple linear regression is used for training and testing the model to predict the average rainfall using the previous months' data from the equivalent time period. Prediction is done month-wise according to the sub-division and compared with the actual value. In this paper, the prediction model basically deals with steps such as data acquisition, data cleaning, feature extraction, prediction. In this experiment getting 0.99 accuracy after prediction the rainfall.

**Keywords:** Multiple Linear Regression (MLR); Rainfall Prediction; Historical Data

## INTRODUCTION

The Analytics which help us in solving many problems, Data analytics is collected from various statistical and analytical methods used to develop new techniques to predict future possibilities. In the current scenario forecasting the rainfall is measured to be an important and thought-provoker task, as it's closely associated with the agriculture, economy, and human life. Accuracy of a rainfall predicts has importance for countries like India whose economy majorly depends on agriculture. The rainfall prediction has to predict the state of the current weather conditions. The weather is dynamic in nature; statistical techniques are unsuccessful to provide thee decent accuracy of rainfall. Agriculture is the largest occupation in India, accounting for about 52% of employment. Because India is an agricultural country and its economy is largely based upon crop productivity. The occurrence of prolonged dry periods or heavy rain at the significant stages of crop growth and development may lead to significantly reduce crop yield.

Rainfall is important for food production plans, water resource management, and all activity plans in nature. Thus rainfall prediction becomes a major factor in agricultural countries. Rainfall prediction has been one of the most scientifically and technologically difficult problems around the world in the last century [1]. There is much





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application that this system is used such as Air Traffic, Agriculture, Marine, Forestry, Navy, and Military, etc. The training of the data is done using a modified version of the linear regression method. The error percentage between the actual and predicted is used to improve the training set and train the data with the new inputs. Thus, with the advantages of this method; forecast the outcomes till there is no further improvement in the error percentage. This method can be used to forecast the rainfall and prevent the destruction caused by it to the life or property [2]. Indian Government has undertaken many research studies to analyze the impact of global warming and climate change on rainfall patterns in India. The analyses were made using experimental rainfall data from more than 3000 rain-gauge stations spread over the country for 115 years (1901-2015). In this field the major inferences from these studies based on the 115 years of rainfall data are as follows:

The analysis of 115 years of monsoon rainfall data suggest that there is no long term change in the monsoon rainfall averaged over the country. Even though there are no changes in the all-India rainfall, there are significant changes in annual rainfall in some meteorological sub-divisions. With this data with more variations of average rainfall, it is very difficult for a numerical model to predict the required data point. Here implement multiple linear regression to predict the average rainfall, the regression is used to create multiple features that help in predicting the data points with more seasonal variations. The rest of the paper is structured as provided below. In Section 2, the related work and plans for future research are introduced. Next, in Section 3, methodology, where explained how to predict the data. In Section 4, historical data collected for prediction. In Section this this paper is divided into five section i.e. 1. Introduction, 2. Related Work, 3. Methodology, 4. Dataset, 5. Result Discussion and Conclusion in Section 6.

### Related Work

Different scientists, researchers, and students doing prediction in different ways like Daniela Şchiopu [4] and his team in his publication used SPSS 13.0 tool and forecasted temperature from data collected from Hong Kong Observatory website. They used a factor analysis technique in the SPSS tool to reduce the complexity in calculations the temperature using correlation and regression. Samuel and Rajalakshmi [5] used multiple linear regression to predict the monsoon rainfall by using outgoing long wave radiations, global temperatures, and sunspots out of Tamil Nadu. They collected data from 110 years from the Indian Meteorological Department, Chennai. Hirani and Nitin [6] proposed different methods to estimate rainfall. The methods include Autoregressive Integrated Moving Average (ARIMA), Multiple Linear Regression (MLR), Genetic Algorithm, Support Vector Machine (SVM), Back-Propagation Neural Network (BPNN), Adaptive Splines Threshold Autoregressive (ASTAR) modeling and others. Paras and Sanjay [7] developed a forecasting model using mathematical regression.

The weather data is collected for a period of 3 years and this model can predict max and min temperatures for a period of 15 to 45 weeks into the future. Goutami [8] used Multiple Linear Regression to estimate average summer – monsoon rainfall on the data from 1871 to 1999. She analyzed the monthly rainfall of Indian summer monsoon months. Kannan, Ramachandran, and Prabhakaran [9] implemented Multiple linear regression and Karl Pearson coefficient. They made a short – term forecast over a particular state. They used fuzzy sets, neural networks to analyze the data. Returns and Delson [10] developed a weighted multiple regression model. They used a combination of time series analysis and regression to offer a powerful system for predicting annual rainfall. Timothy and Shukla [11] proposed the F-test and Screening procedure. a cross-validation procedure is used first to screens models out that are all likely to poorly perform on independent datasets, then the error of each model is compared with those all other models to determine a threshold of significance in error variance. Guhathakurta [12] used dynamic models on nonlinear equations that the atmospheric system governs. They implemented neural networks with three layers that works on one input, one output, and one hidden layer. The network training is carried out till the mean square error of 0.0005 to 0.001. Nikhil [13] proposed correlation and regression both linear and multiple linear regression. He estimated the rainfall by analyzing the atmospheric factors like precipitation, vapor pressure, average temperature and cloud cover.





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## METHODOLOGY

### Algorithm

**STEP I:** In dataset the attributes are subdivision, year, month from jan-dec, jan-feb ,feb-mar and take the months as X attributes and predict the annual rainfall column(Y attributes).

**STEP II:** After imported all the modules panda, numpy, math, sklearn, seaborn and matplotlib, and need to do some data preprocessing such as removing null values or filling them with mean.

**STEP III:** Then checking the data types of the attributes.

**STEP IV:** Now grouping by subdivision and getting the co-variance and co-relation because Correlation, statistical technique which determines how one variables moves in relation with the other variable and co-variance indicates the direction of the linear relationship between variables.

**STEP V:** Apply the linear regression to train the model using train\_test\_split and test it using various performance measures like Mean Squared error(MSE),root mean squared error(RMSE). And modeling the classifier by using training dataset (80% of the data from the CSV.file).

**STEP VI:** Validating the model Using Testing dataset (rest of the 20% data) and Comparison of result  
There are six important stages that are proposed in this model: Data acquisition, Data preprocessing, Data selection, Reduction of explanatory predictor, Model design, and last Model validation as shown in [Figure.1].

### Multiple Linear Regressions (MLR)

In this article, use Linear Regression to predict the amount of rainfall. Linear Regression helps how many inches of rainfall expect. It is applied to the set of data and the coefficients are used to predict the rainfall based on the corresponding values of the parameters. The main advantages of this model are that it estimates the rainfall based on the previous correlation between the different atmospheric parameters.

It is a method used for defining the relation between a dependent variable (z) and one or more independent variables or explanatory variables, denoted by (x). For multiple explanatory variable, the process is defined as Multiple Linear Regression (MLR). The general equation for linear regression is given in equation (1) as  $z_i = \beta_0 + \beta_1 x_{i1} + \dots + \beta_p x_{ip} + \epsilon_i = x_i^T \beta + \epsilon_i$  (1)

where z denotes the dependent variable (rainfall) and  $x_i$  where  $i=1,2,\dots,n$ , denotes the explanatory or independent variables and  $\beta$  is called the intercept.

The Multiple linear regression equation used in this proposed system is given equation (2) as Rainfall =  $(\text{AvgTemp} * \beta_1) + (\text{Humidity} * \beta_2) + \beta_3$  (2)  
where  $\beta_1, \beta_2, \beta_3$  represents the different coefficients for different districts.

### Datasets

There are six important stages that are proposed in this model

### Data Acquisition

The data need for predict the rainfall. The data of rainfall prediction have been collected from kaggle repository the collected dataset has 115 years' time period from 1901 to 2015 sub division wise monthly data. Format of data is csv





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file. It is historical data. This data is used to process in the system to predict the rainfall. Source: <https://www.kaggle.com/rajanand/rainfall-in-india-1901-2015>

### Data Pre-Processing

The Data Pre-processing is the next challenging task, the data obtained till now is noisy and there are some missing values and some unwanted data. The data have to clean by filling missing values and removing the irrelevant data.

### Data Selection

In this section to select the data which are relevant to analysis and left all other data use correlation to determine which are correlated or not.

### Reduction of explanatory predictor

After that the predictors which have high inter correlation with others are reduced because the presence of many highly inter correlated explanatory variables may significantly increase the sampling variation of the regression coefficients, and degrade the model predictive ability.

### Model design

The next step after the reduction explanatory predictors is the building model with the use of training data. Training/Testing is split in the ratio 80:20 randomly. The technique used here is linear regression technique.

### Model validation

After training the model with the training set, get the validating results and tuning the hyper parameters with the validation set till the reach a satisfactory performance metric. Once this stage is completed, then testing the model with the test set to predict and evaluate the performance.

## RESULT AND DISCUSSION

The experiments were performed to evaluate the accuracy of rainfall prediction using multiple linear regressions.

In this experiment data is collected for every state for a period of 115 years from 1901 to 2015 for all months i.e. from January to December. And visualized the data using various plots in the given below. These plots help to predict the future trend on the basis of current relationship between variables.

- In [Figure.3] Subdivisions with highest annual rainfall are "Arunachal Pradesh", "Coastal Karnataka" and "Konkan& Goa" with approximate annual rainfall of 3418.857143mm, 3408.409649mm and 2977.686087mm respectively.
- Subdivisions with lowest annual rainfall are "West Rajasthan", "Saurashtra& Kutch" and "Haryana Delhi & Chandigarh" with approximate annual rainfall of 292.673043mm, 495.161739mm and 530.496522mm respectively.
- In [Figure.4] Maximum overall rainfall (sum of all 36 subdivision) of 61815.6mm occurred in the year 1961
- Minimum overall rainfall (sum of all 36 subdivision) of 41273.6mm occurred in the year 1972
- Average (of all 36 subdivisions) overall rainfall (sum of all 36 subdivision) is 50182.832mm
- Highest average rainfall of 348.5675mm occurred in the month of July
- Lowest average rainfall of 19.1113mm occurred in the month of January

After train the model using `train_test_split`, and test it using various performance measures, Like mean squared error(MSE), root mean squared error(RMSE), mean absolute Error(MAE),  $R^2$  score. And also plot the scatter plot of expected vs predicted values shown in [Figure.6]. From get good results because Mean Absolute Error (MAE), Root Mean Squared Error(RMSE) are relatively less values, and scatter plot is pretty concentrated as straight line.





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After that measure the classifier performance. F1-score is composite metrics that combine the precision and recall of a classifier. Precision is the fraction of true positives out of all positives; recall is the fraction of true positives out of all relevant elements. Higher precision and recall are, the better the classifier performs because it detects most of the positive data (high recall) and does not detect many data that should not be detected (high precision). In this experiment the higher precision and recall are, the higher F1-score is 1.00, and it proves that the better classifier of the model as shown in [Table.1]. And finally get the accuracy 0.9983805668016195. The true positive rates against the false positive rate at various cut points. It also demonstrates a trade-off between sensitivity as shown [Figure.7].

## CONCLUSION

Rainfall Prediction is the application of science and technology to predict the amount of rainfall over a region. Agricultural sectors can avail the benefits of knowing weather condition in advance and take precautionary steps accordingly. This directly helps in improvement of national economy as well. A rainfall prediction method has been proposed. This experiment used to multiple linear regression approach to predict the rainfall prediction because multiple linear regression has less error percentage and getting the accuracy 0.99. The model is robust and accurate as it trained and tested with a large size dataset for every state for a period of 115 years from 1901 to 2015 for all months i.e. from January to December. Rainfall over Kerala, East Madhya Pradesh, Jharkhand, Arunachal Pradesh, and Nagaland, Manipur, Mizoram, and Tripura show a decreasing trend. But, rainfall over coastal Karnataka, Maharashtra, and Jammu and Kashmir show an increasing trend.

There is a general tendency of increasing the frequency of extreme rainfall (heavy rainfall events) over India, especially over the central parts of India during the southwest (June- September) monsoon season. There is no fact of global warming on the observed changes in annual or seasonal rainfall over India. However, there is growing evidence suggesting that increasing the frequency of extreme rainfall is due to global warming. The climate change assessment made by the Intergovernmental Panel on Climate Change (IPCC) suggests that in the future, the frequency of extreme rainfall may increase over India due to increase in global warming. However, there are no other long term changes/trends in rainfall over India which can be attributed to global warming. The Indian Monsoon is found to be a stable system.

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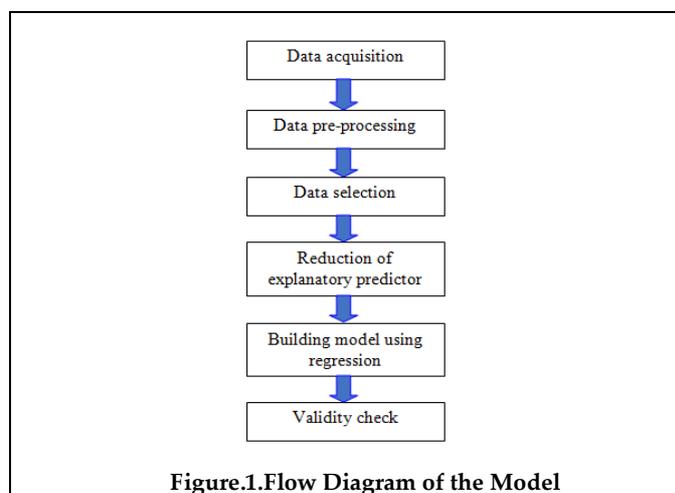


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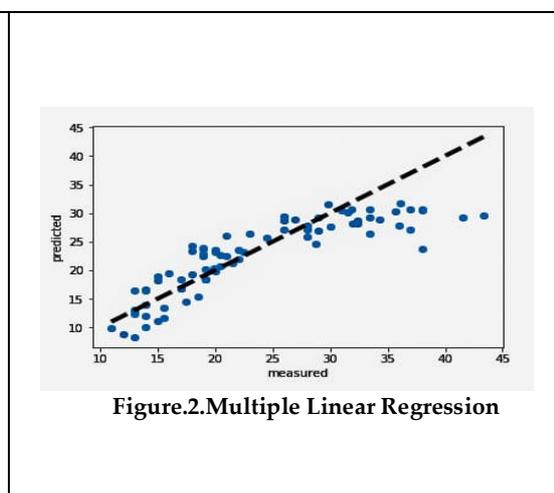
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**Table.1.Classification**

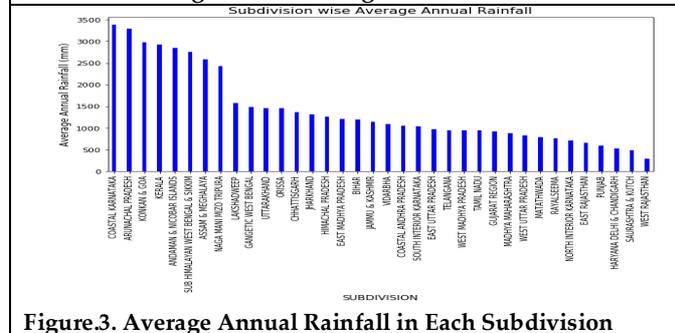
	Precision	Recall	F1-score	support
High	1.00	0.99	1.00	237
Low	1.00	1.00	1.00	998
Avg/total	1.00	1.00	1.00	1235



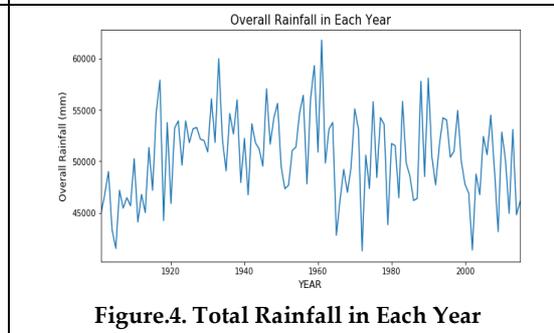
**Figure.1.Flow Diagram of the Model**



**Figure.2.Multiple Linear Regression**



**Figure.3. Average Annual Rainfall in Each Subdivision**



**Figure.4. Total Rainfall in Each Year**







## Short Term Electricity Price Forecasting For Deregulated Energy Market

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### ABSTRACT

With the spread of privatization, liberalization and globalization, economic activities are increasingly being de-controlled and de-regulated all across the globe. Forecasting plays a very important role in economic optimization of electricity usage. In the new competitive framework, short-term Price Forecasting is required by producers and consumers to derive their bidding strategies to the electricity market. This paper proposes an Extreme Learning Machine approach for forecasting short-term electricity prices. We evaluate the accuracy of the price forecasting attained with the proposed ELM approach. The proposed method is tested on Ontario Energy Market datasets. To overcome the limitations of the Artificial Neural Network model, ELM model is used for forecasting the short term electricity price of foreign electricity market. The results were showed that the proposed approaches are successful. Consumer and producers needs accurate price forecasting tools which are required for producers to maximize their profit and consumers required for maximize their utilities. The main objective is to predict the value or price of each unit so that consumers and producers get their benefits. Therefore, we evaluate the future price movements by adopting ELM. From result there is a close call between tribas and radbas but by considering both parameters processing time and accuracy tribas shows a promising result. The accuracy achieved is 92.506 with 10 numbers of hidden nodes.

**Keywords:** Price Forecasting; De-Regulated Energy Market; ELM; ANN

### INTRODUCTION

Market is the key aspect in every field of economic activities. And electricity market is no exception [1]. With an objective to restructure the electric power industry, different companies like generating companies and supplying companies need to meet in a market place to survey and evaluate the electricity price [2]. Nowadays, all over the

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world electricity forecasting provides a competitive frame work. There are a lot of researchers are engaged for developing algorithms and tools for load and price forecasting. Price forecasting tools are essential for all companies and consumers for their survival under new deregulated environment [3]. There are two different types of business strategy in the electricity market like the poll& bilateral contracts. In the poll, the producers and consumers submit their own bids. Then the next day market operator announced a set of accurate price. Bilateral contract is an agreement between seller & buyer. It is a tool for the companies to secure them against the price manipulation [4-5]. For both cases, predict the price of electricity for tomorrow or for next 12 month is most important for electric companies to adjust their daily bids and monthly schedules. Electricity has different characteristics from other commodities for e.g. electricity storage and supplying are more expensive [6]. The main objective of an electricity market is to decrease the cost of electricity through competition. Pricing mechanism can affect the competition, number of consumer, efficiency and strategy applied by the competitors in the electric market [7].

Producers and consumers depend on Price Forecast information to prepare their corresponding bidding strategies. If a producer has a good forecast of market prices it can develop a strategy to maximize its own benefit and establish a bidding techniqueto achieve its maximum benefit. More and more attention has been paid to price forecasting in the deregulation technique. Different forecasting techniques such as expert system, Artificial Neural Network, fuzzy logic, Extreme Learning Machine, wavelets have been developed for showing improving results [8]. Using ELM method the accurate electricity price has been calculated. In the proposed algorithm, the input weights and hidden biases are randomly chosen, and the output weights are determined analytically by using the Moore–Penrose (MP) generalized inverse. ELM surpasses the traditional gradient-based learning methods in terms of faster learning speed with a higher generalization and it also avoids many difficulties faced by gradient-based learning methods such as stopping criteria, learning rate, learning epochs, local minima, and the over-tuning problems [9-10]. Up to now, the ELM has been successfully applied in various areas such as classification, terrain reconstruction and protein structure prediction. The ELM technique has been applied for the case of electricity price forecasting in where the advantages of ELM over traditional ANN structures were highlighted and also the uncertainties related to prediction were quantified using the bootstrapping technique [11].

### Literature survey

In deregulated energy market, price of electricity has taken more importance. Accurate and efficient electricity price forecasting is more important factor. This topic provides us scope to enhance the methods used in it and gives us correct prediction in deregulated energy market.Using Artificial intelligence and Extreme Learning Machine (ELM) techniques to predict the monthly electricity prices and the day-ahead usage of electricity are proposed by VrushabGosalia and PradipAndhare[1-2]. Here using ANN model which is used for forecasting the behavior of the electricity market based on the different factors such as historical price, calendar date, occasions, and load. In this paper system will have gained high relevance and will represent one of the main sources of information that can bias one common base for system user for bidding in the electricity market. Such as for generator companies, forecasting of electricity price and consumption level can be used as possible value for finalizing the price level in this competitive market[3].Another topic on a detailed analysis on extreme learning machine and novel approaches based on ELM by Omer Faruk and Yilmaz Kaya has briefly discuss about ELM method[4-6]. In this paper accuracy of randomly selected input weights and biases was compared with new proposed approaches like ELM-P, ELM back propagation (ELM-B), single layer ELM (s-ELM), tuning ELM (t-ELM), ELM based on linear regression (ELM-r).

Another topic on a hybrid wavelet-ELM based short term price forecasting for electricity markets by N.A Shrivastava and B.K Panigrahi is used ELM technique coupled with wavelet technique to develop a hybrid model called as WELM (wavelet based ELM) to improve the forecasting accuracy as well as reliability [7-8]. The author concluded that the hybrid wavelet-ELM model can produce smaller predicting errors than the existing techniques.Using ELM and wavelet transform method and modified artificial bee colony (MABC) algorithm, a novel Short-term load forecasting method is proposed by Song Li, LalitGoel and Peng Wang [9-10]. Wavelet transform is used to decompose the load series into a set of different frequency components, which are more predictable. Moreover, a



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modified ABC algorithm is proposed to choose the optimal set of input weights and hidden biases for ELM. The ELM-MABC algorithm has better convergence performance than the conventional Neuro-Evolution method, leading to a significant improvement in forecasting accuracy. The proposed method produce excellent forecasting result compared to other established methods [11]. In the paper by Rafał Weron [12-13] the author review an article of electricity price forecasting (EPF) to explain the complexity of available solutions, their strengths and weakness, and the opportunities and threats that the forecasting tools offer or that may be encountered. In this paper the author discussed all the methods, problems, suggestions to develop more efficient and better grounded models and techniques for electricity price forecasting area.

In the paper by Ling Tang, Wei Dai [14] the authors have use Extended Extreme Learning machine (EELM) and coupling complementary ensemble empirical mode decomposition (CEEMD) to predict the accuracy of crude oil price based on the principle of decomposition and ensemble". This novel CEEMD-based EELM model is actually an extension on existing ensemble models and the main contribution to literature is to introduce the current algorithms of CEEMD and EELM and to test their effectiveness in formulating the powerful decomposition and ensemble" learning paradigm. Another topic on what are Extreme Learning Machines? Filling the Gap between Frank Rosenblatt's Dream and John von Neumann's Puzzle by Guang-Bin Huang [15] has briefly discuss about ELM method. This paper wishes to clarify the ELM theories manage to address the open problem which has puzzled the neural networks, machine learning and neuroscience communities and compare ELM, SVM and LS-SVM tend to provide sub Optimal solutions.

This paper is composed of a total of four sessions. Session 1 is the current chapter and introduces the topic of thesis and describes the previous contributions in this dataset using Evolutionary Algorithm. Session 2 states the methodology of our research, where it showed the dataset which we obtained from Ontario energy market and describes the proposed model based on Extreme Learning Machine (ELM). Session 3 describes the result. Session 4 summarizes our research and also highlights the Future work.

## MATERIAL AND METHODS

### Data

The experimental data are obtained from Ontario, Energy markets. The Ontario data set consists of hourly electricity price from May 01, 2002 to December 26, 2006. The total numbers of samples taken from Ontario are  $(40824 \times 3)$  1, 22, 472.

### Extreme Learning Machine (ELM)

As compared to ANN which is time delay process due to the number of iteration, ELM is much faster to train. It provides no iterative training using generalization pseudo inverse operation. ELM is neural nets with a single hidden layer, where the 1<sup>st</sup> weight matrix is initialized randomly. This allows the output matrix to be estimated via least square, which is very quickly done [12-13].

ELM says "only learn the last layer" whereas ANN says "learn all the layers". 'Extreme' in ELM means to move beyond conventional artificial learning technology and to move towards brain alike learning. It is a feed-forward neural network for classification, regression, clustering, sparse approximation compression and feature learning with a single layer or multiple layers of hidden nodes. ELM aims to break the barriers between the conventional Artificial Learning techniques and biological learning mechanism. Extreme learning machine (ELM) represents a suite of machine learning techniques in which hidden neurons need not be tuned with the consideration of neural network generalization theory, control theory, matrix theory and linear system theory. In order to have clearer understanding of ELM, it is better to analyze ELM in the aspects of its philosophy, theories, network architecture, network neuron types and its learning objectives and algorithms [14-15].





Activation Functions: In ELM method different activation function is used to identify the accuracy for different hidden nodes. Basically 5 types of activation function are used such as hard limit, sigmoid, sine, triangular basis and radial basis function. The activation function is the nonlinear transformation of the weighted input signals and bias.

### Proposed Algorithm

The main puzzle in network, machine learning or neuroscience for many years, whether hidden nodes need to be tuned or not. It is generalized both for single hidden layer feed-forward network (SLFN) and multi hidden layer feed-forward network (MLFN) [10]. ELM is basically 2 types: multi layer ELM (MLELM) and hierarchical ELM (H-ELM). ML-ELM and H-ELM has a smaller training time than DBM (Decision boundary making) [16].

Extreme learning machine (ELM) is a learning method for training single hidden layer feed-forward neural network (SLFN), which generates input weights and biases randomly. Later, the output weights are computed analytically [17]. There are some basic differences between, ANN and ELM such as non-differentiable or discrete transfer functions can be used at ELM, ELM does not need the optimization parameters (such as momentum, learning rate), which are important for accuracy of ANN, ELM overcomes falling into local minima and also ANN is a slow method because of the need of tuning all network parameters. Where,  $x_i$  identifies input,  $y_k$  shows the output and network having  $n$  neuron in the hidden layer,  $n$  neuron in the input layer and  $k$  is the number of output. ELM is an emerging learning algorithm for SLFN, which randomly chooses the input weights and hidden biases and determines the output weights directly by a least squares method.

Consider a training set of  $N$  samples  $(x_i, t_i)$ , the SLFN can be modeled by

$$\sum_{j=1}^n g(w_j \cdot x_i + b_j) = o_i, i=1 \dots N \quad (1)$$

where  $x_i$  is the input vector,  $t_i$  is the output vector,  $n$  is the number of hidden nodes,  $g(x)$  is the activation function,  $w_j$  is the input weight vector,  $b_j$  is the hidden bias vector,  $\beta_j$  is the output weight vector and  $o_i$  is the actual network output.

If ELM fits all the training samples  $(x_i, t_i)$  with zero error, it can be said that there exist

$\beta_j, w_j$  and  $b_j$  such that

$$\sum_{j=1}^n g(w_j \cdot x_i + b_j) = t_i, i=1 \dots N \quad (2)$$

The compact form of (2) can be given by  $H\beta = T$ ,

where  $\beta = [\beta_1, \dots, \beta_n]^T$ ,  $T = [t_1, \dots, t_N]^T$  and  $H$  is called the hidden layer output matrix.

ELM cannot obtain the perfect zero error because the number of hidden nodes  $n$  is usually less than the number of training samples  $N$ . In ELM, the input weights  $w_j$  and hidden biases  $b_j$  are randomly initialized. For  $w_j$  and  $b_j$ , the SLFN becomes an over-determined linear system and the output weights  $\beta$  can be calculated by a least squares method. A special solution is given by  $\beta^* = H^+T$ , where  $H^+$  is the Moore-Penrose (MP) inverse of  $H$ . It is suggested that the singular value decomposition method is well-suited to compute the MP inverse of  $H$  in all cases. The special solution  $\beta^*$  is one of the least squares solutions of the linear system  $H\beta = T$ , which implies that ELM can reach the minimum error of the current system [18-19].

In SLFN a bias is used to absorb the system error along with activation function. But in case of ELM there is no need of bias. There are three levels of randomness in ELM:

- Fully connected, hidden node parameters are randomly generated.
- Connection can be randomly generated, not all input nodes are connected to a particular hidden node. Possibly only some input nodes in some local field are connected to one hidden node.
- A hidden node itself can be a sub network formed by several nodes.



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The Hidden nodes of wide types of multi-hidden-layer networks (MLFN) do not need to be tuned. Although multilayer of ELM concepts have been given in ELM theories has not been used until recently.

## RESULTS

To develop a model, a number of case studies are performed and performance of the model under different conditions is investigated. The major advantage of ELM over traditional neural network models is that the parameters do not require any tuning in the former case thus eliminating the need for repetitive tuning and cross validation to come up with the best model [20]. The learning capacity of ELM is very fast and it gives excellent performance when the training data set is shown even once to the network. Price forecasting is computed using historical data of Ontario energy system for year 2002/01/May to 2006/26/ Dec. Data of Ontario electricity market has been obtained from their website. Due to the demerger of Ontario Hydro in early 1999, Ontario electricity prices may be assumed to have had no major impact on the load of interest. However, due to the large power exchange between Pennsylvania-New Jersey- Maryland (PJM) and Ontario, and the fact that PJM has operated a large energy spot market for a while, one may reasonably assume that these prices may have had a significant impact on the overall Ontario Hydro system for the period of interest. Thus, PJM electricity spot price data for the corresponding time period is used here as the price input for the forecasting process.

In this work, the requirement of a separate validation set is eliminated because the ELM model does not require any iterative tuning based on validation set. The trained model was directly validated using the testing data. In the first case study, a basic ELM network was tuned with a simple data without any decomposition and with different activation function to determine the most suitable activation function for the fixed number of hidden nodes. The performance with sigmoid, sinusoidal and hard limit, triangular, radial basics function was evaluated for the selection of activation function. Figure 7 shows the performance comparison and it was observed that Hard limit and sigmoid function gives a poor performance in comparison to radbas, tribas and sin. The performance of tribas activation function was still on the better side and is used as a default activation function in all the further analysis.

Above figure 7 represents accuracy of different activation functions with a fixed number of hidden nodes. As per the figure there is a close accuracy between tribas and radbas, whereas tribas is having high as compared to radbas.

The same result of previous Figure 7 has been represented in bar plot Figure 8 so as to distinguish the difference between different activation functions.

Once the activation function has been identified the robustness of the activation function has been analyzed for different number of nodes for all activation functions. And there is a remarkable difference between tribas activation function and rest of the activation functions. For different number of hidden nodes tribas activation function shows an average accuracy of 80% and with 10 numbers of hidden nodes the result is even better with an accuracy of around 98%. Though processing time is not that much to be considered as a decision making parameter for the application but even with selected number of hidden nodes and with selected activation function the result is very much encouraging. This execution time has been represented in above figure 10. Here radbas is faster as compared to tribas, but by considering both timing accuracy tribas is better. Above plot represents the same with a distinguishable difference between different numbers of hidden nodes for tribas activation function. Though there is little difference between 10 and 30 number of hidden nodes. 10 number of hidden nodes chosen considering both accuracy and time. Once the activation function, the number of hidden nodes and the training period duration is fixed for the ELM model as explained above, training and testing data sets corresponding to different markets are given to the model and next hour prices are predicted.





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## CONCLUSION

In the present scenario where competition and globalization is overtaking all fields of life, electricity price forecasting plays a more and more prominent role in a decision support system of power market participants as well as consumers. Developing more accurate and timely price forecasting methods have become an important research topic. ANN technique has been proved as an effective methodology in forecasting of price in electricity market with minimum error. But the randomness of ANN and processing time makes it unusable while dealing with large datasets. In this research work we apply relatively novel neural network technique; we apply ELM powerful technique for electricity price forecasting. The work has been verified in two phases, first phase selects activation function with respect to accuracy and in second phase the timing has been analyzed. And of course to check the robustness of the selected activation function the result has been analyzed for all other activation function. From result there is a close call between tribas and radbas but by considering both parameters processing time and accuracy tribas shows a promising result. The accuracy achieved is 92.506 with 10 numbers of hidden nodes.

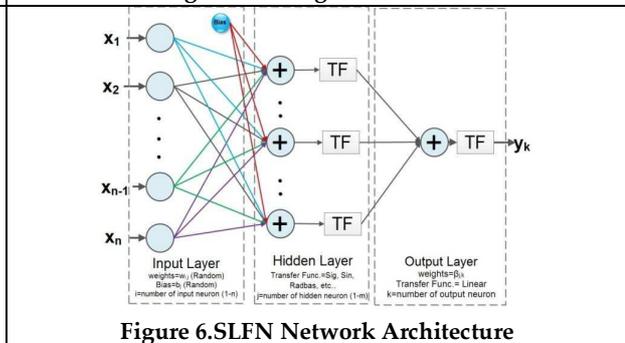
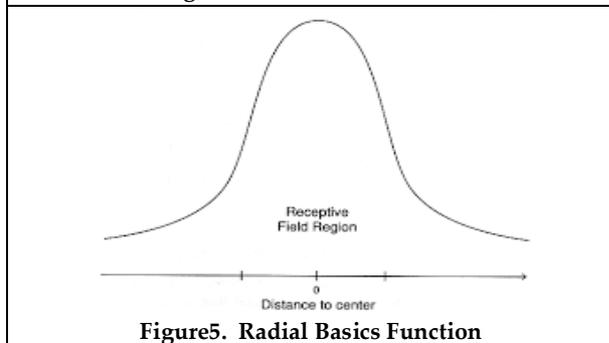
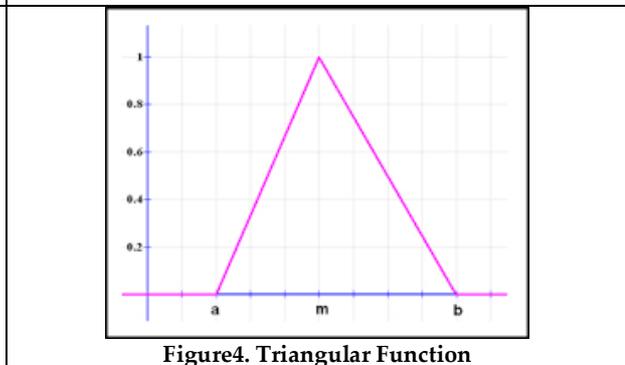
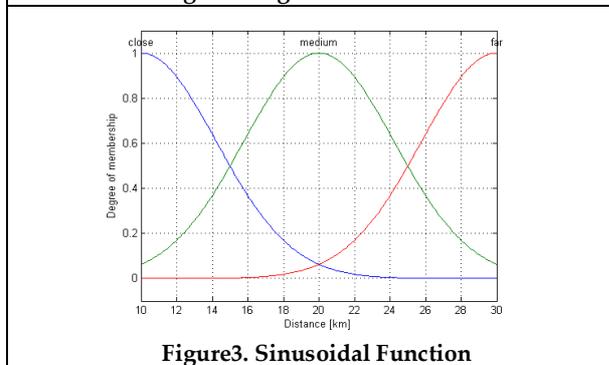
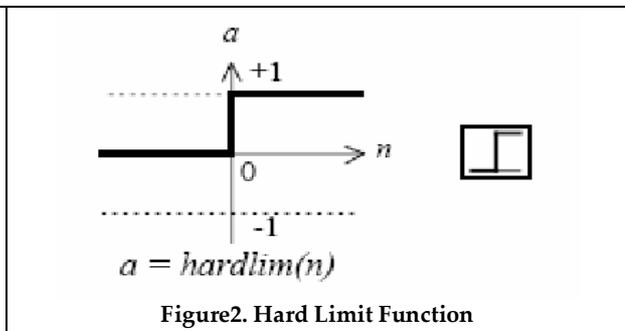
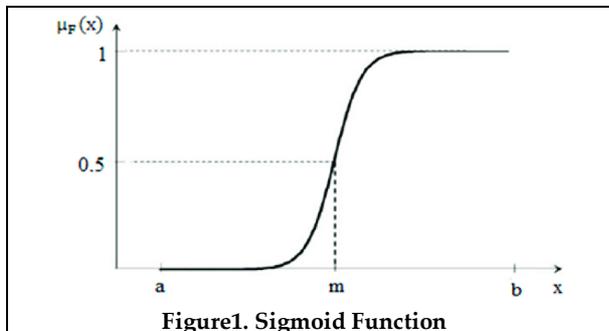
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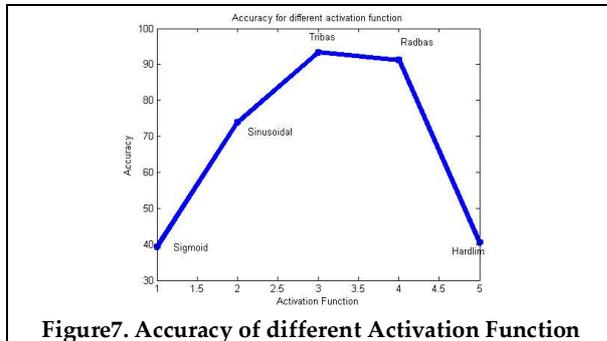


Figure7. Accuracy of different Activation Function

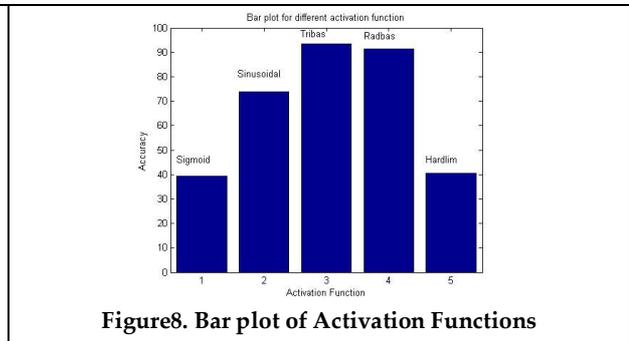


Figure8. Bar plot of Activation Functions

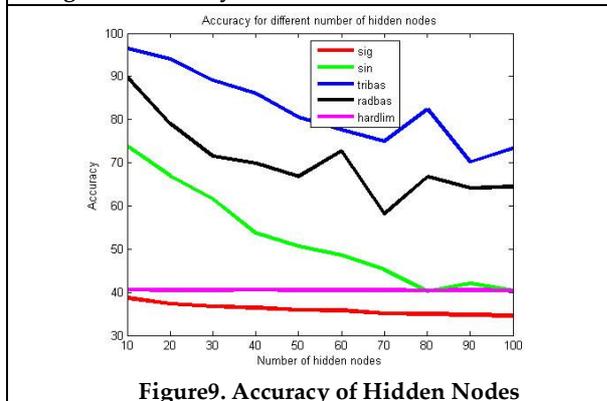


Figure9. Accuracy of Hidden Nodes

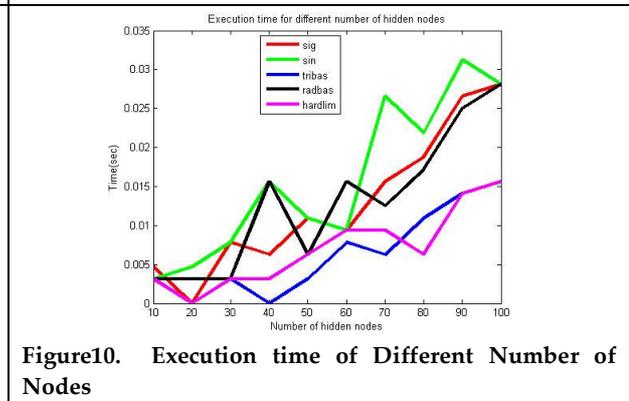


Figure10. Execution time of Different Number of Nodes

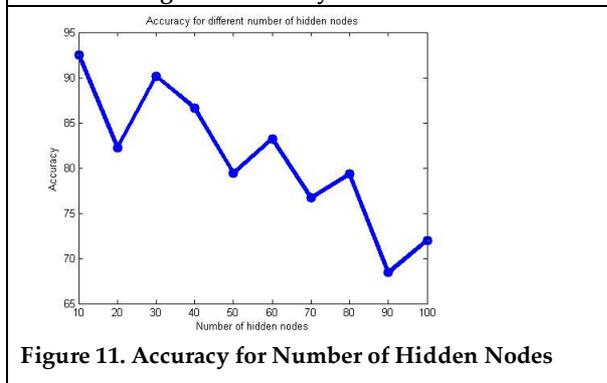


Figure 11. Accuracy for Number of Hidden Nodes

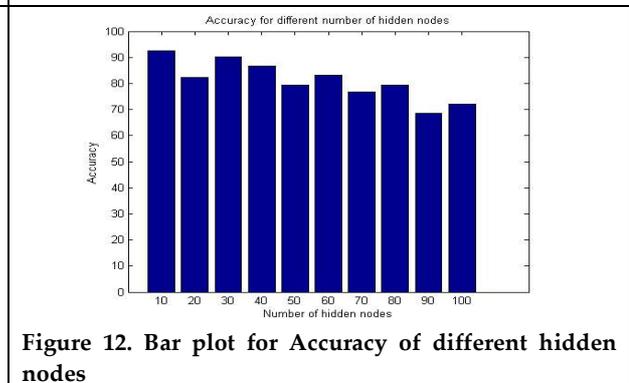


Figure 12. Bar plot for Accuracy of different hidden nodes





## Soil Health Monitoring using Machine Learning Techniques

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### ABSTRACT

Agriculture depends on many factors, soil is one of them. There are innumerable number of components present in the soil, which are important for different types of farming and its total production amount. This paper used a set of well-known Machine learning algorithms to remotely monitor soil and track parameters present in it. The objective of the paper is to determine the important factors that are present in the soil and their amount, which can be used to increase the productivity by choosing the appropriate fertilizers or manure for the particular soil. The proposed system has achieved an overall accuracy of 93% using Support Vector Machine for an underlying dataset containing 92,832 number of soil samples, collected by Karnataka State Government and available in Kaggle repository.

**Keywords:** Machine Learning; Support Vector Machine (SVM)

## INTRODUCTION

India is a country well known for its innumerable Agricultural products and where the majority of the population relies heavily on the agricultural sector. For agriculture, the soil is the basic component that is required. In soil there are many factors like pH, Electrical Conductivity, Organic carbon, Potassium, Phosphorus, Sulphur, Manganese, Zinc, Boron, Copper, and Iron, those have a high on amount and quality of farming. Agriculture land area in India spans around 159.7 million hectares which is the second largest in the world. Its gross irrigated crop area of 82.6 million hectares is the largest in the world. The Indian agricultural industry accounts for 18 per cent of India's Gross Domestic Product (GDP) and generates 50% of the country's workforce with employment. Soil is very essential for every human being and is a valuable resource. [1].



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There are a number of factors behind these soil variations. Soil health is a state of a soil linking the range of ecosystem functions to its environment. The health of soil arises from favourable interactions of all components of the soil that belongs together. Soil health monitoring is carried out as a status assessment but moves to be restricted to agronomic targets, for obvious reasons. Soil health depends on soil biodiversity and can be improved by proper management. Inorganic fertilizers do not necessarily damage soil health if it can be used in an appropriate quantity without excessive use. Soils differ considerably in their chemical and physical properties, depending on their age and the environments in which they are produced (parent material, atmosphere, topography and vegetation) [2]. Because of the climate conditions, the soils vary mainly from region to region. Visually observable data are difficult to decipher at a single glance, leading to many farmers making inaccurate assumptions about the soil [3].

As a result, sometimes it's harmful to the soil. Farmers lack some advice from the expert on how to deal with the soil's fertilizer. There has been insufficient knowledge regarding the deficiency of the parameters [4]. This is an underlying experience for the proposed methodology that aims to accurately detect the deficiency. The methodology suggested in the paper comprises the common deficiency of the parameters in the state of Karnataka and they are Phosphorus, Potassium, Zinc, Boron, Manganese, Iron, and Copper. The dataset used in this project contains 92832 rows, which are the data of different farmers of the different districts in Karnataka. Broadly, the proposed methodology consists of three major steps: data acquisition, pre-processing, and classification. The dataset is acquired by the Karnataka Government. In the next step, normalization of the dataset is required where NaN values were there. After that pre-processed the data including some visualization techniques. After that classification is done by dividing the dataset into correct and deficient one and by using deep learning Support Vector Machine.

Soil health can't be determined by only calculating crop yield, water quality, or any other single test. Soil health cannot be directly measured. Soil health requires knowledge its physical, chemical and biological properties [5]. And in this project, the chemical properties of the soil are included which will be taken by Machine Learning, and by the use of IoT it will take all the physical properties [6]. In this, biological indicators are not that much needed because it's hard to find the indicators from the soil [7]. We can find the biodiversity in the soil in different regions.

We have developed a soil quality index assessment method by taking into account soil texture, organic carbon, pH, water available, cation exchange capacity, bulk density, total porosity, saturated hydraulic conductivity, salinity, aggregate stability, and slope and soil depth [8]. They are Alluvial Soil, Black Soil, Red Soil, and Desert Soil. And basically, in the state of Karnataka, Red Soil and Black Soil is found. So, the soil is deficient in lime, phosphate, manganese, nitrogen, humus, potash, nitrogen, phosphorus, and organic matter. Basically in India, Rice-wheat system covers about 32% of the total rice area and 42% of the total wheat area in the Indo-Gangetic plains (IGP) and accounts for one quarter to one-third of the total rice and wheat production [9].

So, for farming people always busy for six months only. The identification of such components in the soil is very important in preventing any heavy losses in yield as well as the quantity of the agriculture field. Monitoring of the soil manually is a difficult task due to its complex nature and it's a time-consuming process. In addition, a soil rich in organic carbon and nutrients (commonly known as high-quality soils) cannot be considered a good soil if it causes harm to crops or supports large parasite populations [10]. Therefore, to reduce the manual effort this project has been designed. This project is useful in several fields whenever we need to monitor the soil. With that, this project can send a notification to the respective farmers and give some idea on which fertilizers will be the best for their field. Additionally, we could add IoT into it with which it can measure the humidity, moisture, temperature, water of the soil which are some environmental properties of the soil. This Soil Monitoring System based on Machine Learning and IoT can be accessed remotely by using a simple interface.

This paper has been organized into four sections. Section-2 demonstrates the proposed system and its methodology. Section-3 provides an analysis of results. Finally, Section-4 concludes this study.





## METHODOLOGY

The project approaches three important stages:

Data Acquisition, Data pre-processing, and Classification as shown in [Figure-1].

### Data Acquisition

The soil dataset consists of soil samples of different villages in Karnataka. The dataset was downloaded using from Kaggle repository. The acquired dataset consists of around 92832 rows belonging to 4 classes. The dataset includes data of different parameters (chemical properties) which are stored in different columns. This dataset includes 11 number of columns. Each of the data belongs to the different farmers of different districts of the Karnataka state.

### Data Pre-Processing

The acquired dataset consisted of rows with minimal NaN (Not a Number) values and to update the NaN values the average of each column was taken. The data in the dataset were normalized in order to speed up the training process and make the model training computationally. The process of standardizing both input and output variables moves to speed up the training process. We established a specific method for selecting the most representative indicators from the existing large data sets, merging indicators into location-specific indices of soil quality [11]. The improvement of the numerical data of the optimization issue is done through this. To visualize the data, the dataset is grouped by different districts of the state and find out the similarities in the components by which anyone can get those things easily.

### Classification

In this paper the support vector machine (SVM) algorithm is studied in detail. SVM is a common nonlinear technique and a theoretically powerful tool for the classification of all types of datasets [12]. Support Vector Machine (SVM) is a supervised machine learning algorithm that can be applied on classification or regression problems. It's mostly used in classification issues though. They're able to categorize the new class after giving an SVM model sets of named training data for each group. Enter Support Vector Machines (SVM): a simple and efficient classification algorithm with a limited amount of data that performs very well. In each class the closest points are denoted as support vectors. If other points are omitted in the training set the measured judgment boundary remains the same [12]. We extract the necessary functions and segment them into data for training and testing.

Eighty percent of the data is used for training and the remaining 20 percent for testing. The SVM model was constructed using the NumPy library. An  $\alpha$  (0.0001) is the learning rate and is set to 1 / epochs by the regularization parameter  $\lambda$ . Hence the regularizing value reduces the amount of increases in epochs. After classifying the dataset, we get the deficient data from which to apply the proposed model [13]. Various ML techniques like linear regression, Decision tree, Random Forest, and Support Vector Machine (SVM) are used to construct the classifier. Where is a strong complete method for building the model among all of SVM? SVM is used as a classifier in this methodology. It's mostly used in classification issues though. We map each data element in the SVM algorithm as a point in n-dimensional space (where n is the number of features you have) with each feature being the value of a particular coordinate. Then, by finding the hyper plane which differentiates the two classes very well, we perform classification.

## RESULT AND DISCUSSION

To analyze the performance of the defined models based on the input extracted feature set, Overall curacy has been considered and listed in [Table-2].





The best classification accuracy of 93.33% is achieved by the classifier model using SVM that is shown by GREEN color in bar graph [Figure-5]. The other models using Linear Regression and Naïve Bayes are also performing well on the underlying dataset and compared.

## CONCLUSION AND FUTURE WORK

In India, Agricultural sector is one of the most important sector over which majority of the population is relies on. Detection of deficiency in soil is critical for the growth of Indian economy. The proposed system has achieved an overall accuracy of 93% using Support Vector Machine for an underlying dataset containing 92,832 number of soil samples. In future the model can be remodeled to predict and classify soil samples on the basis of image data.

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**Table-1: Dataset Details**

DATASET	INFORMATION
Collected from	Karnataka State Government
Format	csv
Total no. of Rows	92832
Rows for training	74266
Rows for testing	18566





Table-2: Accuracy comparison of different models

	MODEL	ACCURACY (in %)
1.	Support Vector Machine	93.3
2.	Linear Regression	82.2
3.	Naïve Bayes	78.7

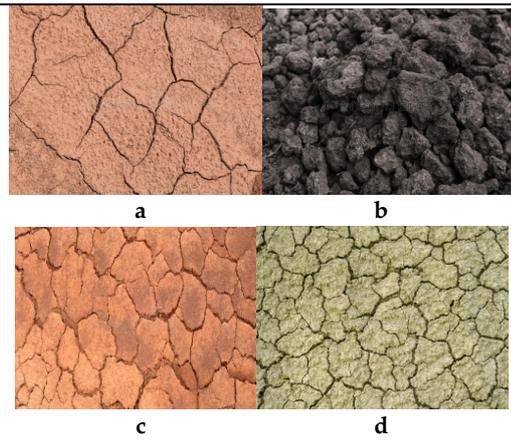
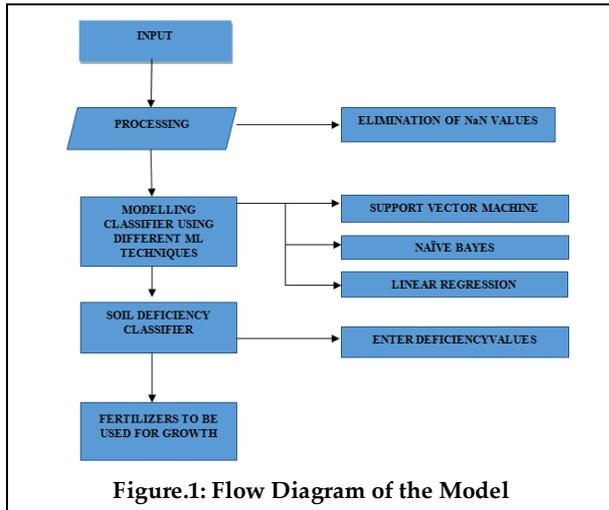


Figure.2: (a) Brown soil; (b) Black soil; (C) Red soil; (d) Alluvial soil;

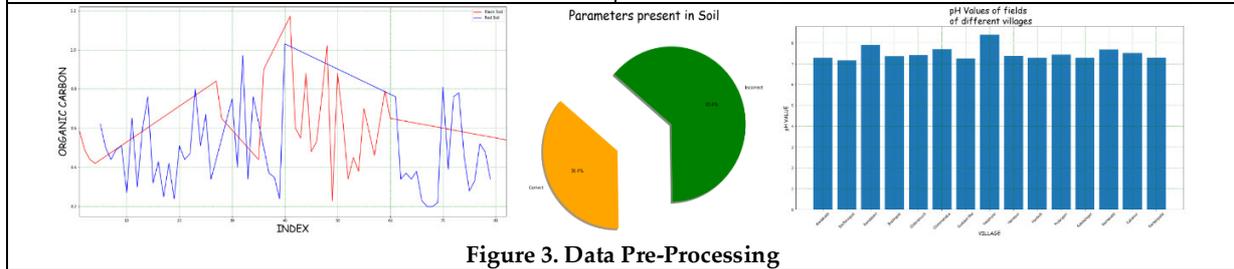


Figure 3. Data Pre-Processing

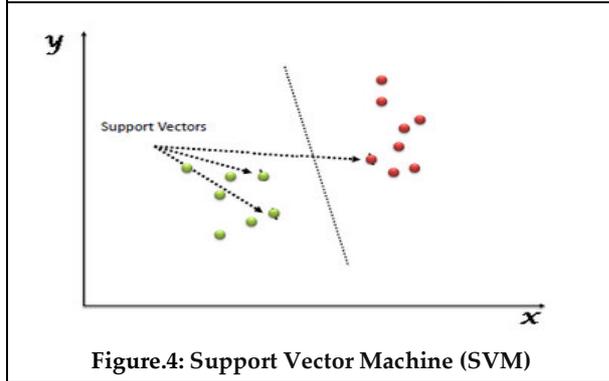


Figure.4: Support Vector Machine (SVM)

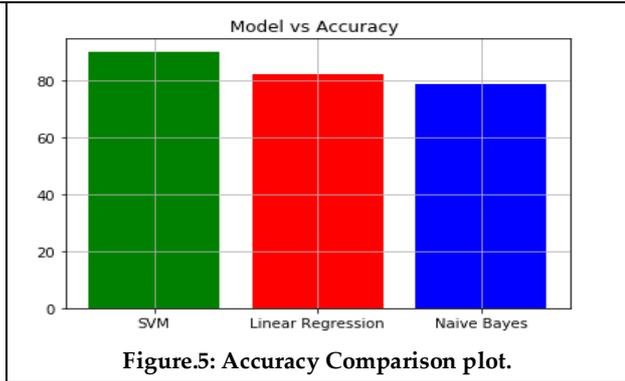


Figure.5: Accuracy Comparison plot.





## Twitter Sentiment Analysis using Computational Intelligence Techniques

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### ABSTRACT

Sentiment Analysis is one of the notable subjects in the discipline of opinion mining which falls under the category of Machine Learning domain where it deals with the recognition and exploration of sentimental texts available on the social media. Likely, Twitter is also one of a kind social platform where it streams millions and millions of tweets from users. The aim of this project is to compare different supervised learning methodologies for binary classifications of unknown live streaming tweets and find out their accuracy rate for correct results. These results will be helpful to conduct the survey on user's tone of the sentiment on various issues by the help of passing a keyword and it conducts search on tweets in relation to the keyword.

**Keywords:** Twitter Sentiment Analysis, Natural Language Processing, Supervised Binary Classification, Positive and Negative Tweets

### INTRODUCTION

The advent of social media such as Facebook, Twitter, Google Plus, etc. has attracted a massive number of active internet users who have found a very innovative, cheap and easy way to get themselves connected with their kith and kin.[9] Communication is not just restricted to personal grounds, people have used social media to start small businesses and reach out to the rest of the world to sell their products. Even firms who are not connected to the outside world through the Internet have found this way of marketing attractive and have extended their frontiers to the digital platform for the purpose of advertising and escalating their sales.





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Social media has gained popularity on political grounds too, where the political parties put forward their propaganda on the social media sites and try to influence the mass through their slogans, promises and records of their past achievements of welfare. So, why are we discussing this? Over the last few years, sentiment analysers have gained huge popularity particularly among marketers, especially operating in the digital world. By analysing the tone of the people over the Internet, we can have a rough idea about the predications of a forthcoming outcome of any major event occurring in our nation or at any part of the world.

This is a very innovative way that substitutes the traditional method of collecting feedback from people that used to be very hectic and biased. But through the Internet, people can raise out their voices fearlessly against any odd, even anonymously if they don't want their identity to be revealed to the general public. Among all, Twitter has become very popular and precise when it comes to analysing the sentiments of the people on trending topics is its exclusive functionality. Retrieving data from social media has fascinated many researchers for working in text analysis. Insights of such work can be found in the works of Sandhu[3], who has proved the same. "Twitter Sentiment Analysis" is a simple implementation of a sentiment analyser which aims to classify the sentiment polarity of a tweet[13]. Our purpose is to fetch live tweets from the Twitter and apply machine learning techniques to predict the polarity of the tone of the people on any particular issue. There is an implementation of one of the Natural Language Processing model, i.e., TF-IDF Vectorizer for text vectorization. This is a very basic implementation and hence we have limited ourselves to predict if a tweet is giving a positive or a negative tone. In the rest of the paper, we have discussed about pre-processing, model building, training & testing, and finding the best result and implementing it on the Twitter data.

#### **RELATED WORK**

There has been a lot of work in this area that are published in the top machine learning platforms that are periodically updated with new functionalities for a better comprehension for the readers. Pang [6], in his work has made use of SVM and Naïve Bayes and concluded that in spite of their simplistic approach, these two algorithms do not work well in sentiment classifications and hence the problem becomes a more challenging task. Kotsiantis [1], has demonstrated all possible supervised learning algorithms, also providing a useful guide to the research work. Kharde [2], has provided insights on the surveys concerning twitter sentiment analysis. Another work, Mathews [4], on opinion mining shows analogy. Scikit-learn[7], helped a lot to understand the algorithms and the codes. The content is updated and easy to understand.

#### **DATASET**

For our work, we have used the Cornell Dataset that contains 1000 positive and 1000 negative tweets on movies. This dataset can be downloaded from the following site: <http://www.cs.cornell.edu/people/pabo/movie-review-data/> which is considered as training set for our model to find out the best supervised learning binary classifier to deploy it on testing set. This has been extensively exclusively for training in projects concerning opinion mining. A reference can be found in the work of Pang [6]. Using Twitter API, tweets fetched from Twitter are testing set used as corpus of text [10] posts for the model deployment for predicting the sentiment of the tweet to check the binary classifier gets the correct result or not which had the higher accuracy score than rest of the classifiers.

#### **PREPROCESSING TECHNIQUES OF DATA**

Data pre-processing is the most vital step followed by data gathering and collection in Machine Learning process. Our dataset includes raw data [12] which needs to be processed first for better analysis of sentiments. This technique is applied on both training and testing set. Therefore the proposed model uses these following techniques for pre-processing like





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### Tokenization

Tokenization is the first step in pre-processing of the raw tweets which involves noise in terms of unwanted fuzzy words, junk characters and symbols and stopwords etc.[12]

There are two types of tokenization. They are:

- Firstly, sentence tokenization that breaks paragraph into sentences.
- Secondly, word tokenization that breaks paragraphs into words.

For example: “Where are you from? I am from India.” When we performed sentence tokenize operation on the paragraph, it yielded: ['Where are you from?', 'I am from India.']. When we performed word tokenize operation on the paragraph, it yielded: ['Where', 'are', 'you', 'from', '?', 'I', 'am', 'from', 'India', '.'].]

### Stopwords

Stop words are also referred to as noise in sentences. These need to be filtered out while performing sentiment analysis because they do not convey any sentiment and should hence be discarded. In the previous example (4.1), when the tokenized text, ['Where', 'are', 'you', 'from', '?', 'I', 'am', 'from', 'India', '.'] is given as input, it compares each word with the built in list of stopwords. Those words that do not match with the existing list of stopwords are appended into another list. The example yields an output, ['Where', '?', 'I', 'India', '.'].]

### Regular Expression

A Regular Expression is a text string that identifies a specific search pattern which is used to match or replace patterns inside a string with minimal code for removal of unwanted characters so as to generate the clean corpus. It comes with some pre-defined methods that help us achieve the task instead of going for loops. Special characters like “\$”, “#”, “%”, etc. can be removed using methods available in re module. Similarly, letters and punctuations that do not convey any meaning can be discarded using regular expression. For example '\s+' matches any whitespace character. The '+' notation on the end suggests a match with one or more spaces. Regular expressions are a relief when we are working on a huge amount of text data by reducing code size.

## METHODOLOGY

### TF-IDF Model

It is a numerical statistic feature extractor model that is intended to detect how important a word is to a document in a collection or corpus. The TF-IDF value is directly proportional to the number of times a word appears in the document intending the frequency of the word in the corpus. A reference to this model can be found in the works of Ramos[5]. This model is one of the many existing vectorizer models in equation (1).

$$\text{TF-IDF Model} = \text{TF} * \text{IDF} \quad (1)$$

Where TF (Term Frequency) = (Number of occurrences of a word in a document)/ (Total number of sentences containing the word)

IDF (Inverse Document Frequency) = log base (Number of sentences)/(Total number of sentences containing the word)

Example:

“Service is good today.”

“Ambience is really nice.”

“Today food is good and salad is nice.”





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Demonstrating the above example on how to find the values for each word using TF-IDF Model to prioritize the words which will help in prediction the sentiment of the texts more than the other words, i.e., less the number of occurrences of words, higher the value. Table 1 evaluates the Term Frequency (TF) of each word of every 3 sentences as shown in example. Table 2 evaluates the Inverse Document Frequency (IDF) of each word same as TF. Table 3 evaluates the product of TF and IDF values taken from the results of above table. Table 4 demonstrates the word values from each sentences and it's clearly noticeable that the words which add meaning to the texts have values to them. These results are useful when it comes to pass the input texts through different classifiers to predict sentiment of the text.

**Logistic Regression classifier**

It is a binary classifier named after the logistic function, also called the sigmoid function which is an S-shaped curve that takes any real number as input and map it into a value in between the range of 0 and 1. Mathematically, this can be expressed in equation (2) as

$$y = 1 / (1 + e^{-x}) \tag{2}$$

where the x-axis represents input data and the y-axis represents the probabilistic output, ranging from 0 to 1, through a continuous set of values.

**Naive Bayes Classifier**

It is also a binary classifier probabilistic machine learning model which predicts the outcomes on the basis of the previous data records and follows the principle of Bayes Theorem. Mathematically, this can be expressed in equation (3) as

$$P(y|X) = \{P(X|y)P(y)\} / P(X) \tag{3}$$

where y represents the class variable given a previous condition. X represents the parameters or features and is a set.  $X = \{x_1, x_2, x_3, \dots, x_n\}$ . For example, if I need to visit a fair, I need to keep in mind some pre-defined conditions as in the weather, availability of a friend and the proximity of the fair from my house. These all conditions can be denoted as  $x_1, x_2$  and  $x_3$ . The probability of visiting the fair,  $P(y|Z)$  depends on these conditions.. A reference on the implementation of this algorithm can be found in Kharde [2].

**K-Nearest Neighbour Classifier**

It is a Machine Learning algorithm that can be used for both regression as well as classification problems. Classification problems, where K-Nearest neighbor is in effect, we go for voting of neighboring values with respect to the value under study. Mathematically, KNN makes use of the Euclidean distance formula for calculating the distance between the value under study and its neighbors. New cluster-head  $C_i$  of each cluster is calculated using following formula in equation (4):

$$C_i = \frac{1}{n_i} \sum_{d_j \in S_i} d_j \quad i = 1, 2, \dots, k \tag{4}$$

where  $d_j$  denotes the data points that belong to the cluster  $S_i$ ;  $n_i$  is the number of documents in cluster  $S_i$

**Decision Tree Classifier**

It a general, predictive modelling tool that is used in non-linear decision making with simple linear decision surface. It is a tree-like graph with nodes representing the place where we choose an attribute and ask a queries. The edges depict response to the queries and the leaves depict the actual outcomes or class label. For example, we need to find out if a person is physically fit, taking ideal criteria into consideration.





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The [Figure-2] demonstrates the working of decision tree classifier as it suggests node represents the chosen attribute like this system projects texts or tweets to receive a response either 1 or 0, i.e, 1 represents positive tone and 0 represents negative tone are the outcomes at the leaves.

### Random Forest Classifier

It consists of a bunch of decision trees. Decision trees are very data sensitive. Hence, small changes in the training set makes dramatic changes in the tree structures, a process known as bagging. The principle this algorithm follows is that a tree is not behaviorally related to any other tree in the model. The chances of making correct prediction increases with an increase in the number of uncorrelated trees. General equation (5) of Random Forest Prediction for a classification problem:

$$f(X) = \text{majority vote of all predicted classes 1 over 0 or 0 over 1} \quad (5)$$

### Support Vector Machine

It is a linear model also for both classification and regression problems. The idea of SVM is simple: The algorithm creates a separator or a hyper-plane which separates the data into classes.

A reference on the implementation of this algorithm can be found in Kharde [2], whose work shows detailed use of SVM in sentiment analysis. The [Figure-2] illustrates support vectors falling on either side of the hyper-plane can be categorized into two classes 1 or -1.

### Passive Aggressive Algorithms

It is an umbrella term for a group of online learning algorithms for both classification and regression suggested by Crammer [8] et al. The objective of this algorithm is to train a model in an incremental manner while modifying the parameters only when needed and discarding the updates that might alter the equilibrium. Contextually, these are very similar to Perceptron. They make use of a regularization parameter(c).

### Perceptron Binary Classifier

It is an algorithm for supervised learning of binary classifiers. The idea of perceptron was inspired from information processing in a neuron. In a perceptron, the input data from the training set is combined and passed through a linear equation, that is, the activation function. Mathematically, this is expressed in equation (6) as activation = sum (weight<sub>i</sub> \* x<sub>i</sub>) + bias (6)

This value is then transformed into a prediction using the transfer function. Mathematically, this is expressed as prediction = 1.0 if activation  $\geq$  0.0 else 0. The [Figure-3] shows that let's suppose every single words are taken as inputs (x<sub>1</sub>, x<sub>2</sub>, x<sub>3</sub>, ..., x<sub>n</sub>) after the pre-processing of dataset and then put into binary classifier that makes prediction depending upon linear predictor function combining a set of weights with the feature vectors (Term Frequency and/or Inverse Document Frequency) and provides output y(1) or y(0).

## TESTS AND RESULTS

The machine learning algorithms were applied on the training set and accuracy was obtained for each case. The model that gave the highest accuracy was dumped in a pickle file for further implementation on the live streaming twitter data.[11]

Table 5 below presents the accuracy percentage of different classifiers in sentiment prediction of training set. Out of which Simple Perceptron for Binary Classification have highest accuracy percentage followed by Logistic Regression Classifier. These accuracy percentage becomes the deciding factor for which classifier to be used for predicting the tone of tweets fetched through Twitter in our proposed system.



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The [Figure-4] illustrates the graphical representations of the accuracy percentage of the models used for analysing the sentiment of the texts in the form of bar charts. The [Figure-5] depicts the graphical representation of count of positive and negative tweets from the set of 1000 tweets fetched from Twitter on any matter.

## CONCLUSION

In this paper, we have applied eight different machine learning algorithms on the Cornell Dataset. We used the TF-IDF (Term Frequency – Inverse Documentation Frequency) vectorizer, a numerical statistic that helped us to find out how important a word is in a corpus. Among all the machine learning algorithms we have implemented, we found that SVM, Logistic Regression and Perceptron give the highest accuracy that is 83%, with very narrow deviations. So, in order to perform a sentiment analysis on the above data, we can choose any one of the algorithms. Twitter Sentiment Analysis is one of the topics that is widely worked upon by computer scientists, researchers, teachers, students and business analysts from all over the world. We have restricted our work to the utmost basic level that can be very well comprehended by people who are new in this field. Here, we have done a binary classification that is grouping the tweets into positive and negative sentiments. Further classifications can include tweets that intend racial or non-racial, sexist or non-sexist, neutral, happiness or sadness.

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**Table 1 TF Values**

WORD	SENTENCE 1	SENTENCE 2	SENTENCE 3
Is	$\frac{1}{4} = 0.25$	$\frac{1}{4} = 0.25$	$\frac{2}{8} = 0.25$
Good	0.25	0	0.125
Nice	0	0.25	0.125
Today	0.25	0	0.125
Service	0.25	0	0

**Table 2 IDF Values**

WORD	IDF
Is	$\log(3/3) = 0$
Good	$\log(3/2) = 0.41$
Nice	$\log(3/2) = 0.41$
Today	$\log(3/2) = 0.41$
Service	$\log(3/1) = 1.09$

**Table 3 Product of TF and IDF values (Table 4)**

SENTENCE	is	Good	nice	today	service
Service is good today.	$0.25*0$	$0.25*0.41$	$0*0.41$	$0.25*0.41$	$0.25*1.09$
Ambience is really nice.	$0*0$	$0*0.41$	$0.25*0.41$	$0*0.41$	$0*1.09$
Today food is good and salad is nice.	$0*0$	$0.125*0.41$	$0.125*0.41$	$0.125*0.41$	$0*1$

**Table 4 Product values for sentiment prediction of sentences.**

SENTENCE	Is	good	nice	today	Service
Service is good today.	0	0.1025	0	0	0.2725
Ambience is really nice.	0	0	0.1025	0.1025	0
Today food is good and salad is nice.	0	0.05125	0.05125	0.05125	0

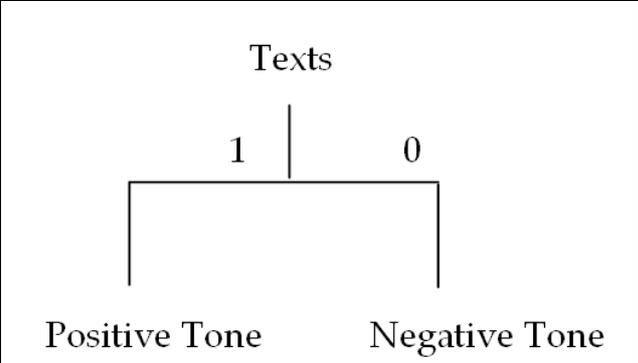
**Table 5 Accuracy Score Table**

Sl. No.	CLASSIFIER	ACCURACY %
1.	Support Vector Machine	83.00
2.	K-Nearest Neighbour	66.75
3.	Logistic Regression	83.25
4.	Naïve Bayes	81.00
5.	Passive Aggression	81.75
6.	Decision Tree	62.25
7.	Random Forest	68.25
8.	Simple Perceptron For Binary Classification	83.50

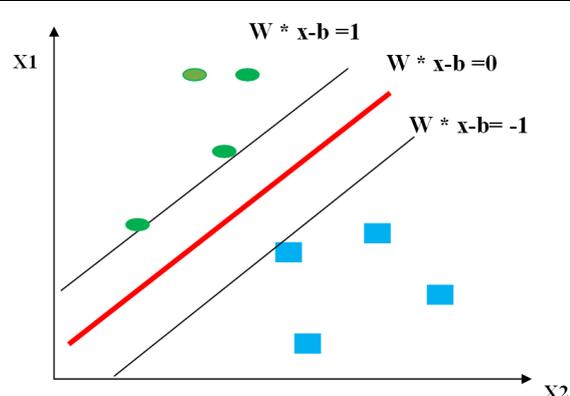




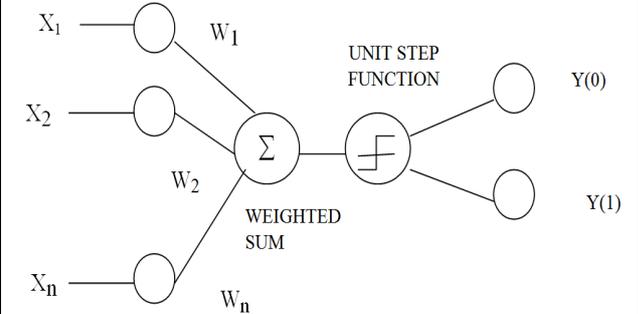
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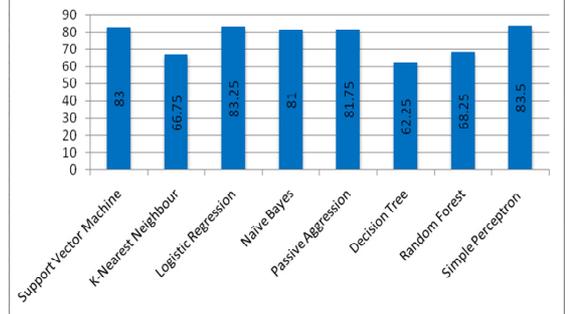
**Fig.1. Decision Tree on texts for predicting the tone of the texts**



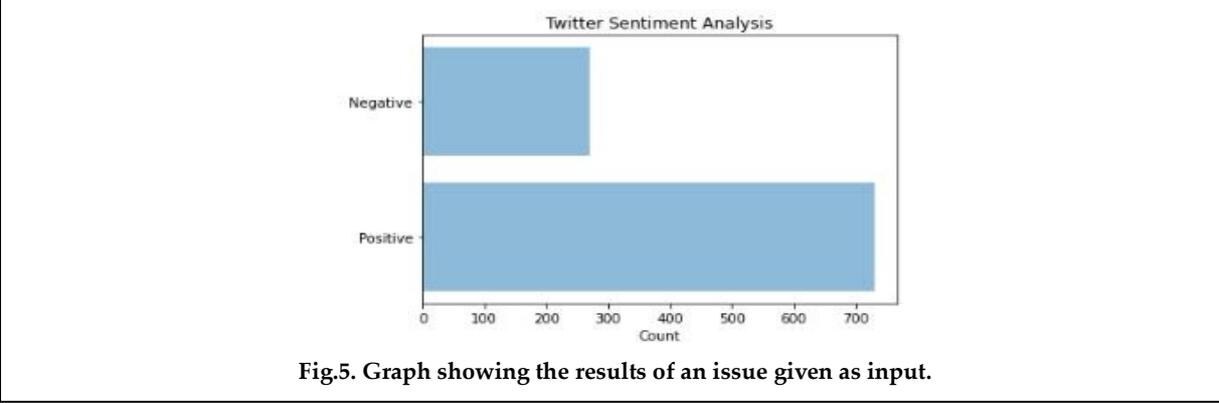
**Fig.2. Support vectors that helps building SVM**



**Fig.3. Single Perceptron for our proposed system**



**Fig.4. Graphical Representation of Accuracies**



**Fig.5. Graph showing the results of an issue given as input.**





## Big Data Analytics: Theory, Applications and Research Challenges

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### ABSTRACT

Our daily life is connected with Data, where enormous data is generated and processed with modern computing techniques. Big data is not about enormous data but it is all about different sources of data in form of volume, Variety, velocity and value of data. Big data applications offer a wide range of business solutions based on business data such as education, health care, Finance, Banking and appropriate for real world data problems. This paper is predominantly focused on big data theoretical knowledge, big data analytics life cycle, applications, trends and research challenges.

**Keywords:** big data security, Smart Farming, Volume, Velocity, Variety.

### INTRODUCTION

In Today's competitive world, Data is the main resource for any business activity. Now day's organizations are facing problem in dealing with huge volumes of data challenges for their better business. Huge volumes data is being generated from different sources like networks, machines, social media, and business processes or business applications. Data is rapidly growing in terms of images, video, social media networks, collected and transmitted data. The most effective problems in traditional databases are not to handle huge data, in which huge data may not fit for current data database storage capacity, so in order to improve huge data storage, data processing and transmission of data from peer to peer communication, for all these problems the cutting-edge clarification is big data analytics. Big data name itself suggest that definition is huge data with limited storage capacity, that means Big data raises to immense and enormous data sets that may be in structured or unstructured format. Big data evolution starts in 21<sup>st</sup> century and every technology is making use of big data technologies. According to Gartner: Big data is huge-volume, fast-velocity and different-variety information assets that demand innovative platform for enhanced insights and decision making. The Big Data analytics is indeed a revolution in the field of Information Technology. The use of Data analytics by the companies is enhancing every year [1]. The best examples for big data is internet applications, Mobile internet, Google data, Facebook data, twitter data, movie reviews, product reviews etc. Big data structure defined in three ways: structured, unstructured and semi-structured data. Structured data defined as data is processed, stored and accessed in a fixed format. It follows a well-structured model and consistency, Ex: JSON, XML, CSV, TSV, and email. Unstructured data is defined by means of the collected data is not in consistent

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order or it may not follow the standard data models, Web applications data like transaction history files, blogs are considered as examples of unstructured data. Finally semi-structured data, in which data may be in either structured data format or unstructured dataformat.

**Big Data Analytics Life Cycle**

Big Data Analytics (BDA) analysis process stays different from traditional analysis process because of its faces such as volume, variety, veracity, velocity and Value. In order to address requirements of the huge volumes of data analysis through BDA, a step- by-step procedure is required.

Big data analytics life cycle process is alienated into the following nine phases

1. Business CaseAssessment
2. Data Identification
3. Data Acquisition &Filtering
4. Data Extraction
5. Data Validation & Cleaning
6. Data Aggregation & Representation
7. Data Analysis
8. Data Visualization
9. Exploitation of AnalysisResults

**Business CaseAssessment**

Big data analytics life cycle starts with a well-structured business data for clear understanding, motivation and proper justification of analysis. In this stage business data will be created, accessed and approved for further data processing of BDA. Business case evaluation determined the business requirements like it helps to decision makers to understand business needs, it also helps to determine business assessment criteria. This is a first stage in which all the business requirements are well documented. The outcome of this stage is provides all budget matters in which it specifies about purchase of implements, hardware and exercise must be in advance.

**Data Identification**

In This stage, identifying a variety of data resources based on business development and nature of the business determination. The mandatory data sets may be collected either internal or external. In case of internal, data sets collected from internal resources, and this data is compiled and well-defined. In case of external, data sets collected from third party dataproviders.

**Data Acquisition & Filtering**

In prior stage, data is identified in various resources and identified in different formats. Once data is identified then data may be collected based on requirements, at this stage, collected data is filtered by removing error data or missing values in order to make sure that data is used to fulfill analysis objectives. Filtering applied on both internal data sets and external data sets, through this process data may be filtered based on the needs of analysis process.

**Data Extraction**

Whatever data sets are acquired as input for big data solution, that data might be not well-suitedthrough the actual requirement of big data result, data extraction stage remains focused on extracting distinct data and transforming data into suitable data for big data result then it can be used for analyticdetermination.

**Data Validation & Cleaning**

In big data solution data can be unstructured data or may be redundant data. When this data is considered for big data data analysis then invalid data can produce falsify data. So it is very much required the removing of redundant and invalid data from the given input. Data validation and cleaning is dedicated to validate data and removing invalid data.





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### Data Aggregation & Representation

Data collected for big data solution may be distributed across multiple data sets. Data aggregation and representation is focused on distributed data is represented group data through its common fields.

### Data Analysis

This stage carry out the data analytics task, in which the required data is analyzed depending on type of data set, Data analysis is an iterative process in which data is analysed until the proper data pattern covered. Data analysis can be two way process such as confirmatory analysis or exploratory analysis.

### Data Visualization

Data analysis stage provides clear insights of data as per the required pattern. But still it may not understand the data for business users. In order to elucidate the data analysis results, the results must remain representing in graphical representation with the data analysis outcome data. Data visualization is a visualize tool in which data can be represented in form of graphical representation like charts, graphs and plot for a better interpretation of business users.

### Exploitation of Analysis Results

This is the last stage of big data analytics life cycle, in which data analysis results used for decision making and further developments.

### Big Data Trends & Research Challenges

#### Big data Security

Big Data security provides strong protection for the deployed data where the big data is restricted to access by unauthorized persons. The main emphasis of big data security is unofficial users and interventions with firewalls, strong user authentication, end-user training, and intrusion protection systems (IPS) and intrusion detection systems (IDS). The following are identified as Data Security challenges [2]

- Vulnerability to fake data generation
- Potential presence of untrusted mappers
- Troubles of cryptographic protection
- Possibility of sensitive information mining
- Struggles of granular access control
- Data provenance difficulties
- High speed of NoSQL databases' evolution and lack of security focus
- Absent security audits
- Securing and protecting data in real-time

### Big data Analytics in the Cloud

In Current computing world, big data and cloud computing are center concern of IT. Both are available with own services for better business solution. Big data is deals with huge data in form of structured, unstructured and semi structured, cloud computing deals with services and infrastructure. Cloud computing provides on demand services with pay and use mode. Big data in cloud providing new business opportunities and supporting big data analysis

### Data Storage

Several solutions were proposed to store and retrieve large amounts of data demanded by Big Data, some of which are currently used in Clouds. Internet-scale file systems such as the Google File System (GFS) attempt to provide the robustness, scalability, and reliability that certain Internet services need [4]. Other solutions provide object-store capabilities where files can be replicated across multiple geographical sites to improve redundancy, scalability, and data availability. Example includes Amazon Simple Storage Service (S3), Nirvanix Cloud Storage, Open Stack Swift and Windows Azure Binary Large Object (Blob) storage. Although these solutions provide the scalability and

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redundancy that many Cloud applications require, they sometimes do not meet the concurrency and performance needs of certain analytics applications [5].

Big data security is the combined term for all the measures and tools used to safeguard both the data and analytics processes from attacks, theft, or other malicious activities that could harm or negatively affect them. Cloud computing involves Peer-to-peer network with decentralized network design on liberated nodes without any central control. When data is decentralized and distributed among different nodes, data may be exposed to other problems like security and privacy. Sensitive information in the perspective of cloud computing incorporates data from a wide range of different nodes and disciplines. Security and privacy remains one of the critical concerns of big data in cloud computing. Ensuring data security and protecting privacy has become extremely difficult as information is spread and replicated around the globe [6]. The major security challenges are data breach [10] and Multi-tenancy [9].

#### Big Data in Smart Farming

Smart Farming is an evolving growth that accentuates the use of modern technologies like IoT and Cloud technology for better productivity and optimized man power in farm management. Farming through technology, which requires huge value of data with wide variability of data that can be bagged, and analyzed for better result making. When this process starts with huge data then big data plays major role for storing, analyzing used for further process of farm management. Big data application in smart farming is mainly focused on social and economic challenges to be identified. Big data technologies are live an essential, common role in this development [7]. Life cycle process of Smart farming using Big data- access include the following steps; 1) Smart sensing and monitoring- to identify soil, water, light, humidity and temperature, 2) Smart control- mainly focused on data generation, data capture, data analysis, data processing and data transfer, 3) Smart analysis and planning- main role is to identify soil type, yield prediction, soil health and crop health. 4) Data storage- cloud based, hybrid data Storage, cloud-based warehouse. Big data in Smart farming [7]; the following key challenges are identified as big data applications in smart farming.

- Boosting productivity and innovation Managing environmental challenges
- Better supply chain management
- Cost savings and business opportunities

## CONCLUSIONS

Big Data has become important for both public and private organizations to manage their data, data processing in order to solve domain specific public and private problems. I understood and believe the importance of big data, based on that, I have present some important and relevant topics of big data and also described the role of Big data in different emerging fields like cloud computing, data security, smart farming. In my future work may be based on the above said challenges of big data.

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**Table-1 5Vs of big data**

Characteristics	Definition	Example
Volume	Volume refers the huge amount of data, refers the size of ever increasing data of the computation world	Data is being generated in every second through internet applications or social media, for example Google generated data Gmail data, Google search engine data, YouTube data. Facebook data, Instagram data, WhatsApp data
Velocity	Velocity measures how fast data is produced, processed and modified. It refers high speed of growth of data	72 hours of video are uploaded to YouTube every minute[8]
Variety	Variety refers the type and nature of data, that means data available from various sources in various formats	Structured, unstructured and semi structured data
Veracity	Veracity signifies the quality then validity of the data files collected. It is basically the degree of credibility and reliability of collected data.	High speed Data processing in various computing applications
Value	It is not about the huge data collected, but it is all about amount of valuable, reliable and genuine data collected.	

**Table-2: Big data Applications**

Sl.NO.	Big Data Applications	Examples
1	Health Care	Clinical decision Support, Disease Pattern Analysis Electronic Health cards , Mobilized health record Disease Register data , Disease risk prevention Drug discovery development analysis
2	Telecommunication	Customer Call Record , Mobile user tracking Network analysis, Revenue analysis
3	Transportation Industry	Direction planning, traffic management road infrastructure
4	Financial &Investment Sectors	Mismanagement of credit/debit cards, User segmentation, Improves Cyber security, Efficient risk management, Trade surveillance
5	Government Sector	Welfare Schemes Cyber Security
6	Media	Predicting the interests of audiences sentiment analysis





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		of customer reviews, on-demand scheduling of media streams in digital media distribution platforms
7	Education	Customize Programs, Reduce dropouts, Improve Learning Possibilities, Grading Systems Career Prediction

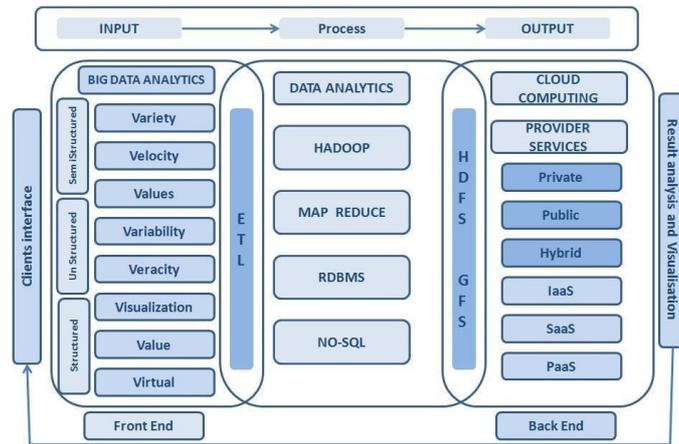


Figure.1 Big Data and Cloud Computing Relationship Model Source [3]





## Implementation of Segmentation Techniques based on Medical Image

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### ABSTRACT

Medical Image plays an important role in medical field. In this context, this paper is predominantly focused on applying image segmentation techniques on medical image. Image segmentation is one of the basic requirements of image processing. Its objective is to determine a partition of an image into a finite number of semantically important regions. Image segmentation process aims to divide an image into various regions for better image processing, usually used in patter recognition. In this paper deafened different medical image modalities, also define segmentation techniques and its implementation based on a medical image.

**Keywords:** Segmentation, image modalities, threshold, edge based, clustering based.

### INTRODUCTION

The Key role of Medical images has worthy effect on medicine, diagnosis, and treatment. Medical imaging is the technique of producing visual representations of areas inside the human body to diagnose medical problems and monitor treatment. It has had a huge impact on public health. Medical imaging is performed in various modalities such as CT (Computer Tomography), MRI (Magnetic Resonance Imaging), Ultrasound, X-ray, ultrasound and positron emission tomography (PET), etc. The most important part of image processing is image segmentation. The increased availability and usage of modern medical imaging induced a strong need for automatic medical image segmentation. The aim of semantic segmentation is to identify common features in an input image by learning and then labelling each pixel in an image with a class (e.g. background, kidney or tumour) [1].

The most important part of medical image processing is image segmentation. Image segmentation is a procedure for extracting the region of interest (ROI) through an automatic or semi-automatic process. Many image segmentation methods have been used in medical applications to segment tissues and body organs [2]. Based on the recent studies or research, image segmentation widely used in medical image analysis in order to segment body organs, Automatic Liver Segmentation [3], Automatic Brain Tissue Segmentation [4], Automatic Tissue Image Segmentation





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[5]. Segmentation is a process of partition an image into different regions containing each region with same attributes. To be meaningful and useful for image analysis and interpretation, the regions should strongly relate to depicted objects or features of interest. Meaningful segmentation is the first step from low-level image processing transforming a greyscale or colour image into one or more other images to high-level image description in terms of features, objects, and scenes. The success of image analysis depends on reliability of segmentation, but an accurate partitioning of an image is generally a very challenging problem. The Basic

### principles for Segmentation

1. All pixels have to be assigned to regions.
2. Each pixel has to belong to a single region only.
3. Each region is a connected set of pixels.
4. Each region has to be uniform with respect to a given predicate.
5. Any merged pair of adjacent regions has to be non-uniform.

### The main contributions of this paper is as follows

1. Defining different Image modalities
2. Discussed related work of image segmentation
3. Define and implements segmentation techniques.

### Image Modalities: MRI, CT, US

The imaging modalities used in biology and medicine are based on a variety of energy sources, including light, electrons, lasers, X-rays, radionuclides, ultrasound and nuclear magnetic resonance image [13]. Common Image Modalities includes CT (Computer Tomography), MRI (Magnetic Resonance Imaging), Ultrasound, X-ray. These modalities are very useful for patient follow-up, with regards to the progress of the disease state, which has already been diagnosed, and/or is undergoing a treatment plan [ref-1:16]. CT scans are a form of X-ray that creates a 3D picture for diagnosis. CT scans provide greater clarity than conventional X-rays with more detailed images of the internal organs, bones, soft tissue and blood vessels within the body [17].

CT scan combines a series of x-ray images taken from many different angles and computer processing to create cross-sectional images of the bones and soft tissues inside a body. The resulting image can be compared to a slice of bread. Each slice can be viewed individually from the whole "loaf" to get a better visualization of the body. CT scan images can provide much more information than plain X-rays [18]. MRI, Commonly used to examine internal body structures to diagnose strokes, tumours, spinal cord injuries, aneurysms and brain function. MR imaging of the body is performed to evaluate: [19]

- Organs of the chest and abdomen—including the heart, liver, biliary tract, kidneys, spleen, bowel, pancreas, and adrenal glands.
- pelvic organs including the bladder and the reproductive organs such as the uterus and ovaries in females and the prostate gland in males.
- blood vessels (including MR Angiography).
- lymph nodes.

**Ultrasound imaging (sonography)** uses high-frequency sound waves to view inside the body. Because ultrasound images are captured in real-time, they can also show movement of the body's internal organs as well as blood flowing through the blood vessels [20].

### Related Work

This section mainly focuses on different applications of segmentation on medical imaging. Medical imaging is one of the emerging research areas for decades, in past years there will be enough research already in progressed. One of the basic problems in medical imaging is to precisely segment structures of interest from a huge dataset, accurately

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represent them, efficiently visualize them, and perform measurements appropriate for diagnosis, surgery, and therapy guidance, or other applications [6],[7].LixuGu, *et al.* Propose a novel multistage method for three-dimensional (3-D) segmentation of medical images and a new radial distance-based segmentation validation approach. This approach is tested on 12 CT and 3 MRI images of the brain, heart, and kidney, to demonstrate the effectiveness and accuracy of this technique across a variety of imaging modalities and organ systems [8]. Automatic medical image segmentation is challenging task in which it extracts highly variable objects form images where image is low quality, lack of contrast, missing data in image to be segmented and difficult to determined edge and boundary of image. Olivier Ecabert et al. focused on Automatic Model-Based Segmentation for Heart CT images and using automatic image processing methods, where these methods are a prerequisite to efficiently analyze the large amount of image data produced by computed tomography (CT) scanners during cardiac exams [9]. Jing Wang et al. discussed texture-based segmentation to extracting descriptive characteristics of real world scenes based on image textures[10]. Watershed segmentation an image is regarded as a topographic landscape with ridges and valleys. The elevation values of the landscape are typically defined by the gray values of the respective pixels or their gradient magnitude [11],[12] Proposes a fast watershed segmentation algorithm which overcomes the heavy burden on computation and time consuming, but can't solve the problem of over-segmentation.[13] Proposes a neural network based supervised segmentation algorithm for retinal vessel delineation.

**Implementation of segmentation Techniques**

This section focused on implementation of segmentation techniques and image processing concepts based on a medical image using python libraries. The following figure describes different techniques followed by implementation. In order to implement the above techniques, the following are steps followed such as medical image collection and loading image using python programming. The following techniques are implemented based on the above said image using different python packages.

**Thresholding** Image thresholding is a simple form of image segmentation. Image thresholding is a simple and effective, way of partitioning an image into a foreground and background. Itsplits an image into a foreground pixels and background pixels. If pixel value is greater than a threshold value, it is assigned one value (may be white), else it is assigned another value (may be black). The function used is **cv2.threshold** in python programming to perform image thresholding.Thresholding converts grayscale images into binary images or distinguishes the lighter and darker pixels of a color image.

**K-means clustering.** In k-means clustering, it partitions a collection of data into a k number group of data an algorithm identifies groups in the data, with the variable K representing the number of groups. The algorithm assigns each data point (or pixel) to one of the groups based on feature similarity. Rather than analysing predefined groups, clustering works iteratively to organically form groups. Histogram-based image segmentationuses a histogram to group pixels based on “gray levels”. Simple images consist of an object and a background. The background is usually one gray level and is the larger entity. Thus, a large peak represents the background gray level in the histogram. A smaller peak represents the object, which is another gray level.

**Edge detection**

identifies sharp changes or discontinuities in brightness. Edge detection usually involves arranging points of discontinuity into curved line segments, or edges. For example, the border between a block of red and a block of blue.

**Image Gradients**

An image gradient is a directional change in the intensity or color in an image. The gradient of the image is one of the fundamental building blocks in image processing.The gradient of an image measures how it is changing. It provides two pieces of information. The magnitude of the gradient tells us how quickly the image is changing, while the





direction of the gradient tells us the direction in which the image is changing most rapidly. In Python Program used the following three functions `cv2.Sobel()`, `cv2.Scharr()`, `cv2.Laplacian()`.

### Smoothing Images

Image smoothing is used to reduce noise within an image or to produce a less pixelated image. Most smoothing methods are based on low pass filters. Smoothing is also usually based on a single value representing the image, such as the average value of the image or the middle (median) value.

### Gaussian and Median Filtering

Averaging is process of convolving the image with a normalized box filter. It simply takes the average of all the pixels under kernel area and replaces the central element with this average. This is done by the function `cv2.blur()` or `cv2.boxFilter()`. In Gaussian instead of a box filter consisting of equal filter coefficients, a Gaussian kernel is used. It is done with the function, `cv2.GaussianBlur()`. In Median Filtering the function `cv2.medianBlur()` computes the median of all the pixels under the kernel window and the central pixel is replaced with this median value.

### Image Segmentation Using Watershed Approach

Watershed transformation also called, as watershed method is a powerful mathematical morphological tool for the image segmentation. The watershed transformation is a powerful tool for image segmentation. It is a hybrid technique because it is the result of threshold based, edge and region based techniques using morphological watershed transform. The watershed transformation is popular image segmentation technique for gray scale images [14]. Computation complexity is one of the important criteria for image segmentation which should be considered carefully when real time image segmentation is required.

Watershed based image segmentation algorithms are less computational complex and provide very good segmentation results. If image is viewed as geological landscape, the watershed line determines boundaries which separate image regions. The watershed transform computes catchment basins and ridgelines (also known as watershed lines), where catchment basins corresponding to image regions and ridgelines relating to region boundaries [15]. The watershed based image segmentation produces mostly an over-segmentation of the image. Pre-processing and post-processing of an image is performed to overcome this problem. Pre-processing is mainly applied to the image before the watershed segmentation. The following steps are involved in pre-processing.

Input Image → Median Filter → Morphological Gradient → Thresholding → Output Image

## CONCLUSIONS

In this paper, I have discussed about image segmentation along with its techniques and also implemented those techniques using python programming. In order to implement segmentation techniques, I have taken one medical image for segmentation purpose and applied all segmentation techniques based on medical image.

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19. <https://www.radiologyinfo.org/en/info.cfm?pg=bodymr>
20. <https://www.fda.gov/radiation-emitting-products/medical-imaging/ultrasound-imaging>

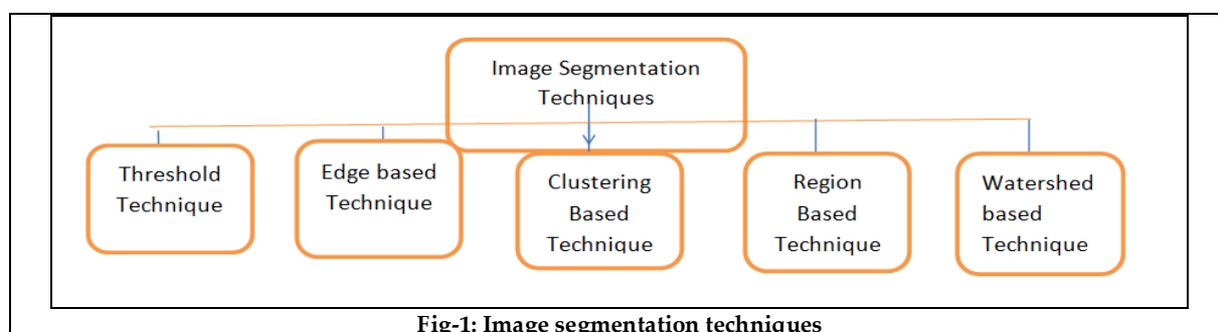


Fig-1: Image segmentation techniques



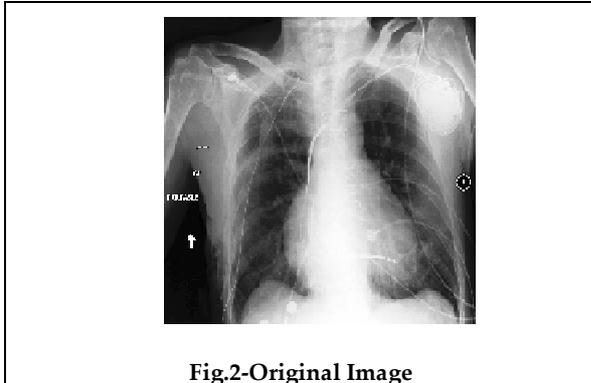


Fig.2-Original Image

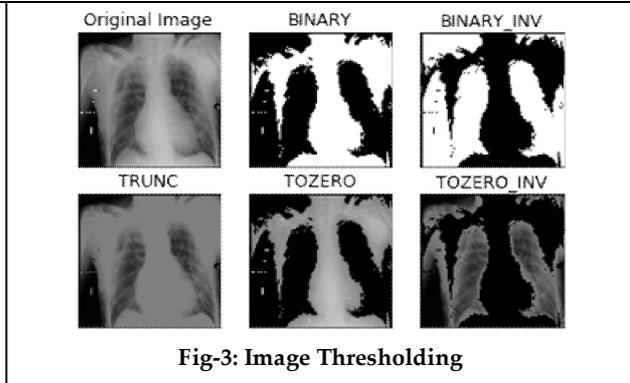


Fig-3: Image Thresholding

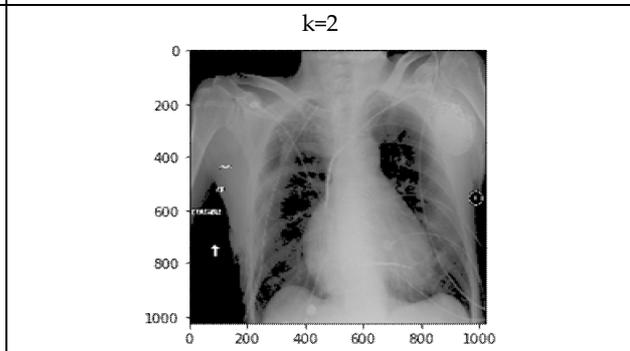
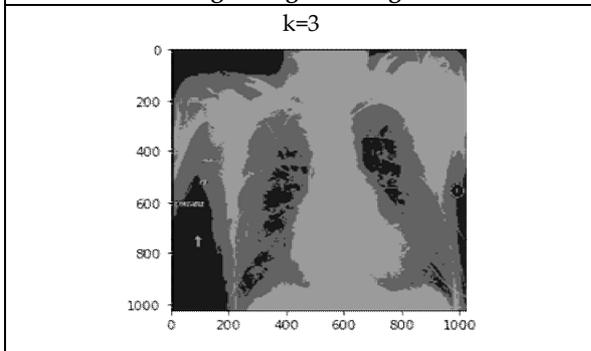


Fig-4: K-means clustering

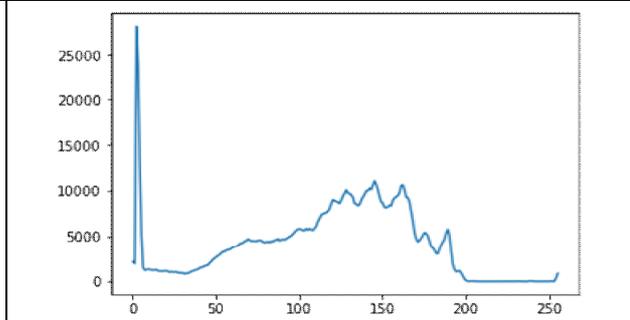
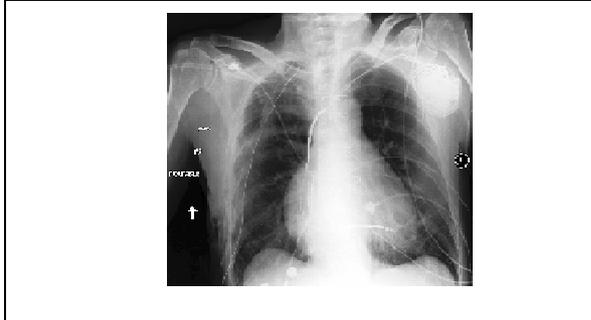


Fig-5: Image Histogram

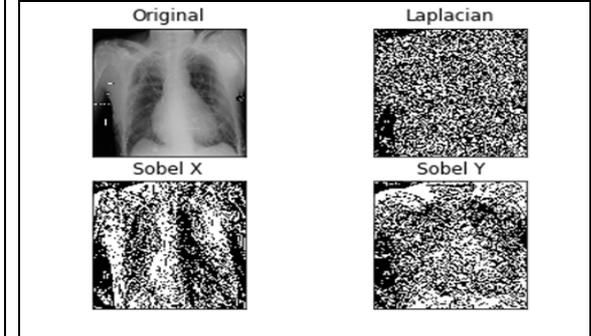


Fig-6: Image Gradients

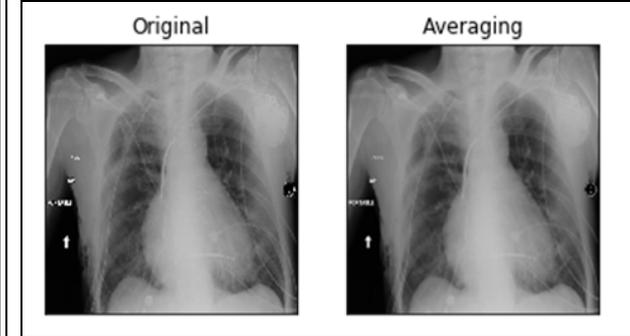


Fig-7: Smoothing Image



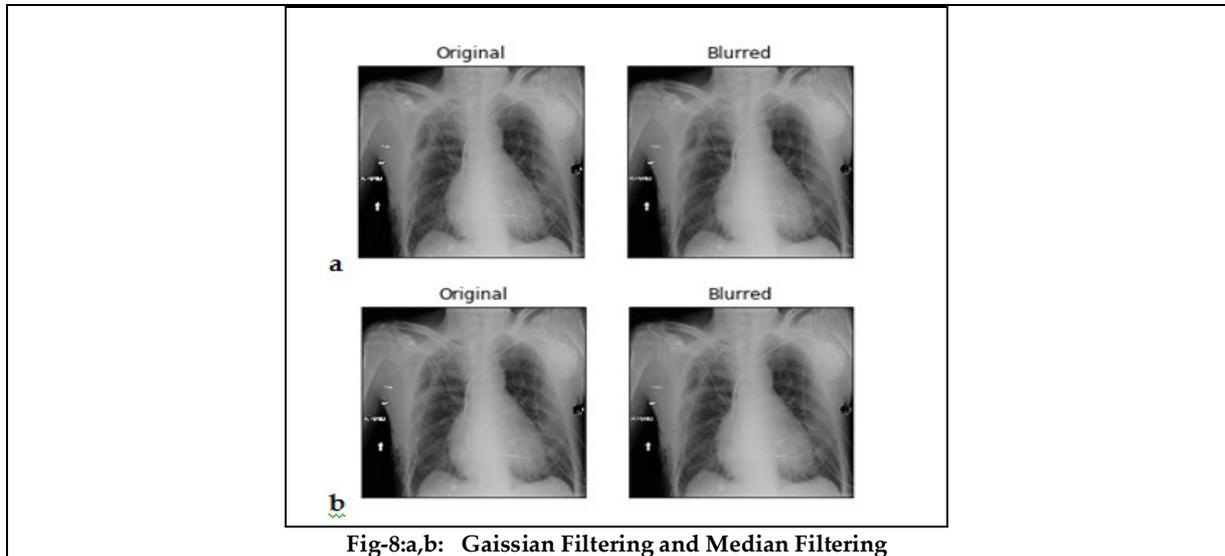


Fig-8:a,b: Gaussian Filtering and Median Filtering





## Implementation of Machine Learning Approach to predict Heart Disease

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### ABSTRACT

The main objective of present paper is to determine the impact of machine learning in medical diagnostic. Medical diagnostics are a kind of medical investigations designed to identify infections, conditions and diseases. In health care field, Medical Diagnostic is a process of collecting samples from patients to detect patient's health condition and diseases. Medical diagnostic provides technical health records to detect the disease and also identify the primary information of a patient. This paper aims to implement machine learning approaches to predict Heart disease, and also afford performance analysis based on accuracy.

**Keywords:** Machine learning, heart disease, KNN, Decision tree, Linear Kernel, Support Vector

## INTRODUCTION

According to WHO statistics, every year 17 millions people died of heart disease, one third of disease death are heart disease death. According to survey, heart disease is the leading cause of death in the world every year. Heart disease, which is usually called coronary artery disease (CAD), is a broad term that can refer to any Condition that affects the heart [1]. Heart disease is any illness that disturbs the structure or function of the heart. There are different types of heart diseases, such as Coronary artery and vascular disease, heart rhythm disorders (arrhythmias), Structural heart disease. Coronary artery and vascular disease occurs like heart attack, chest pain. Heart rhythm disorders cause the heart to beat too slowly, too quickly or in a disorganised fashion [20]. Structural heart disease refers to abnormalities of the heart's structure including its valves, walls, muscles or blood vessels near the heart [20]. In order to ensure the better cure results from treatment, it is very clear that the diagnosis electronic records plays major role. In this process, machine learning consider for medical filed, and also applied for reasons in medical filed, such as disease diagnosis, medical image analysis etc. Machine learning is one of the technology trendsetters in computing world, and also proved that machine learning used for decades in different research. Machine learning is an application of artificial intelligence (AI) that delivers classifications the ability to mechanically learn and improve from experience without being explicitly programmed [21]. Machine learning emphasizes on the advance of computer programs that can acquire data and used it learn for themselves through algorithms [21]. In Machine learning the learning process initiates with observations or data, such as examples, direct experience, or instruction, in order to look for patterns in data and make better decisions in the future based on the examples. The main objective is to allow the computers

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learn mechanically deprived of human intervention or support and modify actions therefore. Machine learning is purely creating healthcare smarter. Machine learning has proved really life-impacting prospective in healthcare, predominantly in the area of medical diagnosis. There are numerous difficulties deterring faster integration of machine learning in healthcare today. One of the biggest challenges is the ability to acquire patient data sets which have the essential size and quality of samples needed to train state-of-the-art machine learning models.

### ROLE OF MACHINE LEARNING IN HEART DISEASE DIAGNOSIS

This section presents existing research work of Heart Disease Diagnosis through Machine learning approach. Shashikant Ghumbre et al[2], projected a Decision Support System for the diagnosis of Heart disease by means of radial basis function network structure and Support Vector Machine and concluded that SVM with Sequential minimize optimization is equivalently good as the Radial basis function network in the diagnosis of Heart disease.

Haiyan Yang et al[3] focused on the application of support vector machine (SVM) approach based on the statistics-learning theory of structural risk minimization in heart disease diagnosis and also experimented with chaotic PSO's support vector machine algorithm for the diagnosis of heart disease in the sample data set on the basis of feature selection. My Chau Tu et al[4] proposed Bagging Approach to identify the warning signs of heart disease in patients and also to compare the effectiveness of the bagging algorithm with the decision tree algorithm and results shows that bagging algorithm has better performance and accuracy than the decision tree that is often used in medical data mining.

Proposed [5] SVM based on hybrid kernel function and apply the model to test the heart disease dataset and also used properties of kernel function is analysed, and the linear combinations of different kernels are to construct hybrid kernel function. In the process of the establishing model, PSO algorithm is used to optimize the parameters which are concerned, and classifier model of SVM recognize the heart disease data. Implemented [6] Extreme Learning Machine (ELM) and compared results with backpropagation ANN, Support Vector Machine (SVM), and decision tree and results stated that ELM model has potentially implemented to help medical professional diagnosing heart disease. Developed [7] effective alternating decision tree approach for early diagnosis of heart disease and also used Alternating decision trees are new representation for classification rule which are easy to implement, robust and interpretable, finally results stated that proposed approach achieved an accuracy of 91.66%. Described [8] an Health Decision Support System (HDSS) that combines Wearable Medical Sensors (WMSs) and Computer-based clinical decision support systems (CDSSs).

It incorporates a hierarchical and closed-loop multi-tier structure supported by robust machine learning ensembles. Proposed [9] model consists of two classification stages, three techniques composed of Support Vector Machine (SVM), K-Nearest Neighbor (KNN) method and Naïve Bayes approach are applied to combine into a mixture model based on multi-layer perceptron and back-propagation learning algorithm for solving heart disease problem. Used [10] the Least Squares Twin-Support Vector Machine, which unlike ordinary support vector machine, is based on a Non-parallel margin, investigated and compared several approaches such as: neural networks, SVM, Decision tree, and some improved SVMs in the accuracy for ECG Arrhythmia classification. Focused [11] on developing a fast and accurate automatic ischemic heart disease detection/localization methodology.

Methods: T wave was segmented from averaged Magnetocardiography (MCG) recordings and 164 features were subsequently extracted compared different machine learning classifiers including: k-nearest neighbour, decision tree, support vector machine (SVM), and XGBoost, to identify ischemia heart disease (IHD) case selected three classifiers with best performance and applied model ensemble to average results. Proposed [12] a hybrid Dynamic ant colony system three update levels, with wavelets transform, and singular value decomposition integrating support vector machine and the outcome of the proposed method seeks to minimize subset of features to attain a satisfactory disease diagnosis on a wide range of diseases with the highest accuracy, sensitivity, and specificity. Focused [13] on identifying optimum machine learning classifier among several different machine learning classifiers for heart disease





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diagnosis and prototyping personal healthcare devices, use Bluetooth Low Energy for data transmission and development of iOS mobile application for integrating diagnosing and monitoring systems. Presented [14] an approach of utilizing machine learning to assist cardiac auscultation for heart murmur detection, compare the effectiveness and advantages of both supervised and unsupervised techniques in performing clustering and classification of selected sets of different heart murmur episodes. Proposed [15] development an Intelligent Heart Diseases Diagnosis Algorithm (IHDDA) which reads heart signals (e.g. ECG graphs etc.) and reaches on a flawless diagnosis in fraction of seconds. This paper [18] aims to improve the HF prediction accuracy using UCI heart disease dataset. For this, multiple machine learning approaches used to understand the data and predict the HF chances in a medical database and also provided result performance analysis.

### Comparison of Machine Learning methods for Heart disease Prediction

This section provides a level comparison between all the research papers described above. The comparison is made on the basis of evaluation which is presented in the existing work and can be seen in table.

### Machine Learning Approach

#### Data and Data Pre-processing

The dataset used in this paper is collected from Kaggle data domain, which is related to heart disease [19]. Dataset contains fourteen attributes and 303 records. The following details are related to dataset which provides information about used dataset. Used a variety of Machine Learning algorithms, implemented in Python, to predict the presence of heart disease in a patient. This is a classification problem, with input features as a variety of parameters, and the target variable as a binary variable, predicting whether heart disease is present or not. The following code provides the detail information about number of patients who have heart disease

```
df.target.value_counts()

1  165
0  138
Name: target, dtype: int64
```

Here 1 and 0 represents target value (have disease or not (1=yes, 0=no): 1-Yes, 0-No, that is 165 actually have heart disease. The following graph is represents the above data and also visualize gender wise.

From the above, the maximum heart rate occurs in between age 50–60 years. The following procedure is followed to implement KNN model, K-NN model is ready with K=4.

- Then the next step is label the data,
- After that dataset is divided into test data(25%) and train data(75%) respectively.
- Normalize the dataset by using StandardScaler() from sci-kit learn
- K-NN model and train it with the training data by considering K value.
- Confusion Matrix

```
[[25  8]
 [ 3 40]]
```

In the output, 25 and 40 are correct predictions, and 8 and 3 are incorrect predictions.

### Support Vector Machine

Support vector machine (SVM) is a classification method, used in different types of classification and regression problems. SVM can handle continuous and discrete variables. In SVM classification hyperplane line separates in multidimensional data points to separate different classes. SVM generates ideal hyperplane in a recursive manner,



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which is used to minimize an error. The main idea of SVM is to find a maximum marginal hyperplane (MMH) that best divides the dataset into classes. SVM used basic terms defined as follows; Support vectors are the data points, which are closest to the hyperplane. These data points will define the separating line better by calculating margins. A hyperplane is a decision plane which separates between a set of objects having different class memberships. A margin is a gap between the two lines on the closest class points. This is calculated as the perpendicular distance from the line to support vectors or closest points. If the margin is larger in between the classes, then it is considered a good margin, a smaller margin is a bad margin. Working of SVM as follows, the main objective is to segregate the given dataset in the best possible way. The main objective is to segregate the given dataset in the best possible way. The distance between the either nearest points is known as the margin. The objective is to select a hyperplane with the maximum possible margin between support vectors in the given dataset. SVM searches for the maximum marginal hyperplane in the following steps:

Step1: Generate hyperplanes which segregates the data points in the best way.

Step-2: Select the right hyperplane with the maximum segregation from the either nearest data points.

The SVM algorithm is implemented in practice using a kernel. A kernel transforms an input data space into the required form. SVM uses a technique called the kernel trick. SVM supports the following kernel types: Linear, Polynomial, Radial basis function (RBF), Sigmoid. In order to implement SVM to predict heart disease, the above said dataset is used. In Data Processing, to work with categorical variables, dataset should break each categorical column into dummy columns with 1s and 0s. After applying Support Vector classifier based on the given dataset, the following are predicted. The score for Support Vector Classifier is 85 % with rbf and sigmoid kernel. The score for Decision Tree Classifier is 79.0% with [2, 4, 18] maximum features. The score for Random Forest (RF) Classifier is 88% with [200] estimators. The score for K Neighbours Classifier is 87.0% with 7 and 8 neighbours. The accuracy score achieved using XGBoost is 86%. By comparing the above results; results concluded that RF is the best model with 88% accuracy. Results generated based on data by using machine learning techniques. Results concludes that best performance techniques is Random Forest classifier, This performance may be increased by applying normalization on data and by using grid search approach.

## CONCLUSIONS

Machine learning models or approaches plays major role in current research studies. In this paper I have discussed about the importance of machine learning in medical field and also provide summary discoveries as a comparison table. This paper aims to describe machine learning models to classify heart disease dataset to diagnose heart disease based on the dataset and finally provides result analysis of different machine learning models.

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**Table-1: Review Summary results**

Publication	Method/Algorithm	Problem/Target area	Evaluation Matrix		
			Recall/ Sensitivity	Precision/ Specificity	accuracy
[9]	Mixed Classifier(SVM,Naïve Bayes,KNN)	Diagnosis of Heart Disease	18.71%	9.76%	86.16%
[10]	Least Squares Twin-Support Vector Machine	ECG Arrhythmia Classification	NA	NA	97.10%





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[13]	Machine Learning Algorithms and iOS Mobile Application	Heart Diseases Diagnosis and Monitoring	NaïveBayes0.830, DecisionTree0.811 SVM0.830 KNN0.819	NaïveBayes0.830 DecisionTree0.814 SVM0.831 KNN0.819	NaïveBayes 82.90% DecisionTree 81.11% SVM82.94% KNN 81.85%
[15]	Intelligent Heart Diseases Diagnosis Algorithm (IHDDA)	Heart Diseases Diagnosis	NA	NA	97%
[11]	machine learning classifiers	Magnetocardiography-Based Ischemic Heart Disease Detection	KNN 0.8536 DT 0.8976 SVM0.8963 XGBoost0.9333	KNN 0.7134 DT 0.7601 SVM 0.7796 XGBoost0.8646	KNN086.08% DT 88.31% SVM 88.84% XGBoost93.23%
[4]	bagging algorithm with the decision tree algorithm that	Diagnosis of Heart Disease	Bagging 74.93 DT 72.01	Bagging 86.64 DT 84.48	Bagging 81.41% DT 78.91%
[5]	Application of SVM based on hybrid kernel function	heart disease diagnoses	NA	NA	Linear 0.8385 Poly0.8642 K-Type 0.8769 RBF 0.8615
[6]	Extreme Learning Based Neural Networks	Heart Disease Diagnosis	ELM 88%	ELM 82%	ELM 83%
[7]	Alternating decision trees	diagnosis of heart disease	NA	NA	AD Tree and PCA 92.2%
[16]	Machine Learning (ML) classifiers and deep learning classifier for heart disease identification	Designing Heart Disease Detection System	NA	NA	SVM 92.30% BPNN 93%
[17]	Machine Learning Approach	Cardiac Arrhythmia Diagnosis System	GaussianSVM100 FSCNCAGaussianSVM100% FSCNCANeuralNetwork98.71%	GaussianSVM16.16 FSCNCAGaussianSVM27.77% FSCNCANeuralNetwork50%	GaussianSVM84.37% FSCNCAGaussianSVM85.42% FSCNCANeuralNetwork89.58%





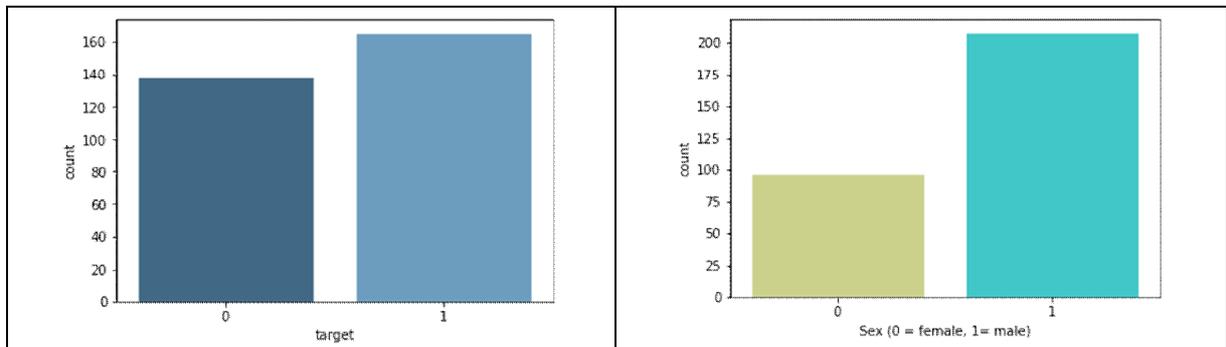
**P. Annan Naidu**

**Table-2:Dataset**

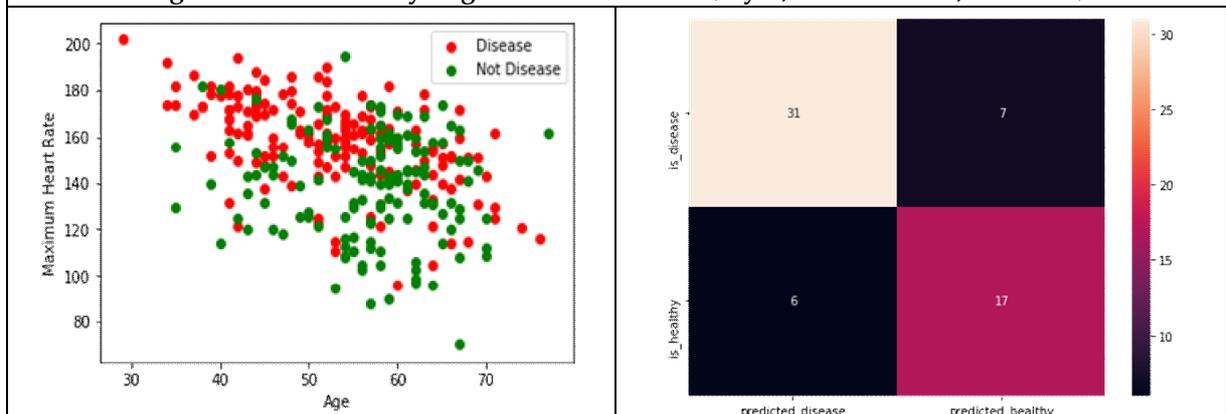
	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
0	63	1	3	145	233	1	0	150	0	2.3	0	0	1	1
1	37	1	2	130	250	0	1	187	0	3.5	0	0	2	1
2	41	0	1	130	204	0	0	172	0	1.4	2	0	2	1
3	56	1	1	120	236	0	1	178	0	0.8	2	0	2	1
4	57	0	0	120	354	0	1	163	1	0.6	2	0	2	1

**Table -3: Predicted Values**

	predicted_disease	predicted_healthy
is_disease	31	7
is_healthy	6	17



**Fig-1:Visualize classify target variable between(1=yes,0=no& male=1, female=0)**



**Fig-2:relation between "Maximum Heart Rate" and "Age"**

**Fig-3: Heat map of Predicted Values (Represents data in 2D matrix)**





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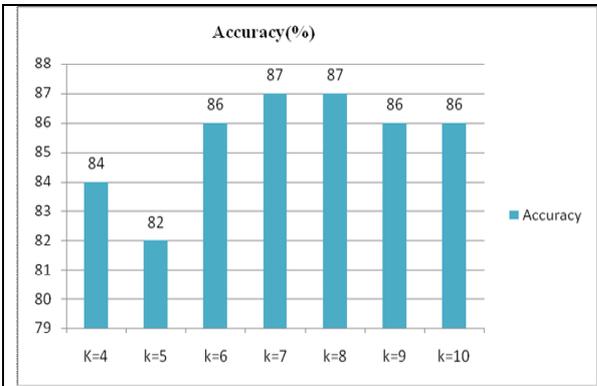


Fig-4:K-Neighbours accuracy comparison based on K value.

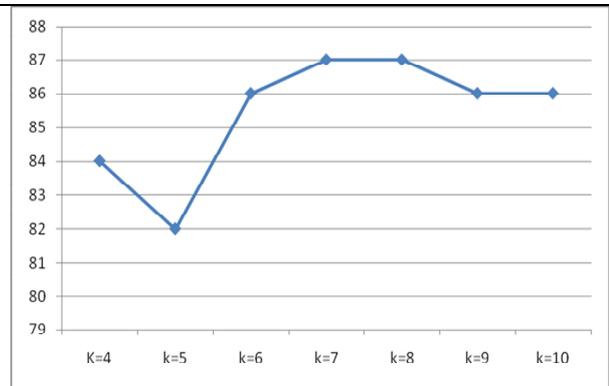


Fig-5: K-Neighbours accuracy comparison based on K value.

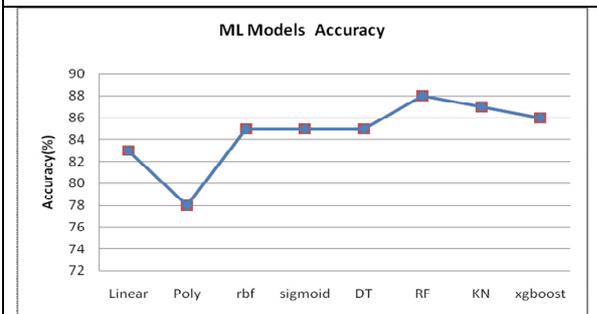


Fig-6: Machine learning Models Performance

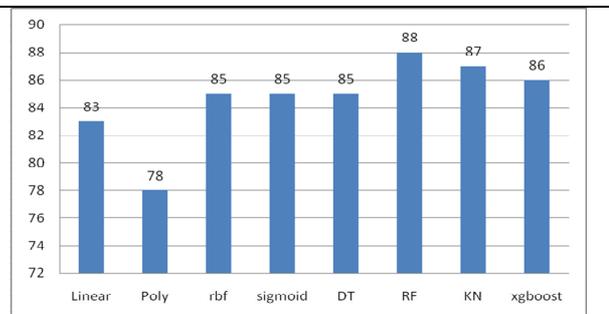


Fig-7: Machine learning Models Performance based on heart disease data





## Applications of Natural Language Processing using NLTK-NLP Library

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### ABSTRACT

Natural Language processing (NLP) is a process of understanding data in natural languages through computer programs. NLP is used in sentiment analysis, speech recognition, call centres, to create chatbots, spell checking, machine translation etc. The main concern of this paper is the compressive study on NLP with its application. This paper presents NLP concepts and applications of NLP through python programming. In this paper, developed different applications based on website data and twitter datasets.

**Keywords:** Natural Language, Tokenization, Stemming, Morphology, Semantics

## INTRODUCTION

In 20<sup>th</sup> century, World is consolidated on computer applications and data. Social media networks generates huge amount of data through internet applications or services. This social media data available for business purpose, where data extracted, pre-processed ,apply different models or techniques and produce relevant results based on requirements then same results can be used for further decision making. In real world scenario, NLP is used in many applications, one such application is digital phone calls, generally when me make a call to any customer care service, we may experienced like "this call may be recorded for training purposes," in this case they will record our voice for training purpose, by using this database company can analyse customers views called sentiment analysis. Similarly NLP also used in chatbots, smart assistants, search results and email filters.

### Natural Language Processing

Data is one of the prominent requirements in today's business. In our day-to-day life huge amount of data is produced in various formats from different resources. One of biggest source of data is social media networks or internet applications like Facebook, Twitter, WhatsApp, Google etc. Conferring to industry assessments, only 21% of the available data is present in structured form and available unstructured data (approx.80).When the requirements demands the understanding of unstructured data for their business, In order to produce significant and actionable insights from text data, this type of issues can be solved by different computing methods, one such method is Natural Language processing (NLP).Natural Language processing is a sub filed of data science, linguistics, Artificial Intelligence, The main concern of NLP is the interactions between computer program and human languages.NLP is

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a systematic processes for analysing, understanding, and deriving information from the text data in a smart and efficient manner. By using NLP components and its techniques, one can perform various automated tasks like sentiment analysis, speech recognition, topic segmentation, relationship extraction. NLP means processing of human language automatically.

**Classification of NLP**

Phonology refers to the science of understanding sound, Morphology refers to word formation, and syntax refers to structure whereas Pragmatics refers to understanding.

When a person talks to each other, first other person understands the context then gives reply accordingly. So here natural language understanding refers understanding the context and natural language generation relate to response. NLP is used in the following common applications, such as

- Language Translation applications, Ex: Google Translate
- To check grammatical accuracy of texts, Ex: Word Processors
- Interactive Voice Response (IVR) applications Ex: Call centres
- Personal assistant applications, Ex: OK Google, Siri, Cortana, and Alexa.

“Natural Language Processing is a field that covers computer understanding and manipulation of human language, and it’s ripe with possibilities for news gathering,” Anthony Pesce said in Natural Language Processing in the kitchen [1]. While natural language processing used where the technology is rapidly advancing to an increased interest in human-to-machine communications, plus an availability of big data, powerful computing and enhanced algorithms. As a human, you may speak and write in English, but a computer’s native language known as machine code or machine language is largely incomprehensible to most people. At your device’s lowest levels, communication occurs not with words but through millions of zeros and ones that produce logical actions.

**Step-by-Step-by process flow of NLP**

**Step-1: Text collection:** Collecting data from various social media networks

**Step-2: Text Cleaning:** Removing links, urls and tags etc.

**Step-3: Tokenization:** Breakdown the text into meaningful words and terms

**Step-4: Word Stemming:** Reducing a word form to a base form or root form

Ex: Playing, Plays, Played are common root from ‘play’.

Ex: Likes, Likely, Liking, Liked are common root from ‘like’.

**Step-5: Stop word Removal:** Removing stop words like the, of, a, an, and.

**Step-6: Custom Dictionary Creation:** Creating domain specific dictionary with words used for different meanings in different context.

**Step-7: N gram analysis:** Check if sequences of words convey a different meaning than each word used separately.

**Step-8: POS tagging:** Part of Speech tagging helps in identifying whether a word is used as noun, Adverb or adjective.

**Step-9: Entity Recognition:** Entity Recognition based on location, organizations and places is performed.

**Step-10: Sentiment Scoring:** Score each document based on the sentiment associated with each word in a given text.

**Step-11: Sentiment Classification:** Based on the sentiment scoring the text is classified as positive, negative or neutral.

**Applications of NLP based on Web Page data and Twitter data****Case-1: Identifying what a web page content**

In this case, I have used web page [3] for identifying what this web page is speaks about by using python nltk package.





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**Step- 1:**Take a webpage and analyze the text to observe what the page is about. This is possible by using import urllib.request, this package is used to read web page.

```
b'\n<!DOCTYPE html>\n<html class="client-nojs" lang="en" dir="ltr">\n<head>\n<meta
charset="UTF-8"/>\n<title>Health care -
Wikipedia</title>\n<script>document.documentElement.className="client-
js";RLCONF={"wgBreakFrames":!1,"wgSeparatorTransformTable":["",""],"wgDigitTransformTa
ble":["",""],"wgDefaultDateFormat":"dmy","wgMonthNames":["","January","February","Marc
h","April","May","June","July","August","September","October","November","December"],"
wgRequestId":"78e8de8a-0253-4e2b-b125-
8363de94186a","wgCSPNonce":!1,"wgCanonicalNamespace":"","wgCanonicalSpecialPageName":!
1,"wgNamespaceNumber":0,"wgPageName":"Health_care",".
```

**Step-2:**Extract Data from web page(out of HTML and XML files )using from bs4 import BeautifulSouppython package.

```
Health care - Wikipediadocument.documentElement.className="client-
js";RLCONF={"wgBreakFrames":!1,"wgSeparatorTransformTable":["",""],"wgDigitTransformTa
ble":["",""],"wgDefaultDateFormat":"dmy","wgMonthNames":["","January","February","Marc
h","April","May","June","July","August","September","October","November","December"],"
wgRequestId.
```

**Step-3:** clean text from the web page and convert the text into tokens

```
'Health', 'care', '-', 'Wikipediadocument.documentElement.className="client-
js";RLCONF={"wgBreakFrames":!1,"wgSeparatorTransformTable":["",""],"wgDigitTransformTa
ble":["",""],"wgDefaultDateFormat":"dmy","wgMonthNames":["","January","February","Marc
h","April","May","June","July","August","September","October","November","December"],"
wgRequestId":"78e8de8a-0253-4e2b-b125-
8363de94186a","wgCSPNonce":!1,"wgCanonicalNamespace":"","wgCanonicalSpecialPageName":!
1,"wgNamespaceNumber":0,"wgPageName":"Health_care","wgTitle":"Health',
'care',"wgCurRevisionId".
```

**Step-4:** Count Word Frequency

Freq Dist() is used to find out frequency of words in web page data, and also remove stop words (a, at, the, for etc) from web page as these words not required for word frequency count. Then plot the graph for most frequently occurring words in the webpage in order to get the clear picture of the context of the web page

```
Health:34
care:101
-:7
Wikipediadocument.documentElement.className="client-
js";RLCONF={"wgBreakFrames":!1,"wgSeparatorTransformTable":["",""],"wgDigitTransformTa
ble":["",""],"wgDefaultDateFormat":"dmy","wgMonthNames":["","January","February","Marc
h","April","May","June","July","August","September","October","November","December"],"
wgRequestId":"78e8de8a-0253-4e2b-b125-
8363de94186a","wgCSPNonce":!1,"wgCanonicalNamespace":"","wgCanonicalSpecialPageName":!
1,"wgNamespaceNumber":0,"wgPageName":"Health_care","wgTitle":"Health:1
care","wgCurRevisionId":960570959,"wgRevisionId":960570959,"wgArticleId":261925,"wgIsA
rticle":!0,"wgIsRedirect":!1,"wgAction":"view","wgUserName":null,"wgUserGroups":["*"],
"wgCategories":["Webarchive:1
template:2
wayback:2
links","Pages:1
```







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A user-defined function (defremove\_ pattern (input\_txt, pattern)used to remove text outlineswhich are not carry much information from the tweets. It takes two arguments, one is the original dataset values and the other is the text pattern whichis eliminated from the string.The following code is used for the following actions, removing twitter handles through tidy\_tweet, removing Punctuations, Numbers, and Special Characters and removing short words.

```
# Eliminate twitter handles (@user)
c['tidy_tweet'] = n.vectorize(remove_pattern)(c['tweet'], "@[\w]*")
#Eliminate Punctuations, Numbers, and Special Characters
c['tidy_tweet'] = c['tidy_tweet'].str.replace("[^a-zA-Z#]", " ")
#Removing Short Words
c['tidy_tweet'] = c['tidy_tweet'].apply(lambda x: ' '.join([w for w in x.split() if len(w)>3]))
```

After applying the above steps,such as removing twitter handles, combined train and test data, removing short words, removing Punctuations, Numbers, and Special Characters.

id	tweet	label	tidy_tweet
0	31963 #studiolife #aislife #requires #passion #dedic... #passion #dedic...	NaN	#studiolife #aislife #requires
1	31964 @user #white #supremacists want everyone to s... everyone #birds #mov...	NaN	#white #supremacists want
2	31965 safe ways to heal your #acne!! #altwaystohe... #altwaystoheal #heal...	NaN	safe ways heal your #acne
3	31966 is the hp and the cursed child book up for res... already where w...	NaN	cursed child book reservations
4	31967 3rd #bihday to my amazing, hilarious #nephew... #nephew ahmiruncle ...	NaN	#bihday amazing hilarious

Compare the difference between the original tweets and the prepared tweets (tidy\_tweet) prettyvisibly. Only the important words in the tweets are remaining there in the tweets and the noise (numbers, punctuations, and special characters) has been removed.

**Step-3:Tokenization**

Tokenization is a process of break the senteces into individual words or terms.

```
0 [#studiolife, #aislife, #requires, #passion, #...
1 [#white, #supremacists, want, everyone, #birds...
2 [safe, ways, heal, your, #acne, #altwaystoheal...
3 [cursed, child, book, reservations, already, w...
4 [#bihday, amazing, hilarious, #nephew, ahmir, ...
Name: tidy_tweet, dtype: object
```

**Step-4: Stemming**

Reducing a word form to a base form or root form

Ex: Playing, Plays, Played are common root from 'play'.

Ex: Likes, Likely, Liking, Liked are common root from 'like'.

```
0 [#studiolif, #aislif, #requir, #passion, #dedi...
1 [#white, #supremacist, want, everyon, #bird, #...
2 [safe, way, heal, your, #acn, #altwaystoh, #he...
3 [curs, child, book, reserv, alreadi, where, wh...
4 [#bihday, amaz, hilari, #nephew, ahmir, uncl, ...
Name: tidy_tweet, dtype: object
```





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id	tweet	label	tidy_tweet
0	31963 #studiolife #aislife #requires #passion #dedic...	NaN	#studiolif #aislif
1	31964 @user #white #supremacists want everyone to s...	NaN	#white #suprem
2	31965 safe ways to heal your #acne!! #altwaystohe...	NaN	safe wayhea
3	31966 is the hp and the cursed child book up for res...	NaN	curschildbo
4	31967 3rd #bihday to my amazing, hilarious #nephew...	NaN	#bihdayama

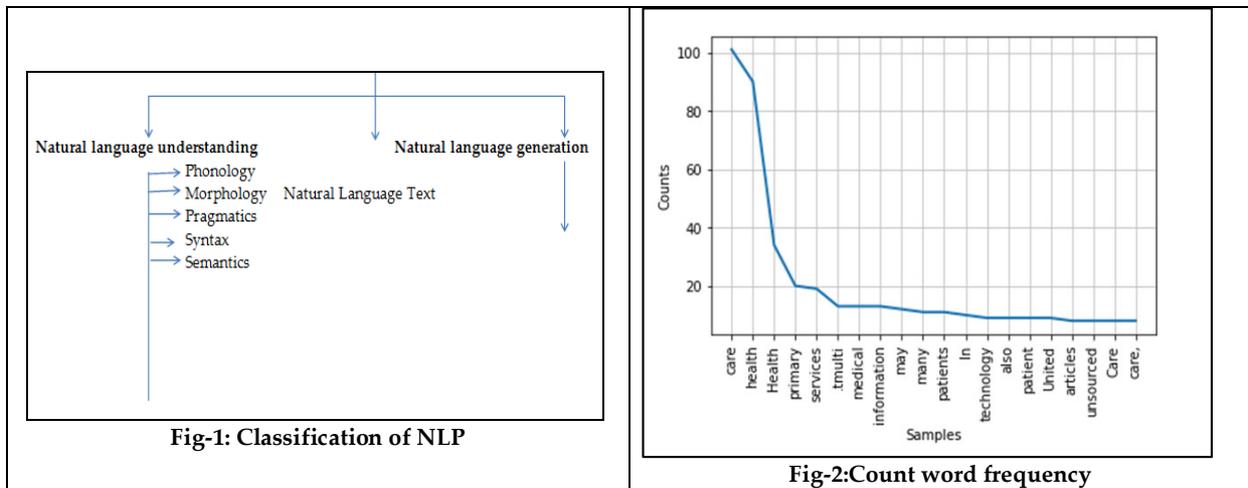
When compare the above result with the original dataset, the above results conclude that data presents without twitter handles, short words, numbers, punctuations, special characters. In this case, the process limited up to stemming.

### CONCLUSIONS

This study focused on the theoretical approach, step-by-step process flow of NLP and development of NLP applications based on web site data and twitter data.

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## Machine Learning in Smart Healthcare Applications-2020 and Beyond

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### ABSTRACT

Healthcare is an essential diligence which offers value-based care to millions of people, while at the same time becoming top revenue earners for many countries. Today technology is allowing healthcare specialists develop alternate staffing models, provide smart healthcare and reducing administrative and supply costs. Machine learning in healthcare is one such area which is seeing gradual acceptance in the healthcare industry. This paper aims to provide the comprehensive study on Machine learning and its role in smart Healthcare.

**Keywords:** Machine learning, Healthcare, Drug Discovery, Imaging Diagnosis, Clinical Trial

## INTRODUCTION

### Machine Learning in Healthcare: Related Work

The healthcare sector has always been one of the greatest proponents of innovative technology, Machine Learning are no exceptions. Technology-enabled smart healthcare and Internet-connected medical devices are holding the health system [18]. Machine learning has virtually endless applications in the healthcare industry. Today, machine learning is helping to streamline administrative processes in hospitals, map and treat infectious diseases and personalize medical treatments [19]. Machine learning in medicine has recently made headlines. Google recently developed a machine-learning algorithm to identify cancerous tumours in mammograms, and researchers in Stanford University are using deep learning to identify skin cancer [20]. ML in healthcare helps to analyse thousands of different data points and suggest outcomes, provides timely risk scores, precise resource allocation, and has many other applications. This section briefly describes the role of machine learning in healthcare for last 10 years.

This study provides existing work of machine learning based on healthcare or medical field. In Machine learning, there are different types algorithms known as supervised learning, unsupervised learning and reinforcement algorithms. Most of the medical field or healthcare applications are developed by using machine learning techniques or algorithms. [1] The purpose of this research study was to compare the performance of various ML models for predicting surgical infection after neurosurgical operations. Implemented Supervised ML algorithms, evaluate



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model with test data and also defined accuracy, sensitivity, specificity of the models. [2] In This paper, research work focused on the effect of diabetes on eye which leads to diabetic retinopathy by using Self Organizing Map and K-means algorithm, the results concluded that the SOM is able to show a 3D weighted map illustrating the noticeable difference between the normal and diabetic retinopathy images. In this work, authors [3] evaluated the performance of machine learning based techniques for Parkinson's disease diagnosis based on dysphonia symptoms by using by means of a tenfold cross validation protocol.

The results concluded the support vector machine classifier shows superior performance compared to the other classifiers. Objective of the present paper is to demonstrate the potential of Computational Intelligence in applications pertaining to the automatic identification categorisation of Cardiocograms using Machine Learning Algorithms and Artificial Neural Networks [4]. In this paper [5] author proposed adaptive ensemble voting method for diagnosed breast cancer using Wisconsin Breast Cancer database. The main contribution of this work to compare and explain how ANN and logistic algorithm provide better solution when its work with ensemble machine learning algorithms for diagnosing breast cancer even the variables are reduced.

Then main focus of this paper is to predict Interactive Thyroid Disease with help of different machine learning techniques and diagnosis for the prevention of thyroid. Machine Learning Algorithms, support vector machine (SVM), K-NN, Decision Trees were used to predict the estimated risk on a patient's chance of obtaining thyroid disease [6]. This paper presented the role of machine learning applications in early disease detection through different datasets like heart, breast cancer and diabetes and also implemented different machine learning algorithms [7]. The objective this work is carried out to choose the best tool for diagnosis and detection of Hepatitis as well as for the prediction of life expectancy of Hepatitis patients and also presented the comparison between different machine learning techniques. The performance of models evaluated based on accuracy and mean square error [8]. This paper aims at building a classifier model using WEKA tool to predict diabetes disease by employing Naive Bayes, Support Vector Machine, Random Forest and Simple CART algorithm and also projected a Decision Support System for the diagnosis of Heart disease by means of radial basis function network structure and Support Vector Machine [9].

**Machine Learning in Healthcare**

This section briefly explains about the role of machine learning in healthcare applications. As per the existing study, there is a lot of research has already implemented in health sector using machine learning approach. This section aims to provide healthcare applications through machine learning.

**Identifying Diseases and Diagnosis**

Machine learning methods are used in one of the important field in healthcare that is prediction of diseases and diagnosis. The machine learning can be applied on the following applications such as heart disease, Breast cancer, Cardiac Arrhythmia Diagnosis System, coronary heart disease, tongue disease diagnosis, Diagnosis of Diabetes Mellitus [10], Thyroid Disease Diagnosis. For the above said applications, machine learning techniques are applied based on dataset, and follow the following procedure: data pre-processing, data feature scaling, apply machine learning model, predict accuracy, evaluate model using evaluation metrics, comparing methods with its accuracy, sensitivity, specificity.

**Drug Discovery and Manufacturing**

Machine learning (ML), a branch of artificial intelligence for discerning patterns from complex data sets, has proven to be a valuable method in various fields of research over the past few decades [11]. ML algorithms have found great utility in several applications including drug discovery and manufacturing, exploring different material properties such as elasticity, plasticity, fatigue life, wear performance, and buckling [12]. The key areas of drug discovery process is ensuring drug safety, interpreting information of the known effects of drugs and envisaging their side effects. The



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most of researchers and scientists are focused on obtained meaningful clinical data from clinical trials using machine learning techniques. In drug development the most expensive task is clinical trials, in order to reduce the cost effective of clinical trials, machine learning techniques are used to integrate with biomedical data and analysed interpreted clinical data to detect side effects of drug discovery.

**Medical Imaging Diagnosis**

Medical image analysis and processing has great significance in the field of medicine and clinical study. Medical imaging incorporates various imaging modalities and processes to image the human body for diagnostic and treatment purposes and therefore plays an important role in initiatives to improve public health for all population groups[13]. Machine learning techniques are applied on different medical image modalities to diagnose the disease or to prepare clinical health records. In medical imaging, diseases are identified through different medical images by using image processing techniques through machine learning techniques. Machine learning techniques in the following medical imaging research challenges such X-ray images, CT scan images and Ultrasound (US) images which includes brain related disease, bone related disease and human body internal organs related diseases. In this case, machine learning techniques follow the basic procedure that is image acquisition from CT or MR; apply image processing techniques, segmentation, detection and diagnosis.

**Personalized Medicine**

Personalized medicine represents a significant application for the health informatics community. The main objective of Personalized Medicine is to provide patients clinical history without appear drug data, design clinical database and optimize, clinical data analysis. The main challenges of Personalized Medicine through machine learning are as follows; Data representation of multiple relations, Data uncertainty, missing data and incomplete data.

**Smart Health Records**

Patient's clinical reports are plays major role in treatment, which is essential for disease detection to disease diagnosis. In order to understand the patient health condition, it is very much essential to predict the best values with respective their health condition from current and previous health records. In this concern, machine learning is a sophisticated approach to maintain and analyse patient health records, In order to create smart health records which includes modern computing processes such as data collection, data processing, data security, networking and computing techniques. The idea of a smart health system is that it uses all data coming from sensors on the patient body, smart homes, smart city infrastructure, and robots to help make better decisions and improve healthcare by providing emergency response and paging doctors, nurses, and technicians[14]. Electronic health records, digital health cards are best examples so far implemented.

**Clinical Trial and Research**

Clinical trial is a scientific experiments conducted to find best way to treat diseases and diagnosis. Clinical trials produce high quality health data for health care decision making. FDA's (Food and Drug Administration) Scott Gottlieb[15] says Real-world data gathered directly from EHRs and other data sources, paired with advances in machine learning, will be crucial for architecting the next generation of successful clinical trials. This paper describes MLBCD (Machine Learning for Big Clinical Data), MLBCD integrates techniques of fast pivoting, visual query building, efficient and automatic selection of machine learning algorithms and hyper-parameter values, and scalable machine learning.

**Scaled Up / Crowdsourced Medical Data Collection**

Crowd-sourcing has become a popular means of acquiring labelled data for many tasks where humans are more accurate computers, such as image tagging, entity resolution, and sentiment analysis [16]. Crowdsourcing refers to a large group of people collectively solving a problem or completing a task for an individual or an organisation. The





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field of crowdsourcing has developed in information technology or business, but crowdsourcing can be a promising tool in health and in global health in particular [17].

### Future Applications/Challenges in Healthcare

- Robotic Surgery
- Automatic Treatment or Recommendation
- Autonomous Robotic Surgery
- Radiomics
- Augmented reality(AR)/ Virtual reality(VR) in the Future of Medical field
- Reforming drug development
- Nanotechnology in healthcare
- 3D-printing in healthcare

### CONCLUSIONS

Healthcare is one of the emerging fields, where it supports to doctors and patients for clinical treatments. Smart healthcare provides value added services depends on technology enabled services. In current scenario healthcare applications also developed by using various computing technologies. This paper presented the impact of machine learning in the developments of healthcare applications. Section-1 describes machine learning and its related work, section-2 discussed about different healthcare applications with support of machine learning and also presents future challenges(beyond 2020)of healthcare.

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## Anti-Bacterial Activity and Catalytic Degradation by Silver Nanoparticle from *Plumeria rubra* and *Plumeria alba*

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### ABSTRACT

Bioinspired eco-friendly Silver nanoparticles were synthesized by a green method from *Plumeria rubra* Flower Extract (PRFE) and *Plumeria alba* Flower Extract(PAFE). The use of two different concentration (1% and 5%) of PAFE resulted in two different sizes of two *Plumeria* SP as *Plumeria alba* Silver Nanoparticles (PASNPs1 and PASNPs2) and *Plumeria rubra* Silver Nanoparticles (PRSNPs1 and PRSNPs2). The controlled formation of silver nanoparticles was indicated by FTIR and XRD with increasing concentration of PAFE and PRFE. The antibacterial activity of PASNPs1, PRSNPs1 and PASNPs2. PRSNPs2 was tested against a nosocomial microbe, the small sized PASNPs1 and PRSNPs1 exhibited better antibacterial activity with highest 3.5cm zone of inhibition at a concentration of 200µg/ml. The PASNPs and PRSNPs shows great catalytic degradation activity against industrial dyes like Methylene blue (MB), Congo RED (CR), Methyl Orange (MO). The green synthesis of nanoparticles in bulk suggests the potential industrial applications.

**Key-words-** Silver nanoparticles, catalytic degradation, leaf, bark, flower, Green synthesis

### INTRODUCTION

*Plumeria rubra* and *Plumeria alba* belong to family Apocynaceae is a succulent, 2-8 mtr evergreen shrub having narrow elongated leaves, large and strongly perfumed white and pink flowers. Flowers are edible while heart of the wood used in medical preparation in form of vermifuge or laxative. Essential oil of *Plumeria* has antifungal efficacy and have potential for antimicrobial agents and also have pharmaceutical, anti-inflammatory, diuretic, emmenagogue, febrifuge, purgative applications and used as a tonic and expectorant [1].

Plant mediated synthesis of metal nanoparticles is more effective among green synthesis over microbial methods. Also this method is cost effective, improved stability, a wide range of biological activities and rapid synthesis due to



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active presence of many phyto-compounds. [2]. SNPs or Silver nanoparticles give different colors according to their aggregation ability and shape and size. Many previously reported data on the green synthesis of SNPs include the use of plants such as *Medicago sativa*, *Aloe vera*, *Pelargonium graveolens*, *Tamarindus indica*, *Cassia auriculata*, and *Coriandrum sativum*. Because the SNPs possess a high surface area and various sizes as well as shapes, they are also widely used in catalysis [3].

Dyes referred as principal pollutants for environment as it predominantly used in many industries like cosmetics, textiles, leather, plastic industries food, and also directly disposed into local river or other water reservoirs. These harmful dyes give toxic effects which negatively affect the aquatic life also result some mutagenic or carcinogenic effect to the nature, and the azo and nitro compounds of these harmful dyes take long times to degrade or for the deep soil accumulation and remain indefinitely in nature [4]. Many effective methods have been arisen to treat these dyes based upon adsorption, microwave-assisted degradation, photoelectric degradation and photocatalytic reduction. But all of these methods use the organic solvents which are cost effective and energy consuming. So as an alternative to this, many modern methods based on bio-green nanoparticles initiated to treat these harmful dyes which can be an alternative to those as the methods are operated under mild conditions and also uncomplicated [5].

This study reports a simple and green method for synthesizing silver nanoparticles using an aqueous extract of *Plumeria alba* and *Plumeria rubra* flowers (PAFE, PRFE). The PAFE and PRFE contains a mixture of phyto-compounds including amyriacetate, amyriins,  $\beta$ -sitosterol, scopotetin, the iridoid isoplumericin, plumieride, plumieridecoumerate, and plumieridecoumerate glucoside [6]. The synthesized P. alba P. rubra silver nanoparticles (PASNPs and PRSNPs) are characterized by particle size analysis, fourier transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), ultraviolet-visible (UV-visible) spectroscopy, energy dispersive X-ray spectroscopy (EDAX), and X-ray diffraction (XRD) analysis. The antibacterial potential of the PASNPs is analyzed against *Escherichia coli*. The catalytic property of PASNPs to degrade different organic dyes such as methylene blue (MB), methyl orange (MO), Congo red (CR) are analyzed.

## MATERIALS AND METHODS

### Collection and extraction

Leaves of *Plumeria* were collected from GIET Campus, Gunupur and authenticated by a botanist at the Plant Anatomy Research Centre (PARC), Chennai, Tamil Nadu, India. Leaf, Bark, Flower of *Plumeria* of different species of different month were collected. The collection were dried in shade for 15 days and then grinded to form powder.

### Preparation of flower extract

1 and 5 gm of flower powder was mixed individually with 100 mL of distilled water in 250 mL flasks. Then it was kept in an orbital shaker for 12 hours at room temperature. The supernatant was being filtered for thrice by a Whatman No. 1 filter paper and the collected extract was stored at 4 °C for future investigation.

### Green synthesis of silver nanoparticles

About 10 mL of 1% and 5% PAFE (*Plumeria alba* Flower Extract) and PRFE (*Plumeria rubra* Flower Extract) was added separately to 25 mL of AgNO<sub>3</sub> (1 mM) aqueous solution at room temperature, whereupon two minutes of incubation produced a noticeable color change in the reaction mixture from yellow to orange or blue, depending upon the concentration of flower extract. The color of the reaction mixture was changed which indicate of the formation of PASNPs and PRSNPs. The nanoparticles were further confirmed by UV-visible spectroscopy. These synthesized nanoparticles were collected by centrifugation (18,000 rpm) and then it washed with double distilled water followed by air dry and used for further investigation.



**Lopamudra Samantaray and Yashaswi Nayak****Characterization of Silver nanoparticles**

Bio-reduction and the formation of PASNPs and PRSNPs was monitored using a UV–visible spectrophotometer (UV-1700, Shimadzu, Japan) at wavelengths (350 and 700 nm), where the UV–visible spectrum of the PASNPs and PRSNPs at different time intervals was recorded. The average size and size distribution of the samples labelled PASNPs1 and PRSNPs1 (synthesized with 1% PAFE and PRFE) and PASNPs2 and PRSNPs2 (synthesized with 5% PAFE and PRFE) in liquid colloidal solution was measured by DLS instrumentation (Zetasizer Nano ZS, Malvern Instruments, UK). Morphology and the elemental composition of PASNPs1, PRSNPs1 and PASNPs2, PRSNPs2 samples were examined using TEM (Tecnai G2 30, FEI, USA) and an EDAX analyzer (SEM S-4500, Hitachi, Japan).

Samples were prepared by dropping the nanoparticle colloidal solution in methanol onto an aluminum-coated copper grid and placed at a 20 kV potential. Functional groups present in the PAFE involved in the formation of the PASNPs and PRSNPs were analyzed by FTIR (Thermo Nicolet Nexus 6700 spectrometer, Thermal Electron Corporation, USA) analysis. The nano-powder and PAFE and PRFE samples were uniformly mixed with potassium bromide (KBr) and compressed with a hydraulic press to prepare disks, which were then used for FTIR analysis.

**Antibacterial activity**

The antibacterial activity of the green-synthesized PASNPs1, PRSNPs1 and PASNPs2, PRSNPs2 samples was evaluated using nosocomial microbes of strain 1, 2 and 3 from R & D Laboratory via the modified disc diffusion method of Kirby–Bauer [7]. The antibacterial potential was screened using muellerhinton agar (MHA), where the MHA plates were prepared by pouring 20 mL of molten media into sterile Petri plates. The plates were solidified for 5 min, then 100  $\mu$ L of inoculum suspension was swabbed on the surface and allowed to dry for about 5 min. Three concentrations (400, 300, and 200 g/mL) of the PASNPs1, PRSNPs1 and PASNPs2, PRSNPs2 samples were loaded on 3 mm-diameter sterile individual discs, which were placed on the surface of the medium and the compound was allowed to diffuse for 5 min, after which the plates were kept for incubation at 37 °C for 24 h.

The growth inhibitory effect of the PASNPs1, PRSNPs1 and PASNPs2, PRSNPs2 samples in nosocomial microbes of R & D Laboratory was studied using three different PASNP and PRSNP concentrations like 400, 300, and 200 g/mL. In this study, the growth phase of the hospital microbes was being cultured with and without PASNPs1, PRSNPs1 and PASNPs2, PRSNPs2. The growth was measured at continuous time intervals using the UV–visible spectrophotometer (600 nm wavelengths), and growth curves were plotted.

**RESULT AND DISCUSSION**

The synthesis of silver nanoparticles was accomplished using two different concentrations (1% and 5%) of aqueous PAFE, PRFE and keeping the AgNO<sub>3</sub> (1 mM) concentration constant. The PASNPs1 and PRSNPs1 sample, synthesized with 1% PAFE and PRFE, exhibits an intense blue color while the PASNPs2 sample, synthesized with 5% PAFE, PRFE, manifests a pink color, and both of the samples were found to be stable for a period of three months. The PASNPs1, PRSNPs1 and PASNPs2, PRSNPs2 samples also show a pronounced difference in their UV–visible spectra, with their max located at 552 and 532 nm, respectively (Fig. 1(a) and (b)).

Also, the SPR peak intensity of PASNPs1, PRSNPs1 and PASNPs2, PRSNPs2 increased with the reaction time owing to the continued reduction of Ag ions and to the increased formation of nanoparticles, and the SPR peak location of the samples exhibits a blue shift with increasing PAFE concentrations. A possible explanation for the formation of smaller particles in PASNPs2, PRSNPs2 could be the presence of the increased number of nucleation sites for AgNO<sub>3</sub> – complexation with the increasing concentration of the PAFE. Whereas in PASNPs1, PRSNPs1, less nucleation sites were present this may lead to more reduction at one nucleation and formation of bigger particles. These investigations are indicating that the size of the nanoparticles can be controlled by changing the concentration of plant extracts in different variations.



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The TEM analysis of the PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> and PASNPs<sub>2</sub>, PRSNPs<sub>2</sub>, enabling us to make accurate size measurements of samples found to be  $28 \pm 5.6$  and  $15.6 \pm 3.4$  nm, respectively. The morphology of the PASNPs, PRSNPs is spherical in shape, and the TEM data also illustrate the increased size of the PASNPs<sub>1</sub> sample compared to that of PASNPs<sub>2</sub>, which is in good agreement with the UV-visible analysis. To investigate the possible active groups present in the PAFE that are involved in the formation of the PASNPs, we performed FTIR spectral analysis on the samples. The IR spectrum of the synthesized PASNPs, PRSNPs sample is compared with pure PAFE and PRFE. The PAFE and PRFE displays intense vibrational stretching at  $3211\text{ cm}^{-1}$  (C H stretching),  $1685\text{ cm}^{-1}$  (C O stretching of carboxylic acids),  $1411\text{ cm}^{-1}$  (C C ring stretching of aromatics), and  $1046\text{ cm}^{-1}$  (C N stretching of aliphatic amines).

All of the peaks obtained with FTIR, therefore, confirm the presence of various phyto- components of the PAFE, PRFE. The IR spectra of the PASNPs, PRSNPs exhibit intense peak shifts from the locations observed for PAFE, PRFE sample, with shifts from  $3211$  to  $3348\text{ cm}^{-1}$  (N H stretching of  $1^\circ$  and  $2^\circ$  amines and amides) and from  $1046$  to  $1036\text{ cm}^{-1}$  (C N stretching of aliphatic amines), which may be owing to the reduction of  $\text{Ag}^{3+}$  to  $\text{Ag}^0$  and the capping of the PASNPs, PRSNPs by the phyto-compounds in the PAFE, PRFE. The other peaks observed in the IR spectra of the PASNPs, PRSNPs located at  $2900\text{ cm}^{-1}$  (C -H stretching of alkanes),  $1566\text{ cm}^{-1}$  (C - C ring stretching of aromatics), and  $1356\text{ cm}^{-1}$  (N- O symmetric stretching of nitro compounds) also are derived from the PAFE, PRFE and are involved in the formation of the PASNPs. The N H and C H (proteins or sugars) groups of the PAFE, PRFE may be involved in the formation of PASNPs, PRSNPs mainly.

Based upon the above results, the functional groups of PRFE, PAFE are involved in the formation and capping of PASNPs, PRSNPs. The thermal stability of the PASNPs, PRSNPs was studied by TG-DSC. The endothermic peak found at  $52^\circ\text{C}$  is owing to the transition temperature, as shown in. The TG plot of the PASNPs, PRSNPs exhibits initial 4% weight loss due to moisture loss in the temperature range ( $10\text{--}50^\circ\text{C}$ ), with a further weight loss up to 30% observed ( $50$  and  $350^\circ\text{C}$ ) that attributed to the degradation of the organic phase of the PASNPs, PRSNPs. No more weight loss was observed ( $800^\circ\text{C}$ ), which because the rest were PASNPs content which was only silver metal.

**Antibacterial activity**

The antibacterial activity of biosynthesized PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> and PASNPs<sub>2</sub>, PRSNPs<sub>2</sub> samples are tested using different concentrations against a nosocomial via the modified disk diffusion method and the zone of inhibition obtained indicates that the PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> and PASNPs<sub>2</sub>, PRSNPs<sub>2</sub> exhibit antibacterial activity in a dose-dependent manner. At  $200$ , the PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> exhibit inhibition zones of  $1$  to  $3.5\text{cm}$  and the PASNPs<sub>2</sub>, PRSNPs<sub>2</sub> exhibit inhibition zone of  $1\text{ cm}$  to  $3.2\text{cm}$ . This work indicate that the antimicrobial activity of silver nanoparticles (SNPs) depends upon their size, that smaller the particle size inducing greater activity.

**Catalytic Degradation**

The catalytic activity of PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> and PASNPs<sub>2</sub>, PRSNPs<sub>2</sub> is evaluated in the presence of  $\text{NaBH}_4$  on various dyes such as MO, CR, and MB. The addition of  $\text{NaBH}_4$  alone to vital dyes does not change the absorption intensity of the dyes, as shown in suggesting that the dye degradation does not take place in the absence of PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> and PASNPs<sub>2</sub>, PRSNPs<sub>2</sub>. Methylene blue. PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> were added independently to this aqueous solution causes degradation of MB, which displays a decreasing trend in the absorption intensity. The complete degradation of MB was done within  $70$  and  $40$  min by PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> and PASNPs<sub>2</sub>, PRSNPs<sub>2</sub>, respectively. Of the two samples, PASNPs<sub>2</sub>, PRSNPs<sub>2</sub> exhibits a higher catalytic activity with Methylene Blue (MB). The effect of the smaller particle size was more in improving the catalytic properties. Congo red catalytically degraded by PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> and PASNPs<sub>2</sub>, PRSNPs<sub>2</sub> in the presence of  $\text{NaBH}_4$ . The intensity of the absorption peak at  $490\text{ nm}$  is reduced significantly in the presence of the PASNPs, PRSNPs, and the PASNPs<sub>2</sub>, PRSNPs<sub>2</sub> sample exhibits superior catalytic activity, causing a complete reduction of MR by  $75$ .



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Methyl Orange found to be 40 and 60 min for PASNPs<sub>2</sub>, PRSNPs<sub>2</sub> and PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> respectively and it seen that the PASNPs<sub>2</sub>, PRSNPs<sub>2</sub> exhibits better catalytic degradation of EB at 40 min, while the PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> sample shown the same degradation at 60 min. This slower activity of the PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> sample due to large particle size, which hinders the catalytic efficiency. The color degradation of all of the dyes used in this study in the presence of the PASNPs, PRSNPs is presented in Supplementary data. Of the two PASNP, PRSNP samples synthesized in this study.

Plumeria is of particular technological interest due to the synthesise and fixative capability of the plant parts like flower, bark and flower, but also to its protective or resistance to peculiar wood degradation agents. In this study, regular harvesting of Plumeria extract was readily obtained on monthly basis in 2016 as mother plants were stooled and pollarded. The air-dried extract subjected to mechanical and chemical extraction processes sequentially yielded appreciable quantity of  $5.67\% \pm 0.04$  ( $n = 4$ )  $\pm$  S.D. Storing of sample ensured fresh and sufficient quantity that can be explored for commercial use as Plumeria protectant.

**CONCLUSION**

Plumeria is an abundant resource that could provide a renewable alternative source of natural preservative. It imparted significant antimicrobial actions. Green silver nanoparticles were synthesized from Plumeria flower extract successfully by a methodology and they were added with catalytic and biological activities. Presence of phytochemicals were confirmed FTIR analysis that were involved in stabilization of nanoparticles. The green synthesized PASNPs and PRSNPs also displayed immensely powerful catalytic activity. A green-synthesis strategy was adopted in this study to avoid using hazardous chemical reducing agents. We synthesized silver nanoparticle samples of two different sizes, called PASNPs<sub>1</sub>, PRSNPs<sub>1</sub> and PASNPs<sub>2</sub>, PRSNPs<sub>2</sub>, using various concentrations of PAFE and PRFE. The size of the PASNPs controlled by varying within different concentrations of the sample extract, and thereby increasing their catalytic efficiency.

Among all July (leaf) PRSNPs<sub>1</sub>, October (leaf) PASNPs<sub>1</sub>, October (Bark) PRSNPs<sub>5</sub> and October (Flower) show best catalytic activity than others. PRSNPs<sub>1</sub> The green-synthesized silver nanoparticles exhibited size-dependent antibacterial activity where the small-sized leaf- PRSNPs<sub>1</sub>, bark-PASNPs and flower-PRSNPs<sub>1</sub> of displayed superior inhibition against microbes compared to that of PASNPs<sub>2</sub>, also shown significant size-dependent catalytic properties in carrying out the degradation of organic dyes. These simple biological procedures open new possible catalytic and biological models in material science with industrial applications. These simple ecofriendly silver nanoparticles can be considered in nanotechnology with promising catalytic and biomedical applications.

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**Conflict of interest**

We declare that we have no conflict of interest.

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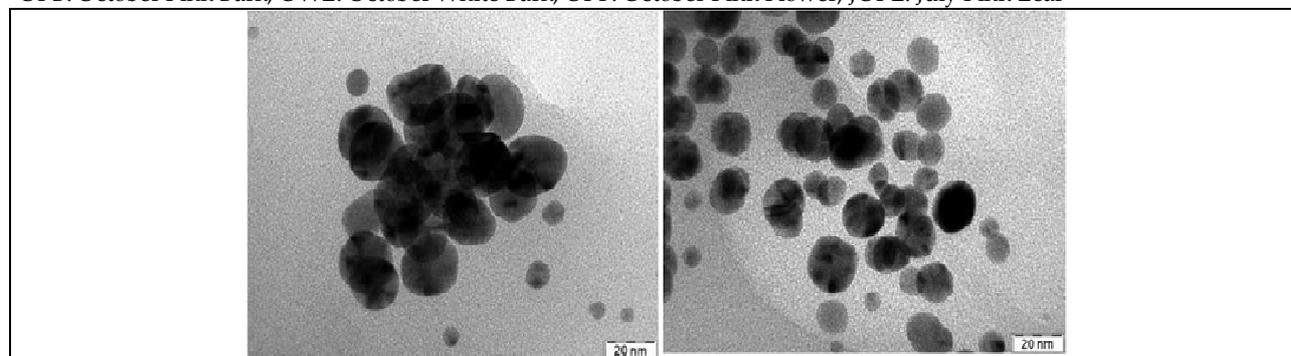
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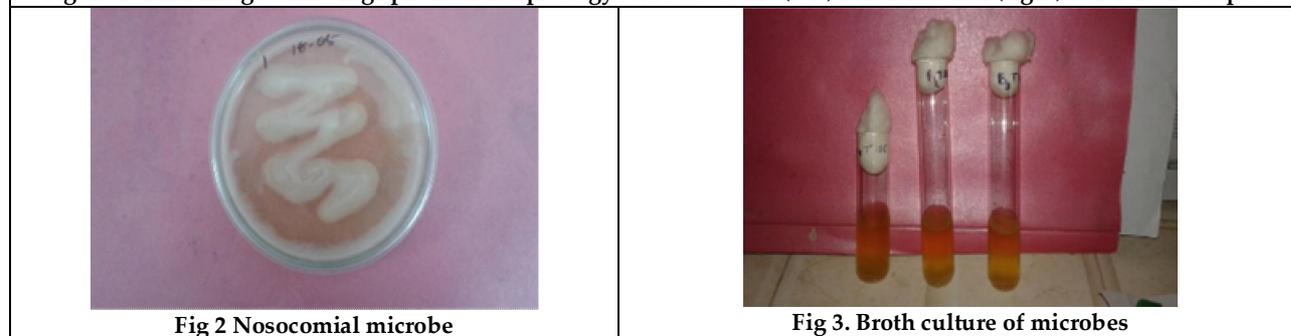
**Table 1. Catalytic degradation**

Methyl Blue				Congo Red				Methyl Orange			
Untreated		Treated		Untreated		Treated		Untreated		Treated	
Sample	O.D	Sample	O.D	Sample	O.D	Sample	O.D	Sample	O.D	Sample	O.D
		OPB	2.5			OPB	2.41			OPB	2.29
<b>Control</b>	2.5			<b>Control</b>	1.81			<b>Control</b>	2.20		
		OWL	2.5			OWL	2.41			OWL	2.24
		OPF	2.5			OPF	2.51			OPF	2.29
		JPL	2.5			JPL	2.41			JPL	2.29

\*OPB: October Pink Bark, OWL: October White Bark, OPF: October Pink Flower, JOPL: July Pink Leaf



**Figure 1. TEM images showing spherical morphology and size of the (left) PASNPs1 and (right) PASNPs 2 samples**





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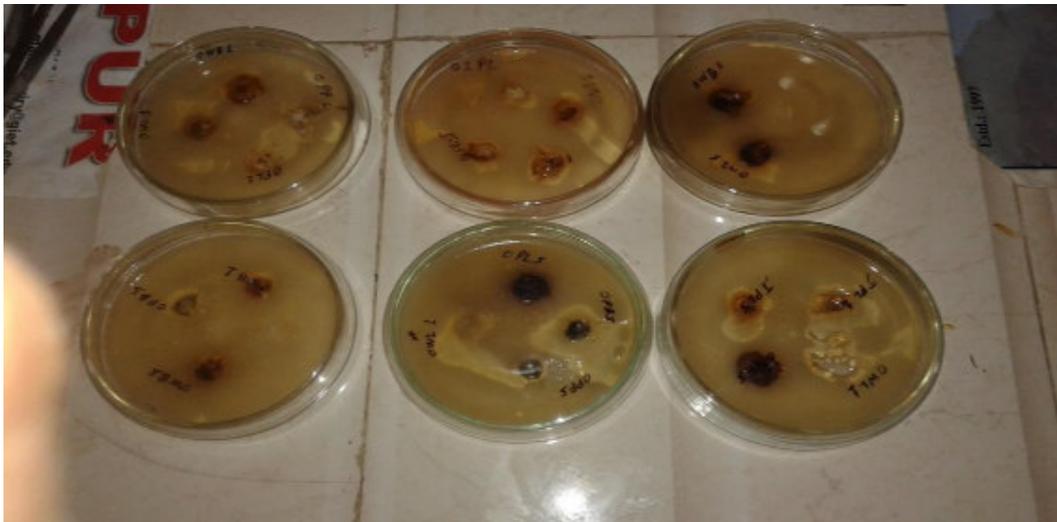


Fig 4. PASNPs and PRSNPs inhibit growth of microbes





## Effect of Classical Music Stimuli on Laying Performance and Egg Quality Characteristics of Duck (*Anas platyrhynchos*) & Swan Geese (*Anser cygnoides*)

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### ABSTRACT

The present investigation was carried out to determine the effect of music stimuli in laying performance and egg quality characteristics of duck (*Anas platyrhynchos*) and geese (*Ansercygnoides*). The study was conducted in the farm of CUTM campus from September 2019 to February 2020. The laying performance was assessed in both the bird species and egg quality was measured for internal and external parameters. A total of 90 ducks and geese were exposed to three types of treatments viz. Classical, Random and Control. Analysis revealed that geese and ducks exposed to classical music showed significant results with increased body weight than the control also the egg quality parameters. Although the results disclose comparable similar egg yolk weight and albumen with the weight of egg regardless of types of music consequences showed and proved that duck and geese barren with classical music significantly improved eating habits and increase the production rate with better egg quality which will help the normal management practices with good profit in those birds who are reared without music.

**Key words:** Classical music, Egg feed price ratio, External and internal egg quality characteristics, Feed conversion ratio, Random music

### INTRODUCTION

Music seems a more fundamentally human art form the most. The science of music's effect on animals and even plants reveals something startling. Music is therapeutic, it evokes memories and emotions of the birds as well as animals. The music specifically effect different reaction towards birds. These classical music tunes soothe and



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alleviate anxiety which will help to smoothen the experiment. It is just an art form when animals are introduced into classical music and when they are listening to slow jam produce more eggs and improve egg production by reducing the stress stimuli of birds. Commotion is a potential stressor to animals and has an important psychological component which provides a source of potential fear of animals (Campo, 2005). Classical music definitely has a more calming effect on them than random music. On the other hand, the positive physiological and psychological effects of music on humans are well known (Standley, 1986; Snyder and Chan, 1999).

Various types of music influence the laying performance and economic of quail production (Retallack, 2008; Morell, 2013; Lokuta, 2013; poultry hub, 2006). Different type of music influences the performance, egg quality, behavior and economics of raising Japanese quails (Cabara, 2017). Sonic booms did not initiate abnormal behavior that would result in decreased productivity in wild turkeys (Lynch and Speake 1978). Classical music intensity the auditory stimuli and reaction of the birds towards the music stimuli which enhances the birds to be more relaxed in their environment and provide the birds to lay eggs comfortably and stimulates the reproductive system for better egg quality and production performance (Morell, 2013). The slow tunes increases in the baseline steroid level when exposed to the stimuli was observed in white leg horns (Borg, 1981). The quality, shape and size along with the rate of production of eggs are important for commercial point of view. Normal production performance during its reproductive age it lays 100-110 eggs. Earlier, there is no report on effect of music on duck and geese. So, the study was conducted on *Anas platyrhynchos* and *Ansercygnoides* which belong to the order Anseriformes and family Anatidae of phylum Chordata.

**MATERIALS AND METHODS****Birds and experimental design**

The ducks (*Anas platyrhynchos*) and swan geese (*Ansercygnoides*) were distributed separately into three treatments during the experiments conducted from September 2019 to February 2020. A total of ninety, one-month old birds of both the breed were randomly assigned into the treatments with three replications comprising of five birds each (3 females & 2 males). The birds were reared in grower and cages with sound proof materials, furnished with drinking water and feeding troughs.

**Music and light management**

They were given three treatments, viz. Control (without music), Random music and Classical music. There were nine cages with 1 meter in length, 1 meter in width and 40 cm in height. They were kept at a distance of 5 meter from each other. Cages used in the study were cleaned and disinfected thoroughly. During experiment period music was played for 12hrs with speakers as source of music. Classical music soothes the vibration of body by giving positive vibes. It is the magnificent form of art planted in the traditions of both eastern and western culture including both secular and sacramental music. Birds were treated with Hindustani vocal and Beethoven music as well as chants as classical music. Random music included heavy metal, reggae, jazz, rock music was given for the experiment. These are all popular distinctive music of the generation and it gives a soulful distraction. The cages were provided with 10 watts LED bulb as source of light. Bulbs were turned on at 06:00 pm and turned off at 10:00 pm to maintain light and heat.

**Feeds and feeding**

Ad libitum feeding for birds in all treatments was practiced. At the beginning of the study, all the birds were fed with starter feed. After 20<sup>th</sup> day grower feeding was given to all birds. Shifting of feed was done gradually by considering the adapting capability of birds, feed was gradually converted to grower feed. At the 6<sup>th</sup> week of the study, feeds were gradually converted to layer feed which was recommended as per the regulation of CPDO, Bhubaneswar. In addition, fresh and clean water were also given ad libitum. The birds were taken care for proper management in a hygienic manner with suitable environment. Proper cleanliness with sanitation of the cages was done in order to prevent diseases.





## Data Collection

### Egg Production

#### % Bird-day production

The average number of eggs produced by duck and geese was determined by getting the ratio of the number of egg produced and the number of birds per replication the day the birds start laying eggs. The % bird-day production was calculated using this following formula:

$$\% \text{ Bird-day production} \times 100 = \frac{\text{total number of egg produced}}{\text{total number of birds}}$$

### Feed consumption

Feed consumption was estimated by subtracting the amount of feed refused from the amount of feed offered per cage. In addition, total and average feed consumption per replication was also collected.

### Feed conversion ratio

Feed conversion ratio (FCR) was obtained after 80 to 90 days of rearing. Calculation was done by dividing the feed consumption (total feed consumed divided to the number of birds per replication) by the dozen of egg.

### Egg quality

The characteristics include egg length, egg breadth, egg weight, yolk length, yolk breadth, albumen length, albumen breadth, shell weight and egg shell thickness of eggs laid by both duck and geese exposed to different types of music was also considered. All eggs laid during experimental period were subjected to egg quality test.

### Fertility rate

All eggs collected between 20<sup>th</sup> to 24<sup>th</sup> week were set in the automatic incubator for incubation and fertility test. Fertility rate was analyzed by dividing the number of fertile eggs by the total number of eggs set in the incubator multiplied by 100 the formula is given below.

$$\text{Fertility rate} \times 100 = \frac{\text{total number of fertile eggs}}{\text{number of eggs set in the incubator}}$$

### Hatchability rate

All fertile eggs remained in the automatic incubator for hatching. Hatchability rate was calculated by dividing the number of hatches by the total number of fertile eggs in the incubator multiplied by 100. The formula is presented below.

$$\text{Hatchability rate} \times 100 = \frac{\text{total number of hatches}}{\text{no.of fertile eggs in the incubator}}$$

## Economics

### Egg Feed Price Ratio

EFPR is the ratio between the receipts from egg and expenditure on feed. This was computed using the following formula: EFPR

$$= \frac{\text{total value of egg produced}}{\text{total value of feed consumed}}$$





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### Statistical Analysis

ANOVA (Analysis of variance) was used to analyze the significant differences in fertility, hatchability rate and egg quality characteristics. Data were estimated and analyzed by using PAST 3 software with one-way ANOVA and subsequently Tukey's Post hoc test.

## RESULTS AND DISCUSSION

The different parameters estimated in the performance of egg laying bird i.e. duck and geese during the growing and laying period including % bird-day production, feed consumption, feed conversion ratio (FCR) are presented in Table 1. External and internal parameters of eggs viz. egg weight, yolk length and breadth, albumen length and breadth, length and breadth of egg, shell width, shell thickness, fertility and hatchability rate exposed under different types of music are depicted in Table 2 and 3.

### Percentage Bird-day production

The average number of eggs produced by both the birds was determined by getting the ratio of the number of egg produced and the number of birds per replication the day the birds start laying eggs between 24<sup>th</sup> to 22<sup>nd</sup> weeks. Results showed significant ( $P < 0.05$ ) differences in the %bird-day production of duck exposed to random as well as classical music in comparison to the control. Ducks exposed to random music had significantly lower % bird-day production (73.3%) compared to the exposure to classical music (86.66%). The ducks which are not exposed to any kind of music was having 60% bird-day production and the difference was significant ( $P < 0.05$ ). Results revealed that geese which were exposed to classical music had significantly higher ( $P < 0.05$ ) % bird-day production with 66.66% compared to those geese which were exposed to random music with 33.33% and geese which are revealed to no music (control) is having 46.66%. Although birds exposed to random music showed less bird-day production than control the value was not statistically different. The higher egg production observed in the birds exposed to classical music than control may be attributed to their feed intake.

### Feed Consumption

Data presented in Table 1 revealed the feed consumption of both the birds to different types of music. In case of ducks the feed consumption for both random and classical music exposure was higher and highly significant over control ( $P < 0.05$ ) while the values for both types of music were at par. However in case of geese, listening to classical music resulted significantly more feed consumption (2842g/day) than control (2513g/day). These results were in line with the findings of Miclus (2011), Christopher (2011), Patricelli and Blickley (2006), and who mentioned that classical music results to regular eating and resting for a longer period without excessive movement which eventually lengthens the meal duration and more feed intake in comparison to the birds not exposed to any kind of music and noise. Similarly, Davila (2011) reported that layers provided with classical music reduces stress due to auditory enrichments, thus improves feed consumption.

### Feed Conversion Ratio

Feed conversion ratio (FCR) depends on the quantity of feeds needed to produce a dozen of eggs. The data revealed that random music was less efficient ( $P < 0.05$ ) in changing feeds into dozen of eggs compared to those exposed to classical in both the bird species. However, the values were statistically significant over control ( $P < 0.05$ ).

### Fertility and hatchability rate

In ducks the fertility (74.07%) and hatchability (80%) values for random music exposed birds were comparable to the control but significantly higher for classical music. However, in case of geese these values were significantly higher ( $P < 0.01$ ) for both types of music compared to the control. There is no direct study regarding the effect of specific music on the fertility and hatchability rate. Moreover, favourable background music helps like classical music cover





up loud noises keeping the birds more relaxed in their environment (Retallack, 2008) which helps the birds to comfortably lay eggs and activated the bird's reproductive system and made them lay eggs with thicker shell.

### External and Internal parameters of duck and geese

Table 2 presents the data on external and internal parameters of eggs in ducks. Result revealed that the external parameters viz. egg length, egg breadth, egg weight were significantly higher to control when exposed to classical music as well as random music in comparison to control. Egg shape index value and egg weight were at par for control and random whereas significantly higher in case of classical music ( $P < 0.001$ ). The yolk length, yolk height, albumen length values for both random and classical music were also significantly high in random and classical music. On the other hand although ANOVA revealed variation ( $P < 0.001$ ), albumen height was similar in all cases. Shell weight and thickness values were highly significant for both types of music ( $P < 0.001$ ) over control and there was difference between two types of music exposed birds. ANOVA revealed significant difference in all parameters among three types of treatments ( $F = 7.39$  to  $120.00$ ,  $P < 0.01$  to  $0.001$ ).

For geese there was significant difference in all parameters among three types of treatments ( $F = 5.23$  to  $80.443$ ,  $P < 0.05$  to  $0.001$ ). Classical music exposed geese excelled in all external parameters in comparison to control, while random music exposed birds showed intermediate values. In case of the yolk length, albumen length and height, there was clear difference among all the groups as they were separated by Tukey's LSD. There was no statistical difference between control and random music for albumen shape index while for other internal parameters both types of music significantly affected the geese for higher values. The shell weight and thickness were at par for both types of music and significantly higher over control ( $P < 0.01$ ). Thus exposure of classical music to both ducks and geese revealed positive effect on external and internal egg parameters.

### Economics

#### Egg Feed Price ratio (EFPR)

Egg-feed price ratio is used to indicate the relative profitability of egg production obtained by analyzing the relationship between egg prices and the cost of feed. This is calculated by dividing the total value of egg produced over total value of feed consumed, the EFPR of both duck and geese birds introduced to different types of music had relevantly higher ( $P < 0.05$ ) EFPR compared to birds not exposed to any kind of music. Results can be attributed to the significantly higher ( $P < 0.05$ ) egg production (i.e. % bird-day production), lower feed consumption and more efficient FCR of birds exposed to different types of music.

These findings was in line with Davilla, (2011), World poultry (2008) and Hopkins (2000) who reported that provision of music improved egg production and eventually improved the feed conversion efficiency compared to the normal management practices in egg laying birds reared without any supply of music. Observations made on egg laying, egg parameters and clutch size in Mallard *Anas platyrhynchos* (Mustafa shah, 2009). On the other hand studied the combined effect of music, environmental enrichment, and filial imprinting (Gvoryahu et al., 1989). (Ladd et al. 1992) reported that regular exposure to music (country or classical /jazz during 8h) reduce heterophil to lymphocyte ratio and grooming whereas it stimulate feeding and head shaking in laying hens. On the other hand exposure of meat type chicks to two different levels and kinds (rock and roll and dinner) of continuous music did not show any significant results on feed consumption (Christensen and Knight, 1975).

The study displays that classical and random music which is given to egg laying birds i.e. duck and geese are remarkably enhanced and upgraded in the average body weight. However the music helps in reducing the stress level and improved the psychological behaviour of egg laying birds so that the rate of production of eggs increases with its better egg quality. Increase in production and improved quality of eggs regain the economical status and return on investment. When the birds are revealed to musical environment gradually they become less aggressive as compared to when not introduced to any kind of music.





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**Table 1. Percentage bird-day production of both duck & geese raised under application of different type of music stimuli**

Type of music	% bird-day production	FC/day (g)	FCR/ dozen of egg	Fertility rate (%)	Hatchability rate (%)
<b>DUCK</b>					
No music(Control)	60.00	2399	199.91	76.19	81.25
Random music	73.30	2633	219.41	74.07	80
Classical music	86.66	2799	233.25	86.66	92.30
<b>GEESE</b>					
No music(Control)	46.66	2513	209.41	72.22	83.07
Random music	33.33	2656	221.33	80	88.33
Classical music	66.66	2842	236.83	83.33	95

**Table 2. Internal and external parameters of egg laid by duck (*Anas platyrhynchos*) in response to music stimuli (Mean  $\pm$  SEM)**

Parameters	Musical stimuli			F value	P value
	Control	Random	Classical		
Egg length (cm)	4.410 <sup>A</sup> $\pm$ 0.199	5.260 <sup>AB</sup> $\pm$ 0.117	5.720 <sup>B</sup> $\pm$ 0.053	23.714	0.001
Egg breadth (cm)	3.100 <sup>A</sup> $\pm$ 0.140	3.726 <sup>B</sup> $\pm$ 0.083	4.158 <sup>C</sup> $\pm$ 0.026	31.19	0.001
Egg shape Index	70.289 <sup>A</sup> $\pm$ 0.022	70.836 <sup>A</sup> $\pm$ 0.021	72.715 <sup>C</sup> $\pm$ 0.307	51.124	0.001
Egg weight (g)	41.037 <sup>A</sup> $\pm$ 0.200	42.302 <sup>AB</sup> $\pm$ 0.199	44.022 <sup>B</sup> $\pm$ 0.206	14.906	0.01
Yolk length (mm)	5.410 <sup>A</sup> $\pm$ 0.108	5.814 <sup>B</sup> $\pm$ 0.030	5.976 <sup>B</sup> $\pm$ 0.040	17.886	0.001
Yolk height (mm)	1.057 <sup>A</sup> $\pm$ 0.012	1.082 <sup>B</sup> $\pm$ 0.013	1.125 <sup>B</sup> $\pm$ 0.013	7.39	0.01
Yolk shape Index	0.183 <sup>B</sup> $\pm$ 0.002	0.173 <sup>AB</sup> $\pm$ 0.002	0.168 <sup>A</sup> $\pm$ 0.002	14.341	0.001
Albumen length (mm)	2.992 <sup>A</sup> $\pm$ 0.020	3.220 <sup>AB</sup> $\pm$ 0.019	3.488 <sup>B</sup> $\pm$ 0.027	120.66	0.001
Albumen height (mm)	0.153 <sup>A</sup> $\pm$ 0.002	0.180 <sup>A</sup> $\pm$ 0.004	0.212 <sup>A</sup> $\pm$ 0.004	75.522	0.001
Albumen shape index	0.051 <sup>A</sup> $\pm$ 0.001	0.056 <sup>AB</sup> $\pm$ 0.001	0.061 <sup>B</sup> $\pm$ 0.001	21.323	0.001
Shell weight (mg)	18.712 <sup>A</sup> $\pm$ 0.060	19.275 <sup>B</sup> $\pm$ 0.032	19.498 <sup>C</sup> $\pm$ 0.043	76.203	0.001
Shell thickness (mm)	0.518 <sup>A</sup> $\pm$ 0.013	0.603 <sup>B</sup> $\pm$ 0.015	0.655 <sup>C</sup> $\pm$ 0.016	22.181	0.001





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**Table 3. Internal and external parameters of egg laid by *Anser cygnoides* in response to music stimuli (Mean  $\pm$  SEM)**

Parameters	Musical stimuli			F value	P value
	Control	Random	Classical		
Egg length (cm)	8.065 <sup>A</sup> $\pm$ 0.217	8.453 <sup>AB</sup> $\pm$ 0.075	8.855 <sup>B</sup> $\pm$ 0.101	7.425	0.01
Egg breadth (cm)	5.354 <sup>A</sup> $\pm$ 0.056	5.764 <sup>B</sup> $\pm$ 0.038	6.292 <sup>C</sup> $\pm$ 0.078	62.61	0.001
Egg shape Index	66.758 <sup>A</sup> $\pm$ 1.666	68.247 <sup>AB</sup> $\pm$ 0.844	71.081 <sup>B</sup> $\pm$ 0.687	5.23	0.05
Egg weight (g)	111.080 <sup>A</sup> $\pm$ 0.210	112.812 <sup>AB</sup> $\pm$ 0.152	114.328 <sup>B</sup> $\pm$ 0.202	73.309	0.001
Yolk length (mm)	5.850 <sup>A</sup> $\pm$ 0.049	6.373 <sup>B</sup> $\pm$ 0.083	6.765 <sup>C</sup> $\pm$ 0.049	53.894	0.001
Yolk height (mm)	1.567 <sup>A</sup> $\pm$ 0.019	1.763 <sup>B</sup> $\pm$ 0.026	1.882 <sup>B</sup> $\pm$ 0.019	54.223	0.001
Yolk shape Index	0.254 <sup>A</sup> $\pm$ 0.002	0.277 <sup>B</sup> $\pm$ 0.003	0.288 <sup>B</sup> $\pm$ 0.004	29.498	0.001
Albumen length (mm)	12.825 <sup>A</sup> $\pm$ 0.041	13.395 <sup>B</sup> $\pm$ 0.087	14.028 <sup>C</sup> $\pm$ 0.065	80.443	0.001
Albumen height (mm)	0.313 <sup>A</sup> $\pm$ 0.007	0.379 <sup>B</sup> $\pm$ 0.009	0.457 <sup>C</sup> $\pm$ 0.013	51.209	0.001
Albumen shape index	0.024 <sup>A</sup> $\pm$ 0.001	0.028 <sup>A</sup> $\pm$ 0.001	0.033 <sup>B</sup> $\pm$ 0.001	30.043	0.001
Shell weight (mg)	21.077 <sup>A</sup> $\pm$ 0.136	22.628 <sup>B</sup> $\pm$ 0.117	22.888 <sup>B</sup> $\pm$ 0.088	72.006	0.001
Shell thickness (mm)	1.441 <sup>A</sup> $\pm$ 0.010	1.487 <sup>AB</sup> $\pm$ 0.009	1.548 <sup>B</sup> $\pm$ 0.013	24.26	0.001





## Growth Performance of *Penaeus monodon* (Marine Water Prawn) under Different Feeding Supplements

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### ABSTRACT

This paper provides a brief summary of information on growth performance of *P. monodon* under different feeding supplement. The nutritional requirements of *P. monodon* have been little known despite its importance in aquaculture. Recent findings indicate a noticeable difference between some important nutrient requirements of *P. monodon* and *P. japonicus*, the most studied shrimp species. For example, the thiamin requirement for *P. monodon* was estimated to be 14 mg/kg diet, while for *P. japonicus* it is 60-120 mg/kg diet for juveniles and 40-80 mg/kg diet for larvae. The same contrast was also observed in the requirements of riboflavin (22.5 mg/kg in juvenile *P. monodon* vs. 80 mg/kg in larval *P. japonicus*), niacin (6.4 mg/kg vs. 400 mg/kg) and vitamin C (2,000-2,500 mg/kg vs. 10,000 mg/kg). Research efforts to understand the lack of ability for shrimp to effectively use dietary crystalline amino acids have resulted in the development of a microencapsulated amino acid that can be assimilated by *P. monodon* which is incapable of utilizing the essential amino acid in crystalline form. This development enables the quantification of requirements of the amino acid and other essential amino acids for shrimp. A study using cellulose-acetate-phthalate encapsulated arginine indicated that the arginine requirement of postlarval *P. monodon* is 5.47 g/100 g protein (2.50 g/100 g diet). Other aspects concerning the importance of digestive enzymes, dietary requirements of protein, carbohydrate, lipid and vitamin, energy and larval feeding for *P. monodon* were reviewed.

**Key-words:** Substrate, *Penaeus monodon*, Periphyton, Brackishwater shrimp, Conventionally





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## INTRODUCTION

Freshwater prawn culture has now occupied a significant position in inland aquacultural practices. Although India has marine water resources for aquaculture, these are generally being exploited for carp and other finfish culture that's too in a limited scale as discussed by Ramesh et al, 1991 [1]. Tiger shrimp, *Penaeus monodon*, were cultured in commercial ponds and fed diets with or without supplementations of a novel microencapsulated organic acid blend. Over 22 weeks, shrimp growth and various water quality parameters of the ponds were measured. At various intervals during the grow-out period, these farm-raised shrimp were transferred to the laboratory and two separate experiments were performed to determine nutrient utilization efficiencies and subsequent resistance to *V. harveyi*. With the incorporation of more controlled laboratory-based experiments using farm-raised shrimp, this helped provide a broader complement of data to the pond trial and a unique opportunity to assess the potential of dietary organic acids to the shrimp aquaculture industry. *Penaeus monodon* is found at depths from 0 to 110 m, inhabiting bottom mud and sand. Giant tiger prawn live in brackish, estuarine (juveniles) and marine (adults) environments. It is even grown commercially. *Penaeus monodon* appears to select muddy mangrove channels and often associates with marginal or floating vegetation *Penaeus monodon* are generally dark coloured, with the carapace and abdomen transversely banded with black and white. The rest of the body is variable, ranging from light brown to blue or red, while some smaller specimens show a dull red dorsal strip from the rostrum to the sixth abdominal segment.

## MATERIALS AND METHODS

### Experimental Ponds

Black tiger shrimp, *Penaeus monodon fabricus* was cultured for 110 days between December 2019, January, February and March of 2020 in twelve earthen ponds (0.5 ha or 5000 m<sup>2</sup> each) randomly selected in kasia shrimp farm (Basudevapur, Bhadrak, Odisha, India). Three ponds each were used to culture the shrimp for different feeding frequencies: (i) 3 times (T1), (ii) 4 times (T2), (iii) 5 times (T3), and (iv) 6 times (T4) day<sup>-1</sup>. Ponds were selected for each treatment following the random block design (RBD). All the experimental ponds were rectangular in shape with facility of both inlet and outlet structures with average of 1.2 meter water depth. Soil was clayey loam and aeration was maintained for all ponds during the culture period.

### Rearing in ponds

Similar pond management practices like sun drying, tilling, liming, and eradication of predators were performed once prior to water filling in all the experimental ponds during culture. Culture techniques and inputs were same for all ponds of four treatments. The ponds were ploughed conventionally and limed (1.5 ton ha<sup>-1</sup>) to improve the soil condition alkaline. Initial water filling in ponds was done directly with water pumped from Haldi rivercreek after being filtered by fine mesh bag net of 300 micron and chlorination (30 ppm with 60% active ingredients) was done for disinfection and killing of pathogens. After three days of dechlorination, organic fertilizers (poultry litter @ 250 kg ha<sup>-1</sup>) and inorganic fertilizers (urea @20 kg ha<sup>-1</sup>; single super phosphate @ 5 kg ha<sup>-1</sup>) were applied to improve the primary productivity of the cultured ponds. Routine application of urea @6 kg ha<sup>-1</sup> and single super phosphate @2 kg ha<sup>-1</sup> were performed twice a month to maintain development of natural food.

Agricultural lime and dolomite each were applied once a month @ 50 kg ha<sup>-1</sup> during production period. No water exchange was done during initial 20 days and later it was limited to 0-10% in every alternate days from pre-treated reservoir. During raining, only surface draining was maintained to retain salinity. Good quality and disease-free post larvae of 20 days old (PL) of *P. monodon* were procured from a private hatchery (Vaisakhi Hatchery, A.P., India), then acclimatized and stocked @ 20 pieces m<sup>-2</sup> in all the ponds where water quality were almost in same ranges within aquaculture standard (temperature 28.4-28.6°C, dissolved oxygen >4.0 mg l<sup>-1</sup>, pH 7.9-8.1, Secchi's disc transparency 35-45 cm and salinity 7-8 g l<sup>-1</sup>). Harvesting happened after 110 days of culture as per market demand and good quality of shrimps. A bag net was fitted on outlet canal with 20 # mesh (pore size) of width 1 meter and



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length of 4 meter. The water level in the pond was reduced to 60 -70 cm and outlet was opened and shrimp was caught at night, collected with ice and sold to processors on farm-gate price.

**Shrimp seed procurement and stocking**

A survey revealed that 93 percent of the farmers procured *Penaeus monodon* seed through a contract system whereby farmers purchase quality seed in bulk. The farmers enter into an agreement with a hatchery operator one month in advance of delivery. Seventy percent of the seed used in the traditional extensive farming systems were procured from commercial hatcheries, and rest were sourced from the wild as described by Ramaswamy et al 2013 [3]. In the modified extensive farming systems and the semi-intensive farming systems, the seed was sourced exclusively from commercial hatcheries. Farmers procure seed from local hatcheries that are in close proximity to their farms (<8 hrs transportation time). When the transportation time exceeds four hours, the PL are stocked directly into the ponds during the early morning hours. When the transportation periods are less than four hours, the PL are stocked during the late evening. After 45 days, survival estimates are made. These are based on feed consumption rates (using feed trays), and cast net sampling. Until the survival estimations have been made, 80 percent of PL are assumed to have survived, and feed rates are adjusted accordingly.

**Feeding management****Nutrient requirements**

Little is known about the nutrient requirements of *Penaeus monodon*. Like any other organism, however, prawns need nutrients or substances that will provide for normal growth, regulate body processes, and increase resistance to diseases. Shrimps were fed with standard commercial palletized feeds (crude protein-38.35%, Crude fat-7.75%, Crude fiber-3.36%, Total ash-14.25%, calcium-2.2-2.5% and phosphorus-1.5-1.8%) and applied as prescribed by feed company. The feeding regime (frequency, time of feeding and percentage ration) for cultured shrimp was presented in Table 1.

**Farm made feeds**

While twenty percent of the extensive farms reported using farm-made feeds, the study also revealed that 98 percent of the shrimp farmers used manufactured, sinking dry pellets in combination with farm-made feed. Only 20 percent of the extensive farms (<2 percent of the total farming area in the country) were using farm-made feeds; the other 80 percent of the extensive farmers, and all of the modified extensive farms and semi-intensive farms used manufactured, sinking pelleted feeds. The natural food was replenished by regular water exchange during high tide periods. On the smaller modified extensive farms, farm-made feeds were used and were primarily comprised of mixtures of boiled rice, maize and potatoes. During the first month of the production cycle, there was no feeding and the shrimp depended solely on natural pond productivity as discussed by Asaduzzaman et al 2010 [2]. In the second month feed was provided once per day, up to a maximum of 7.5 kg/ha. Groundnut, rice bran, wheat cake and egg yolk were used as ingredients. From the third month, feeding was based on the size of the shrimp, and a minimum of 7.5 kg/ha was fed per day.

**Industrially manufactured pelleted feeds**

India has a well-established capacity to produce shrimp aquafeeds. Prior to 1990, when the manufacturing aquafeed industry was in its infancy, the country relied on farmmade feeds. In the early 1990s, the large quantities of shrimp feeds were imported from Taiwan Province of China and Thailand. Over time, these imports had gradually been replaced by domestically produced feeds. Currently, the capacity of domestic shrimp feed production exceeds the demand.



**Raka Chandrika Panda and Yashaswi Nayak****Feed materials**

The manufactured aquafeeds which were reported during the survey, contain approximately 40 essential nutrients. About 20 to 40 percent of the total ingredients used in commercial shrimp feeds, are derived from marine capture fisheries, which include fishmeal, fish oil, shrimp/crustacean meal, squid meal and other miscellaneous products, such as fish, fish silage, fish/squid-liver meals and seaweed extracts. The principal classes of raw materials that are currently used in the shrimp aquafeeds can be classified as:

- Cereals and cereals by-products.
- Leguminous seeds.
- Vegetable oil residues.
- Animal by-products and oils.
- Miscellaneous ingredients, including vitamins and minerals.

**Diet development**

There are two categories of protein sources: animal and plant. Since prawns tend to be carnivorous, it is suggested that two-thirds of total protein come from animal sources and one-third from plant sources. Likewise, there are two sources of lipids: animal and plant. Of the animal fats, those from marine sources like fish liver oils are preferable. A pelletized artificial diet might be easy to prepare but whether or not the food is attractive and acceptable to the prawn is another problem to consider. Unlike fish that gulps on or swallows its food, *P. monodon* is a nibbler and hence requires a pellet that is stable in water for six or more hours. The effectiveness of a prepared diet is usually expressed in terms of food conversion ratio (FCR) or feed efficiency. This is the amount of dry feed that will produce a unit of wet weight gain.

The vitamin-mineral premix for poultry may not be the best combination but it can be utilized in the absence of concrete findings on the vitamin-mineral requirement of prawns under tropical conditions. The premix should contain Vitamin C which is good for prawn. The other vitamins needed in the mix were A, D, E, K, B1, B2, B6, B12, pantothenic acid, choline, inositol, and folic acid. The minerals calcium, phosphorus, potassium, iron, magnesium,

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It is advisable to have all feedstuffs chemically analyzed.

**RESULT**

For several decades, traditional farming has been practiced in Odisha. In February, ponds are filled during high tide, and PL that are either wild-caught or sourced from hatcheries are stocked at 15 000/ha. After two months of culture partial bi-weekly harvesting starts; 7 500 PL/ha are stocked immediately after each partial harvest and the final harvest takes place after approximately 10 months. The farmers procure seed from commercial nurseries that are supplied with PL from the hatcheries. The dependence on commercial nurseries for seed in Odisha is due to the small quantities that the farmers require to stock their ponds. Farmers feel it is not feasible for them to procure PL directly from the hatcheries because they would be required to purchase large numbers of animals. The production cycle in this system is approximately 10 months. The following tables bring the exact composition of needed supplements from both plants and animal sources as described by Ahmad Ali et al (1992) [4]

**Feeding regimes**

Artificial feeding could start immediately after stocking when natural food was lacking in the pond or when the pond was highly stocked (50,000 and above) as in intensive farming. When feeding, the suggested amount of feed was 10% of the total body weight.





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The suggested feeding schemes and schedules at a stocking density of 25,000/ha were shown below;

1 – 30 days = 10% of body weight

31 – 60 days = 8% of body weight

61 – 90 days = 6% of body weight

91 – 120 days = 4% of body weight

#### Determination of growth and feed utilization efficiency

Cast net was used to measure the growth rate of shrimps during early hours. Shrimps were sampled every fortnight by cast net for monitoring the growth, survival and health conditions of shrimp and for estimation of production yield in the experimental ponds. During stocking average weight of post larvae (PL20) was 0.02 gm and the first sampling was taken after 15 days of grow out phase from four locations of each pond. The average body weight (ABW) was measured at fortnightly intervals till harvest. For measuring ABW, 100 samples of shrimp collected by cast net randomly & mean weight was calculated. For estimation of survival, measured cast net was thrown to ponds randomly 4 times and density calculated as per available shrimps in cast net and total pond area in relation to initial stocking density. FCR (Feed conversion ratio) is calculated as total feed utilized divide by total shrimp yield. Survival, FCR, yield were calculated from 45 days onwards as shrimps were smaller in size. Weight gain (WG), FCR and specific growth rate (SGR) was measured as per conventional method in every fifteen days. Protein efficiency ratio (PER) and feed efficiency ratio (FER) were estimated by routine methods and ABW, survival rate and production yield were calculated. Health conditions were recorded during same samplings for gut and abnormalities. Samplings of shrimps were regularly performed every 15 days until harvest. The formulae to calculate different parameters are as follows:

Average body weight (ABW) = Total weight of 100 shrimps (g) / 100

Weight gain (WG) = Final weight - initial weight

Food conversion ratio (FCR) = Total feed consumed (kg) divided by total yield (kg)

Survival rate = Average no. of shrimps taken/cast net area (m<sup>2</sup>) × pond area (m<sup>2</sup>) × 100/number of post larvae stocked

Specific growth rate (SGR) = 100 multiplied by (W<sub>f</sub> - W<sub>i</sub>)/ period (days) [W<sub>f</sub> = final weight; W<sub>i</sub> = initial weight]

Protein efficiency ratio (PER) = Weight gain (wet)/Protein fed

Feed efficiency ratio (FER) = Final weight - initial weight / total feed intake

Production yield = Survived shrimps number multiplied by ABW

#### RESULT

Feeding was administered according to their body weight and days of culture in a fixed quantity in all treatments (Table 2). Small post larvae were fed two times a day (1-15 days) for providing more availability of feed and they are accustomed to feed on natural foods; slowly increased to three times a day as it grows bigger (16-44 days). Later (45-110) feeding was followed as mentioned in Table. 2 for the experiment that was pallet feed with more quantity. Feed was broadcasted by rope method, i.e., floats tied and moved with rope in lines horizontally in all ponds. Aeration (4-10 hours as per biomass) was kept off for two hours during feed application.

#### DISCUSSION

Water quality parameters during the experimental period are presented in Table 2. The recorded water quality parameters were within the acceptable ranges for brackishwater shrimp culture. Comparatively lower level of total ammonia nitrogen (TAN), NO<sub>3</sub>-N, NO<sub>2</sub>-N and PO<sub>4</sub>-P were observed in substrate based system while no significant difference was noticed among the experimental ponds. This may be attributed to the fact that low stocking density in the present field trial might have kept the water nutrient parameters within the favorable limit in both the treatments. Provision of substrate increased the transparency (p<0.01) and reduced the turbidity (p<0.05) in



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treatment ponds compared to control. This is similar to our earlier findings where a lower turbidity level was noticed in substrate based system as substrate reduces turbidity by trapping suspended particles. Chlorophyll content in the water column is presented in Fig 1. Average chlorophyll a levels in water column were  $15.22 \pm 6.97$  and  $19.06 \pm 8.68 \mu\text{g L}^{-1}$  in substrate and control ponds respectively. Level of chlorophyll a in control ponds showed fluctuation throughout the culture period, and coincided with algal bloom and algal crashes. Similarly, comparatively lower gross primary productivity,  $235 \text{ mg C m}^{-3} \text{ h}^{-1}$  was recorded in substrate based system compared to control ponds ( $258 \text{ mg C m}^{-3} \text{ h}^{-1}$ ). The present findings are in line with the earlier reports where lower level of primary productivity, chlorophyll a and phytoplankton level in the water column were reported in substrate based culture ponds.

**Feed additives**

Seventy-five percent of the respondents were reported using probiotics and feed additives. The use of these additives was dependent upon stocking densities. There was an increase in the use of probiotics and feed additives as the stocking densities increased. No feed additives were used at stocking densities lower than 3-4 PL/m<sup>2</sup>.

**CONCLUSION**

From the above determination, it can be concluded that *P. monodon* reared in substrate based systems had higher biomass and lower FCR compared to shrimps grown in substrate free ponds. Periphytic community developed over the submerged substrate served as quality natural food for shrimps. Regression coefficient closer to isometric value and better Fulton condition factor observed in substrate based treatments reflects better feed utilization and suitable culture environment. Amount of utilization of periphyton by *P. monodon* at higher stocking density and utilization of periphyton at different life stages of black tiger shrimp is a subject of further research.

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Fig. 1 Experimental ponds



Fig. 2 Pond before harvest.



Fig. 3 *Penaeus monodon* after harvest.



Fig. 4 Growing Stage of *P. monodon*





## Studies on Calcium Profile of Some Locally and Commonly Consumed Food Stuff, Dhenkanal, Odisha, India

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### ABSTRACT

Calcium designated as supernutrient in human body by performing vital role. Many serious complications like porous and fragile bones, decay of tooth, cramps in muscle and osteoporosis are result of inadequate intake of calcium. Calcium source for humans is through diet. Therefore, this present study was undertaken for determination of "Calcium profile of locally and commonly consumed food stuff of Dhenkanal (Odisha)". Twenty five foods from five food groups were analysed for their calcium content by EDTA titration. Calcium content in different foods ranged from 8-1145 mg/100g. Pulses and fishes contained the highest calcium content while fruits had the lowest calcium content. Top five foods for Calcium were Puntius sophore (1145 mg/100gm), Marcotylomauniflorum (297mg/100gm), Labeocatla (182mg/100gm), Vigna radiate (152mg/100gm) and Cajanuscajan (145mg/100gm). These outcome results were compared with values reported in the literature.

**Keywords:** Calcium content, Calcium deficiency, EDTA Titration, Fish, Nutrition, Osteoporosis, Staple food

### INTRODUCTION

Minerals like calcium is an essential chemical element for animals to perform various functions of life which make up about 1-2% of body weight of an adult human being [1]. Calcium contribute in maintaining human body health by making the bone and teeth healthy and also act as a mediator of biological processes like muscle contraction secretion, glycolysis, gluconeogenesis, cell division, transportation of ion, cellular growth [2]. A natural tranquilizer is calcium as it calms the nerves of body. Body energy and immune system promoted by calcium. Calcium ion of blood affect the hormone level of body. Inadequate amount of calcium intake causes calcium level depletion and leads to thinning and weakening of bones and osteoporosis. This condition known as Dietary Calcium Deficiency [3].



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Every human being loses bone density between 30-40 age, mostly elderly women above 45 age group [1]. Tetany is initial stage of calcium deficiency, which may be identified by numbness in bones, cramps in muscle, arm and leg muscle tingling. The most common calcium deficiency sign seen in nails, skin, teeth and bones. Cramping during menstrual cycle or changes in menstrual flow indicate that woman suffering from severe calcium deficiency [4]. Calcium deficiency occurs when the bones become weakened or fractured which indicates towards osteoporosis. Osteoporosis is a condition where the bones are porous and fragile because of depletion of calcium level from them. Joint pains, increasing cholesterol level of body, impaired growth, numbness of fingers, arms and legs, joint pains, muscle cramps, irritability of nerves, insomnia, abnormal hormone regulation are common [5]. Good sources of calcium include dairy products, leafy green vegetables, certain fish, oatmeal and other grains, cabbage, summer squash, green beans, garlic, sea vegetables and calcium-fortified foods such as cereals and fruits. Other than that olive oil, soy beans, blueberries and foods rich in omega-3s, like fish oil and flaxseed oil may also have bone boosting benefits [6].

Many small, indigenous fish are important for nutrition because they can be eaten as whole, with bone, head and eye, so that it can provide sufficient calcium and other micronutrients required for human. Small indigenous fishes with a maximum length of 25-30 cm in mature or adult stage of their lifecycle can provide about 30% of total calcium content requirement of an adult human [7]. Fish bone fortification into the main food diet is effectively accepted as it is a cheaper way for providing the daily need for a range of vitamins and minerals that is mainly calcium [8]. The aim of this study is to examine the relationships of health beliefs to calcium intake of human especially women. Identification of amount and relationships of calcium concentration among the staple foods adds to existing calcium concentration knowledge concerning individuals that are at high risk for developing osteoporosis. This knowledge could be used by people in developing creative interventions to effectively modify complex lifestyle practices.

**MATERIALS AND METHODS**

**Collection of samples.** All samples were purchased in the open market in Dhenkanal, Odisha, India. They represent fruits and vegetables as bought by the ordinary consumer. No information about the genetic history of the fruits, vegetables, cereals, pulses and fishes could be obtained. Most of them are, however, not truly native, but were imported samples. Twenty five different food items were collected from local open market and retail stores of Dhenkanal, Odisha, India. **Sample preparation.** The samples investigated for calcium content at Dhenkanal Autonomous College, Dhenkanal. The samples were collected separately from market by clean polythene zipped bags through which contamination could be avoided during the transportation to the laboratory. The samples were stored in refrigerator in the laboratory at 4°C. These samples were digested and analysed within 15 days from the time of collection from local market. Ten staple fishes were washed and boiled separately in distilled water for 30 minutes. The flesh attached to fish was cleaned manually from fish bone and washed with water. Then they were dried in the oven at 100°C for 1 hour by the method of Amitha et al. 2019 [9]. Then samples were kept under direct sunlight for about 12 days. The sample bones were then powdered by using a pestle and mortar at laboratory. The sample fish bone powder was kept in container at room temperature. The calcium content was determined.

**Digestion of sample.** The samples were estimated for calcium content by using standard procedures reported by Lawani et al., 2014 [1]. All the samples were digested by a mixture of conc. nitric acid, sulphuric acid and Hydrogen peroxide. Five grams of each food stuff was put in heat-resistant conical flask. Conc. sulphuric acid (8ml) along with nitric acid (10ml) was added to that flask containing food stuff. The flask was placed in heater and warmed cautiously. **Preparation of solution.** After vigorous heating of the flask the solution began to darken or char. 2cm<sup>3</sup> aliquot of conc. nitric acid was added constantly to avoid charring of the solution at any time the solution began to darken. Addition of conc. nitric acid was continued until the solution stopped darkening on prolonged heating. At this point, the solution was made to cool down and diluted with distilled water (10ml) and boiled to fuming. This boiling to fuming was repeated twice with distilled water (5cm<sup>3</sup>). Addition of hydrogen peroxide (2ml) with drops of



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nitric acid allowed the persistent colour of solution were being cleared. Until there were no further reduction of pale yellow colour was obtained, the solution was heated to fuming state each time with hydrogen peroxide. The solution was allowed to be cool with distilled water (10ml) and made evaporated to fuming once again. Until there was no more fuming this step was continued, then the solution was made up to mark in 100ml volumetric flask. Estimation of calcium by trimetry. Each digested sample (50ml of aliquot) was pipetted into conical flask. pH was adjusted to 12 by 1M NaOH and then solochrome Dark Blue (4 drops) was added. After which the aliquot was immediately titrated against 0.01M EDTA solution to the end blue point.

**RESULT AND DISCUSSION**

The range of calcium content (mg/100g) of twenty five samples analysed are given in Table 1. Out of all staple food stuffs which Pool barb (*Puntius sophore*) (1145mg/100gm) (Figure-2) seen to contain highest calcium content and Banana (*Musa acuminata*) (8mg/100gm) observed to contain lowest calcium content among all. Pulses contribute more calcium than fishes, fruits and vegetables. The total calcium content contributed by pulses is 990mg/500g which make up 43% of total calcium content of all food items. Fishes contribute almost similar to pulses which is 980.5mg/500gm and make up 42% of total calcium content. Fruits contribute 90mg/500g of calcium content which is 4% of total calcium content. Whereas Vegetables contribute about 6% of calcium content which is 137mg/500g, showing in Graph 5. Table 1. Show that all the indigenous fishes contribute remarkable amount of calcium and out of which *Puntius sophore* (1145mg/100gm) contribute highest whereas *Rastrelliger branchy soma* (15gm/100gm) (Figure-5) contribute the lowest calcium content among all fishes and make up 41% and 0.5% in total calcium content respectively. Graph 1

Among pulses (Figure-7) *Marco tyloma uniflorum* contribute 297mg/g out of total pulse content, which is about 46% of the total pulse content, whereas among fishes *Puntius sophore* make up 60% of total fish calcium content with 1145mg/g of calcium. Among Fruits, *Citrus sinensis* contribute 38mg/g of total fruit calcium content which is 42 % of total fruit calcium content. In case of vegetables *Phaseleous coccineus* contribute about 29% of total vegetable calcium content. There were pulses and Cereals were taken into consideration which are two type of rice and three kinds of dal. The two type of rice are of almost same kind but only differ in the after cultivation processing method. Out of these two rice one is parboiled rice, which involves partial boiling of the paddy before milling to increase the nutritional value. White rice is the milled and polished rice which decrease the nutritional value. In that connection parboiled rice contain more calcium content than the white rice. So calcium content shows parboiled rice > white rice. Shows Table 1., but all dal items contain more calcium content than both the rice item. The present work elucidated on the calcium profile of some staple food stuff which are used commonly and has broadened our knowledge on the calcium content of food item like fishes, fruits, vegetables, cereals and pulses.

Lawani et al., 2014[1], investigated the calcium content nine staple food items of their locality and commonly consumed food items which was collected from six towns in North-Central Nigeria by titration. Their work shows much larger variation in calcium content of food items of vegetables and fruits like, *Phaseleous coccineus* and *Musa acuminata* (Table 2) whereas in our work it was 73.68% and 68% higher respectively. But other than cereals food items like parboiled rice show less variation. Their work evaluates calcium content of parboiled rice was evaluated 9.67% higher than our result. (Table 3) Saini and Devar, 2012[10], reported calcium content of locally and commonly consumed food analyzed for their calcium content by AAS of Kurukshetra (Haryana). The reported values of food items are not that much variable expect fruits like *Psidium guajava* and *Malus domestica*. The reported value of *Phaseleous coccineus* by Saini and Devar, 2012, was almost similar to the calcium content of this experiment, which means it is just 0.73% difference between these two content values.

In Table 3., Cunningham et al. 2001<sup>[11]</sup> reported mean calcium content in food samples. All the food samples studied by him contained lower percentage of calcium like *Pisum sativum* (28mg/gm), *Brassica oleracea* (23mg/gm), *Musa*



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*acuminata* (5mg/gm), *Malus dometica* (5mg/gm) in comparison to the calcium content of these respective work. Calcium content of studied food groups were quite similar with the calcium content reported by Longvah et al., 2017 [12] samples in present study calcium content results. The calcium content of *Phaseleous coccineus*(43.28mg/gm), *Pisum sativum* (28.24mg/gm), *Brassica oleracea* (25.16mg/gm), *Beta vulgaris* (17.28mg/gm), *Psidium guajava* (18.52mg/gm), *Vitis crinifera*(14.22mg/gm), *Musa acuminata* (8.73mg/gm), *Cajanus cajan* (139mg/gm) were nearly similar value. Among the similar food items *Cajanus cajan* (139mg/gm) show highest calcium content value whereas parboiled rice (8.11mg/gm) show the lowest value. Among all food items the calcium content of *Pampus argentus*, parboiled rice and white rice show great variation in the high calcium content in percentage than Longvah et al., 2017 [12]. Halevy. 1957 [13] studied on vegetables and fruits among which the calcium content of *Pisum sativum* (30mg/gm) and *Malus dometica*(9mg/gm) was exactly similar with the respective work, shows in Table 3.1.7. But many other food items show higher calcium content like *Brassica oleracea* (43mg/gm), *Beta vulgaris* (32mg/gm), *Allium cepa* (54mg/gm), *Psidium guajava* (49mg/gm) and *Musa acuminata* (18mg/gm). Among all reported food items only *Vitis crinifera*(12mg/gm) shows 55.55 percent lower calcium content.

Siong et al., 1989<sup>[14]</sup> and this respective work show only two similar food items like *Musa acuminata* (6.8mg/gm) and parboiled rice (7.1mg/gm) which had 17.64 percent and 294.36 percent more calcium content. Bogard et al., 2015<sup>[15]</sup> studied on nutrient composition of some important fish species in Bangladesh. The calcium content of *Puntius sophore*, *Oreochromis mossambicus*, *Pampusargentus* of this local work show rise under 30% in comparison to their work. The difference in calcium content of this respective study might have been attributed by different factors. The change could have been caused by anomalies of measurement of sampling, changes in agricultural practices or changes in varieties grown. Soil conditions including fertilizer application and storage and marketing conditions also influence mineral contents of vegetables, fishes, fruits, cereal and pulses. The plant state of maturation, genetic variance and environmental factors were also the possible for the differences observed

## CONCLUSION

Twenty five foods stuffs of 5 category were analysed for their calcium content. The calcium content values per 100g of fresh edible portion were tabulated. The determined average calcium content in present study was higher than the values reported by some other workers elsewhere. Pool barb had highest while banana had the lowest calcium content. Among food categories: Pulses and fishes had highest calcium content followed by vegetables, cereals and fruits respectively. Calcium content knowledge of staple foods and diets can allow an appropriate food selection and estimation of calcium concentration intake thereby improving intake of adequate mineral nutrition.

### Future Scope

Although staple food stuff available locally and commonly, although calcium content play vital role in maintaining skeletal health. Alternative warm possible area of this research relates to the use calcium by fortifying them in consumed foods and treatment of low bone mineral density, osteoporosis and osteomalacia.

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### Conflict of Interest

We declare that we have no conflict of interest.





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Table 1: Selected staple foods analysed for calcium content with their scientific names

Sl No.	Common name	Scientific name	Calcium content (mg/100g)
FISHES			
1.	Short mackerel	<i>Rastrelliger branchy soma</i>	15
2.	Mud carp	<i>Cirrhinus molitorella</i>	42
3.	Amur catfish	<i>Silurus asotus</i>	30
4.	Bleeker's sheatfish	<i>Phalacronotus bleekeri</i>	65
5.	Pool barb	<i>Puntius sophore</i>	1145
6.	Stone moroko	<i>Pseudorasbora parva</i>	129





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7.	Catla	<i>Labeo catla</i>	182
8.	Bonylip barb	<i>Osteochilus vittatus</i>	136
9.	Silver pomfret	<i>Pampus argenteus</i>	40
10.	Tilapia	<i>Oreochromis mossambicus</i>	117
<b>VEGETABLES</b>			
11.	Onion	<i>Allium cepa</i>	25
12.	Green beans	<i>Phaseolus coccineus</i>	40
13.	Beetroot	<i>Beta vulgaris</i>	18
14.	Cauliflower	<i>Brassica oleracea</i>	24
15.	Green pea	<i>Pisum sativum</i>	30
<b>FRUITS</b>			
16.	Apple	<i>Malus domestica</i>	9
17.	Orange	<i>Citrus sinensis</i>	38
18.	Banana	<i>Musa acuminata</i>	8
19.	Grape	<i>Vitis rotundifolia</i>	15
20.	Guava	<i>Psidium guajava</i>	20
<b>CEREALS</b>			
21.	Parboiled rice	<i>Oryza sativa</i>	21
22.	White rice	<i>Oryza sativa</i>	28
<b>PULSES</b>			
23.	Mung beans	<i>Vigna radiata</i>	152
24.	Pigeon pea	<i>Cajanus cajan</i>	145
25.	Kulthi beans	<i>Marcotyloma uniflorum</i>	297

Table 2: Calcium content (mg/100g) of food stuffs of this study compared with some previously published values

Sl. No.	Foodstuff	Calcium content of foods (mg/100g)							
		This work (S)	A*	B*	C*	D*	E*	F*	G*
1.	<i>Rastrelliger branchy soma</i>	15	-	-	-	-	-	-	-
2.	<i>Cirrhinus molitorella</i>	42	-	-	-	-	-	-	-
3.	<i>Silurus asotus</i>	30	-	-	-	-	-	-	-
4.	<i>Phalacrotonotus bleekeri</i>	65	-	-	-	-	-	-	-
5.	<i>Puntius sophore</i>	1145	-	-	-	-	-	-	1042
6.	<i>Pseudorasbora parva</i>	129	-	-	-	-	-	-	-
7.	<i>Labeo catla</i>	182	-	-	-	-	-	-	-
8.	<i>Osteochilus vittatus</i>	136	-	-	-	-	-	-	-
9.	<i>Pampus argenteus</i>	40	-	-	13.64	-	-	-	31
10.	<i>Oreochromis mossambicus</i>	117	-	-	99.39	-	-	-	95
<b>VEGETABLES</b>									
11.	<i>Allium cepa</i>	25	-	31.53	31.12	41	54	-	-
12.	<i>Phaseolus coccineus</i>	40	152	40.3	43.48	52	-	-	-
13.	<i>Beta vulgaris</i>	18	-	-	17.28	-	32	-	-
14.	<i>Brassica oleracea</i>	24	-	27.76	25.16	23	43	-	-
15.	<i>Pisum sativum</i>	30	-	-	28.24	28	30	-	-
<b>FRUITS</b>									
16.	<i>Malus domestica</i>	9	-	2.43	13.68	5	9	-	-
17.	<i>Citrus sinensis</i>	38	-	-	19.52	39	-	-	-





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18.	<i>Musa acuminata</i>	8	25	6.53	8.73	5	18	6.8	-
19.	<i>Vitis crinifera</i>	15	-	-	14.22	16	12	-	-
20.	<i>Psidium guajava</i>	20	-	4.16	18.52	-	49	-	-
<b>CEREALS</b>									
21.	<i>Oryza sativa</i> (Parboiled rice)	28	31	7.9	8.11	-	-	7.1	-
22.	<i>Oryza sativa</i> (White rice)	21	-	-	7.49	-	-	-	-
<b>PULSES</b>									
23.	<i>Vigna radiata</i>	152	-	-	-	-	-	-	-
24.	<i>Cajanus cajan</i>	145	-	-	139	-	-	-	-
25.	<i>Marcotylomau niflorum</i>	297	-	-	-	-	-	-	-

\*Reported value by A): Lawani et al, 2014 [1] B): Saini and Davar, 2012 [10] C):Longvah et al., 2017 [12], D): Cunningham et al., 2001 [11], E): Halevy. 1957 [13], F): Siong et al., 1989 [14], G): Bogard et al., 2015 [15], S): This work

**Table 3: Calcium content (mg/100g) of studied vs reported foods and their percentage increase and decrease**

Percent (%) value of Calcium							
Names	S/A*	S/B*	S/C*	S/D*	S/E*	S/F*	S/G*
<b>FISHES</b>							
<i>Rastrelliger branchy soma</i>	-	-	-	-	-	-	-
<i>Cirrhinus molitorella</i>	-	-	-	-	-	-	-
<i>Silurus asotus</i>	-	-	-	-	-	-	-
<i>Phalacronotus bleekeri</i>	-	-	-	-	-	-	-
<i>Puntius sophore</i>	-	-	-	-	-	-	10↑
<i>Pseudorasbora parva</i>	-	-	-	-	-	-	-
<i>Labeo catla</i>	-	-	-	-	-	-	-
<i>Osteochilus vittatus</i>	-	-	-	-	-	-	-
<i>Pampus argenteus</i>	-	-	194↑	-	-	-	29↑
<i>Oreochromis mossambicus</i>	-	-	18↑	-	-	-	23↑
<b>VEGETABLES</b>							
<i>Allium cepa</i>	-	20.90↓	19.66↓	39.02↓	53.70↓	-	-
<i>Phaselouscoccineus</i>	73.68↓	0.74↓	8.00↓	23.07↓	-	-	-
<i>Beta vulgaris</i>	-	-	4.16↑	-	43.75↓	-	-
<i>Brassica oleracea</i>	-	13.54↓	4.61↓	4.34↑	44.18↓	-	-
<i>Pisum sativum</i>	-	-	6.23↑	7.14↑	S=E*	-	-
<b>FRUITS</b>							
<i>Malus domestica</i>	-	270.37↑	34.21↓	80↑	S=E*	-	-
<i>Citrus sinensis</i>	-	-	94.67↑	2.56↓	-	-	-
<i>Musa acuminata</i>	68↓	22.51↑	8.36↓	60↑	55.55↓	17.64↑	-
<i>Vitis crinifera</i>	-	-	5.48↑	6.25↓	25↑	-	-



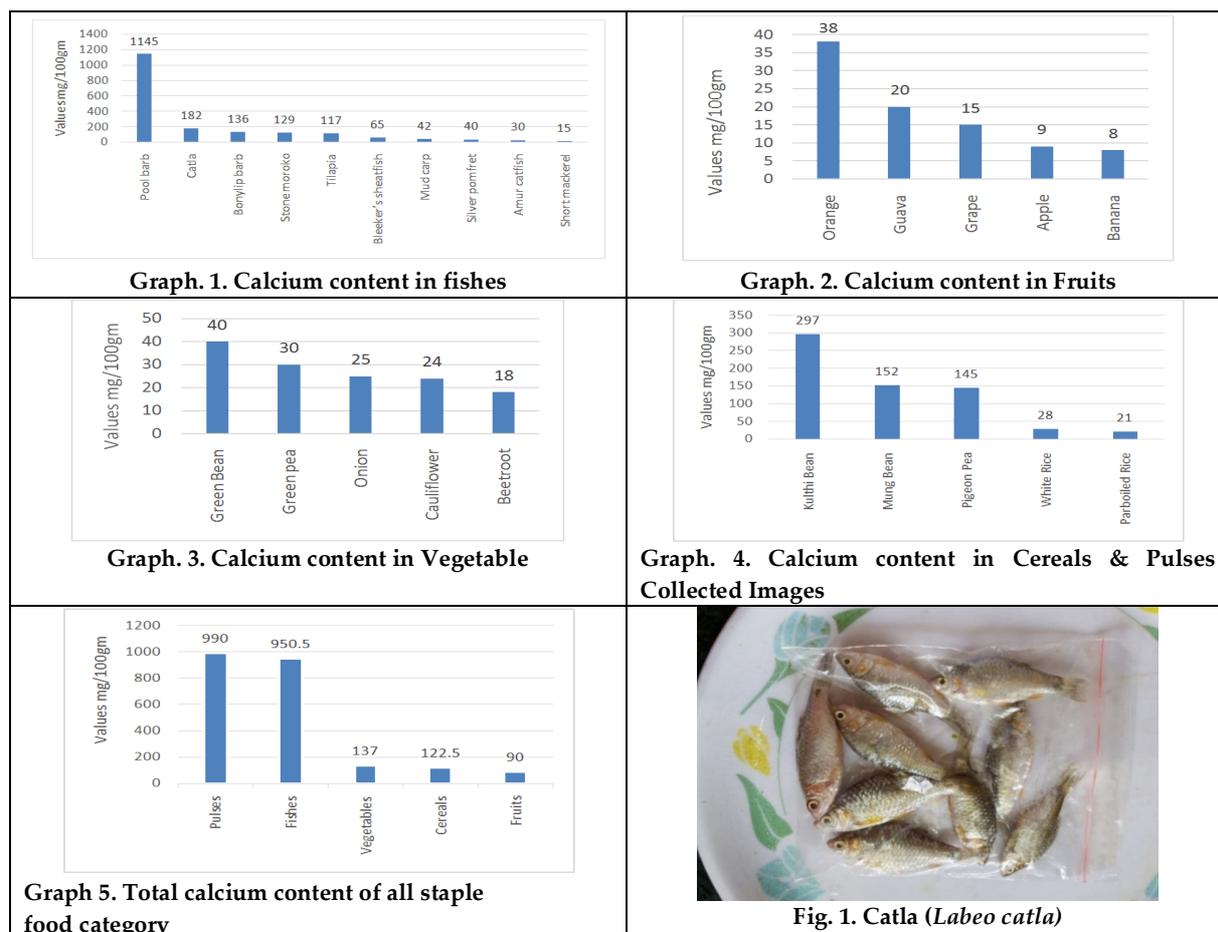


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<i>Psidium guajava</i>	-	380.76↑	7.99↑	-	59.18↓	-	-
<b>CEREALS</b>							
<i>Oryza sativa</i> (Parboiled rice)	9.67↓	254.43↑	245.25↑	-	-	294.36 ↑	-
<i>Oryza sativa</i> (White rice)	-	-	180.37↑	-	-	-	-
<b>PULSES</b>							
<i>Vigna radiate</i>	-	-	-	-	-	-	-
<i>Cajanus cajan</i>	-	-	4.31↑	-	-	-	-
<i>Marcotyloma uniflorum</i>	-	-	-	-	-	-	-

\*Reported value by A): Lawani et al, 2014 [1] B): Saini and Davar, 2012 [10] C): Longvah et al, 2017 [12], D): Cunningham et al., 2001 [11], E): Halevy. 1957 [13], F): Siong et al., 1989 [14], G): Bogard et al., 2015 [15], S): This work.

\*\* Increased/ Decreased = Studied value - Reported value / Reported value X 100 (Decreased denoted as (↓) and increased denoted as (↑))





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Fig. 2. Pool barb (*Puntius sophore*)



Fig. 3. Bonylip barb (*Osteochilus vittatus*)



Fig. 4. Stone moroko (*Pseudorasbora parva*)



Fig. 5. Short mackerel (*Rastrelliger brachy soma*)



Fig. 6. Mud carp (*Cirrhinus molitorella*)



Fig. 7. *Oryza sativa* (White rice and parboiled rice), *Vigna radiate*, *Cajanus cajan*, *Marcotyloma uniflorum*





## *In vitro* Study on the Anticancer Effect of Crude Extract of *Plumbago zeylanica* and Standard *plumbagin*

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### ABSTRACT

Cancer is disease caused by alterations of the genome as well as the proteome. These changes allow the cancer cell to evade normal cellular control mechanisms and to start growing uncontrolled. One of the fundamental features of cancer is tumor clonality, the development of tumors from single cells that begin to proliferate abnormally. The major goal of cancer research is to identify these molecular defects and use this knowledge to develop effective diagnostic, treatment and prevention regimens. The generalized loss of growth control exhibited by cancer cells is the net result of accumulated abnormalities is multiple cell regulatory systems and is reflected in several aspects of cell behavior. *Plumbagozeylanica*, commonly known as ceylon Leadwort or Doctrobush, is a species of *plumbago* is known to have anticancer effect. It causes pharmacological importance in medicine and employed clinically for their antifertility, germicidal, antileptotic and anti-inflammatory activities. Besides it possess central nervous system stimulatory, hepatoprotective, antioxidant, hypolipidaemic and anti-atherosclerotic properties. The root is used as laxative, expectorant, astringent, abortifacient, and in dysentery, the leaves are used as aphrodisiac and in scabies. *Plumbagin*(5-hydroxy-2methyl-1, 4-naphthoquinone) is a naphthoquinone and as the active ingredient Responsible for therapeutic effects. It exhibits effective cell growth inhibition by inducing cancer cells to undergo G2/M phase arrest and apoptosis.



**Divya Sankar et al.****Keywords:** Abnormalities, Anticancer, inhibition, Proteome, Mechanism.

## INTRODUCTION

Cancer is disease caused by alterations of the genome as well as the proteome. These changes allow the cancer cell to evade normal cellular control mechanisms and to start growing uncontrolled. One of the fundamental features of cancer is tumor clonality, the development of tumors from single cells that begin to proliferate abnormally.[24] The major goal of cancer research is to identify these molecular defects and use this knowledge to develop effective diagnostic, treatment and prevention regimens. The generalized loss of growth control exhibited by cancer cells is the net result of accumulated abnormalities in multiple cell regulatory systems and is reflected in several aspects of cell behavior that distinguish cancer cells from their normal counterparts. [1,16]. *Plumbago zeylanica*, commonly known as ceylon Leadwort or Doctrobush, is a species of plumbago is known to have anticancer effect. It causes pharmacological importance in medicine and employed clinically of their antifertility, germicidal, antileptotic and anti-inflammatory activities. Besides it possess central nervous system stimulatory, hepatoprotective, antioxidant, hypolipidaemic and anti-atherosclerotic properties.[20,21,22]The root is used as laxative, expectorant, astringent, abortifacient, and in dysentery, the leaves are used as aphrodisiac and in scabies. Plumbagin (5-hydroxy-2methyl-1, 4-naphthoquinone) is a naphthoquinone and as the active ingredient Responsible for therapeutic effects. It exhibits effective cell growth inhibition by inducing cancer cells to undergo G2/Mphase arrest and apoptosis [10,12,13]

## MATERIALS AND METHODS

### Sample Collection

*Plumbago zeylanica* was collected from the local areas of Thiruvananthapuram.

### Extraction of crude sample by using soxhaling apparatus

- 20 g of air dried roots of *P.zeylanica* was extracted with 300ml of methanol for 7-8 hours using soxhlet apparatus. This methanolic filtrate was dried and was used for further studies.

### Thin Layer Chromatography

- Preparative TLC silica gel plates are used for isolation and purification of alkaloid compounds using the solvent system chloroform: methanol in the ratio 5.5:1. to 20ml of the distilled water reliable amount of silica gel was added to form slurry. It was poured on the glass slide and then dried in the hot air oven. The crude sample i.e. methanolic extract of plumbagin was placed in the TLC plate with capillary tube and the slide was placed in the solvent. The chromatograms were air dried and the bands were viewed under the UV transilluminator.[2]

### Phytochemical Analysis

#### Alkaloids

#### Dragandroff's test

- 8g of  $\text{Bi}(\text{NO}_3)_3 \cdot 5\text{H}_2\text{O}$  was dissolved in 20 ml  $\text{HNO}_3$  and 2.72g of potassium iodide in 50 ml  $\text{H}_2\text{O}$ . These were mixed and allowed to stand. When  $\text{KNO}_3$  crystals out the supernatant was discarded off and made up to 100ml with distilled water. The alkaloids were regenerated from the precipitate by treating with  $\text{Na}_2\text{CO}_3$  followed by extraction of the liberated base with ether.
- To 0.5ml of alcoholic solution of extract was added to 2.0 ml of HCL. To this acidic medium 1.0 ml of Dragandroff reagent was added. If orange red precipitate is produced immediately it indicates the presence of alkaloids.[9]



**Flavanoids**

**Test:** In a test tube containing 0.5 ml of alcoholic extract 5-10 drops of dilute HCL and a small piece of ZnCl<sub>2</sub> or Magnesium were added and the solution was boiled for few minutes. In the presence of flavonoids reddish pink or dirty brown color will be produced.

**Saponins**

**Test:** In a test tube containing 0.5 ml of aqueous extract, a drop of sodium bicarbonate was added. The mixture was shaken vigorously and kept for 3 minutes. If honey comb like froth was formed it shows the presence of Saponins.

**Phenols****Ferric chloride test**

To 1 ml of alcoholic solution of extract, 2 ml of distilled water followed by drops of 10% aqueous solution of FeCl<sub>3</sub> solution were added. Formation of blue or green colour indicated the presence of phenols.

**Steroids****Salkowski test**

To 200 µl of alcoholic solution of extract 800 µl of chloroform was added. 1ml of concentrated H<sub>2</sub>SO<sub>4</sub> acid was added carefully along the side of the test tube. A red colour was produced in the chloroform layer in the presence of steroids.

**Tannins**

**Test:** To 1ml of aqueous extract of sample, few drops of 5% aqueous FeCl<sub>3</sub> solution was added. Formation of bluish black colour which disappears on addition of a few ml of H<sub>2</sub>SO<sub>4</sub> indicates the presence of tannins.

**Carbohydrates****Benedict's test**

To 0.5ml of aqueous extract, 5ml of Benedict's reagent was added and boiled for 5 minutes. Formation of bluish-green precipitate showed the presence of carbohydrate.<sup>[8]</sup>

**Antimicrobial Activity****Preparation of inoculums**

Five colonies of single species i.e. *Pseudomonas*, *E.coli*, *Staphylococcus*, *Streptococcus* and *Klebsiella* were inoculated in separate test tubes containing LB broth and incubated for 24 hours at 37°C.

**Antimicrobial activity**

The Muller Hinton Agar plate was prepared. Five microorganisms (*Pseudomonas*, *E-coli*, *Staphylococcus*, *Streptococcus* and *Klebsiella*) were swabbed separately in different petriplates. Wells were cut in all plates, 50 µl of alcoholic plant extract, 25 µl of DMSO, 5 µl of penicillin were added in the wells and were incubated for 24 hours at 37°C.

**Evaluation of In Vitro Antioxidant Activity****Nitric Oxide radical Scavenging Activity**

5mg of extract was taken and was dissolved in 10µl methanol or dimethyl sulphoxide. The samples were allowed to get completely solubilize and different concentration of sample (50, 100, 200mg/ml) were taken. 50µl of 10µm sodium nitroprusside and 50µl of the test solution was added and finally the solution was made up to 3ml with phosphate buffer (pH 7.4) and it was mixed properly. The solution was incubated at 25-30°C for two and a half hour under fluorescence light. After incubation, 125µl of Griess reagent was added and incubated for 30 minutes at room temperature for color development (light pink color developed). The absorbance was read at 546 nm.





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### Hydroxyl Radical Scavenging Activity

Hydroxyl radical scavenging activity was carried out by measuring the competition between deoxyribose and the extracts for hydroxyl radicals generated from the Fe<sup>3+</sup>/ ascorbate/ ethylene diamine tetra acetic acid/ H<sub>2</sub>O<sub>2</sub> system. Attacks of the hydroxyl radicals on the deoxyribose led to TBARS (Thiobarbituric acid reactive substances) formation. The formed TBARS were measured by the method given by Oshawa *et al.* The different concentration of the extract (25 µl, 50 µl, 100 µl) were added to the reaction mixture containing 30mM deoxyribose, 1mM ferric chloride, 1mM EDTA, 1mM ascorbic acid, 20mM H<sub>2</sub>O<sub>2</sub> and 23mM phosphate buffer (pH 7.4) making a final volume of 1ml. 1ml of TBA (1%) and 1ml of trichloro acetic acid (2.8) were added to the tube and incubated at 100°C for 20 minutes. After boiling for 15 minutes, absorbance was measured at 532nm against a blank containing phosphate buffer.

### Reducing Power Activity

The reducing power of extract was determined by the method of YEN and DUH (1993). The different concentrations of the extract (25 µl, 50 µl, 100 µl) were taken and 2.5ml of phosphate buffer (pH 6.6) was added to the test tubes including control. 25ml of 1% potassium ferric cyanide was added and was boiled for 20 minutes at 50°C. To it 2.5ml of TCA was added and centrifuged for 10 minutes at 2000 rpm. 5ml of supernatant was collected and to it 1ml of distilled water and 250µl of 0.1% ferric chloride was added and the absorbance was read at 700 nm.

### Determination of *In vitro* Anticancer Effect of Plumbago Extracts

0.67g of Eagle's media was suspended in 25ml tissue culture grade water with constant stirring until the powder was completely dissolved. The water should not be heated. 0.187g of NaHCO<sub>3</sub> powder was added and stirred until dissolved. The pH was adjusted to 0.2-0.3 pH units below the desired pH (pH =7.4) using 1N HCl or 1N NaOH since the pH tends to rise during filtration. The final volume was adjusted to 50 ml with tissue culture grade water. The medium was sterilized immediately by filtering through a sterile membrane filter with porosity of 0.22 micron or less, using positive pressure rather than vacuum to minimize the loss of CO<sub>2</sub>. The sterile supplements were aseptically added as required and the desired amount of sterile medium was dispensed into sterile containers. The required medium was stored at 2-8°C and in dark till use.<sup>[17]</sup>

### Apoptotic Effect of Plumbago Extract on L929 And Sk-Mel Cell Lines

#### Passaging of L929 and Sk-MeL

Passaging (also known as subculture or splitting cells) involves transferring a small number of cells into a new vessel. L929 and Sk-MeL was used as the invitro system for assessment of anticancer activity. FBS is used to provide sufficient amount of nutrients for the proper growth of cell lines. The antibiotics present in the media (streptomycin and penicillin) prevent the contamination occurring due to growth of bacteria. In this medium Sk-MeL is grown properly. In order to access the anti-proliferative effect of *Plumbago zeylanica*, cancer cell lines i.e. L929 and Sk-MeL, were subcultured in Eagles Media supplemented with 10% heat inactivated FBS and antibiotics (penicillin and streptomycin). The flask was placed in CO<sub>2</sub> incubator (5% CO<sub>2</sub>) at 37°C for 3 to 5 days to obtain confluent growth.

### Trypsinization

It is the process of using trypsin, a proteolytic enzyme which breaks down proteins, to dissociate adherent cells from the vessels in which they are being cultured. The cell lines were washed with phosphate buffer saline. 500µl of trypsin was added in cultured cells lines for 3 minutes at 37°C. After disaggregation the cells are transferred to other flask and supplemented with media.

### MTT cell viability assay ((Deniel G)

MTT is a colorimetric assay that measures the reduction of 3-(4, 5dimethyl-thiazole-2-yl)-2,5diphenyl tetrazolium bromide (MTT) by mitochondrial succinate dehydrogenase. The MTT enters the cells and passes into the mitochondria where it is reduced to an insoluble colored formazan product. The cells are then solubilized with an





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organic solvent(DMSO) and the released, solubilized formazan reagent is measured by spectrophotometer at 540nm. Since reduction of MTT can only occur in active cells, the levels of activity is a measure of the viability of the cell. MTT cell viability assay is generally considered as a precise technique in determining the cell viability. To the cell culture suspension 30µl MTT was added and kept for incubation at 37°C for 3 hours. After incubation 200µl of DMSO was added to each culture plate, incubated at room temperature for 30 minutes until all cells get lysed and homogenous colour was obtained. After scraping the absorbance was read at 540nm using DMSO as blank and percentage viability was calculated.[10]

#### RPMI (Rosalin park memorial institute)

0.55g RPMI suspended in 25ml tissue culture grade water with constant stirring until the powder is completely dissolved. To this added 1.47g of NaHCO<sub>3</sub> powder and stirred until dissolved. Then added 5.5ml FBS, 100µl streptomycin, 100µl penicillin, 160µl PHA and stirred well. The pH was adjusted to 0.2-0.3 pH units below the desired pH (pH=7.4) using 1N HCl or 1N NaOH since the pH tends to rise during filtration. After that the final volume was made up to 55 ml with tissue culture grade water. Then the medium was sterilized immediately by filtering through a sterile membrane filter with a porosity of 0.22 micron or less. Positive pressure was used rather than vacuum to minimize the loss of CO<sub>2</sub>. Added sterile supplements as required and dispensed the desired amount of sterile medium into sterile containers and stored at 2-8°C.

#### Monocyte Isolation and Genotoxicity

A sterile centrifuge tube was taken and 50µl of heparin was added into it. 3 ml of blood was collected with a sterile syringe and transferred it into the tube containing anticoagulant and mixed gently to avoid coagulation of blood. Another centrifuge tube was taken and equal amount of Hisep was added to it. The blood was carefully transferred in to the tube without mixing it with the Hisep. It was then centrifuged at 2600 rpm for 30 minutes at room temperature. After that clear zone of monocyte was separated and transferred carefully into a new sterile centrifuge tube. The separated monocytes were added into RPMI medium and were kept in CO<sub>2</sub> incubator for 24 hour. After that methanolic extract of plumbagin was added in different concentration (5µl, 10µl and 20 µl) and placed in the CO<sub>2</sub> incubator for another 48 hours.

#### Tryphan Blue Assay

In vitro cytotoxicity testing was based on the effect of peptide on lymphocyte cell viability. A standard cytotoxicity dye elusion assay was employed to determine the effect peptide that reduce the lymphocyte cell viability. A cell suspension was prepared from the assay. A 1:1 dilution of cell suspension of 0.4% tryphan blue was prepared (1:1 dilution in PBS). The counting chamber of the haemocytometer was loaded with the duration. Then place it for 1-2 minutes. The cells were counted at 40x (Olympus CH 20). Dead cells were stained blue which was distinguished from transparent live cells from transparent live cells and the percentage of viability was calculated.[25]

#### Quantitation of DNA Fragmentation with Diphenylamine

This method is based on the notion that extensively fragmented double-stranded DNA can be separated from chromosomal DNA upon centrifugal sedimentation. The protocol includes the lysis of cells and the release of nuclear DNA, a centrifugation step with the generation of two fractions (corresponding to intact and fragmented DNA, respectively), precipitation of DNA, hydrolysis and colorimetric quantization upon staining with diphenylamine (DPA), which binds to deoxyribose.





## METHODOLOGY

After the incubation, the different concentrations of monocyte sample were centrifuged cells at 3500 rpm at 4°C for 10 min. Supernatants were transferred carefully into new tubes labeled S (supernatant). 1.0 ml TTE solution was added to the pellets in tubes B and vortexed vigorously. This procedure allows the release of fragmented chromatin from nuclei, after cell lysis (due to the presence of Triton X-100 in the TTE solution) and disruption of the nuclear structure (following Mg<sup>++</sup> chelation by EDTA in the TTE solution). To separate fragmented DNA from intact chromatin tubes B were centrifuged at 13000 rpm for 10 min at 4°C. Supernatants were transferred carefully into new tubes labeled T. To the small pellet in tubes B 1.0 ml TTE solution was added and mixed well.

Then 1.0 ml of 25% TCA was added into tubes T, B and S and vortexed vigorously. Precipitation was allowed to proceed overnight at 4°C. After incubation, precipitated DNA was recovered by centrifuging for 10 min at 13,000 rpm at 4°C. Supernatants were discarded by aspiration. DNA was hydrolyzed by adding 160 µl of 5% TCA to each pellet and heated for 15 min at 90°C in a heating block. A blank was prepared with 160 µl of 5% TCA alone. To each tube 320 µl of freshly prepared DPA solution was added, then vortexed. Color was allowed to develop for about 4 hours at 37°C (or overnight at room temperature). Optical density was measured at 600 nm, using 5% TCA as blank. The excitation wavelength of 600 nm is the optimal one, but wavelengths from 560 to 620 can be used as well. The percentage of fragmented DNA can be calculated using the formula:

$$: \% \text{ fragmented DNA} = \frac{S+T}{B} \times 100$$

Where, S, T and B are the OD<sub>600</sub> of fragmented DNA in the S, T and B fractions, respectively.

The fragmented DNA released by cells undergoing apoptosis and lysis during the experiment is recovered in the fraction S and should therefore be taken in consideration in particular circumstances. However, since many substances present in the fraction (serum proteins, components of the tissue culture medium, etc.) could heavily interfere with the OD measurement, it could be more convenient to disregard the S tubes (which most of the times contain only negligible amounts of DNA) and to apply the following formula:

$$: \% \text{ fragmented DNA} = \frac{T}{T+B} \times 100$$

### Preparation of Albumin Encapsulated Nanoparticle of Plumbagin

Bovine serum albumin (BSA) was chosen as the material for the particle matrix. BSA has great potential as a Nano carrier in food and pharmaceutical applications. BSA is non-toxic and degradable in vivo, so the nanoparticles generated by using it are easily adaptable to the human body.[3]Desolvation is a thermodynamically driven self-assembly process for polymeric materials. The addition of desolvating agents such as ethanol or acetone separates and coacervates the polymeric molecules in the aqueous phase [4]. The self-assembly of the polymer molecules occurs with electrostatic interactions, since the overall free energy in the system is minimised during desolvation. So, the polymeric molecules form particles of different shapes and sizes depending on the preparation conditions. Hence, a balance between attractive and repulsive forces is necessary for fabricating particles of an appropriate size. The suppression and expression of hydrophobic interactions provide a way to control the size of polymeric particles during desolvation.[5]

### Procedure

BSA nanoparticles were prepared using a desolvation method with minor modifications [3].1gm of BSA powder mixed 0.01mg of plumbagin and was added to distilled water; subsequently, pH and NaCl concentration were adjusted to 7 and 9 with 0.1 M NaOH. The solutions were stirred overnight at 500 rpm using a magnetic stirrer for complete hydration... A desolvating agent, acetone, was added dropwise at a rate of 1 ml/min into the BSA solutions until the solutions became just turbid. Finally, 0.01 ml of a 4% glutaraldehyde-ethanol solution was mixed to induce





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intra-particle cross-linking. The solution was stirred continuously at 500 rpm and room temperature for 3 h. the BSA nanoparticle solutions were centrifuged at 20000 rpm for 30 min. After the centrifugation, the pellets were redispersed to the original volume of absolute ethanol sonicated and were stored in absolute ethanol at 4°C. The size of particles were determined using Scanning electron microscopy.[6,7]

## Evaluation of Bcl-2 Expression in Sk-Mel Cell Lines

### Isolation of RNA

Total RNA was isolated using the total RNA isolation kit according to the manufactures instruction. Addition of RNA sol solution causes the disruption of cells and the release of RNA. Chloroform extraction following centrifugation, separates the mixture into a lower red phenol-chloroform phase, inter phase and the colorless upper aqueous phase. RNA remains exclusively in the aqueous phase whereas proteins are in the interphase and organic phase. On mixing with isopropanol RNA gets precipitated as a white pellet on the side and bottom of the tube.

1ml of SK-MEL cell suspension in a 1.5 ml vial was centrifuged at 10,000 rpm for 10 minutes. The supernatant was removed and the pellet was collected. 500µl RNA sol was added and mixed thoroughly. To this, 200µl chloroform: isoamyl alcohol mixture (24:1) was added. It was mixed well and centrifuged at 10000rpm for 5 minutes at 4°C. The clear upper aqueous layer was transferred into another vial, 3M sodium acetate (pH 5.2) was added 1/10<sup>th</sup> of the sample volume and isopropanol in the ratio of 1:1. The contents were thoroughly mixed and centrifuged at 1000rpm for 10 minutes at 4°C. The RNA pellets were collected and washed with 70% ethanol and centrifuged at 1000rpm for 5 minutes at 4°C. The pellet obtained were dried at 37°C and then suspended in 5µl TE buffer.

### Reverse Transcriptase PCR (RT-PCR)

Reverse transcriptase polymerase chain (RT-PCR) is a variant of polymerase chain reaction (PCR) laboratory technique commonly used in molecular biology to generate many copies of a DNA sequence, a process termed "amplification". In RT-PCR, however an RNA stand is first reversetranscribed into its DNA compliment (Complimentary DNA, or cDNA) using the enzyme reverse transcriptase and the resulting cDNA is amplified using traditional PCR or real time PCR. The RT-PCR technique was performed using primer designed specifically for amplified gene. [11,14]. All the components were thawed before performing the experiment. 5µl of control RNA template (suspended in 50µl of DEPC water and incubated at 65°C for 5 minutes) was mixed with 2µl of control reverse primer and 13µl of DEPC water was added to the RNA primer mix. The above mix was incubated at 65°C for 5 minutes and immediately chilled on ice. Control RT-PCR reaction was set up by adding the components in the following order. 2µl of reaction mixture, 20µl of chilled above sample and 2.5µl forward primer and finally 2µl of enzyme mix was added. The above reaction mix was placed in a thermocycler set to below mentioned conditions.

### Agarose Gel Electrophoresis

Agarose gel electrophoresis is a method for separating and visualizing DNA and RNA fragments. The fragments are separated by charge and size and which move through an agarose gel matrix subjected to an electric field. The electric field is generated by applying potential across an electrolytic solution (buffer). When boiled in aqueous buffer, agar dissolves and upon cooling solidifies to a gel. Agarose gel electrophoresis was performed to check the purity of the isolated RNA.[10,23]

### Procedure

1% agarose gel was prepared in 1xTE buffer. It was melted in hot water bath at 90°C, later cooled down to 45°C, 8µl of 0.5 mg/ml of ethidium bromide was added and poured into gel casting apparatus with gel comb. After setting, the comb was removed from gel. The platform with gel was placed into an electrophoresis tank with sufficient electrophoresis buffer (TBE) to immerse the gel. DNA sample was prepared with an appropriate amount of loading buffer and was loaded into well. The gel was allowed to run. The stained gel was then observed using transilluminator.





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### Determination of apoptosis by fluorescent staining

Apoptosis was determined morphologically after staining with acridine orange or ethidium bromide by fluorescence microscopy. The cell lines were subculture and incubated in carbon dioxide incubator (5% CO<sub>2</sub>) for three days at 37°C. After incubation, sample was added in different concentration (control, 4µg crude, 40µg standard). Again it was incubated at 37°C for 24 hours. Media was decanted; acridine orange and ethidium bromide was added in the ratio 1:1. After 10 minutes, it was washed with 1 ml PBS to remove the stain. The cellular morphology was evaluated by Olympus (CKX41) epifluorescent microscope. [9]

## RESULTS

### Thin layer chromatography

The alkaloid fraction was separated and identified by spraying with Dragandroff's reagent. When the TLC plate was viewed under UV-light, green colour fluorescence was observed. This confirms the presence of alkaloids. Chromatogram of *Plumbago zeylanica*, standard *Plumbago*

**Alkaloids:** Orange red precipitate was produced on addition of Dragandroff reagent which indicates the presence of alkaloids. the solution did not turn to bluish-black, so tannins are absent in the sample.

**Flavanoids:** No color was formed after boiling, so flavanoids are not present in the sample.

**Saponins:** On the addition of NaHCO<sub>3</sub>, no froth was formed, so saponins are not present.

**Phenols:** The color of the solution did not turn blue, so phenols are absent in the sample.

**Steroids:** Red color was not produced in the chloroform layer, so steroids are not present.

**Tannins:** The color of the solution did not turn to bluish-black, so tannins are absent in the sample.

**Carbohydrates:** Bluish-green precipitate was obtained after the addition of Benedict' reagent, which indicates the presence of carbohydrate.

### Antimicrobial Activity of *Plumbago zeylanica*

*Eschericea coli*, *Pseudomonas* (Gram negative) and *Streptococcus aureus*, *Staphylococcus aureus* (Gram positive) were used for the antimicrobial assay. Agar well diffusion assay was performed to evaluate the antimicrobial potential of *Plumbago zeylanica* extract. Penicillin was used as a standard for antimicrobial assay. From the results it can be concluded that *Plumbago zeylanica* contains potent antimicrobial agents than plumbagin. Plumbagin exert antimicrobial, antifungal and antiviral effects [2,14,15]

### Antioxidant activity

#### Nitric Oxide Radical Scavenging Activity

T1- Sample containing 0.1µg of plumbagin extract

T2 - Sample containing 0.2µg of plumbagin extract

T3 - Sample containing 0.4µg of plumbagin extract

Percentage of nitric oxide radical scavenging:

$$= \frac{(\text{Absorbance of control} - \text{Absorbance of sample}) \times 100}{\text{Absorbance of control}}$$

From the graph it was observed that increase in the inhibition efficiency increases the radical scavenging activity.

#### Hydroxyl Radical Activity

T1- Sample containing 0.025µg of plumbagin extract

T2 - Sample containing 0.05µg of plumbagin extract





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T3 - Sample containing 0.1µg of plumbagin extract  
Percentage of hydroxyl radical activity

$$= \frac{(\text{Absorbance of control} - \text{Absorbance of sample}) \times 100}{\text{Absorbance of control}}$$

Absorbance of control

From the graph it was observed that increase in the inhibition efficiency increases the radical scavenging activity.

### Reducing Power Activity

T1- Sample containing 0.025µg of plumbagin extract

T2 - Sample containing 0.05µg of plumbagin extract

T3 - Sample containing 0.1µg of plumbagin extract

Increase in absorbance of the samples indicates an increase in reducing power.

### MTT Assay for L929

T1- Sample containing 0.05µg of plumbagin extract

T2 - Sample containing 0.1µg of plumbagin extract

T3 - Sample containing 0.2µg of plumbagin extract

Percentage of viable cell =  $\frac{\text{Test} \times 100}{\text{Control}}$

Control

From the graph it was observed that increase in plumbagin concentration results in the decrease in the percentage of viability proportionally.

A maximum of 59.6% was observed in culture treated with 0.2µg of plumbagin.

### MTT ASSAY (SK-MEL)

#### MTT Assay for MONOCYTES

T1- Sample containing 0.05µg of plumbagin extract

T2 - Sample containing 0.1µg of plumbagin extract

T3 - Sample containing 0.2µl of plumbagin extract

From the graph it was observed that increase in plumbagin concentration results in the decrease in the percentage of viability proportionally.

A maximum of 40.9% was observed in culture treated with 0.2µg of plumbagin

### Tryphan Blue Assay for Monocytes:

A – Number of viable cells

B – Number of viable cells + number of dead cells

Percentage of viable cell =  $\frac{A \times 100}{B}$

B

1. In 0.05µg of cell sample, percentage of viable cell = 78.65%

2. In 0.1 µg of cell sample, percentage of viable cell = 62.5%

3. In 0.2 µg of cell sample, percentage of viable cell = 43.5%

From the graph it was observed that increase in plumbagin concentration results in the decrease in the percentage of viability proportionally.

A maximum of 43.5% was observed in culture treated with 0.2µg of plumbagin.

### DNA Fragmentation

- A<sub>600</sub> of supernatant 1(S1) from the samples containing 0.05µg, 0.1µg, 0.20µ of plumbagin is denoted as T.
- A<sub>600</sub> of pellet 1(P1) from the samples containing 0.05µg, 0.1 µg, and 0.2µg of plumbagin is denoted as S.





- A<sub>600</sub> of pellet (P2) from the samples containing 0.05µg, 0.1µg, and 0.2µg of plumbagin are denoted as B.

Percentage of fragmented DNA =  $B \times 100 / T + B$

- So, in sample containing 0.05µg of plumbagin extract, percentage of fragmented DNA = 49.30%
- In sample containing 0.1µg of plumbagin extract, percentage of fragmented DNA = 58.32%
- In sample containing 0.2µg of plumbagin extract, percentage of fragmented DNA = 78.7%

From the graph it was observed that increase in plumbagin concentration results in the increase in the percentage of viability proportionally.

### Agarose Gel Electrophoresis

The agarose gel showing the control, standard plumbagin and crude plumbagin loaded in lane 1,2 and 3 respectively.

### Double Staining

Acridine orange and ethidium bromide staining confirms the nuclear integrity of treated cells. Acridine orange selectively stain the living cells as green whereas ethidium bromide stains dead cell DNA as red. From the results it can be observed that crude *Plumbago zeylanica* extract has shown 35% increase in cell death which confirms the anticancer potential of crude extract. The fast growing L929 cell line was used to study the percentage viability by double staining.

## CONCLUSION

Herbal medicine in treatment of cancer as complementary and alternative therapy is one of the most extensively studied areas of recent research. The increased economic burden along with unintentional side effects limits the research and development of pure, novel phytochemicals as therapeutic drug against cancer. [18,19] As an alternative, purified crude extracts of significant plants as dietary supplements and botanical drug products are generating increased acceptance. Plumbagin (5-hydroxy 2 methyl 1,4-naphthoquinone) a quinonoid constituent isolated from *Plumbago* spp. is experimentally proven to inhibit phase arrest in cancer cells thereby promoting apoptosis. The accumulated toxicity of plumbagin to normal cells limits its wide spread application as a potent anticancer drug. In this aspect the current study was designed to compare the anticancer activity of crude and purified plumbagin in Breast cancer cell (MCF-7) and melanoma cell lines (SK-Mel 27). The crude ethanolic extracts (CEE) of *Plumbago zeylanica* was prepared, purified by Silca gel column and analyzed by Thin layer chromatography. In vitro studies using MTT shows significant reduction in cell viability in samples treated with crude extracts when compared with that of standard plumbagin. The study shows synergistic activity of phytochemicals present in crude alcoholic extracts (CEE) of plumbagin which exhibited decreased IC<sub>50</sub> values masking the possible toxicity generated by plumbagin alone. RT PCR analysis shows inhibition of Bcl2 gene by both plumbagin and extracts of *Plumbagozeylanica* in almost same manner.

## ACKNOWLEDGEMENT

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Table 1. RT-PCR Cycle Conditions for Control Reaction Only

42° C	94° C	94° C	55° C	72° C	72° C	4° C
30 min	18 min	30 Sec	30 Sec	30 Sec	2 min	∞

Table 2. BCI-2 Reverse Primer

Amount 5.1OD 127µg	20.6mol	Length 20-mer GC content 50%	Lyophilize
Concentration(Volume) 20.6 pmol /µl			
Volume of pmol/µl	206µl		
Molecular weight TM (thermodynamic) 6193g/mol 49.0°C		A G C T 9 6 4 1	Scale-0.05µmol stan DMT

Table 3. BCI-2 Forward Primer

Amount 8.3OD 236 µg 38.6mol		Length 20-mer GC content 55%	Lyophilize
Concentration(Volume/ml) 38.6pmol/µl			
Volume for 100pmol/µl	386µl		
Molecular weight TM (thermodynamic) 6133g/mol 456.2°C		A G C T 4 6 5 5	Scale-0.05µmol Stan DMT





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Table 4. Antimicrobial Activity of *Plumbago zeylanica*

Microorganisms	Zone of inhibition due to DMSO(negative control)	Zone of inhibition due to an antibiotics(positive control)	Zone of inhibition due to plumbagin extract
<i>Streptococcus</i>	0 cm	3cm	1.8cm
<i>E.coli</i>	0 cm	2cm	1.9cm
<i>Staphylococcus</i>	0 cm	1.8cm	2.7cm
<i>Pseudomonas</i>	0 cm	5 cm	1.8cm

Table 5. Nitric Oxide Radical Scavenging Activity

Samples	Absorbance at 546nm	Percentage of NO radical scavenging activity
Blank	0.000	-
Control	0.096	-
T1	0.042	56 %
T2	0.049	48.9%
T3	0.089	72%

Table 6. Hydroxyl Radical Activity

Samples	Absorbance at 532 nm	Percentage of hydroxyl radical activity
Blank	0.000	-
Control	0.314	-
T1	0.050	84%
T2	0.067	78.6%
T3	0.082	73.8%

Table 7. Reducing Power Activity

Samples	Absorbance at 700 nm
Blank	0.000
Control	0.110
T1	0.056
T2	0.049
T3	0.043

Table 8. MTT Assay for L929

Samples	Absorbance at 540 nm	Percentage of viable cell
Blank	0.000	-
Control	0.604	-
T1	0.0505	83.6%
T2	0.440	72.8%
T3	0.360	59.6%

Table 9. MTT ASSAY (SK-MEL)

Samples	Absorbance at 540 nm	Percentage of viable cell
Blank	0.000	-
Control	0.822	-
T1	0.721	12.28%





Table 10. MTT Assay for MONOCYTES

Samples	Absorbance at 540 nm	Percentage of viable cell
Blank	0.000	-
Control	0.664	-
T1	0.408	61.4%
T2	0.353	53.1%
T3	0.272	40.9%

Table 11. DNA Fragmentation

Sample	Absorbance at 600nm
S1- 0.05µg	0.404
S1- 0.1µg	0.338
S1- 0.2µg	0.128
P1- 0.05µg	0.952
P1- 0.1µg	0.559
P1- 0.2µg	1.289
P2- 0.05µg	0.393
P2- 0.1µg	0.473
P2- 0.2µg	0.473

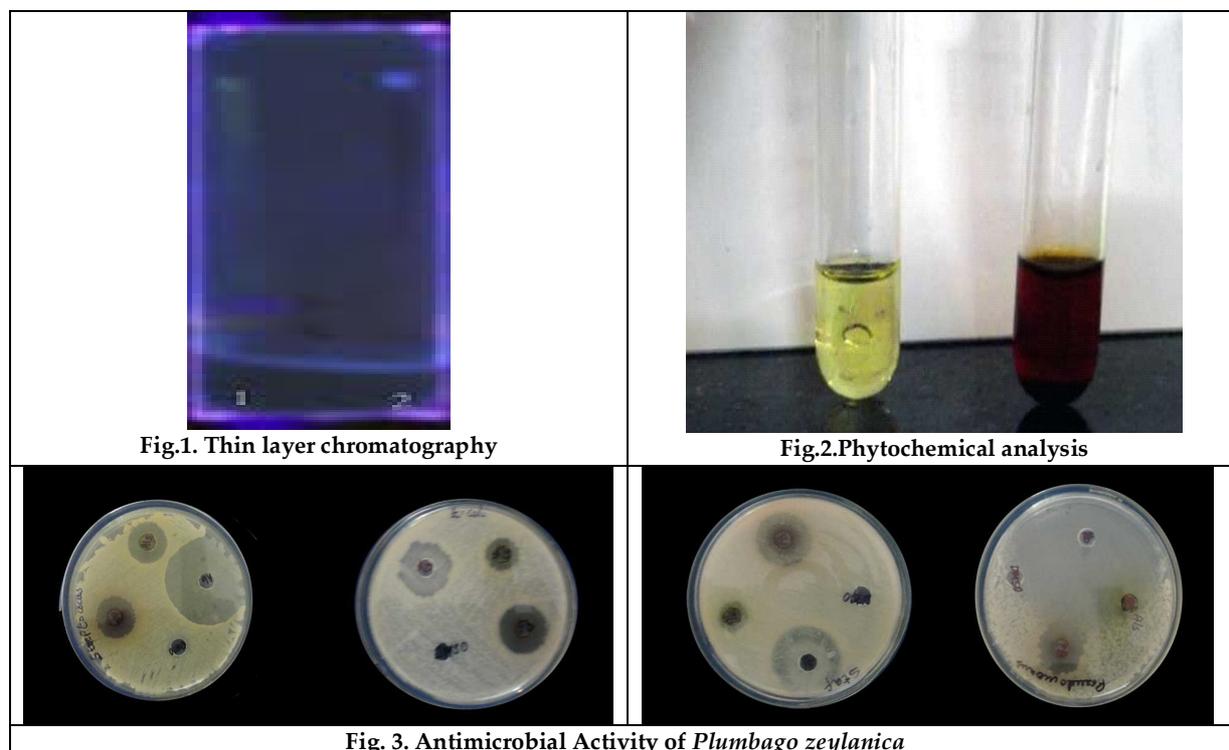


Fig.1. Thin layer chromatography

Fig.2. Phytochemical analysis

Fig. 3. Antimicrobial Activity of *Plumbago zeylanica*





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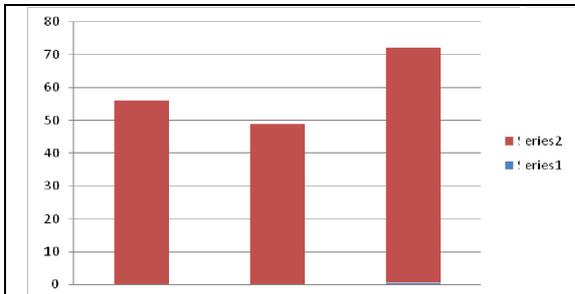


Fig. 4. Nitric Oxide Radical Scavenging Activity

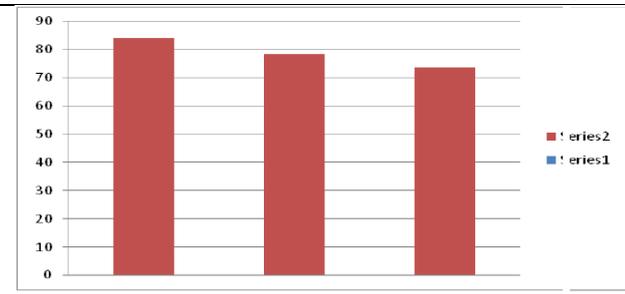


Fig. 5. Hydroxyl Radical Activity

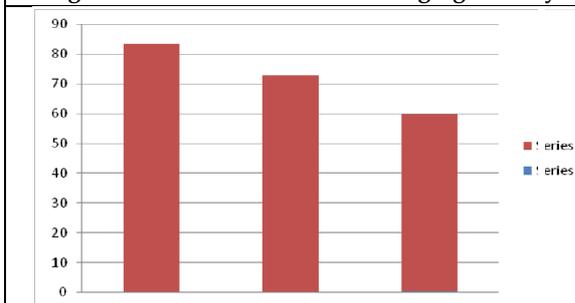


Fig. 6. MTT Assay for L929

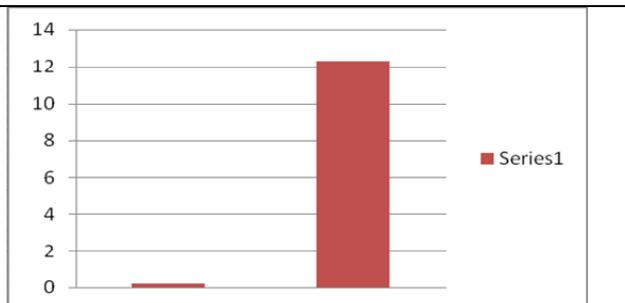


Fig. 7. MTT ASSAY (SK-MEL)

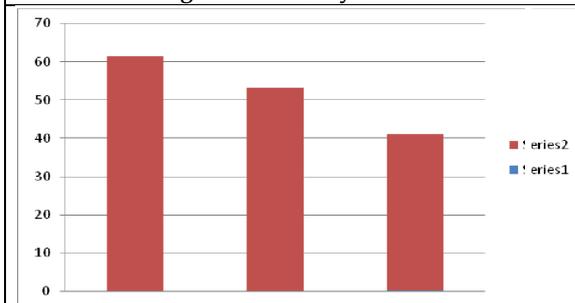


Fig. 8. MTT Assay for MONOCYTES

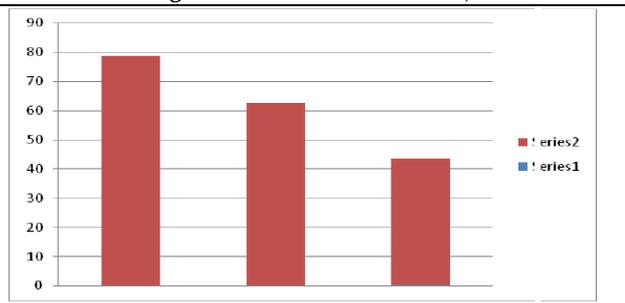


Fig. 9. Tryphan Blue Assay for Monocytes

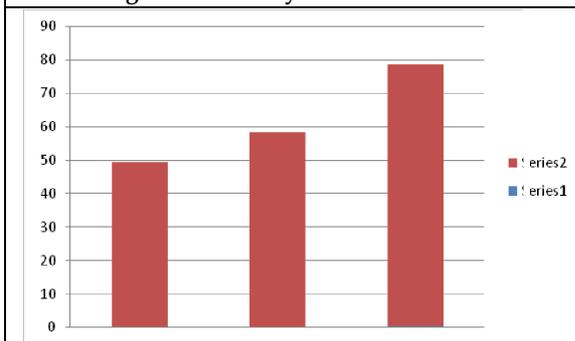


Fig. 10. DNA Fragmentation

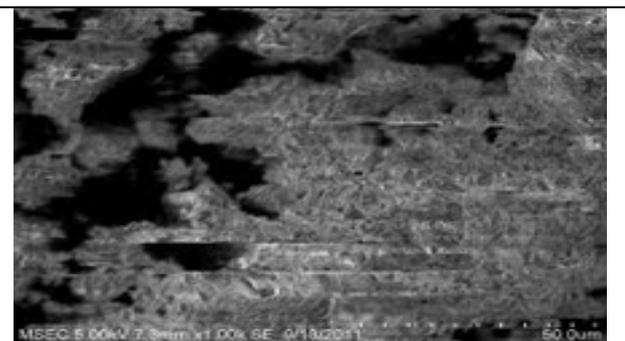


Fig. 11. Sem Analysis of Nanoparticles Encapsulated Plumbagin



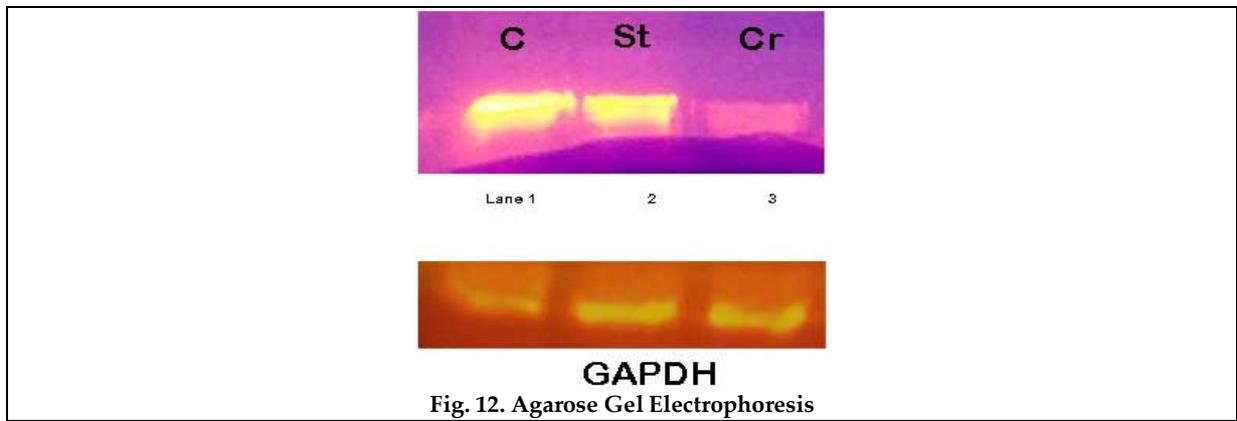


Fig. 12. Agarose Gel Electrophoresis

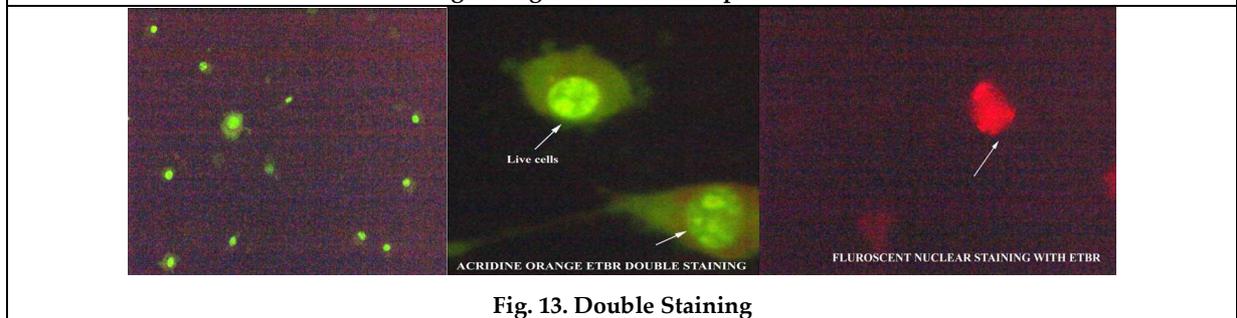


Fig. 13. Double Staining





## Review: Mycotoxin Contamination of Water Bodies Polluted with Aqua and Agri Waste

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### ABSTRACT

Mycotoxins are secondary metabolites produced by toxigenic species of fungi, which can cause toxic effects in humans and animals. Food contamination by mycotoxins has been reported worldwide, mostly in foods that are susceptible to fungal growth, such as grains and cereals. Mycotoxins can lead to damage to health, and economic losses in agriculture. The most common mycotoxins found in routine food consumption and with consumption limits set by many countries, including Brazil, are: aflatoxins B1, B2, G1 and G2, ochratoxin A, zearalenone, deoxynivalenol, T-2 toxin and fumonisin. The contamination of foods and feeds with Mycotoxins can have serious consequences for human and animal health. Mycotoxin exposure is most likely to occur in the developing countries where food handling and storage processes are suboptimal, malnutrition is common, and where handful of regulations exist to protect the exposed populations. The better understanding of the biochemistry and metabolism of mycotoxins is necessary to avoid problems caused by them and minimize their negative effects on agriculture and health.

**Keywords:** Fungi, Mycotoxins, Secondary Metabolites, Toxigenic





## INTRODUCTION

Mycotoxins are produced mainly by the mycelial structure of filamentous fungi, or more specifically, the molds. They are secondary metabolites having no biochemical implication in fungal growth and development (Moss, 1991). Toxicogenic molds are reported to produce one or more of mycotoxins. It is already well-known that not all molds and not all secondary metabolites from molds are toxic. Some of the mycotoxins are of high significance in public health and agro-economy, for example, aflatoxins, trichothecenes, ochratoxins, zearalenone, fumonisins, ergot alkaloids, tremorgenic toxins. These toxins to be held responsible for loss of million dollars per annum worldwide in terms of human health, animal health, and condemned agricultural products (Shane, 1994; Vasanthi and Bhat, 1998).

Elements affecting the presence or production of mycotoxins in foods or feeds are storage condition, environmental, and ecological factors. Many of these secondary metabolites do have biological activity and may be toxic to microorganisms (antibiotics), plants (phytotoxins) or animals (mycotoxins) (Moss, 1996). Mycotoxins that are produced by fungi belonging to *Fusarium* and *Aspergillus* genera (fusariotoxins/ trichothecenes and aflatoxins, respectively) have received special attention, because they are most hazardous for humans and animals and are of economic significance. The terpenoid biosynthetic pathway is a characteristic of fusariotoxins (e.g., trichothecenes like toxin T2 and deoxynivalenol, the main precursors of which are mevalonic acid and farnesyl pyrophosphate).

A large group of mycotoxins, including aflatoxin B1 and zearalenone, are classified with polyketides, an important and large class of natural compounds, the initial stage of biosynthesis is the condensation of acetyl-CoA with several molecules of malonyl-CoA and subsequent multistage conversions of intermediate  $\beta$ -polyketones (Khomutov et al. 2011). Mycotoxins are commonly found in foods and feeds all over the world. It has been estimated that one fourth of the world's crops are contaminated with mycotoxins to some extent (Mannon and Johnson, 1985; Fink and Gremmels, 1999). Moisture, temperature, and insect damage are the most important environmental variables associated with aflatoxin contamination of agricultural commodities (Cast, 2003). Corn, peanuts, cotton, tree nuts, rice, figs, tobacco, and spices are among the most frequently contaminated crops (Detroy et al. 1971; Diener et al., 1987). In storage, the most important variables favoring mold growth are the water content of the substrate and relative humidity of the surrounding environment (Detroy et al. 1971; Wilson et al. 1994). Kuiper-Goodman, a renowned scientist in risk assessment studies, grades mycotoxins as the most significant noninfectious, chronic dietary risk factor. (Kuiper-Goodman, 1998).

In the last few decades, many pollutants have been detected in the surface water and marine environment, and these pose a potential threat to environmental integrity, biodiversity, and human health (Fleming et al. 2006; Hacon et al. 2005; Sherman, 2000). Marine mammals have been proposed as sentinels of marine environmental health, because these organisms are top predators and may accumulate great concentrations of pollutants in their tissues through bioaccumulation and biomagnification processes (Ross and Birnbaum, 2003; Siciliano et al. 2005). Drinking water sources contain different kinds of biological pollutants, such as bacteria, viruses, protozoa, and fungi. Recently, researchers have reported the presence of fungi in drinking water (Goncalves et al. 2006a; Pereira et al. 2010), and have observed that these fungi affect the taste and odor of the water. A wide spectrum of fungal species have been isolated from drinking water. Some of these species are known to be strongly allergenic (e.g., causing skin irritation), or may cause infections in immune-suppressed individuals (e.g., those suffering from AIDS, cancer, asthma or other respiratory diseases, or recovering from organ transplants) (Hageskal et al. 2009; Green et al. 2003). In addition, we describe the fungi that are known to be hazardous, and the nature of the risks they pose to human health, when consumed in contaminated water, food, or are inhaled. Finally, we review selected studies, in which efforts have been made to control fungi or their toxic metabolisms in aquatic environments.





## Major source of Mycotoxins

### Mycotoxins in Agriculture waste

Contamination of mycotoxin can occur at pre-harvest or post-harvest period, i.e., during processing, packaging, distribution, storage of food products. Most of the times, crops and cereals that are improperly stored under high temperature and humidity for a prolonged time, are prone to mold growth and mycotoxin contamination. Maize is most susceptible to mycotoxins contamination, while rice is the least. Mycotoxins can also come to the human plate via animal products such as meat, eggs, milk as the result of the animal eating contaminated feed. Most mycotoxins are chemically and thermally stable during food processing that includes cooking, boiling, baking, frying, roasting, and pasteurization. Mycotoxin Patulin Produced by *Penicillium*, *Aspergillus*, and other genera, patulin most commonly infects non-intact apricots, grapes, peaches, pears, apples, olives, cereals, and low-acid fruit juices (Sewram et al., 2000; Speijers, 2004). Apple juice has historically been a high concern for contamination. *P. expansum* is especially associated with a range of moldy fruits and vegetables. Although this is not a very strong toxin, a genotoxicity was detected in studies, i.e. there is a potential for a mutagenic and/or carcinogenic effect.

The fumonisins are found mainly corn crop, but several researches have reported the occurrence in other grains, such as rice (Park et al.2005), wheat and oat (Mallmann et al.2001). Fumonisin are structurally related molecules and 16 of which have been isolated and characterized: Fumonisin B1 (FB1), FB2, FB3, FB4, A1, A2, A3, AK1, C1, C3, C4, P1, P2, P3, PH1A, PH1B, however, fumonisin B1 and fumonisin B2 are the most important and constitute up to 70% of the fumonisins found in naturally contaminated foods and feeds (Seo et al.2001; Niderkon et al. 2009). Though several fungal genera are capable of producing trichothecene mycotoxins, most of them have been isolated from *Fusarium* spp. The presence of trichothecene mycotoxins in grains and other merchandises like corn, wheat, barley, oats, rice, rye, vegetables, are very common.

### Mycotoxins in Aquaculture waste

In intensive commercial aquaculture operations, the sources of wastewater are primarily from uneaten food and fish feces, which is 30 percent unconsumed dry feed and 30 percent consumed food egested as feces (Axleret al. 1996). The production of aquaculture waste in water can be estimated on the basis of several factors: growth, nutrients, energy gains, energy nutrient needs and excretory feed waste output by the systems in operation (Cho and Bureau, 1997). Aquaculture feeds are highly perishable,

The production of aflatoxins increases at temperatures above 27°C, humidity levels above 62 percent and moisture levels above 14 percent in the feed. Suitable conditions for fungal growth, in terms of warm temperature and moisture, promote mycotoxin contamination. For the main aquaculture producing regions of the world, notably Asia, these climatic factors increase the risk of such contamination. The extent of contamination will further be affected by ingredient and feed storage practices and processing methods. Additionally, long duration of transport under poor conditions and improper storage are crucial factors favoring the growth of aflatoxin-producing molds. Consequently, poorer aquafarmers in developing countries, where quality control of feeds may not be as high as in developed countries, are more likely to acquire contaminated feeds. Further, the Increase in prices of feed ingredients is likely to drive poor farmers to look for cheaper sources and run the risk of purchasing rejected or contaminated ingredients and feeds. Aflatoxin, a ubiquitous mycotoxin, which is produced primarily by the fungus *Aspergillus flavus* is a major concern because of its carcinogenicity, especially in warm and humid climates. Molds produce toxins that can be very damaging to the fish and shrimp. Molds certain species in the genus *Aspergillus* produce aflatoxins, which can cause liver damage to the shrimp. Occasionally feed will already have mold growing on it when it arrives from the feed mill, if the feed is hot condition or not been dried sufficiently.

The use of plant-based ingredients as substitutes for fish protein and oil in aqua feeds increases the risk of contamination by mycotoxins (fungal toxins produced by naturally occurring filamentous fungi or moulds). Several potent mycotoxins have been identified and those of serious concern, based on their toxicity and ubiquity, are



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aflatoxin, ochratoxin A, the trichothecenes (DON, T-2 toxin), zearalenone, fumonisin, and moniliformin (Bhatnagar et al.2004).A survey of the conducted Food and Agriculture Organization of the United Nations in Andhra Pradesh state, India (FAO Fisheries and Aquaculture Technical Paper No. 578. Rome, FAO. 90 pp). Sinking pellets and mash uneaten feed cannot be collected, it may increase the organic loading of the pond waters and result in a deterioration in water quality and leads to contamination by fungal growth. The aquaculture industry has become an axis for criticism from environmental groups because of an apparent negative effect on the environment from the release of wastewater (Doupeet *al.* 1999).

### Detection Techniques

Numerous assay methods for detecting aflatoxins have been developed utilizing virtually all of the common tools of analytical chemistry including thin-layer chromatography, high-performance liquid chromatography, gas chromatography, mass spectrometry, immunoassays, capillary electrophoresis, and biosensors. Older methods rely on solvents for clean-up steps and chromatographic methods for quantification. Recent technologies include immunogenic assays that can be applied to samples with little or no cleanup (Chu,1998). Aflatoxins are considered as non-immunogenic but they can be conjugated to a protein carrier; a number of inexpensive antibody-based kits are now commercially available. Methods for assaying aflatoxins and other mycotoxins have been reviewed (Trucksess and Pohland,2001;Pohland,1993; Scott,1995).

For safety concern detection and quantification of aflatoxin in food,feed and water source is a very important. Different types of culture media have also been used to enumerate fungi; examples are Czapek-Dox Agar and Dichloran Rose Bengal Chloramphenicol (DRBC) (Pereira et al. 2010 ), and Sabouraud Dextrose Agar (Arvanitidou et al. 1999 ; Anaissie et al. 2003 ), although they required adding antibiotics to prevent bacterial growth (Sammon et al. 2010 ; Kanzler et al. 2007 ). Depending on what culture media or process is used, some fungi species may not be successfully isolated from water, even if present. Moreover, the method used for isolation of fungi may affect the frequency results recorded for the fungi. The filter membrane method is better than the direct plate-spread method for studying fungal occurrence in water than the other methods. The reason for this is that the volume of water in the filter membrane method is higher than that used for the plate-spread method. The swabbing method is best for studying the presence of biofilms in surface pipes.

Analytical methods for mycotoxins include Thin layer chromatography (TLC) is among one of the oldest techniques used for aflatoxin detection (Fallah et al.2011), while high performance liquid chromatography (HPLC), liquid chromatography mass spectroscopy (LCMS), and enzyme linked immune-sorbent assay (ELISA) are the methods most frequently used for its detection (Tabari et al.2011; Andrade et al.2013; Sulyok et al.2015). Aflatoxins immobilized on resin beads can induce RTP in the presence or absence of oxygen and heavy atoms (Costa-Fernandez and Sanz-Medel, 2000) and also have high sensitivity and specificity (Li et al.2003). Most patulin testing occurs via the use of HPLC (high performance liquid chromatography)-UV and/or liquid chromatography coupled to tandem mass spectrometry (LC/MS/MS) analyses within a laboratory. Patulin does not employ fluorescent properties and thus the use of UV detection is required. Moreover, several biosensors and immunoassays have been developed to detect ultra-traces of aflatoxins to ensure the food safety.

### Management and Control Strategies

#### TREATMENT AND CONTROL

Mycotoxins cannot be considered a group of toxicants on the basis of their mechanism of action because they are very chemically diverse. It would be impossible to develop one single control method that would ensure the reduction of every mycotoxin present in every agricultural commodity and aquaculture waste. Considering all these factors, it can be concluded that the development of food safety programs for mycotoxin control is not a simple issue (Park, 1993; Park and Liang, 1993).Prevention through pre-harvest management is the best. Pre-harvest, harvest and post-harvest processing minimize the risk (Lopez-Garcia and Park, 1998). Analysis and Critical Control Point



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(HACCP) approach and should involve strategies for prevention, control, good manufacturing practices and quality control at all stages of production, from the field to the final consumer.

### Biological Methods

Biological methods have been explored as options for mycotoxin decontamination, Fermentation with yeasts has also been effective in destroying patulin and rubratoxin B (Lopez- Garcia and Park, 1998). Dimitrokallis et al. ( 2008 ) reported that many microorganisms including bacteria, yeasts, and molds are able to remove or degrade small amounts of aflatoxin in food and feed. The latest approach to mycotoxin control is mycotoxin deactivation. By means of enzymes (esterase, epoxidase), yeast (*Trichosporonmycotoxinvorans*) or bacterial strains (*Eubacterium*BBSH 797), mycotoxins can be reduced during pre-harvesting contamination.

### Chemical treatment

Numerous studies have evaluated the use of chemicals for the inactivation and hazard reduction of selected mycotoxins. Ammoniation is the chemical method that has received the most research attention. Extensive evaluation of this procedure has demonstrated that it is an efficacious and safe way of decontaminating aflatoxin-contaminated feeds. Nixtamalization, the traditional alkaline treatment of maize used to manufacture tortillas in Latin America, partially degrades aflatoxins and fumonisin, but the residual molecules can either be regenerated by digestive processes or become more toxic (Price and Jorgensen, 1985). The addition of oxidizing agents, such as hydrogen peroxide, has been shown to be an effective aid in nixtamalization. These chemicals degrade aflatoxins and fumonisin, thereby reducing toxicity (Lopez-Garcia, 1998; Burgos-Hernandez, 1998). Some recent studies have shown that hydrogen peroxide and sodium bicarbonate are effective for simultaneous degradation/detoxification of aflatoxins and fumonisin. Other chemical processes that have shown promise in controlling aflatoxins are the use of sodium chloride during thermal processing, sodium bisulphite at various temperatures and ozonation.

### Biocontrol agents

The biocontrol principle of competitive exclusion of toxigenic strains of *A. flavus* involves the use of non-toxigenic strains to reduce aflatoxin contamination in maize (Abbas et al., 2006). The use of biocontrol agents such as *Bacillus subtilis*, *Lactobacillus spp.*, *Pseudomonas spp.*, *Ralstonia spp.*, and *Burkholderia spp.* are effective at control and management of aflatoxins (Palumbo et al., 2006). Several strains of *B. subtilis* and *P. solanacearum* isolated from the non-rhizosphere of maize soil have been reported to eliminate aflatoxin (Nesci et al., 2005). Biological control of aflatoxin production in crops in the US has been approved by the Environmental Protection Agency and two commercial products based on atoxigenic *A. flavus* strains are being used (Afla-guard® and AF36®) for the prevention of aflatoxin in peanuts, corn, and cotton seed (Dorner, 2009). Good agricultural practices (GAPs) also help control the toxins to a larger extent, such as timely planting, providing adequate plant nutrition, controlling weeds, and crop rotation, which effectively control *A. flavus* infection in the field (Ehrlich and Cotty, 2004; Waliyar et al., 2013). Biological control is emerging as a promising approach for aflatoxin management in groundnuts using *Trichoderma spp.* and significant reductions of 20–90% infection of aflatoxin have been recorded (Anjaiah et al., 2006; Waliyar et al., 2015).

### Biotechnology approaches

Use of inbred maize lines resistant to aflatoxin has also been employed. Potential biochemical markers and genes for resistance in maize against *Aspergillus* could also be utilized (Chen et al., 2007). Additionally, biotechnological approaches have been reviewed for aflatoxin management strategies (Yu, 2012). Advances in genomic technology based research and decoding of the *A. flavus* genome have supported identification of the genes responsible for production and modification of the aflatoxin biosynthesis process (Bhatnagar et al., 2003; Cleveland, 2006; Holbrook et al., 2006; Ehrlich, 2009). In addition, Wu (2010) suggested that aflatoxin accumulation can be reduced by utilizing transgenic Bt maize with insect resistance traits as the wounding caused by insects helps penetrate the *Aspergillus* in kernels.





### UV irradiation techniques

(Nourmoradi et al. ( 2012 ) studied the effect of UV irradiation on selected *Aspergillus* spp. (Chun et al. (2010 ) studied the effect UV-C irradiation on inactivation of the food-borne pathogens population, and suggested that it can be useful for improving microbial safety of stored food, without impairing quality. (Begum et al. ( 2009 ) suggested that UV-C irradiation can effectively inactivate spores of *A. flavus*, *P.orylophilum*, *E. rubrum* , and *A. niger*, but the efficacy of UV-C radiation against fungal spores varied significantly among genera and method of irradiation exposure. *A. nigeris* more resistant to UV irradiation than other genera such as *A. flavus*, *Mucorspp.*, and *Penicillium*spp. Moreover, (Hijnen et al. ( 2006 ) showed that *Aspergillus* spp. are less sensitive to UV irradiation than are cells of vegetative bacteria species, such as *Campylobacter jejuni* and *Legionella pneumophia*; however, *Aspergillus* spp. are more sensitive than bacterial spore-forming species such as *Bacillus subtilis* and *Clostridium perfringens*. Xiong et al. ( 2010 ) investigated neutralized and acidic electrolyzed oxidizing water, and noted significantly different fungicidal treatment effectiveness against *Aspergillus flavus*, when targeting conidia; the normal cellular functioning of K<sup>+</sup> and Mg<sup>2+</sup> in *A. flavus* conidia was damaged. Similarly, Young et al. ( 2006 ) investigated the degradation of ten trichothecene mycotoxins from exposure to aqueous ozone. They discovered that all studied mycotoxins degraded readily; at pH 7–8 the degree of reactivity was dependent upon the carbon 8 oxidation state, whereas at pH 9, there was little or no reaction.

### Feed storage practices

A significant reduction in mycotoxin formation can be achieved by good agronomic practices. As the toxins are generally very stable, they can persist during storage, independent of storage conditions, and can hence reach the final feed. During storage mold growth and mycotoxin formation can be controlled successfully by controlling moisture content of the feed. If the moisture content is below 12%, molds become metabolically inactive, and no mycotoxins are produced. The incorporation of technical mold inhibitors such as Mold-Zap (Alltech, Inc.) further enhances stability of feed and ingredients during storage. Once any of the ingredients is found affected, complete removal of the contaminated ingredient is the logical solution. But it is often not practical to completely remove certain ingredients due to associated costs. In the feed and food industry it has become common practice to add mycotoxin binding agents such as Montmorillonite or bentonite clay in order to affectively adsorb the mycotoxins. The toxic effects of fumonisin, ochratoxin A, DON and T2 toxin are not mitigated by most sequestering agents. Since not all mycotoxins can be bound to such agents.

### Waste water treatment

Aflatoxins or other fungal toxins may be degraded by physical, chemical, or biological methods (Dimitrokallis et al. 2008 ). Also addressed in some studies is how drinking water can be processed in water treatment plants to reduce the danger of contaminating fungi. Wastewater treatment technology for land based aquaculture is adapted largely from municipal wastewater treatment. Sedimentation is one of the simplest methods to reduce the waste from the aquaculture industry. The basic principle in this system is to allow solid particles, mainly uneaten feed and feces, to settle out of the waste prior to release of effluent water into the environment. In this system, settleable substances can sink and floatable particles can collect on the water surface (Czyszet al. 1989). The separated wastes are removed from surface and bottom of the aquaculture chambers and may undergo further treatment before disposal. Sedimentation is widely applicable in commercial fish farming, as it requires no energy input and no specialized operation skills (Daniel and Trudell 1990). The basic principle in this system is to allow solid particles, mainly uneaten feed and feces, to settle out of the waste prior to release of effluent water into the environment.

Water treatment plants may serve to partially accomplish this, by first filtering the water and finally by adding disinfection, ammonia oxidation, chlorination and aeration treatments adequate to remove or mitigate fungi or their toxic metabolites. Sammon et al. ( 2010 ) showed that coagulation/flocculation, sand filtration, and chlorination was highly effective in removing microfungus contaminants from raw water, although recontamination will occur if supplementary chlorination of all water service reservoirs is not routinely carried out to prevent growth of fungi or



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reduce fungal metabolites (e.g., geosmin, 2-methylisoborneol (2-MIB), and methyl tert-butyl ether (MTBE)) in drinking water. Lin et al. (2003) noted that the presence of chlorine substantially reduced concentrations of geosmin, 2-MIB, and MTBE. Similarly, Wilson et al. (2005) tested the effects of chlorine dioxide gas on growth of some fungi, and showed that it inactivated all organisms except for *C. globosum* colonies, although some Ascospores may also have been destroyed. Pereira et al. (2013) studied the effectiveness of free chlorine for deactivating some species of fungi, and established rate constants for such deactivation. Advances in bioengineering have tendered most methods of wastewater treatment technology effective in the aquaculture industry. The process of water cleaning evolved throughout time, including new techniques such as ultra-filtration. (Guidelines for Drinking Water Quality, 3rd ed.; World Health Organization: Geneva, Switzerland, 2004; p. 515.). Biofiltration is another technology recently being applied in aquaculture for the treatment of wastewater. The basic principle of this technology is the formation of a filter bed through the attachment and growth of beneficial bacteria that extract dissolved chemicals from the water and convert them to particulate biomass or harmless dissolved compounds (Geoffrey 2000).

**ECONOMICS, FOOD SAFETY, AND REGULATION**

The economic consequences of mycotoxin contamination are extreme. In developed countries, crops with high amounts of aflatoxins are either destroyed or diverted into animal feeds; aflatoxins lower the value of grains as an animal feed and as an export commodity (Smith and Moss, 1985). When susceptible animals are fed contaminated feeds it results in reduced growth rates, illness, and death; moreover, their meat and milk may contain toxic biotransformation products. Livestock owners often take farmers and feed companies to court; legal battles can involve considerable amounts of money (Pier et al. 1980).

Special committees and commissions have been established by many countries and international agencies to recommend guidelines, test standardized assay protocols, and maintain up-to-date information on regulatory statutes of aflatoxins and other mycotoxins. These guidelines are developed from epidemiological data and extrapolations from animal models, taking into account the inherent uncertainties associated with both types of analysis. Different national guidelines for safe doses have been established, and hence, there is a need for worldwide harmonization of regulations (Wilson et al. 2002). A compendium summarizing worldwide regulations for mycotoxins has been published by the Food and Agriculture Organization of the United Nations (FAO 1997). The websites for the various commissions and organizations that study mycotoxins are excellent sources for the latest information: see, e.g., the Council for Agricultural Science and Technology (CAST) ([www.cast-science.org](http://www.cast-science.org)); the American Oil Chemists Society Technical Committee on Mycotoxins ([www.aocs.org](http://www.aocs.org)); the Food and Agriculture Organization (FAO) of the United Nations ([www.fao.org](http://www.fao.org)); the International Union for Pure and Applied Chemistry section on Mycotoxins and Phycotoxins ([www.iupac.org](http://www.iupac.org)); and the US Food and Drug Administration Committee on Additives and Contaminants ([www.fda.gov](http://www.fda.gov)).

**CONCLUSION**

Worldwide Mycotoxins are a major source of disease outbreaks, due to consumption of contaminated water, food and feed due to a lack of knowledge. People are increasingly concerned about the safety of drinking water & food. Excessive levels of mycotoxins in food and water of non-industrialized countries are of major concern. Several effective physical, chemical, biological, and genetic engineering techniques have been employed for the mitigation, effective control and management of mycotoxins in food, feed and water. Post-harvest treatments to remove Mycotoxins such as alkalization, ammonization, and heat or gamma radiation are not generally used by farmers. Developing fungal resistant and insect resistant hybrids/crops to combat pre-harvest infections and their outcome is a major issue of concern. However, some of the microorganisms naturally present in soil have the ability to degrade and reduce the aflatoxin contamination in different types of agricultural products. Prevention is the recommended measure to avoid mycotoxins. Feeds should be stored in a cool and dry area. Regular testing is possible by inspecting visually the feed (with or without black light), or by the mean of commercial detection kits. When moulds are



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detected in small quantities, a commercial inactivator can be purchased. However, heavily contaminated feeds and ingredients should be discarded (Royes&Yanong, 2002).

Many national and international public health and governmental authorities such as the US Food and Drug Administration (FDA), World Health Organization (WHO), Food Agriculture Organization (FAO), and the European Food Safety Authority (EFSA), are giving much importance to mycotoxin contaminated food and feed. They have pointed out this serious problem by adopting strict regulatory guidelines for major mycotoxin classes in food and feed. Currently, about 100 countries have established limits on the presence of major mycotoxins in food and feed. Worldwide comprehensive development plan is required for wastewater treatment technology in the aquaculture industry. Only a few countries have developed wastewater management plans for aquaculture for the protection of the environment and its natural resources. Technology for the treatment of wastewater in aquaculture is not only essential for the growth of the industry but also important for environmental sustainability.

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## Physiological and Biochemical changes in Rice (*Oryza sativa* L.) under Complete Submergence

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### ABSTRACT

Rice (*Oryza sativa* L.) is one of the most important staple food crops for approximately 557 million people in Southeast Asia including India. In our state Odisha it is the staple food of 37 million people grown in 4.4 m ha of area. Submergence is one of main environmental stresses to rice growth and productivity in large rice-growing areas, especially in the flood-prone rainfed lowlands in South and Southeast Asia, where it regularly affects about 15 to 20 million hectares of rice land. Flash flooding can cover the entire plant for prolonged periods, and most rice cultivars die within 7 d of complete submergence. Complete submergence of rice leads to reduced growth and yield. Rice is a semi-aquatic species and has a reputation for growing well under flooded conditions however, it is also the case that rice is not well adapted to sudden and total inundation when this is sustained for several days the effect can be fatal. Many physiological and biochemical changes occur during submergence to sustain the plant in harsh condition.

**Keywords:** environmental, Rice, land, growth, yield, semi-aquatic

### INTRODUCTION

Rice (*Oryza sativa* L.) is a plant of Asian origin, widely cultivated in India and South East Asia. The Jeypore belt of Odisha is now considered as the origin of *Oryza sativa* L., the cultivated rice in India. Rice is the staple food for more than half of the world's population. Asia accounts for about 90% of the global rice production. India is the second largest rice-growing country after China, with a production of more than 100 million tonnes. In India, rice is mainly cultivated on tiny farms, primarily to meet the family demand. Marketable surplus for meeting the demand of urban



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populace comes from affluent farmers with large landholdings. Rice production and prices fluctuate widely with the occurrence of drought, flood and many more abiotic and biotic stresses.

Submergence is considered the third most important constraint for higher productivity in eastern India (Setter et al., 1996). Excessive flooding poses risks to human life and is a major contributor to the poverty and vulnerability of marginalized communities. During the past five decades, the flood-affected area in India has more than doubled in size from about 5% (19 million hectares) to 12% (40 million hectares) of the total geographic area (IPCC, 2007; World Bank Report, 2008). In addition, the climate projections suggest that temperatures, precipitation, flooding and sea level rise are likely to increase, with adverse impacts on crop yields and farm income. A spatial shift in the rainfall pattern towards the already flood-prone coastal areas is also projected. As an example of the implied magnitude of this shift, the discharge at the measuring station at Naraj on the Mahanadi River in Odisha, India is likely to rise dramatically from the current level of about 2% to over 10% under the climate change scenario (World Bank Report, 2008; INCCA, 2010). Rainfed lowlands constitute highly fragile ecosystem often prone to flash floods (submergence), with an average productivity of 1.2 t/ha in normal years and hardly 0.5 t/ha in case of the submergence.

Quiescence and elongation are two opposite strategies by which rice adapts to flood depending upon the nature of flooding (Luo et al., 2011). The ethylene response factors genes Snorkel1 (SK1) and Snorkel2 (SK2) allow rice to adapt to deep water whereas Submergence1A-1 (Sub1A-1) allows rice to acclimatize under flash flooding (Xu et al., 2006; Hattori et al., 2009; Nagai et al., 2010). Both SKs genes and Sub1A-1 are connected with gibberellin biosynthesis or signal transduction, yet deepwater and 2 submergence-tolerant rice seem to have opposite flooding response; namely, escape by elongation or remain stunted under water until flood recedes (Xu et al., 2006; Hattori et al., 2009; Sarkar and Panda 2009; Bailey-Serres et al., 2010; Bailey-Serres and Voisenek 2010). Introgression of SUB1 QTL into 'Swarna' greatly enhanced its survival under submergence, and plant productivity under flash flood conditions (Sarkar and Panda 2009). Rice plants that exhibit only limited elongation during submergence often show tolerance to complete flooding. Much of the injury to plants caused by abiotic stresses is associated with oxidative damage at cellular level. Damage to membrane integrity is a common effect of stress, especially in the case of low oxygen. Under anoxia, a decrease in membrane integrity is a symptom of injury, measured as changes in lipid content and composition, and also activation of lipid peroxidation (Blokina et al., 2003).

Plants have active oxygen-scavenging systems consisting of several antioxidant enzymes, and some low molecules of non-enzyme antioxidants, which can neutralize the free radicals and thus retard the progress of many injuries associated with oxidative stress and reactive oxygen species (ROS). ROS are common components of biochemical changes in the chloroplasts, mitochondria or in peroxisomes, when plants are subjected to harmful stress conditions and which can cause oxidative injury which includes super oxide (O<sub>2</sub><sup>-</sup>), hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) and hydroxyl radicals (OH<sup>-</sup>). Via oxidative damage of chlorophyll, DNA, proteins, lipids, nucleic acids and other macro molecules, Oxygen radicals can severely disrupts normal metabolism due to their cytotoxicity. To defend cellular membrane and organelles from injury, plants have developed a multifaceted anti oxidant system to mitigate oxidative damage created during anoxia condition of complete submergence. Antioxidative enzymes like catalase and peroxidase can easily overcome the injury effect (Boni Facio et al., 2011) suggested that H<sub>2</sub>O<sub>2</sub> detoxification followed by the activity of peroxidase.

Two important factors influencing rice plant survival during submergence are limitations to gas diffusion under water, and reduced irradiance that impair photosynthesis and efficient utilization of carbohydrates. Thus, survival during submergence may largely depend on accumulation of high carbohydrate concentration prior to submergence and a capacity for maintaining energy production through rapid alcoholic fermentation under oxygen shortage. During flash flooding, a third factor thought to affect survival is the aerobic shock during the post-submergence period when flood water recedes. Changes in the level of antioxidant and enzymes such as super oxide dismutase (SOD) suggest that tolerant rice cultivars develop protective systems to air after exposure to hypoxic or anoxic environment. These responses are similar to other wetland plants (Sarkar et al., 2006). The capacity to survive



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submergence depends not only on specific environmental factor, but also on the strategy that plants have evolved for adoption to particular flood-prone environments. In view of the above facts the present review is on Physiological and Biochemical changes in Rice under complete submergence.

**Effect of submergence on Morphological Characters****Plant Height**

Submergence increases the endogenous levels of GA1 (bioactive form) and GA20 (inactive form; an immediate precursor of GA1) in the intercalary meristem and elongation zone of inter node sections in deep water rice (Hoffmann-Benning, 1992). In deepwater and floating rice areas, water stagnates for longer duration, Most commonly more than a month, and varieties adapt to these conditions through shoot elongation to avoid complete inundation (Sarkar et al, 1996; Das et al, 2009; Kato et al,2014) Ethylene is a key regulator of the formation of lysigenous aerenchyma, at least in *Z. mays*, through programmed cell death, and stimulated shoot elongation mediated by cell-wall loosening in rice and *Rumex* (Voeselek & Bailey-Serres, 2013) thus affecting nutrients delivery to the shoot. On a shorter time scale, root growth is arrested immediately upon onset of hypoxia, while shoot growth still persists. Waterlogging/flooding treatment induces a “physiological drought”, reducing stomatal conductivity by several fold (Pang et al., 2004; Polacik and Maricle, 2013). The low energy status under hypoxic conditions results in a substantial depolarization of plasma membrane potential (Shabala, 2011). Rice varieties that exhibit limited or no elongation during complete submergence often show tolerance to flash flooding, whereas deepwater rice varieties adopt opposite strategy, displaying greater elongation of leaf and culm (Luo et al, 2011).

**Number of leaves**

R. K. Sarkar (2006) viewed that Low light intensity and hypoxia are the two key factors that limit the ability of rice plants to survive long periods of submergence, due to severe damage to old leaves and the failure of sensitive plants to develop new leaves.

**Number of Tillers**

The tillers of susceptible genotypes damaged due to anoxia stage under submerged condition and the energy required for survival was very less. The effective tillers contribute maximum for higher yield (Bisht et al, 2007). As per Ismail et al, (2009); Singh et al., (2009) modern high-yielding varieties are particularly sensitive to submergence even for a few days. Their yield can be severely reduced because of high mortality, low tillering and slow recovery. Age of tiller and number of tiller per hill were significant on crop growth rate (CGR), relative growth rate (RGR), net-assimilation rate (NAR), specific leaf weight (SLW), leaf area ration (LAR) and leaf area index (LAI) (Hossain et al., 1996).

**Leaf area**

Ali et al., (2003) reported that for maximum crop growth enough leaves must be present in the canopy to intercept most of the incident NAR. Therefore, growth is often expressed on leaf-area basis. According to Zhang et al., (2016) Leaf area in rice increases under submerged condition.

**Effect of submergence on Biochemical Characters****Chlorophyll and carotenoid content**

The chlorophyll content in leaf tissues varies with the age of the plant the species and the growing season. Chlorophyll content decreased proportionately with increase in submergence period (Deka and Baruah, 2000). Sarkar et al., (2006) during their study on physiological basis on rice under submergence, concluded that in complete submergence stress, the degradation of chlorophyll content occurs in susceptible cultivar compared to tolerant one which can be used as indication submergence tolerance. Chlorophyll content decreased proportionately with increase in submergence period (Das et al, 2005). Tolerant cultivars maintained a higher level of chlorophyll during submergence and the subsequent period of re-emergence. (Panda et al, 2008). Submergence resulted in significant



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reduction of chlorophyll content both in susceptible and tolerant cultivars (Panda et al, 2008). According to Rai et al., (2004) yellowing of leaves was found to be a symptom of submergence of seedlings with increase in carotenoid content.

**Proline content**

Suppressions of mitochondrial electron transport is the primary reason for stress induced proline accumulation in susceptible genotypes (Alia, 1993) 7 Under submergence normal growth of mitochondria is affected results in accumulation of proline. In tolerant variety proline accumulation is less than susceptible variety ( Shibasaka and Tsuji, 1988) Proline has also been referred as a supportive index for assuming osmotic deficits out of submergence as studied earlier (Mostajeran and Rahimi-Echi, 2009).

**Catalase and peroxidase activity**

Plants with a high level of antioxidants have greater resistance to this oxidative damage. Hence, monitoring the antioxidant content a few days after submergence could constitute an efficient technique to identify tolerant genotypes. (Rama Krishnaya et al., 1990). Plants have evolved defence mechanisms naturally to scavenge ROS by enzymatic and non-enzymatic antioxidant mechanisms. Several antioxidant enzymes have been evolved in detoxifying ROS. Among them, superoxide dismutase (SOD) is a major scavenger of O<sub>2</sub> – which dismutates O<sub>2</sub> – into H<sub>2</sub>O<sub>2</sub> (Bowler et al. 1992) H<sub>2</sub>O<sub>2</sub> is scavenged by ascorbate peroxidase (APX), glutathione reductase (GR), catalase (CAT), and some peroxidases (POX).

The activities of enzymes like catalase, peroxidase and super oxide dismutase expressed on a per g fresh weight of leaves basis, were higher in FR-13A (tolerant) than other cultivars (susceptible) (Sarkar et al., 2001). To minimize and eliminate oxidative damage, plants have evolved an antioxidant defence system comprising enzymes such as superoxide dismutase, catalase, peroxidase, the antioxidants remove, neutralize, and scavenge the ROS at different cellular locations. Previous studies have indicated that higher activity levels of antioxidant enzymes may contribute to better stress tolerance by increasing the protection capacity against oxidative damage (Sharma and Dubey, 2005). Plant adapted water logged condition, mechanism to cope with this stress such as aerenchyma formation, increase availability soluble sugar ,greater activity of glycolytic pathway, formation of enzyme and involvement of antioxidant enzyme to cope with the post hypoxia/anoxia oxidative stress.

**Lipid peroxidation**

A product of lipid peroxidation called malondialdehyde (MDA) is considered an indicator of oxidative damage. Blokhina et al., (2007) proposed that, reduction in membrane integrity under anoxia is an indication of injury and can be measured by variations in MDA content

**Carbohydrate and Sugar**

Complete submergence of rice leads to low concentration of carbohydrate, reduced growth and,finally death of tissues (Jackson and Ram, 2003). Complete submergence reduces level of carbohydrates up to 4–12 folds but in partial submergence the reduction depends on proportion of leaves below the water (Setter et al., 1997; Manzur et al., 2009). Maintenance of stored carbohydrate before the submergence of rice plant reserve large carbohydrate, is essential for better survival during submergence. Because flood tolerance is related to high carbohydrate supply. (Singh et al., 2009). A rice variety maintaining highest stored structural carbohydrate as well as carbohydrate constituents in the stem is supposedly proved more stress tolerant (Das et al., 2005; Nagai et al., 2010). Under complete submergence, photosynthesis is weakened, and plants exhaust the reserve carbohydrate and ultimately die (Das et al, 2005, 2009; Sarkar and Panda, 2009; Luo et al, 2014).

Some plants are able to sustain their basic metabolism by consuming reserve carbohydrates (Dixon et al., 2006). The reason of reduction of carbohydrate concentration under submergence may be due to the increase in carbohydrate



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consumption for cell division, cell elongation and maintenance of elongation growth (Voeselek et al., 2006). To continue life, exposure of leaf tip above the water surface is vital even for submergence tolerant varieties if flooding duration exceeds more than 2–3 weeks (Bailey-Serres and Voeselek, 2010; Sarkar and Bhattacharjee, 2011; Colmer et al., 2014). Rice genotype with higher deposition of structural carbohydrate on the tissue wall is set as a selective pressure of submergence tolerance (Nagai et al., 2010). The cellulose and hemicellulose undergo chemically turned over into soluble residues and contribute in extension of complex carbohydrate polymers for elongation of culm. Accumulation of carbohydrates and its metabolism happens to be the most crucial in plants under complete inundation and plants are forced to adopt alternative pathways of carbohydrate metabolism through fermentative reactions (Banerjee et al., 2015). Acquisitions of sugar is crucial for survival of plant under submerge condition. Reports suggested that in water logged condition rice plant could utilize sugar, mostly reducing type by hydrolyzing the sucrose and other storage carbohydrate on demand of respiratory substrate for better survival.

**H<sub>2</sub>O<sub>2</sub> and O<sup>2-</sup>**

Reactive oxygen species (ROS) are aggressive oxygen radicals, which can be enhanced by submergence stress in plants. These oxygen radicals are also known as active oxygen species (AOS) or reactive oxygen intermediates (ROI), which can cause oxidative injury which includes superoxide (O<sub>2</sub><sup>-</sup>), hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) and hydroxyl radicals (Cruz de Carvalho 2008). Via oxidative damage of chlorophyll, DNA, proteins, lipids, nucleic acids and other macromolecules, Oxygen radicals can severely disrupt normal metabolism due to their cytotoxicity (T. Colmer and O Pedersen 2008). To defend cellular membranes and organelles from injurious effects of ROS, Plants have developed a multifaceted antioxidant system to mitigate oxidative damage generated by reactive oxygen species. Antioxidative enzymes in combination with numerous peroxidases like ascorbate peroxidase (APX), peroxidase (POD) and glutathione reductase (GR), can ably overcome the activity of ROS (Bonifacio et al., 2011). Bonifacio et al., (2011) concluded that, Hydrogen peroxide detoxification is followed by the activity of an important ascorbate peroxidase (APX), which also catalyses the conversion of hydrogen peroxide to water by the reducing power of ascorbate.

**Effect of submergence on Yield and yield Attributes**

It has been revealed from the study that there is a positive correlation between yield and its component characters such as test weight, number of tillers/plant, number of spikelet/panicle and number of panicles/plant (Sadhu and Chattopadhyay, 2000). There is a positive correlation like plant height, panicle length, and 1000 grain weight, filled grain per panicle, biological yield and harvest index with grain yield. Great biomass accumulation occurs before or after anthesis (Peng et al., 2009; Yang and Zhang, 2006). Ram et al., (2002) reported that yield improvement in introgression lines in rice was observed due to increase in number of ear bearing tillers and number grains per panicle. According to Bisht et al., (2007) the greatest contributors to genetic diversity in grain yield were the flowering time, plant height and tiller number per plant.

The physiological character which is responsible for higher grain yield are high photosynthetic rate and slow leaf senescence revealed that the characters HI, biological yield, tillers per plant flag leaf width, test weight and spikelet per panicle exhibited high positive direct effect on grain yield per plant. Under submergence, rice plants have modulated pattern of partitioning dry matter for grain by enhancing remobilization of pre-stored carbohydrates from pre-flowering photosynthesis. Therefore, the slow and inadequate grain filling in submerged rice varieties might be compounded with lesser carbohydrates mobilization from pre-stored source (as in culm and leaf sheath before flowering and impairment of readily supplied grain filling materials through starch-sucrose metabolic pathway (Tang et al, 2009). Panicle number decreases due to the suppression of tiller growth or mortality of tiller either due to prevalence of less light below 50cm water depth or lack of sufficient supply of oxygen (Haque et al, 2015). In medium-deep water ecology, first elongation does not require, however, main requisite is to stagnant flooding tolerance with slow elongation so that plants can maintain appropriate yield and yield attributes for greater yield (Sarkar and Bhattacharjee, 2011). Genotypes having faster post submergence growth yield more. The decrease in rice yield can be controlled to 10% after the plants suffer from half, 2/3, and complete submergence for 1–3 d of





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field water storage. Yield loss due to floods ranges from 10 to 100 % depending on flood duration, depth and floodwater conditions (Ismail et al., 2013). These Sub1 varieties can survive 2 weeks of complete submergence and they typically provide 1–3 t/ha yield advantage over the original varieties in flood-prone rainfed lowlands. (Ismail et al., 2013).

## CONCLUSION

Various morphological, biochemical and yield attributes changes occurs due to submergence in rice. Plant height, leaf area, days to 50% flowering, total biomass, proline content, catalase, peroxidase, lipid peroxidation content increases due to submergence in rice. Number of tillers, chlorophyll content, carotenoid content, protein, carbohydrate, sugar content, H<sub>2</sub>O<sub>2</sub> activity, O<sup>2</sup> activity, grain yield, grain per panicle and Harvest Index decreases because of complete submergence in rice.

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## Dyadic Communication Pattern among the Farm Families for Taking Decision

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### ABSTRACT

Dyadic communication plays a very important role in taking decision in farm families. It helps for passing informations among the family members, The research study indicates that tolerance and keeping patience is very important in dyadic communication between father and son. The direct communication is very much important for taking decision. Keeping faith between the dyads, father and son helps for better interaction in the farm situations. Faith has the highest contribution to predict the variable dyadic communication in case of father and son.

**Keywords:** Dyadic, communication, highest, farm

## INTRODUCTION

A dyad is smallest possible social group. It consists of two people. They can be linked by romantic interest, family relation, interests, work, partners (Dyad, Wikipedia, 2019). A person shares thoughts with another person in dyadic communication. The communicator can use charts, slides, graphs, own voice, body language, facial expressions for communicating with the person (Owlgen, 2020). The two-person group, dyad, is the most frequent of all social groupings (Coleman et al(1961), Fisher et al(1953), James et al(1951), American Sociological review(1953). The dyad is probably the most important of all social groups (Tagiuri et al(1958), Yablonsky, Lewis(1955). The two-or three-boy relationship was more valued than the relation to the larger gang as a whole. It is to the dyadic institution of marriage that most persons try to find emotional and physical fulfillment (Thrasher, 1927).





### Objective

- (1) To study the dyadic communication pattern between Family head and son
- (2) To find out the distance maintained while communicating in different dyadic situations.

### MATERIALS AND METHODS

The blocks Digapahandi and Chikiti of Ganjam district in Odisha were purposively selected for the study. Two villages Gadagovindapur and B-Nuapada were randomly selected under these two blocks.. Fifty farmers were taken from each village from the two blocks. purposive as well as simple random techniques were adopted for the study. For the selection of districts and blocks purposive sampling technique was adopted while in case of selection of villages and respondents simple random sampling technique was adopted. The total number of farm respondents were one hundred under the study. Dyadic communication among the farm family members with respect to the farming operations is the dependent variable of the study. The study was conducted in 2003.

### Analysis

The variable faith of the family head on his son shows a negative significant association with the dyadic communication between family head and son with respect to different farming operations and allied activities. It is due to the reason that their son's information endowment regarding agricultural technology is not at par with head of the family. The heads of the families (fathers) did not show significant faith on their sons regarding farming operations in dyadic communication situations.

Above table represents the multiple regression analysis between the dependent variable communication in case of dyad 2 and 18 predicted variables. It was observed that the variable tolerance and faith are significantly and positively effective to delineate the dependent one. Tolerance is an inherent quality to other farmers' information. To tolerate others is a good quality which influences the communication process. The  $\beta \times R$  value in case of the variable faith is 35.56% which indicates that the variable faith has the highest contribution to predict the variable dyadic communication in case of father and son. The  $R^2$  value being 0.247 indicates that 24% of the total variation of dyadic communication in case of dyad 2 is explained by 18 causal variables.

### CONCLUSION

Dyadic communication between family members is very important to take decision in farming situation. It plays a crucial role for maintaining group relationship, group solidarity and farmers do not feel alone. Better is the dyadic communication between the family members better is the coordination between them for ensuring any kind of decision at various stages of farming operations. Due to lack of dyadic communication between various farm families, farmers are facing lot of problems and feeling isolated and that leads to depression.

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**Table 1: Coefficient of correlation between dyadic communication and 18 causal variables**

SI No	Variables	Family head and Son
1	Age(x <sub>1</sub> )	0.1051
2	Occupation(x <sub>2</sub> )	0.1074
3	Caste(x <sub>3</sub> )	-0.1074
4	Educational level(x <sub>4</sub> )	-0.1179
5	Family education status(x <sub>5</sub> )	-0.1469
6	Family size(x <sub>6</sub> )	0.0336
7	Social Participation(x <sub>7</sub> )	0.0958
8	House Type(x <sub>8</sub> )	0.0321
9	Material Possession(x <sub>9</sub> )	-0.0528
10	Land holding(x <sub>10</sub> )	-0.0210
11	Agricultural Implements(x <sub>11</sub> )	0.0164
12	Risk taking ability(x <sub>12</sub> )	0.1825
13	Cosmopolitaness(x <sub>13</sub> )	0.0213
14	Mass Media Exposure(x <sub>14</sub> )	0.1231
15	Fatalism(x <sub>15</sub> )	0.1437
16	Dependence(x <sub>16</sub> )	-0.0900
17	Tolerance(x <sub>17</sub> )	0.1122
18	Faith(x <sub>18</sub> )	-0.2674 *

**Table 2: Multiple regression analysis of dyadic communication pattern (D2) and 18 causal variables**

SI No	Variables	Standardized regression coefficient(β)	β×R	Multiple regression Coefficient	SE of 'b'	t value of 'b'
1	Age	0.089	3.769	0.066	0.111	0.592
2	Occupation	0.111	4.844	1.179	1.248	0.945
3	Caste	-0.157	6.837	-1.536	1.043	1.473
4	Educational level	0.013	-0.624	0.029	0.277	0.105
5	Family education status	-0.187	11.102	-0.580	0.385	1.506
6	Family size	-0.047	0.641	-0.107	0.351	0.305
7	Social Participation	0.093	3.623	0.340	0.444	0.767
8	House Type	0.105	1.364	1.161	1.580	0.735
9	Material Possession	-0.032	0.683	-0.046	0.196	0.236
10	Land holding	-0.137	0.666	-0.084	0.093	0.902
11	Agricultural Implements	0.063	0.410	0.139	0.310	0.448
12	Risk taking ability	0.164	12.095	2.807	2.081	1.349
13	Cosmopolitaness	-0.114	-0.983	-0.715	0.812	0.880
14	Mass Media	0.107	5.343	0.131	0.185	0.706





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	Exposure					
15	Fatalism	0.059	3.437	0.056	0.123	0.453
16	Dependence	-0.078	2.842	-0.166	0.233	0.713
17	Tolerance	0.213	9.668	0.965	0.467	2.064*
18	Faith	-0.329	35.564	-1.166	0.445	2.623*





## Psychological Challenges of Farmers and Remedial Measures

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### ABSTRACT

At present farmers are facing several types of stresses. Earlier, people considered farming to be a pleasurable occupation but times have changed. Climate change, global warming, more insect pest and disease infestation in crops, exposure of farmers to continuous use of pesticides, commodity price fluctuations, and crop losses due to natural calamities such as drought, floods, and cyclones, are affecting the mental health of farmers. Farmers are showing various signs of stress, such as loss of memory, headache, body pains, lack of motivation, insomnia, irritability, and breathlessness. Possible remedial strategies include maintaining positive attitude, proper rest and sleep, doing regular exercises, humor and recreation, counselling, staying connected with others, being active, willing to learn, taking responsibility, and giving to others.

### INTRODUCTION

The physical, mental, and emotional response to a stress causing factor or 'stressor' is called stress. Stress makes one feel frustrated, angry, nervous or anxious, and can originate from any situation or thought. Each individual reacts differently to stressful situations. Some people manage a crisis or other stressful circumstances by focusing on the problem and putting everything else apart. Some of the signs that one may be under considerable stress are problems with concentration or memory, lack of motivation, lack of interest in activities like socializing, sleeping

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problems such as insomnia, early waking or over sleeping, change in appetite such as eating too little or too much or eating unhealthy foods, mood changes such as irritability, physical problems such as chronic headache and stomach ache, heart palpitation and breathlessness, and general ill health for long term (Better Health Channel, 2019). Financial difficulties, price and marketing uncertainties, farm transfer issues, production challenges, marital difficulties, and social pressure can be sources of stress for farmers and farm family members (Minnesota Department of Agriculture, 2020).

**Problems Faced by Farmers and Farming Industry**

The farming industry has many stress factors, which are imposing increasing pressure on workers and putting them at greater risk of mental health. These are long hours working in isolation, not making distinction between work and home life, and financial uncertainty (The Poultry Site, 2020). Several factors are responsible for depression and anxiety among farmers and their employees. Serious weather events can adversely affect finances by having extreme impact on a season's yield. As compared to other industries agricultural workers are rated as 46% more likely to face illness overall. They are facing physical illnesses like lung and musculoskeletal diseases higher than those for other workers. Many farm jobs are companionless and can go for longer duration without interaction with other people. This leads to depression (Morrison, 2020). Life is hard going for farmers. Farmers deal with unpredictability of weather, instability of markets, commodity supply trade disputes, global economic forces, estate and succession plans, family relationships, and natural disasters (Spangler, 2019).

Depression impacts one among five farmers. It is recognized by medical practitioners that whole health starts with mental health. The farm business owners may be stressed due to low commodity prices, debt load, family disagreement, and negative weather events. In the United States, farming is listed among the top ten stressful occupations as per survey. Accordingly, about 20% of farmers may suffer from depression and statistical data has indicated high suicide rates. Men on farms today commit suicide nearly twice as frequently as other men in the general population. The Centre for Disease Control and Prevention (2016) reported that the rates of suicides by occupation were highest in farming, fishing, and forestry. The report noted that farmers' chronic exposure to pesticides might affect the neuro-system and give rise to depressive symptoms. Other factors contributing to suicide are social isolation, financial losses, barriers to and unwillingness to seek mental health service, and access to lethal means (Mohr, 2017).

Depression is a common disorder that many people may experience sometime in their lives. In busy farming, it can be one of those stressed feelings that gets ignored. Depression interferes with mental health and it can affect physical health. Christensen, a therapist who farms near Rush Ford, Minnesota, said whole health begins with mental health. When we talk about mental health many are simply referring to the state of psychological or emotional well being. A healthy psychological state is the ability to successfully manage the ups and downs in life and to have a cheerful outlook (Mohr, 2017). A farmer may not admit that he or she is suffering from depression. Those kind of feelings of helplessness do not line up with the traditional image of farmer endurance and independence. There continues to be a significant stigma on those with mental health challenges as noted by Christensen. The emotion that goes with the stigma is often shame so that the farmer believes that there is something wrong with him that he cannot manage life the way others are dealing with. People who are struggling with emotion get good at emotional concealing, which is hiding one's true emotions and pretending that everything is fine when it is not (Mohr, 2017). National Institute of Health, USA reported that farmers breathe in pesticides while spraying and these are absorbed through their skin and can have neurological effects that can lead to depression and that farmers have more and easy way of access to lethal equipment (Countryfile, 2015).

**Warning Signs of Stress (Rural Mutual Insurance Company, 2020)**

- (1) Change in routine
- (2) Decline in the care of domestic animals
- (3) Increase in illness





- (4) Increase in farm accidents
- (5) Decline in appearance of farm stead
- (6) Signs of stress in children
- (7) Decreased interest

### Signs of Chronic Prolonged Stress

Table 1 indicates the various physical, emotional, behavioural, Cognitive and self-esteem signs of chronic stress. An Irish project found out research from across the world on proven actions that can help one to feel good and function well (Mental Health Ireland, 2020). There are simple actions of five ways of well being should be practiced daily to maintain or improve one's mental health.

- If there will be small improvements in well being, that can improve one's ability to lead a more fulfilling life.
- By doing each action in the five ways to well being can make a positive difference to one's life.
- The five ways to well being are free and easy to include into one's life.
- Someone may be probably doing some of these actions already without being aware of it.
- To get the most benefit from the five ways to well being, one should amalgamate all of them on a daily basis.

### Well being

Wellbeing is feeling good about oneself, the world around, and functioning well in everyday life. An important quality of well being is to be strong and coping with the normal stresses of life. Many things are there to influence one's well being. These include doing regular exercises, diet, and sense of belonging, relationship, career, self care, spirituality, money, where we live, and sense of purpose. Well being includes how satisfied one is with one's life, one's sense of purpose, and how in control one feels.

### Connecting

One should find time each day connecting with the people around like family, friends, colleagues, and neighbours, and at home, work, school or in a local community. By being connected and developing these relationships people feel happier and more secure, giving a better sense of purpose.

### Being Active

One should look for ways to be active every day and go for a walk or a run. One should step outside, cycle, play a game, garden or dance. One should find a physical activity one enjoys, which suits one's life style and level of mobility and fitness. Being physically active can improve one's mental health and well being.

### Taking Notice

One should be aware of the world around him, be curious and enjoy the beauty around. One should pay attention to changing seasons, savour the moment, eating lunch with friends, paying attention to one's present moment like thoughts and feelings.

### Keep Learning

One should try something new, regain an old interest, signing up for that course, cook a new recipe, and take a new responsibility, setting a new challenge and learning a new skill. These will increase one's confidence which can improve one's mental health and well being.

### Giving

One should give to others, do something good for someone. One should thank someone for the help and cooperation he is getting, volunteer time or join a community group. Linking one's happiness to the wider community can be extremely rewarding and creates connectedness with the people around.



**Five Steps to Help Someone at Risk** (Rural Mutual Insurance Company, 2020)

- (1) By asking others
- (2) Keeping others safe
- (3) Being there for others
- (4) By helping others connect
- (5) Following up on earlier events

**CONCLUSION**

With little human contact, farmers work in isolation for long hours in the fields. This can breed mental health problems and suicidal thoughts. According to the psychiatrist David Middleton when farmers do not seek help whenever stress comes, more serious and fatal consequences happen. Entire days without seeing anyone and social isolation can lead to mental illness symptoms (Countryfile, 2015). Visiting a doctor, family support, mental health services, and self help are necessary (NHS, 2019). Social activities are playing important role to support mental health. Getting off from the farm and taking breaks is very important. Practicing regular aerobic exercises will help for managing the stress. Giving attention to parents, daughters, sons, and friends has a positive impact on mental health (St Patrick's Mental Health Services, 2019).

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**Table 1. Signs of chronic prolonged stress as given by Fetsch and William (2020)**

Sl No	Physical	Emotional	Behavioural	Cognitive	Self-esteem
1	Headaches	Sadness	Irritability	Memory loss	“I am a failure.”
2	Ulcers	Depression	Backbiting	Lack of concentration	“I blew it.”
3	Backaches	Bitterness	Acting out	Inability to take decisions	“Why cannot I...?.”
4	Eating irregularities	Anger	Withdrawal	-	-
5	Sleeping disturbances	Anxiety	Passive aggressiveness	-	-
6	Frequent Sickness	Loss of spirit	Alcoholism	-	-
7	Exhaustion	Loss of humour	Violence	-	-





## Psychological Health of Farmers – A Rising Concern

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### ABSTRACT

Farmers now face major problems, such as aberrant weather, low commodity prices, and trade wars. They are undergoing increasing mental stress and anxiety. The poor mental health of farmers may be ascribed to long working hours, lack of adequate rest and sleep, not enough time available for family and social gatherings, and less control on their emotions. Farmers often work continuously in isolation. They are under constant mental stress but are unable to express their feelings to others and seek counseling due to the social stigma attached to mental illnesses. Farmers do not feel comfortable talking of their psychological problems to friends or relatives. Farmers face several stressful situations in their profession. More mental health campaigns should be organized to create awareness among farmers and to motivate them to express their emotions and seek advice when facing any psychological problems.

**Keywords:** Farmers, problems, health, emotions, stress

## INTRODUCTION

Mental health of farmers is a growing concern. Agricultural Consumer & Environmental Sciences (ACES) expects to manage this problem by conducting workshops to increase awareness among farmers and improve access to mental health resources. A majority of farmers show symptoms of anxiety or depression as per a study by Josephine Rudolph, assistant professor in ACES( The Daily Illini, 2020).Among professions, farming was found to have very high suicide rate. This problem is due to substance abuse, social stigma attached to psychological illnesses, and perception of mental health treatment. Many rural areas are provided with inadequate services by the healthcare

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system overall as studied by Rudolphi (The Daily Illini, 2020). This problem was managed by organizing 'Agricultural Mental Health and Stress Management' programs. The goal of such programs is to connect local farmers with mental health resources and provide techniques making one stress-free and raising awareness about the problem (Caruso, 2020). Farmers have little control over problems with machinery, weather, labour, animal or plant diseases, commodity prices, and economics. The farmers can be provided with support when warning signs of stress are evident. Warning signs of stress include changes in emotions, changes in attitudes and cognitive skills, changes in behavior, and changes on the farm or ranch. The farmers can be helped by practicing active listening and empathizing (Sanguesa and Thompson, 2019).

**Causes of Poor Mental Health and Coping Strategies**

A recent study at the International Institute of Population Science found that in Vidarbha region of Maharashtra around 60% farmers needed help for mental illnesses and there is the need of trained rural counselors. Bombie and Hemkothang (Newslick, 2020) surveyed three hundred households in Vidarbha region and found that 34.7% farmers suffered from somatic symptoms, a mental illness that leads to neurological issues including body ache. In the survey, 55% farmers complained of anxiety, 7.3% showed symptoms of social dysfunction, and 24.7% showed signs of clinical depression. The farmers who had agricultural loans of more than Rs 25,000 had anxiety and depression (Newslick, 2020).

Large cover of cotton farmers in central India were the epicenter of a debt crisis that gripped the rural population. For years now it has propelled thousands of farmers to commit suicide. These suicides are a loss of human lives as well as weakening marks on a nation's development canvas. While debates continue on improving the agricultural sector to improve the economic conditions of the farmer, there has not been any attempt to focus on possible psychological problems arising out of economic stress that may be leading to suicides (Qazi, 2017). Mississippi's farmers, ranchers, and rural communities faced numerous adversities for the last two years including flooding, trade wars, and low commodity prices, creating a decline in the issue of mental health on farm and in rural areas. The already rising number of challenges these farmers and rural communities have experienced are expected to increase during and after the COVID 19 pandemic, doing it more important to have mental health research available according to Mississippi farm bureau federation president Mike McCormick. A recent survey (AFBF, 2019) showed that a large majority of farmers and farm workers said financial issues, farm or business problems, and fear of losing their farm negatively affected their mental health. In addition to that 48% of rural adults said they were personally experiencing more mental health challenges than they were a year ago. Almost one in three farmers does not feel comfortable talking to friends and family members about solution for a mental health condition (Lowery, 2020).

In the report entitled 'Healthy Minds Healthy Farms', most farmers reported unpleasant coping mechanisms that may contribute to poor mental health including working more hours and losing sleep, less attending the family and social gatherings, feeling less in control of their emotions. Stress is everywhere in farming. Over half of Canadian farmers were categorized in the mid stress scores, whereas 14% were identified with high stress. Three out of four Canadian farmers felt moderate to high stress about unpredictable interference, workload pressure, lack of time, and financial constraints. Women and young farmers felt more stressed. The report also recommended actions like doing awareness programs about the importance of farmer mental health, improvement of mental health literacy of farmers, delivering business management advice, tools and training that focus on risk management and preparedness as a means of facing uncertainty, and advocating farmer specific mental health services (Real Agriculture News Team, 2020). Studies show that farmers' suicide rates were nearly four times higher than those of the general occupational population. Calculating these rates is extremely difficult and unique to the agricultural profession. It is a challenge to study the farmers' suicide rates and also critical in determining ways to promote suicide prevention. Above all, after decades of mental illness awareness programs on stigmatism and suicides, farmers and agricultural workers are becoming more comfortable expressing their struggles and seeking professional helper (Raschke, 2019).



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Farming is full of challenges that can take a charge on the mental health even under the best of circumstances. Presently in uncertain times of global COVID 19 pandemic which impact just about every aspect of life, emotional wellness is critically important for farmers. Few ideas that can help are taking care of oneself, developing a regular exercise routine, reading for pleasure, reconnecting with an old hobby, writing a list of relationships and things for which one is grateful, changing up listening routine, giving time to sit in silence, and meeting with a counselor or a therapist (Paff, 2020).

Nine in ten farmers and farm workers tell financial issues affect farmers' mental health. Nearly half of rural adults say they are experiencing more mental health challenges than they were a year ago, as per poll commissioned by the American Farm Bureau Federation. Kansas created a website offering research and support to individuals struggling with agriculture related stress. Research specific to different age groups and separate pages for men and women in agriculture is offered by the website. Resources include those related to financial counseling, legal assistance, substance abuse, gambling problem, and domestic violence. There is information in the site about the roots of farmers' stress and how to manage. It helps connect people to the services they need (Lenis, 2019). It is not a secret that farming life can be hard work. The most often quiet is the strain on farmers' mental health as a result as reported by Hicks (Farmers Guide, 2020).. Isolation for long hours for the farmers and financial pressures can be stressful enough, but sudden and uncontrollable factors like abnormal weather conditions, loss of vital chemical treatments and different political climate with an unstable trade system, their vulnerability is particularly apparent (Farmers Guide, 2020).

The Farm Stress Programme of the Michigan State University Extension is meant for farmers facing stress and mental health issues with online counseling. Farmers are connected with licensed mental health therapist by MSU Extension. Teletherapy provides mental health and counseling services through the internet rather than in-person. It is offered by video between mental health service providers and clients. It helps people to access behavioral health supports in their own environment. Farmers can access behavioral health services with the 'Stay Home, Stay Safe' executive orders, (Karbowski and Gross, 2020). The virtual mental health services are offered by Ontario government from May 2020 to thousands of Ontarions those who are experiencing anxiety and depression and it includes frontline health care workers during the COVID 19 outbreak. These Internet-based Cognitive Therapies were developed in partnership with Mind Beacon and Morneau Shepell . These would provided at no out-of-pocket costs to Ontarions across the province (Mental Health News, 2020).

Week-long mind your head campaign conducted by the farm safety foundation aims to raise awareness about mental health with stories and short films on social media. Recent research by the foundation charity found that that 81% of farmers under 40 believe that mental health is the biggest hidden problem facing farmers today. Other 92% believe that promoting good mental health is important. Lives can be saved and farmers are can be kept safe by promoting mental health (Hailstone, 2019). Suicide and mental disorder are major public health problems in India. Nearly 1000 farmers ended their lives every year in the Vidarbha region since 2001 according to the National Crime Records Bureau. Several experts mention higher as many cases do not even get reported. The report also indicated that the cause of suicide is varied, like gender disadvantage, caste discrimination, and debt. The most important at individual level determinant is mental disorder. The most common mental disorders that contribute to this risk are stress and depression. It can be a result of a range of social and health factors mainly in rural communities. A community initiative called Vidarbha Stress and Health Programme (VISHRAM) is an effective for bringing reduction in suicidal behavior and encourages people to seek professional help for depression (Pal, 2017).



**Chitrasena Padhy and Pakalpati Satyanarayana Raju****CONCLUSION**

There is an association between crop failure due to unexpected droughts and suicide attempts by farmers. Failure of a crop can lead to economic difficulties. When depending on low precipitation, the farmer might not be able to sustain the expenses of the family and becomes a victim of the debt trap to meet the expenses. The mental health risks among the farmers increase by climate change such as rise in temperature (Psychology Today, 2017). Agricultural networks such as farmers' unions or societies help the farmers to get together and share and discuss common problems. Farmers can get useful information on various farming issues such as good farming practices, health and safety, coping with issues etc. (Parry *et al*, 2005). Training and education are required for farmers to face uncertainties (Olesen and Bindi, 2002).

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## Population Dynamics of Pests Occurring on *Pongamia pinnata* (*Milletia pinnata* L.) and their Natural Enemies

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### ABSTRACT

The studies on the population dynamics of major pests of *Pongamia* were conducted during 2016-2018 in the agricultural fields of Bangalore, India. 20 species of pests were recorded on *Pongamia*. Nineteen species were recorded and found to be common both under nursery and field conditions. leaf webber, *Glyphodes negotialis* exclusively present only in nursery and flower gall inucer *Aspondylia pongamiae* was exclusively formed in field condition. The mite, *Aceria pongamiae* Channabasavanna, leaf blotch miner, *Acrocercops anthrauris* Fabricius, spiraling whitefly *Aleurodicus disperses* Russel and common banded awl *Hasora chromus* Cramer and web mite, *Schizotetranychus lespedezae* Beglyarov& Mitrofanov, were the major ones. Further, five species of insect pests were recorded on *Pongamia* under storage conditions.

**Key words:** Mite, *Aceria*, *Pongamia*, Leaf webber, Pests, blotch miner

### INTRODUCTION

*Pongamia pinnata*, commonly known as karanja is a leguminous oil yielding multipurpose tree. , it can tolerate a range of different conditions with mean annual rainfall between 500–2500 mm and temperatures of 0 – 16°C minimum and 27–50°C maximum where mature trees can cope with light frosts, but require a dry period of 2–6 months (Duke, 1983; Daniel, 1997). There are so many pests present on *Pongamia*, in that tree is attacked by a number of insect pests among the important insect pests, the common banded awl, *Hasora chromus* is one of the major defoliator causing heavy losses, the mite, *Aceria pongamiae* Channabasavanna, leaf blotch miner, *Acrocercops anthrauris* Fabricius, spiraling whitefly *Aleurodicus disperses* Russel and common banded awl *Hasora chromus* Cramer and web mite, *Schizotetranychus lespedezae* Beglyarov& Mitrofanov, were the major ones. However, leaf





webber, *Glyphodes negatalis* Walker, two tailed mealybug, *Ferisia virgata* (Cockerell), *Maruca amboinalis* Felder, *Euproctis* sp. Hubner, *Indarbela tetraonis* Moore, *Cyclopelta siccifolia* Westwood, *Nezara viridula* (Linnaeus), common cerulean *Jamides celen* Cramer, spherical mealybug *Nipaeococcus viridis* (Newstead), wasp moth *Amatapassalis* Fabricius, tree hopper *Oxyrachis* sp., *Chrysocoris stolli* (Wolff), cowbug, *Tricentrus bicolor* Distant are present.

## MATERIALS AND METHODS

### To record and document the pests and their natural enemies occurring on *Pongamia* under nursery, main field and storage condition

Studies to document the occurrence of major pests of *Pongamia* were carried out during 2016-17 and 2017-18 in nurseries, main field and storage. For this purpose surveys were conducted in *Pongamia* plots and the *Pongamia* nursery in UAS, GKVK, Bengaluru and Zonal Agricultural Research Station, GKVK and also in the surroundings of UAS, GKVK, Bengaluru.

### Location of plots for collection of pests

Frequent visits were made to both nurseries and plots of *Pongamia* for collecting the insect pests on *Pongamia* and their natural enemies in and around UAS, GKVK, Bengaluru from September 2016 - December 2017. The present study was based on random collection from time to time, covering different plants of *Pongamia*. In storage the pods which were collected from the *Pongamia* plants and also from godowns and were stored in containers like plastic boxes, polythene covers and cloth bags as well as in open conditions and observed on a daily basis to collect storage pests and to document them.

### Collection equipment

The basic equipment utilized for field and nursery collection comprised of forceps, scissors, vials containing 70 per cent ethyl alcohol, insect killing bottles, small boxes or containers of cardboard for storing specimens after their removal from killing bottles, small envelopes for temporary storage of delicate specimens or gel caps for tiny specimens, one or more aspirators, absorbent tissue for use in killing bottles and aspirators, field observation book, a strong secateur cutting twigs, white card board sheets for jarring, muslin cloth, rubber bands, soft camel brush, bags for storing plant material, hand lens etc.

### Collection of pests and their natural enemies on *Pongamia*

The insect pests present on *Pongamia* were collected both at their immature stages (eggs, larvae, pupae, maggots, grubs, nymphs, etc.) and also adults from *Pongamia* plants. The immature stages were collected alive from field in collection jars, collection tubes, paper bags or polythene bags, in order to carry them to laboratory for rearing them and their natural enemies, if any. The collection jars were thoroughly washed and sun dried prior to their use. Collection jars containing relevant insect material were covered with muslin cloth or cotton wool for aeration purpose. They were provided with absorbent paper to absorb extra moisture during carriage. The adult stage of the insects were collected and presented for identification. The predators devouring insect pests damaging *Pongamia* were raised by rearing their immature stages along with the host insects in the laboratory. Some coccinellids, preying mantids, spiders and hemipteran bugs were also collected as adults while they were preying on their host insects as per the methodology suggested by Lecker and Deay (1969) was adopted for this purpose. Various collection methods employed were:

### Hand picking

Based on keen visual observation this method was used for collecting caterpillars, grubs, maggots, blotch miners, galls, borers and mealybugs. Insects were picked by means of a forceps or by a camel hair brush and drawn into a collecting jar/ bags as suggested by Banks (1909).





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### Beating / Jarring

This method proved efficient whenever the weather turned cold or early and late in the day, when normally insects seek shelter in vegetation and were otherwise difficult to detect. In this method a white drawing sheet was placed under a branch which was then hit with a stick, the insects that fell off on the sheet were picked by a moistened brush or with forceps. This method gave a good collection of bugs, and larval Lepidoptera which was as per the methodology suggested by Banks (1909).

### Aspirator

It was used to capture live tiny insects like thrips, white flies, etc. for further studies as suggested by Banks (1909).

### Flower gall inducer (*Asphondylia pongamiae* Mani)

To study the presence of different stages and to know how flower gall formation occurs, flower buds were collected in polythene covers and brought to the laboratory.

### Collection of flower buds

Visits were made every week when new leaves and flowering was observed on *Pongamia*. Fifty fresh flower buds were collected each day, dissected and viewed under a stereo zoom microscope to detect symptoms of oviposition by *A. pongamiae*.

### Dissection of flower buds

From the commencement of bud formation in *Pongamia*, 50 fresh buds/galls were plucked and brought to the laboratory at weekly intervals. Samples were dissected with a sharp blade and other required accessories. Care was taken to avoid any damage to the growing stages of *A. pongamiae* within the galls. The developmental stages were observed within the flower galls by periodical dissection.

### Methods of collection of pest mites

Samples of infested leaves of *Pongamia* were plucked and put in Zip-lock plastic bags for subsequent screening of pests harboured by them in the laboratory. Within the laboratory, individual leaf was thoroughly examined under a stereo zoom microscope for the recovery of pest mites. A small quantity of the sampled mites and insects were preserved in 70% ethyl alcohol for taxonomic studies.

### Clearing and mounting of specimens

The specimens of phytoseiid mites and pest mites which were preserved in 70% alcohol were then upgraded through 80 per cent, 90 per cent and absolute alcohol series and mounted in Hoyer's medium for identification.

### Preparation of mounting medium (Hoyer's Medium)

Hoyer's medium was prepared by careful and proper mixing of the following ingredients. The mixture was then filtered through two folds of thin cloth or glass wool and stored in a coloured bottle. Distilled water - 50 ml, gum-Arabic crystals - 30gms, chloral hydrate -200 gms, glycerine -20 ml.

## RESULTS AND DISCUSSION

### Insect pests recorded on *Pongamia* under nursery, main field, storage and their natural enemies

During the study, twenty pest species were recorded on *Pongamia* (Table 1), of which 20 pest species were present both under nursery and main field. However, leaf webber, *Glyphodes negotialis* exclusively present only in nursery and flower gall inucer *Asphondylia pongamiae* was exclusively present only under field condition. Further, five species of insect pests were recorded on *Pongamia* under storage (Table 1).





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### **Pests recorded under nursery and field conditions**

Among the twenty species of insect pests recorded on *Pongamia* in nursery, the mite, *Aceria pongamiae* Channabasavanna, leaf blotch miner, *Acrocercops anthrauris* Fabricius, spiraling whitefly *Aleurodicus dispersus* Russel and common banded awl *Hasora chromus* Cramer and web mite, *Schizotetranychus lespedezae* Beglyarov & Mitrofanov, were the major ones. However, leaf webber, *Glyphodes negatalis* Walker, two tailed mealybug, *Ferisia virgata* (Cockerell), *Maruca amboinalis* Felder, *Euproctis* sp. Hubner, *Indarbela tetraonis* Moore, *Cyclopelta siccifolia* Westwood, *Nezara viridula* (Linnaeus), common cerulean *Jamides celen* Cramer, spherical mealybug *Nipaecoccus viridis* (Newstead), wasp moth *Amatapassalis* Fabricius, tree hopper *Oxyrachis* sp., *Chrysocoris stollii* (Wolff), cowbug, *Tricentrus bicolor* Distant and 20 species of pests were recorded on *Pongamia* (Table 2). Nineteen species were recorded and found to be common both under nursery and field conditions (Table 1).

### **Common banded awl, *Hasora chromus* Cramer (Lepidoptera: Hesperidae)**

Eggs were laid singly or in small groups of 2-3 on young shoots like a staple of the leaves or on the margin of the upper surface of young leaves. Eggs were bun shaped with ridges running from top to base. The eggs were flattened at the base which helped to be attached onto the substratum. The freshly laid eggs were whitish in colour but later turned pinkish and finally turned into silvery white colour, just before hatching. The larval head was blackish and they fed on the upper portion of the chorion and cut a hole to emerge out of the eggshell. After emergence larvae did not feed on the entire shell but fed only partly. The adult butterfly was brownish black in colour, the wings were completely covered with scales. The wings of a male butterfly were unmarked, whereas the female butterfly had two spots on both sides of the forewings and horizontal white band was present in both sexes, on the lower side of hind wings. *Hasora chromus* is dimorphic and the wings of a male being unmarked, whereas female having two pale yellow crescentic spots on the hind wing. The adult butterfly was very active. Antenna was enlarged gradually towards the tip with hook-like projection on the terminal segment. These results are similar to the findings of Harinath et al. (2012).

### **Spiralling whitefly *Aleurodicus dispersus* Russel (Hemiptera: Aleyrodidae)**

The white fly feeds on the underside of plant leaves by piercing their stylets into the phloem of plants, introducing toxic saliva and decreasing the plant vigour. Direct damage is caused by the piercing and sucking of sap from foliage by immature and adult stages. The majority of feeding damage was done by the first three nymphal stages. This feeding caused premature dropping of leaves. Indirect damage was due to the accumulation of honeydew and white, waxy flocculent material they produce. Subsequently they produce honeydew, which is sweet and watery excrement, often fed on by bees and ants, which in turn, may tend and offer protection to the whiteflies. The honeydew also serves as a substrate for the sooty mold growth, which blackens the leaf surface and decreases photosynthetic activity, decreases vigour and often causes disfigurement of the host and lessens the market value of the plant or makes it unmarketable.

The flocculent material produced by the nymphs was scattered by the wind and creates nuisance. Adults were similar in appearance to those of many other species of whiteflies. They were white and quite small in length and coated with a fine dust-like waxy secretion. They resembled tiny moths and both sexes were winged. Eyes of these whiteflies were dark reddish-brown. Wings were transparent after emergence from the pupal case, but developed a white powder (wax) covering after a few hours. Each forewing had two characteristic black spots. These results are similar to the findings of Paulson and Kumashiro (1985), Berlinger (1986) and Waterhouse and Norris (1989).

### **Bean pod borer, *Maruca amboinalis* (Felder & Rogenhofer) (Lepidoptera: Crambidae)**

*Maruca amboinalis* is a member of the subfamily Spilomelinae of the Crambidae family. The forewing of this species is dark brown, with a yellowish brown colour along the leading edge, a silvery white spot on the front end of the middle chamber; a white bottom on the hindwing, and a dark brown spot on the top corner extending to about half of the outer edge. The outer center line is a black wavy line. In addition to other species, there are also *M. vitrata*. The





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fine-grained pods are similar to the pods damaged by the podborers and can be distinguished by the following characteristics: 1. The fore-wings have only white spots at the front end of the middle chamber and are only as wide as the middle chamber, and the latter is developed with white spots, and more than one piece; 2. The former hind wings are dark brown. The spot is rounder and the latter is longer. This species is rare compared to the pea pod borers that are considered to be pests. *Maruca amboinalis* represents one of the two *Maruca* species which could be distinguished from *Maruca vitrata*, the other *Maruca* species, by the following characters: 1. Only one undeveloped white spot on forewing; 2. Round dark-brown marking on the hindwing.

#### **Leaf webber, *Glyphodes negatalis* Walker (Lepidoptera: Pyralidae)**

Adults are white with several ragged pale brown submarginal bands outlined in dark brown. The hind wings are white with brown veins and brown margins. It is a defoliator of *Pongamia pinnata*.

#### **Leaf blotch miner, *Acrocerops antraulis* Fabr. (Lepidoptera: Gracillariidae)**

It is a very serious and common pest of *Pongamia pinnata*. The larvae make circular blotches on the upper (dorsal) surface of the leaves. Its damage reduces photosynthetic area of the leaves, thus hindering the growth and vigour of the plants. The full-grown larvae were slender, minute, and orange-yellow with a large black head.

#### **Hairy caterpillar, *Euproctis* sp.**

Hairy caterpillar, *Euproctis* sp. was noticed in very low numbers. Early instar larvae of a hairy caterpillar, *Euproctis* sp. fed on the green part of the leaves and skeletonized them but later instar larvae completely fed on the leaves along with soft apical shoots of plants.

#### **Flower gall inducer, *Aspondylia pongamiae* Mani (Diptera: Cecidomyiidae)**

It will affect the seed set, and causes reduction of the plant growth. Presence of strong needle shaped ovipositor, and the abdominal segments with combination of yellow black band, which differentiate females from males. The colour, body size and wing size of male and female *A. pongamiae* are as follows: Female: Brownish black, Male: Light brown in colour. Symptoms of infestation were evident within 10 - 15 days of egg laying. When flower buds were oviposited by the gall inducer, the freshly emerged larvae lacerate the developing ovary in a floret on oozing cell-sap. The buds turned into young sub globular galls due to the infestation within a month and petals towards the bulged portion of the infested ovary turned whitish green and coarse. After two months of gall development, the petals and sepals dropped from the gall and only the developed nut shaped galls were apparent on the trees. The fully matured galls were dull green in colour and had an average diameter of 1 cm.

#### **Metallic shield bug, *Chrysocoris stollii* (Wolff) (Hemiptera: Scutellaridae)**

The dorsum was metallic blue, green, or purple in colour abdomen of ventral region was yellow, broadly margined with purple laterad to spiracles, spiracles II-VII each surrounded by a rounded black spot; pro-, meso- and metepimeroids together with the supra coxal lobes yellow; coxae and trochanters pale yellow, femora with an apical annulus and longitudinal blackbands, tibiae and tarsi black. The pest feeds on plant sap of *Pongamia* plant due to which they cause extensive yield reduction.

#### **Common cerulean, *Jamides celen* Cramer (Lepidoptera: Lycaenidae)**

In case of the male upper side is pale bluish white. The forewing has the terminal margin narrowly edged with black that broadens very slightly towards the apex of the wing. The cilia are brownish black. Hind wing is uniformly coloured, except for an anteciliary black line faintly edged on the inner side by a white line within which and touching it is a row of black spots, the anterior spots are very faint, the spot in inter space 2 large and well-defined, two geminate (paired) spots in inter space 1 and a very small black lunular dot in inter space 1a; cilia brown, white at the base in the interspaces.



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In the female adult the upper side colour is paler than in the male, often quite white; terminal black edging to forewing very much broader, broadest at apex, its margin there diffuse. Hind wing differs from that of the male with respect to costal margin broadly dusky black; a post discal transverse series of dusky-black connected lunules often more or less obsolescent; this is followed by a series of black spots each set in a background of the white ground colour; an anteciliary slender black line as in the male. The underside ground colour is paler than in the male, the markings however are identical. Antenna, head, thorax and abdomen are similar to that of male. It is a defoliator on *Pongamia*.

**Spherical mealybug, *Nipaecoccus viridis* (Newstead) (Hemiptera: Pseudococcidae)**

Adult female is oval; body segmentation is visible prior to oviposition and covered by wax. The body is dark green purple, or dark brown purple, beneath the white-creamy or pale-yellowish wax cover; it is 2.5-4 mm long and 1.5-3 mm wide, depending on the host plant and the specific feeding site. The adult male is brown-purple with well developed forewings, elongated more than body. The pest causes curling and dwarfing of young growth. Heavy infestations result in deterioration of the crown, which turns yellow, wilts and subsequently dies. The pest occurs on all plant parts causing injuries, It prefers to colonize fast growing tissues, contaminating them with honeydew, which results in a thick cover of sooty mold.

**Wasp moth, *Amata passalis* (Fabricius) (Lepidoptera: Amatidae)**

Adult moth can be broadly defined by the wing characteristics, forewings chocolate brown in colour with white spots. It feeds on the leaves of *Pongamia* plants.

**Metallic shield bug, *Scutellera perplexa* (Westwood) (Hemiptera: Scutellaridae)**

The bug is oblong elongate scutellerid with metallic green color and small or large spots of black on pronotum and scutellum. Body finely pilose. As is typical for Scutelleridae family, scutellum very long covering most of the body, wings not visible. Coloration of body underneath, rostrum and legs reddish, underside of head, lateral side of sternum, part of rostrum as well as lateral bands on abdominal segments are metallic bluish green. The adult suck the sap from the leaf petiole, stem, or on the pod surface. These bugs caused direct damage by sucking sap.

**Bug, *Tricentrus bicolor* Dist. (Hemiptera: Membracidae)**

The pest is recognized by the structure of pronotum which takes curious bizarre shapes in this, those have earned the name "Cow bugs" or "Horn bugs". Both nymphs and adults suck the plant sap and exude honeydew which attracts the black ant, *Camponotus compressus*. The damage caused is seldom severe resulting in drying of leaves/plant

**Leaf hopper, *Empoasca* sp. (Hemiptera: Cicadellidae)**

Their pronotum and scutellum are green. The green leafhopper, *Empoasca* sp., inserts its stylets into the plant and releases toxic substances present in the saliva into the plant vascular system, causing phytotoxicity.

**Pests recorded under storage conditions**

Totally five insect pest species were recorded on *Pongamia* under storage conditions, they were bruchid, *Caryedon serratus*, pulse beetle *Callosobruchus maculatus*, Saw toothed grain beetle *Oryzaephilus surinamensis* (Linnaeus), Rice moth *Corcyra cephalonica* (Stainton) and Mediterranean flour moth, *Ephesia kuhniella* (Zeller).

**Bruchid: *Caryedon serratus* (Olivier) (Coleoptera: Chrysomellidae)**

The adults were dark brown in colour, 4-7 mm long and show sexual dimorphism where, antennae are long and serrated in males than in females, whereas the pygidium (dorsum of the posterior abdomen) is more exposed in females than in males. The hind leg femur is serrated and 5 mm wide in both females and males. Grubs are pink in colour, 10 mm long and possess abdominal uromeres. Grubs inflict damage to both kernels as well as pods.





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Infestation starts from the field where the adults lay eggs on exposed pods and it is carry forwarded to storage (Table 2). The first visual symptom is the exit hole of final instar larva before pupation.

**Pulse beetle: *Callosobruchus maculatus* (Fabricius) (Coleoptera: Chrysomellidae)**

The body of the adult is 3-4.5 mm long, reddish-brown, with black spots on the prothorax and elytra. The last segment of the abdomen extends out from under the short elytra and also with black spots. The females are sometimes larger and darker than the males. The larva is whitish in colour. The female attaches its eggs on the surface of seeds in the field or in storage. The larvae burrow into the seeds where their complete development occurs. The larvae cannot move among seeds; thus they are restricted to the seed that the adult bruchid has chosen for them (Table2). The larva makes tunnels through the pod until it is ready to pupate. Mature adults emerge from the seed, biting a neat circular exit from the seed.

**Rice moth, *Corcyra cephalonica* (Stainton)**

Hind-wings pale-buff, fore-wings mid- or greyish-brown with thin vague lines of darker brown along wing veins. Larva feed on *Pongamia* stored pods.

**Saw toothed grain beetle, *Oryzaephilus surinamensis* (Linnaeus) (Coleoptera: Chrysomellidae)**

It is adark brown beetle; it is unable to fly even small distances.Larval feeding results in shrinkage of the dry mass of the infested seeds.

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Table 1: Pests of *Pongamia* recorded under nursery and field conditions during 2016-17 and 2017-18

Sl. No.	Common name	Scientific name	Order	Family	Nursery	Field
1.	Common bandedawl	<i>Hasora chromus</i> Cramer	Lepidoptera	Hesperidae	✓	✓
2.	Leaf webber	<i>Glyphodes negatalis</i> Walker	Lepidoptera	Pyralidae	✓	×
3.	Bean pod borer	<i>Maruca amboinalis</i> Felder	Lepidoptera	Crambidae	✓	✓
4.	Leaf blotch miner	<i>Acrocercops anthrauris</i> Fabricius	Lepidoptera	Gracillariidae	✓	✓
5.	Leaf-eating caterpillar	<i>Euproctis</i> sp. Hubner	Lepidoptera	Lymantridae	✓	✓
6.	Bark eating caterpillar	<i>Indarbela tetraonis</i> Moore	Lepidoptera	Cossidae	✓	✓
7.	Common cerulean	<i>Jamides celen</i> Cramer	Lepidoptera	Lycaenidae	✓	✓
8.	Wasp moth	<i>Amata</i> sp.	Lepidoptera	Erebidae	✓	✓
9.	Two tailed mealybugs	<i>Ferisia virgata</i> (Cockerell)	Hemiptera	Pseudococcidae	✓	✓
10.	Spiralling whitefly	<i>Aleurodicus disperses</i> Russel	Hemiptera	Aleyrodidae	✓	✓
11.	Gundhi bug	<i>Leptocoris oratoria</i> (Fabricius)	Hemiptera	Alydidae	✓	✓
12.	Pentatomid bug	<i>Cyclopelta siccifolia</i> Westwood	Hemiptera	Pentatomoidae	✓	✓
13.	Green stink bug	<i>Nezara viridula</i> (Linnaeus)	Hemiptera	Pentatomidae	✓	✓
14.	Spherical mealybug	<i>Nipaecoccus viridis</i> (Newstead)	Hemiptera	Pseudococcidae	✓	✓
15.	Metallic shield bug	<i>Chrysocoris stollii</i> (Wolff)	Hemiptera	Scutellaridae	✓	✓
16.	Leaf hopper	<i>Empoasca</i> sp	Hemiptera	Cicadellidae	✓	✓
17.	Cowbug	<i>Tricentrus bicolor</i> Distant	Hemiptera	Membracidae	✓	✓
18.	Flower gall inducer	<i>Asphondylia pongamiae</i> Mani	Diptera	Cecidomyiidae	×	✓
19.	Leaf gall inducer	Eriophyid mite, <i>Aceria</i> <i>pongamiae</i> <i>Channabasavanna</i>	Acari	Eriophyidae	✓	✓
20.	Web mite	<i>Schizotetranychus lespedezae</i>	Acari	Tetranychidae	✓	✓

Table 2: Pests of *Pongamia* occurred in storage conditions

Sl. No.	Common name	Scientific name	Order	Family
1	Rice moth	<i>Corcyra cephalonica</i> (Stainton)	Lepidoptera	Pyralidae
2	Mediterranean flour moth	<i>Ephestia kuehniella</i> (Zeller)	Lepidoptera	Pyralidae
3	Sawtoothed grainbeetle	<i>Oryzaephilus surinamensis</i> (Linnaeus)	Coleoptera	Chrysomelidae
4	Bruchid	<i>Caryedon serratus</i> (Olivier)	Coleoptera	Chrysomelidae
5	Pulse beetle:	<i>Callosobruchus maculatus</i> (Fabricius)	Coleoptera	Chrysomelidae





## Varietal Evaluation of Bitter Gourd (*Momordica charantia* L.) In Paralakhemundi, Gajapati District

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### ABSTRACT

A field trial was conducted in a randomized block design with three replications at M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Gajapati district, Odisha, during the summer season 2020 to evaluate different bitter gourd genotypes. Observations recorded on eleven quantitative characters. Analysis of variance revealed that the genotypes evaluated differed significantly among all the eleven characters. The genotype Uchha Bolder has taken the minimum number of node bearing 1<sup>st</sup> pistillate flower (11.00) and the maximum number of fruits vine<sup>-1</sup> (39.00). Fruit diameter and average fruit weight were maximum in Priya (4.60 cm and 106.04 g, respectively). Among genotypes, Meghana produced maximum fruit yield vine<sup>-1</sup> (2.36 kg) followed by Green Long (2.10 kg) and Priya (2.00 kg). Meghana was found superior based on overall performance in terms of growth and yield under Paralakhemundi, Gajapati District agro-climate condition.

**Keywords:** fruit, yield, performance, genotypes, season

### INTRODUCTION

Bitter gourd (syn. Bitter melon; *Momordica charantia* L.) is an economically important vegetable crop belongs to the family Cucurbitaceae (De Wilde and Duyfjes, 2002). It is widely cultivated in India, China, Malaysia, Africa and South America (Raj *et al.*, 1993). The immature stage of fruits and seeds of bitter gourd possess medicinal properties



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such as anti-diabetes (Chen *et al.*, 2003), anti-HIV activity (Lee *et al.*, 1995), charantin (Yeh *et al.*, 2003), momorcharin (Leung *et al.*, 1997), hypoglycaemic compounds (Jayasooriya *et al.*, 2000) and anti-carcinogenic and hypercholesterolemic (Ahmed *et al.*, 2001). Among the cucurbitaceous vegetable crops, bitter melon possesses a comparatively high concentration of ascorbic acid and iron. Even though India is a major producer of bitter melon in the world, the average productivity is very low. Most of the farmers are still cultivating nearby local cultivar. There is lack of appropriate cultivars in paralkhemundi region. So, there is need to find out the most suitable genotype in terms of yield and its attribute traits in this region.

## MATERIALS AND METHODS

The present study was carried out at Department of Horticulture, M.S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Gajapati district, Odisha during summer season 2020. The experimental materials of the present study comprised of 10 genotypes. Five plants were selected randomly for recording observations of eleven quantitative characters *viz.*, vine length (m), number of primary branches vine<sup>-1</sup>, days to 1<sup>st</sup> staminate flower appearance, days to 1<sup>st</sup> pistillate flower appearance, number of node bearing 1<sup>st</sup> staminate flower, number of node bearing 1<sup>st</sup> pistillate flower, fruit length (cm), fruit diameter (cm), average fruit weight (kg), number of fruits vine<sup>-1</sup> and fruit yield vine<sup>-1</sup> (kg). Data were statistically analyzed by following Panse and Sukhatme (1985).

## RESULTS AND DISCUSSION

Analysis of variance for eleven quantitative characters was studied for different genotypes of bitter melon are presented in Table 1. The analysis of variance showed that highly significant differences existed among the test genotypes for all the eleven quantitative traits. The mean performances of the genotypes in different characters are presented below as per Table 2. In respect of vine length, shortest vine length was observed in Arka Harit (2.50 m) followed by Pusa Aushadhi (2.62 m) and VNR 28 (2.75 m) while the 3 tallest genotypes were BBG 5 (4.40 m), Green Long (4.20 m) and Priya (4.11 m). The number of primary branches vine<sup>-1</sup> varied from 16.50 in Uchha Bolder to 8.10 in Pusa Aushadhi. The genotypes VNR28 (15.65) and Green Long (14.53) also recorded good number of primary branches vine<sup>-1</sup>. The early staminate flowering appeared in genotype Pusa Aushadhi (36.00 days) followed by VNR28 (36.50 days) and Arka Harit (37.50 days) and late staminate flowering was observed in genotype Pathapatnam Local (47.00 days). Days to 1<sup>st</sup> pistillate flower appearance ranged from 36.75 days in Pusa Aushadhi to 52.75 days in BBG-5. Other early genotypes are VNR28 (36.50 days) and Arka Harit (37.50 days).

Minimum number of node bearing 1<sup>st</sup> staminate flower recorded in VNR28 (8.50), followed by Pusa Aushadhi (8.75) and Uchha Bolder (9.00). The genotypes Uchha Bolder (11.00) and BBG-5 (25.00) had the minimum and the maximum number of node bearing 1<sup>st</sup> pistillate flower. The varieties Green Long and Uchha Bolder produced the longest fruits (21.50 cm) and shortest fruits (6.50 cm), respectively. The genotypes Meghana (17.25 cm) and Priya (17.00 cm) also had longer fruits. Variation in fruit diameter ranged from 3.20 cm in BBG-5 to 4.60 cm in Priya. The genotypes Meghana (4.50 cm) and Nobel Katahi (4.50 cm) also recorded maximum fruit diameter. The mean fruit weight varied from Uchha Bolder (30.00 gm) to Priya (106.04 gm). The genotypes Meghana (104.50 gm) and Green Long (101.25 gm) also produced reasonably heavy fruits. The mean number of fruits per plant varied from 16.00 in the variety Nobel Katahi to 39.00 in the genotype Uchha Bolder. The two genotypes VNR28 (30.00) and Meghana (23.25) also produced higher number of fruits plant<sup>-1</sup>. The fruit yield vine<sup>-1</sup> varied from 0.71 kg in the genotype BBG-5 to 2.36 kg in Meghana. The next two top yielders were Green Long (2.10 kg) and Priya (2.00 kg). These results agree with that of Yadagiri *et al.* (2017), Thakur *et al.* (2018), Adarsh *et al.* (2019) and Mounica *et al.* (2019). Among the evaluated genotypes, Meghana could be identified as the best genotype based on yield and its attribute traits.





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Table 1. Analysis of variance for 11 quantitative characters in bitter gourd genotypes

Characters	Mean sum of squares		Error (18)
	Replication (2)	Variety (9)	
Vine length (m)	0.07	1.67**	0.03
Number of primary branches vine <sup>-1</sup>	1.60	26.29**	0.40
Days to 1 <sup>st</sup> staminate flower appearance	21.31	36.83**	5.08
Days to 1 <sup>st</sup> pistillate flower appearance	26.50	74.01**	7.64
Number of node bearing 1 <sup>st</sup> staminate flower	4.18	20.57**	0.90
Number of node bearing 1 <sup>st</sup> pistillate flower	7.16	74.65**	2.18
Fruit length (cm)	3.37	72.90**	0.84
Fruit diameter (cm)	0.21	0.69**	0.05
Average fruit weight (kg)	104.81	3278.41**	27.30
Number of fruits vine <sup>-1</sup>	6.85	148.91**	2.13
Fruit yield vine <sup>-1</sup> (kg)	0.03	1.13**	0.01

\*\* Significant at 1% level

Figures in parentheses indicates degree of freedom (df) for corresponding sources of variation





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**Table 2. Mean values of bitter gourd genotypes for 11 quantitative characters**

Genotypes	1	2	3	4	5	6	7	8	9	10	11
Arka Harit	2.50	8.50	37.50	43.75	9.25	18.50	10.25	3.75	48.50	18.75	0.87
Pusa Aushadhi	2.62	8.10	36.00	36.75	8.75	12.25	13.50	3.95	56.85	17.12	0.93
VNR28	2.75	15.65	36.50	38.50	8.50	13.75	6.75	4.10	32.75	30.00	0.96
Meghana	4.10	13.50	41.00	46.50	11.00	23.00	17.25	4.50	104.50	23.25	2.36
Green Long	4.20	14.53	43.00	48.00	14.00	22.00	21.50	4.30	101.25	21.50	2.10
Nobel Katahi	3.65	12.50	41.00	46.00	15.00	24.00	15.65	4.50	100.00	16.00	1.56
Priya	4.11	12.00	41.20	45.25	12.50	17.50	17.00	4.60	106.04	19.50	2.00
Uchha Bolder	3.00	16.50	40.00	43.50	9.00	11.00	6.50	3.50	30.00	39.00	1.17
BBG-5	4.40	11.50	44.53	52.75	15.00	25.00	10.50	3.20	34.50	21.00	0.71
Pathapatnam Local	4.13	9.00	47.00	51.00	10.00	19.00	9.80	3.60	42.15	18.00	0.77
CD@5%	0.29	1.09	3.90	4.78	1.64	2.55	1.58	0.38	9.03	2.52	0.15
SE(d)	0.14	0.51	1.84	2.26	0.77	1.21	0.75	0.18	4.27	1.19	0.07
CV	4.67	5.16	5.53	6.12	8.37	7.94	7.12	5.43	7.96	6.51	6.64

1 - Vine length (m), 2 - Number of primary branches vine<sup>-1</sup>, 3 - Days to 1<sup>st</sup> staminate flower appearance, 4 - Days to 1<sup>st</sup> pistillate flower appearance, 5 - Number of node bearing 1<sup>st</sup> staminate flower, 6 - Number of node bearing 1<sup>st</sup> pistillate flower, 7 - Fruit length (cm), 8 - Fruit diameter (cm), 9 - Average fruit weight (kg), 10 - Number of fruits vine<sup>-1</sup>, 11 - Fruit yield vine<sup>-1</sup> (kg)





## Programmed Cell Death Studies in *Saccharomyces cerevisiae*

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### ABSTRACT

Yeast strains lacking mRNA decapping activation factors (*LSM1*), decapping factor (*DCP2*), cytoplasmic exosome function (*SKI2*) or cytoplasmic deadenylases (*CCR4* alone or double deletion of *CCR4* and *PAN2*) displayed apoptotic phenotype with typical markers of eukaryotic apoptosis such as cellular ROS generation, externalization of phosphatidyl serine, enhanced caspase gene (*YCA1*) expression and protein activity in mid-log phase cultures. In the present study, apoptotic yeast strains showed reduced gene expression for the key enzymes of TCA cycle (*Aco1*, *Cit1*, *Cit2* and *IDH1*) and *in-vivo* protein activity in mid-log phase cultures. Analysis of different Lsm1 C terminal deletion (CTD) mutants suggested strong association between mRNA decapping defects and apoptosis. Except in the *dcp2Δ* strain, all the strains undergoing apoptosis (*lsm1Δ*, *ski2Δ*, *ccr4Δ* and *ccr4Δpan2Δ* mutants) displayed clear-cut stabilization of protein A mRNA suggesting mRNA stability is not linked to caspase mediated apoptosis in strains compromised with *DCP2*.

**Keywords:** deadenylases, mRNA degradation, apoptosis, metacaspase, decapping, Real Time-PCR, flow-cytometer, yeast.

### INTRODUCTION

The condensation of acetyl-CoA and oxaloacetate to form citrate is the first reaction of the tricarboxylic acid (TCA) cycle and is catalyzed by the major mitochondrial citrate synthase (*Cit1*) in *S. cerevisiae*. Thus, *Cit1* functions as a rate-limiting enzyme of the TCA cycle [1]. *Cit2* is a peroxisomal citrate synthase involved in the glyoxylate cycle [1, 2]. Both *Cit1* and *Cit2* are involved in synthesis of citrate, which is expected to be converted into glutamate via  $\alpha$ -



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ketoglutarate. Thus, the absence of both Cit1 and Cit2 causes glutamate auxotrophy, whereas the presence of either Cit1 or Cit2 does not [3, 4, 5]. Yeast cells with *cit1* deletion showed much higher susceptibility to chronological aging-induced cell death accompanied by the typical hallmarks of apoptosis, such as reactive oxygen species (ROS) accumulation, phosphatidylserine externalization, nuclear fragmentation, and DNA breakage [5]. Aconitase (Aco1) is another important enzyme required for the second step of tricarboxylic acid (TCA) cycle and also independently required for mitochondrial genome maintenance [6, 7]. NAD(+)-dependent Isocitrate dehydrogenase (IDH) is an enzyme that is used during the third step of the citric acid cycle. Its main function is to catalyze the oxidative decarboxylation of isocitrate into alpha-ketoglutarate and consistent with its role in TCA cycle yeast strains compromised with IDH2 exhibits slow growth phenotype [8].

Two major mRNA decay pathways exist in eukaryotes. Both pathways are initiated by poly(A) shortening of the mRNA. In the 5' to 3' decay pathway, the Dcp1p/Dcp2p decapping enzyme complex can hydrolyze the cap structure following deadenylation by Pan2p and Ccr4p enzymes and the mRNA is subsequently degraded from the 5' end by Xrn1 nuclease [9, 10, 11]. In the 3' to 5' decay pathway, deadenylated mRNAs are degraded in a 3' to 5' exonucleolytic manner and require two multiprotein complexes: the exosome containing various 3'-exonucleases and the Ski complex consisting of RNA helicase Ski2p, Ski3p, Ski7p and Ski8p [12, 13]. The Lsm1-7-Pat1 complex is made up of the Pat1 subunit and the seven highly conserved Sm-like protein subunits, Lsm1 through Lsm7. The Lsm1-7-Pat1 complex promotes mRNA decay through the 5' to 3' pathway by facilitating mRNA decapping via an unknown mechanism [14, 15]. Yeast Lsm1 has extended N- and C-terminal domains (40 and 55 residues, respectively) flanking the Sm-domain, with C-terminal domain (CTD) being functionally indispensable both for both mRNA decay and 3'-end protection [16]. Infact CTD is able to support the function of this Lsm1-7-Pat1 complex in trans even when it is not contiguous with the Sm-domain of Lsm [17]. Mutagenic analysis of the C-terminal extension of Lsm1 revealed that C-terminal most residues are essential for RNA binding activity of Lsm1-7-Pat1 complex and deletion of C-terminal most 8 residues of Lsm1 results in clear, though moderate, defect in mRNA decay even when the C-terminal extension is contiguous with the Sm domain of Lsm1 [17, 18]. Analysis of CTD mutants of yeast Lsm1 suggests strong association between apoptosis and mRNA decay defects. The key enzymes of TCA cycle catalyzing the first three steps of TCA cycle (*CIT1*, *ACO1* and *IDH*) are rapidly declined in the apoptotic yeast strains defective in decapping (*lsm1Δ*) and deadenylation (*ccr4Δ* and *ccr4Δpan2Δ*mutants).

## MATERIALS AND METHODS

### Strains and Growth Conditions

Cells were grown in a mechanical shaker (220 rpm) at 26°C in minimal medium (0.5% ammonium sulphate, 0.17% yeast nitrogen base) containing 2% glucose (SD) supplemented with 0.079 % Synthetic Complete drop-out Medium Mix. Yeast strains used in this study are listed in Table 1. Inoculation was carried out by addition of a freshly revived colony of *Saccharomyces cerevisiae* to the medium, incubated at 26 ± 2°C under shaking conditions and yeast strains were harvested at mid-log phase OD≤0.5 for Quantitative RT-PCR and protein activity studies.

### Assessment of intracellular reactive oxygen species (ROS) by flow cytometry

Free intracellular ROS were detected with dihydrorhodamine 123 (DHR123) (Molecular Probes, Eugene, OR, USA). Multiple ROS convert DHR123 to the stable fluorescent derivative DHR with excitation and emission wavelengths at 500 nm and 530 nm, respectively. DHR123 was added from a 1 mg/ml stock solution in ethanol, to 5×10<sup>6</sup> cells/ml suspended in PBS, reaching a final concentration of 10 µg/ml. Cells were viewed without further processing through a rhodamine optical filter after 90 minute incubation at 28°C in the dark as described previously [19]. For flow cytometric analysis, the samples were labeled with DHR123 as described above except that 1×10<sup>6</sup> cells were washed with PBS prior to acquisition on a Guava easyCyte 8HT flow cytometer (Millipore). 488 excitation laser and 525/30nm bandpass filters were used to capture the emission of rodamine. For all the assays done, data was acquired



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with Express Pro software and analysed by FlowJo software (Version 7.6). 20,000 events were acquired at a flow rate of 0.59 $\mu$ L/sec per sample.

**In vivo caspase detection by Flow Cytometric Analysis**

Endogenous caspase activity was measured using Calbiochem® Caspase Detection Kit as described previously [20].

**Real-time PCR**

Total RNA isolation and real-time PCR was performed as described previously [20]. The different primers used in the study are listed in Table-2.

**Total cellular citrate synthase assay**

Citrate synthase activity was determined in whole cell extract using assay kit (705502; Cayman Chemical Company, USA). Yeast cells were harvested at mid-log phase ( $OD_{600} \leq 0.5$ ), washed once with PBS and cell wall digested with 40 U/ml lyticase (Sigma Chemical Co.) in assay buffer for 15 min at 30°C. For whole cell extracts, spheroplasts were treated with CellLytic M cell lysis reagent and the total protein was determined in triplicate by the method of Bradford, and the protein concentration of all samples equalized. Citrate synthase activity was measured by following the color of TNB (2-nitro-5-thiobenzoic acid) at a wavelength of 412 nm at 25°C on a spectrophotometer (Elico Systems, Hyderabad, India). In a 0.5 ml cuvette, 25  $\mu$ l of sample was added to a reaction medium containing 465  $\mu$ l assay buffer, 5  $\mu$ l of 30 mM acetyl coenzyme A and 5  $\mu$ l of 10 mM DTNB solution. The baseline assay solution absorbance was recorded, reactions were initiated by addition of 12.5  $\mu$ l oxaloacetic acid, and the change in absorbance measured after 1.5 min.

**Aconitase assay**

Aconitase activity was determined in whole cell extract using assay kit (CS0720; Sigma-Aldrich, USA). This assay measures the absorbance of NAD(P)H at 340 nm, which is generated in the coupled reactions of aconitase with isocitric dehydrogenase. The rate at which NAD(P)H is generated is proportional to the activity of aconitase. In a 0.5 ml cuvette, 100  $\mu$ l of sample was added to a reaction medium containing 10  $\mu$ l of assay buffer, 100  $\mu$ l of NADP<sup>+</sup> reagent, 100  $\mu$ l of isocitric dehydrogenase and 100  $\mu$ l of substrate solution. The reaction mixture was incubated for 30 minutes at 37°C and the absorbance measured on a spectrophotometer at 340 nm. The baseline assay solution absorbance was recorded in the absence of substrate solution.

**Isocitrate dehydrogenase assay**

Isocitrate dehydrogenase (IDH) activity is determined using the assay kit from Sigma-Aldrich (MAK062). In this assay, cellular isocitrate as the substrate in an enzyme reaction, which results in a colorimetric (450 nm) product proportional to the enzymatic activity present.

**RESULTS AND DISCUSSION****Quantification of cellular ROS levels in *lsm1* CTD mutants**

To understand the role of Lsm1 C-terminal domain (CTD) in apoptosis, CTD mutants *lsm1-27*, *lsm1-28* & *lsm1-29* that expressed truncated versions of Lsm1p having deletions of 55, 43, and 28 amino acid residues respectively from the very C terminus end, but carrying intact Sm-domain and N-terminal extension (i.e., residues 1–117), were analyzed (Fig 1a). Key event in apoptotic cells is generation of ROS. Previously reported that about 40% of *Kllsm4 $\Delta$ 1* cells displayed intense intracellular staining with dihydrorhodamine 123 [21]. Flow cytometric studies were carried to determine cellular ROS levels by incubation with DHR123. Intense cellular fluorescence was observed in *lsm1 $\Delta$* , *lsm1-27* and *lsm1-28* cells with  $44 \pm 2.12$ ,  $36.0 \pm 2.13$  and  $32.0 \pm 0.70$  median fluorescence intensity (MFI) respectively. Cellular ROS levels were perceptible in *lsm1-29* strain relative to wild type strain (Fig 1b).



**Kalidindi Krishnam Raju****In vivo caspase assay in yeast strains defective in decapping and degradation**

Yeast metacaspase (*YCA1*) plays an important role in regulating apoptosis triggered by oxidative stress, chronological ageing or stabilization of mRNAs [19]. caspase protein activation in vivo was quantitated with FITC labelled VAD-FMK by flow cytometry in strains defective in decapping activators (*lsm1Δ* strain as well as CTD mutants of Lsm1p such as *lsm1-27*, *lsm1-28* & *lsm1-29*). Based on median fluorescence intensity (MFI) values relative to untreated wild type control, *lsm1Δ* mutants display highest caspase activity with 76.05±2.12 MFI values followed by *lsm1-27* (69.8±0.99 MFI) and *lsm1-28* strains (36.55±2.05 MFI). *lsm1-29* (15.3±0.28 MFI) strain show noticeable caspase activity with 1.5-fold higher endogenous caspase activity than wild type strain with MFI 10.3±0.7 (Fig 2a & 2b).

**Quantification of cellular citrate synthase, peroxisomal citrate synthase, aconitase and iso-citrate dehydrogenase transcript levels in apoptotic and non-apoptotic cells**

Quantitative Real Time-PCR (qRT-PCR) was performed to analyze mitochondrial citrate synthase (*CIT1*), peroxisomal citrate synthase (*CIT2*), iso-citrate dehydrogenase (*IDH1*) and aconitase (*ACO1*) transcript levels in wild type (WT) as well as mutants defective in decapping (*lsm1Δ*) or cytoplasmic deadenylation (*pan2Δ*, *ccr4Δ* and *ccr4Δpan2Δ* strains). Based on median fluorescence intensity (MFI) values relative to untreated wild type control, *CIT1*, *CIT2*, *IDH1* and *ACO1* transcript levels showed highest reduction in *lsm1Δ* (0.2295±0.099, 0.216±0.0462, 0.163±0.063, 0.292±0.124 respectively) and *ccr4Δpan2Δ* mutants (0.307±0.0183, 0.231±0.004, 0.3845±0.044, 0.35±0.042 respectively) followed by *ccr4Δ* mutant. In *ccr4Δ* mutant the *CIT1*, *CIT2*, *IDH1* and *ACO1* MFI values relative to untreated wild type control are 0.808±0.115, 0.558±0.060, 0.483±0.066 and 0.7545±0.126 respectively. In *pan2Δ* mutant cells *CIT1*, *CIT2*, *IDH1* and *ACO1* mRNA levels were comparable to the wild type strain (Fig 3a & Fig 3b).

Based on median protein activity expressed in unit, non-apoptotic wild type and *pan2Δ* strains showed optimum citrate synthase activity (1 unit). Total citrate synthase activity was considerably reduced in *lsm1Δ* and *ccr4Δpan2Δ* mutants with 0.541±0.036 and 0.452±0.114 units respectively followed by *ccr4Δ* strain (0.791±0.086 units) (Fig 4a). Consistent with *ACO1* transcript levels, Aco1p activity was considerably reduced in *lsm1Δ* and *ccr4Δpan2Δ* mutants followed by *ccr4Δ* strain with 4.26±0.234, 3.93±0.152 and 6.47±0.282 nmoles/min/ml respectively. Wild type and *pan2Δ* strains showed comparable Aco1p levels of 8.35±0.199 and 8.33±0.245 nmoles/min/ml respectively (Fig 4b). Likewise cellular Isocitrate dehydrogenase activity of mid-log phase cultures were considerably reduced in *lsm1Δ* and *ccr4Δpan2Δ* mutants followed by *ccr4Δ* strain when compared to wild type and *pan2Δ* strains (Fig 4c).

**Stabilized mRNAs trigger caspase mediated apoptosis but not in *dcp2Δ* strain**

Previously reported that mutations in mRNA decapping activators such as *LSM4* gene leads to increased mRNA stability and caspase-mediated apoptosis [21]. Yeast strains defective in deadenylation (*ccr4Δ* and *ccr4Δpan2Δ* strains) accumulate all the mRNAs tested and also undergo caspase mediated apoptosis [20, 22]. In the present study, we used the construct expressing (from *GAL* promoter) the Protein A mRNA carrying tract of 12U residues at 3' end and GFP coding regions separated by the hammerhead ribozyme sequence. Stability of the protein A mRNA was determined from the steady-state kinetics of this cleaved 5' fragment of protein A mRNA with 12U tract in both apoptotic and non-apoptotic cells. Except in wild type, *pan2Δ* and *dcp2Δ* strains, the strains undergoing apoptosis (*lsm1Δ*, *ski2Δ*, *ccr4Δ* and *ccr4Δpan2Δ* mutants) displayed stabilization of protein A mRNA (Fig 5) [22].

Increased cellular ROS levels and cellular caspase activity were observed in *lsm1Δ* strain as well as CTD mutants of Lsm1p such as *lsm1-27* and *lsm1-28*. Relative to WT strain, *lsm1-29* strain displayed 1.5 fold higher caspase activity and increased ROS levels. Mutagenic analysis of CTD mutants of Lsm1 revealed the importance of C-terminal most 8 amino acid residues of Lsm1 in facilitating RNA binding of the Lsm1-7-Pat1 complex and deletion or mutation these C-terminal eight residues can result in clear, though moderate, mRNA decay defect even when the C-terminal extension is contiguous with the Sm domain of Lsm1[18].



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Minor but measurable cell death in *lsm1-29* strain having deletion of just 28 amino acids from the very C-terminal end suggest strong association between apoptosis and mRNA decay defects in yeast. *CIT1*, *ACO1* and *IDH1/2* are regulated by HAP complex in respiratory competent cells but are under the control of RTG genes in response to a reduction or loss of respiratory function [23]. Our studies demonstrate rapid decline of key respiratory enzymes (*CIT1*, *ACO1* and *IDH*) in the apoptotic yeast strains defective in decapping (*lsm1Δ*) and deadenylation (*ccr4Δ* and *ccr4Δpan2Δ*mutants) suggesting loss of mitochondrial respiratory chain function and consequent ROS generation [24]. But the intracellular increase in ROS in response to DNA damage is not directly related to cell death. Recent studies reveal autophagy contributes to caspase-mediated apoptosis in response to ROS generation and DNA damage [25, 26]. While mRNA stability is linked to caspase dependent apoptosis in yeast strains lacking mRNA decapping activation factors (*LSM1*), cytoplasmic exosome function (*SKI2*) or cytoplasmic deadenylases (double deletion of *CCR4* and *PAN2*), the lack of protein A mRNA stability in the apoptotic *dcp2Δ* strain suggest role of alternative pathways such as autophagy in cell death (Fig 5) [21]. The executioners of yeast apoptosis such as metacaspases (*Yca1p*) were shown to play important roles in autophagy [25, 26]. While autophagy is known to replenish key TCA cycle intermediates as a part of its pro-survival mechanism, its role in yeast apoptosis is complex and remains to be understood [25, 27].

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**Table 1: Yeast strains used in this study**

Strain no.	Genotype
yRP840	MAT a, leu2, his4, trp1, ura3, cup1 <sup>+</sup> :LEU2PM
yST456	MatA, his4, leu2, trp1, ura3, lys2, cup1Δ::LEU2PM, dcp2Δ::TRP1
yRP1195	MAT a, his4, leu2, trp1, ura3, cup1 <sup>+</sup> :LEU2PM, ski2 <sup>+</sup> :LEU2
yRP1365	MAT α; leu2; trp1; lys2; ura3; cup1Δ::LEU2PM; lsm1Δ::TRP1
yRP1616	MAT a, trp1, ura3, leu2, his4, cup1 <sup>+</sup> :LEU2PM, ccr4Δ <sup>+</sup> :NEO
yRP1619	MAT a, ura3, leu2, his4, cup1 <sup>+</sup> :LEU2PM, pan2Δ <sup>+</sup> :URA3
yRP1620	MAT a, trp1, ura3, leu2, his4, cup1 <sup>+</sup> :LEU2PM, ccr4Δ <sup>+</sup> :NEO, pan2Δ <sup>+</sup> :URA3

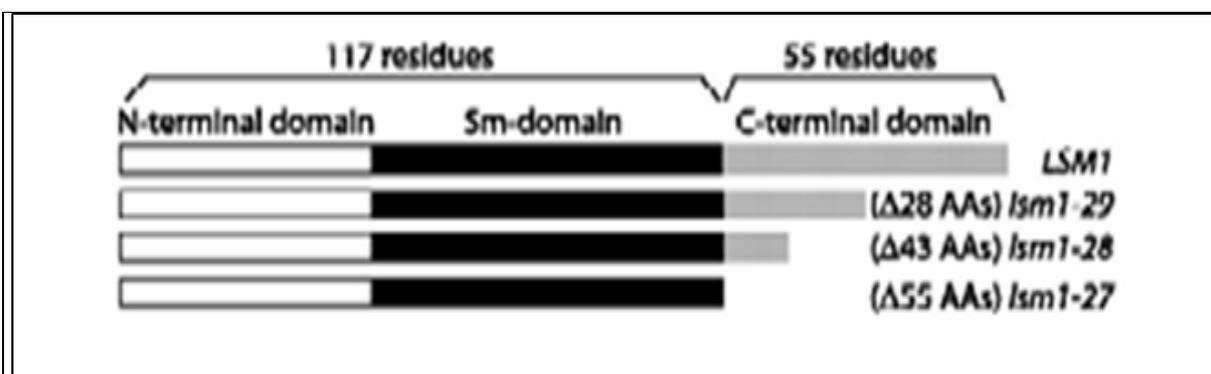




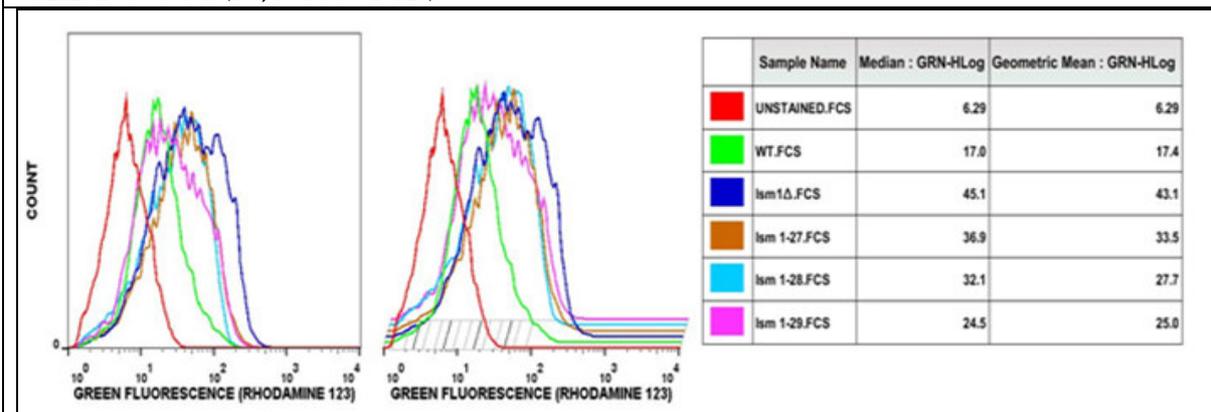
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**Table 2: Primers used for RT-qPCR**

oligo	Sequence
CIT1 Forward	5' CATTACATGGTCGTGCCAAT 3'
CIT1 Reverse	5' GGCCATAACCAGGAACAAC 3'
CIT2 Forward	5' GGTCATGCTGTGCTAAGGAA 3'
CIT2 Reverse	5' AGTCAATACGCCAGGTGCTA 3'
ACO1 Forward	5' TTGATGTTATGGCAGGTCGT 3'
ACO1 Reverse	5' GGAGAAGTCCAACCGTTCAT 3'
IDH1 Forward	5' CCAACTTTGGCAGGGACTAT 3'
IDH1 Reverse	5' GAGGAAAGGATCATGGCAGT 3'
SCR1 Forward	5' GGCTGTAATGGCTTTCTGGT 3'
SCR1 Reverse	5' ACGGTGCGGAATAGAGAACT 3'



**Figure 1a:** LSM1 and its c-terminal deletion mutants (CTD) in yeast (*Saccharomyces cerevisiae*); wild type (WT), *lsm1Δ* strain as well as its CTD mutants *lsm1-27*, *lsm1-28* & *lsm1-29* that expressed truncated versions of Lsm1p lacking 55, 43, and 28 residues, respectively, from the C terminus, but carrying intact Sm-domain and N-terminal extension (i.e., residues 1–117).



**Figure 1b:** Representative graph showing cellular ROS (reactive oxygen species) levels in different yeast strains. Cells were incubated with Dihydrorhodamine 123 (DHR123) and ROS levels were analyzed by flow cytometer. The table in the right represents median fluorescent intensity (MFI) values for ROS against each individual strain (WT, *lsm1Δ* strain as well as CTD mutants of Lsm1p such as *lsm1-27*, *lsm1-28* & *lsm1-29*). 20,000 events were acquired each time at a flow rate of 0.59μL/sec per sample.





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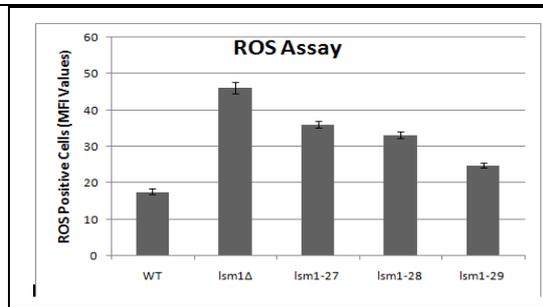


Figure 1c: Bar graph shows ROS generation in different yeast strains (WT, *lsm1Δ* strain as well as CTD mutants of Lsm1p such as *lsm1-27*, *lsm1-28* & *lsm1-29*). Cells were incubated with DHR123 and ROS levels were studied by flow cytometry. The different yeast strains used for the study are represented on X-axis. Bar graph shows results from the mean of three independent experiments and relative DHR fluorescence was expressed as MFI values. Error bars indicate standard deviations.

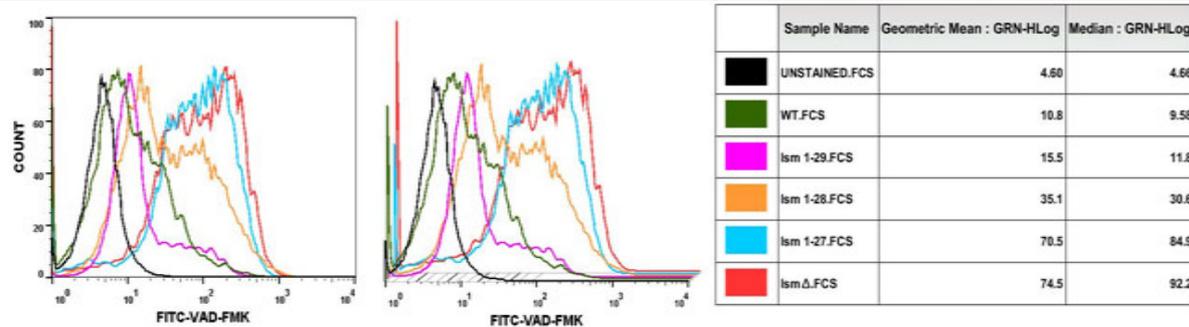


Figure 2a: Quantification of caspase activity from WT, *lsm1Δ* strain as well as CTD mutants of Lsm1p such as *lsm1-27*, *lsm1-28* & *lsm1-29*. The table in the right represents median fluorescent intensity (MFI) values for ROS against each individual strain. 20,000 events were acquired each time at a flow rate of 0.59μL/sec per sample.

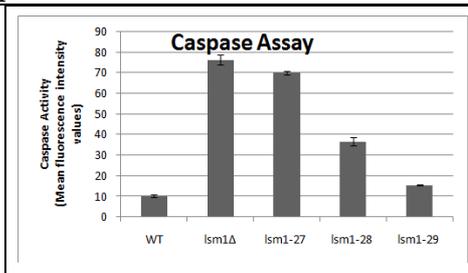


Figure 2b: Bar graph representing caspase activity (expressed as MFI values) contained in different yeast strains labeled on X-axis (WT, *lsm1Δ* strain as well as CTD mutants of Lsm1p such as *lsm1-27*, *lsm1-28* & *lsm1-29*). Data and error bars represent the average and standard deviation of 3 independent experiments (n=3).

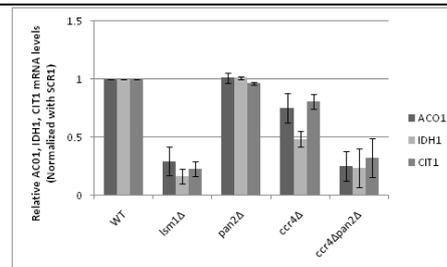


Figure 3a: Quantitative Real Time-PCR (qRT-PCR) analysis of *CIT1*, *IDH1* and *ACO1* transcript levels in strains defective in decapping (*lsm1Δ*) or cytoplasmic deadenylation (*pan2Δ*, *ccr4Δ* and *ccr4Δpan2Δ* strains) relative to wild type strain. Each RT-qPCR experiment was performed twice in duplicate.  $C_T$  values for *CIT1*, *IDH1* and *ACO1* and standard reference (*SCR1*) are average of results from one typical experiment. The  $C_T$  values of both the wild type and mutant strains were normalized to standard reference gene *SCR1*. Data and error bars represent the average and standard deviation of





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<p><b>Figure 3b: Quantitative Real Time-PCR (qRT-PCR) analysis of <i>CIT2</i> transcript levels in strains defective in decapping (<i>lsm1Δ</i>) or cytoplasmic deadenylation (<i>pan2Δ</i>, <i>ccr4Δ</i> and <i>ccr4Δpan2Δ</i> strains) relative to wild type strain. Each RT-qPCR experiment was performed twice in duplicate. <math>C_T</math> values for <i>CIT2</i> and standard reference (<i>SCR1</i>) are average of results from one typical experiment. The <math>C_T</math> values of both the wild type and mutant strains were normalized to standard reference gene <i>SCR1</i>. Data and error bars represent the average and standard deviation of 3 independent experiments (n=3).</b></p>	<p style="text-align: center;">3 independent experiments (n=3).</p> <p><b>Figure 4a: Bar graph representing endogenous citrate synthase activity of mid-log phase yeast cultures (WT, <i>lsm1Δ</i>, <i>pan2Δ</i>, <i>ccr4Δ</i> and <i>ccr4Δpan2Δ</i> mutants). Each experiment was performed twice in duplicate and protein activity expressed in units (unit=<math>\mu</math>mole/ml/min). Data and error bars represent the average and standard deviation of 3 independent experiments(n=3).</b></p>
<p><b>Figure 4b: Bar graph representing endogenous Aconitase activity of mid-log phase yeast cultures (WT, <i>lsm1Δ</i>, <i>pan2Δ</i>, <i>ccr4Δ</i> and <i>ccr4Δpan2Δ</i> mutants). Each experiment was performed twice in duplicate and protein activity expressed in nmoles/min/mL. Data and error bars represent the average and standard deviation of 3 independent experiments (n=3).</b></p>	<p style="text-align: center;"><b>IDH</b></p> <p><b>Figure 4c: Bar graph representing endogenous Isocitrate dehydrogenase activity of mid-log phase yeast cultures (WT, <i>lsm1Δ</i>, <i>pan2Δ</i>, <i>ccr4Δ</i> and <i>ccr4Δpan2Δ</i> mutants). Each experiment was performed twice in duplicate and protein activity expressed in milliunits/mL. Data and error bars represent the average and standard deviation of 3 independent experiments (n=3).</b></p>





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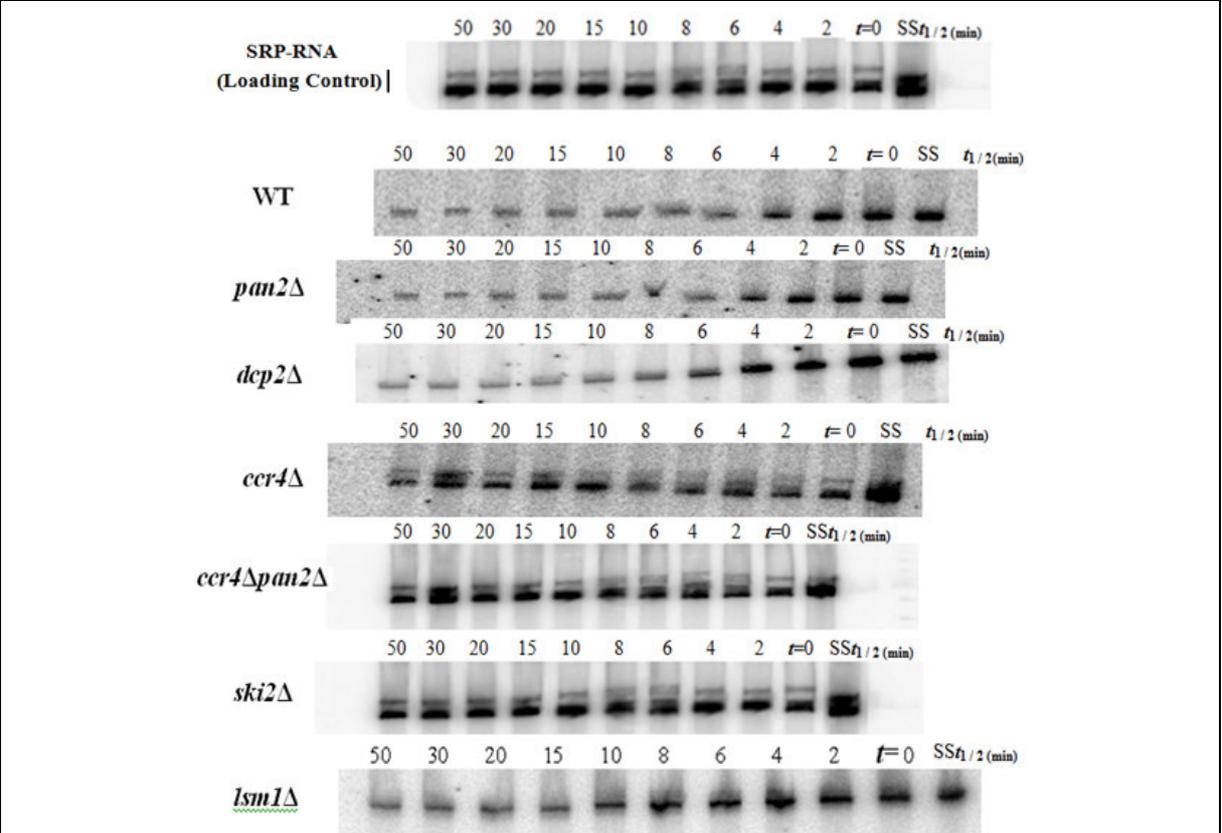


Figure 5: Transcription (Dextrose) shut-off experiments to determine the stability of protein A mRNAs (isolated at mid-log phase) from cells grown in gal medium. In the Dex-shutoff experiment, protein A mRNA transcription was shut-off after addition of 2% glucose. Later the cells were harvested at the indicated time points and the total RNA purified using phenol lysis method. The signals were quantitated using a phosphorimager and corrected for loading using the signal recognition particle (SRP) RNA.





## mRNA Decapping and Degradation and its Interconnection with Apoptosis in *Saccharomyces cerevisiae*

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### ABSTRACT

The messenger RNA decay pathways and decay factors are well conserved in all eukaryotes from yeast to humans. Two major pathways of mRNA decay exist in eukaryotes. Both pathways are initiated by poly(A) shortening of the mRNA. In the 5' to 3' decay pathway, the Dcp1p/Dcp2p decapping enzyme complex can hydrolyze the cap structure following deadenylation by Pan2p and Ccr4p enzymes and the mRNA is subsequently degraded from the 5' end by Xrn1 nuclease. Misregulation of apoptosis or mRNA turnover can result in many human diseases. Apoptotic studies in yeast suggested interconnecting mechanism between mRNA metabolism and apoptosis.

**Keywords:** Apoptosis, mRNA turnover, yeast, decapping complex, deadenylation.

### INTRODUCTION

mRNA turnover is an important control point in gene expression. Firstly, in assessing the accuracy of mRNA biogenesis. Second, in degradation of aberrant transcripts that contributes to disease development. Messenger RNA decay is therefore important for normal cellular physiology. The major mRNA surveillance pathways in mammalian cells include nonsense-mediated mRNA decay (NMD) and nonstop mRNA decay (NSD). Unlike NMD, NSD is activated only in the presence of mRNA transcripts missing a stop codon. In mammalian cells, eRF3-like factor Ski7 appears to detect the presence of stalled RNA-ribosome complex at the 3' end of RNA transcripts that lack a stop codon, targeting them to the RNA exosome for elimination. This NSD pathway, however, is not well characterized in humans. The phenomenon of nonsense-mediated mRNA decay (NMD) surveillance pathway was first described in





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human cells and in yeast almost simultaneously in 1979 and mainly operates to reduce errors in gene expression by eliminating mRNA transcripts that contain both normal mRNAs (that includes alternatively spliced exons) and abnormal mRNAs with premature termination codon (PTC)[1]. Translation of aberrant mRNAs with premature termination codons (PTC) could, in some cases, lead to deleterious gain-of-function or dominant-negative activity of the resulting proteins and hence contribute to about one-third of human diseases [2].

#### Canonical NMD pathway

NMD is mediated by either the RNA exosome in the 3'–5' direction or by processing bodies (P-bodies) in the 5'–3' direction by the Xrn1 exoribonuclease after an initial removal of poly(A) tail by deadenylases followed by decapping by decapping complex (Dcp1/Dcp 2 complex). Decapping proteins participate in mRNA turnover and nonsense-mediated decay (NMD). A 7-kDa human microprotein called non-annotated P-body dissociating polypeptide (NoBody) interacts with mRNA decapping proteins, which remove the 5' cap from mRNAs to promote 5'-to-3' decay [3]. In the 3' to 5' decay pathway, deadenylated mRNAs are degraded in a 3' to 5' exonucleolytic manner and require two multiprotein complexes: the exosome containing various 3'-exonucleases and the Ski complex consisting of RNA helicase Ski2p, Ski3p, Ski7p and Ski8p (Figure 1)[4].

The major mRNA decay pathway in both yeast and human cells is the 5' to 3' decay pathway wherein the Dcp1p/Dcp2p decapping enzyme complex hydrolyze the 5' cap structure (5' m<sup>7</sup>GpppN cap where N is any nucleotide) following deadenylation by Pop2p and Ccr4p enzymes and the decapped mRNAs are subsequently degraded from the 5' end by Xrn1 exoribonuclease (Figure 2). The scavenger decapping enzyme, DcpS, hydrolyzes the cap structure generated by the 3' to 5' decay pathway. The initial event in mRNA decapping and degradation is the 3' shortening of poly(A) tail (A<sub>70</sub>) to oligo (A<sub>9-15</sub>) by the cellular Ccr4p and Pan2 deadenylases and recruitment of the decapping activator complex (Lsm1p-7p/Pat1p/ Dhh1p complex) to the oligo(A) tract. Therefore, mRNA A-tail is a critical determinant of the eukaryotic mRNA decay. Binding of this decapping activator complex may remodel the mRNA structure to allow the decapping enzyme (Dcp I/ Dcp2) to access the cap. The removal of the cap structure by the decapping enzyme may expose the 5' end of the mRNA to Xrn1 5' to 3' exoribonucleolytic activity (Figure 2) [5].

*In vivo* the heteroheptameric Lsm1p-7p complex (made of seven Sm-like proteins, Lsm1p through Lsm7p) physically interacts with Xrn1p, Dhh1p, MRT1 and Pat1p and colocalizes at cytoplasmic foci known as processing (P)-bodies. P-bodies are believed to be the site of decapping and 5'–3' mRNA decay. *In vitro* purified Lsm1–7–Pat1 complex, an activator of decapping, is able to bind RNA *in vitro* and exhibits a strong binding preference for RNA substrates with oligo(A) tail instead of unadenylated and polyadenylated RNA [6,7]. The Dhh1 protein is a DExD/H-box RNA helicase involved in both mRNA decapping and translation. Yeast genetic studies revealed that both Dhh1p, Edc1-3 proteins (Enhancer of Decapping), Scd6 and Pat1p act as inhibitors of translation and switches the mRNA from a translation-competent status to a degrading-competent form that requires an mRNP rearrangement involving removal of translation factors (such as cap binding complex elf4E/elf4G, and Poly(A) binding proteins) and recruitment of decapping factors for decapping to occur *in vivo* (Figure 3). The various enzymes that play a role in mRNA turnover were mentioned in Table-1 & Table-2.

#### Decay of Eukaryotic mRNA via Endonucleolytic Cleavage

Eukaryotic mRNAs can also be degraded via endonucleolytic cleavage prior to deadenylation. Evidence for this mechanism is based on the *in vivo* detection of 5' and/or 3' portions of the transcript such as mammalian 9E3, transferrin receptor, c-myc, insulin-like growth factor II, serum albumin, vitellogenin mRNA, and β-globin mRNA. For example, the endonuclease suggested to be responsible for β-globin decay appears to cleave at UG and UC dinucleotides, whereas decay of the eNOS pre-mRNA appears to occur by cleavage at CA repeats [5]. Endonucleolytic cleavage is also paramount in RNA-mediated gene silencing (RNAi). The process of RNAi appears to defend the genome against viruses and transposons as well as control gene expression of some endogenous mRNAs. MicroRNAs (miRNAs) is a small non-coding RNA molecule (20-25 nucleotides) found in plants and animals. Once made, miRNAs base-pair with 3' UTR region of specific mRNAs and reduce their translation or



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promote degradation by Xrn1/exosome [5]. The long miRNA precursors are synthesized by RNA polymerase II and are capped and polyadenylated. They then undergo a special type of processing by dicer-1 enzyme, after which the miRNA is assembled with a set of proteins such as argonaute to form an RNA-induced silencing complex or RISC. Once formed, the RISC seeks out its target mRNAs by searching for complementary nucleotide sequences. This search is greatly facilitated by the Argonaute protein, a component of RISC, which holds the 5' region of the miRNA so that it is optimally positioned for base-pairing to another RNA molecule. Once target mRNA has been bound by miRNA, several outcomes are possible. If the base-pairing is extensive (which is unusual in humans but common in many plants), the mRNA is cleaved by the Argonaute protein. Following cleavage of the mRNA, the RISC with its associated miRNA is released, and it can seek out additional mRNAs. Thus, a single miRNA can act catalytically to destroy many complementary mRNAs. These miRNAs can be thus thought of as guide sequences that bring destruction of specific mRNAs. If the base-pairing between the miRNA and the mRNA is less extensive (typically seven nucleotide pairs for most human miRNAs), Argonaute does not slice the mRNA; rather, translation of the mRNA is repressed and the target mRNA is shuttled to P-bodies where it eventually undergoes poly-A tail shortening, decapping and degradation. A single miRNA can control hundreds of different mRNAs. Several features make miRNAs especially useful regulators of gene expression. MicroRNAs and RNA binding proteins repress translation or degrade target mRNAs through recognition of cis-regulatory elements located primarily in the 3'UTR.

**Stabilized mRNAs trigger apoptosis in yeast**

In eukaryotes, programmed cell death (PCD) is a genetically regulated self-destruction process for the elimination of damaged or unwanted cells. It plays an important role in the development and maintenance of the integrity of organisms. The basic molecular machinery governing apoptosis in mammals has been very much conserved in yeast, including the yeast metacaspase Yca1p, the mitochondrially located proteins such as apoptosis-inducing factor 1 (Aif1p), HtrA2/Omi (Nma111p) and AMID (Ndi1p), and the anti-apoptotic proteins Cdc48p and Bir1p. Apoptosis in yeast may be initiated during physiological scenarios such as ageing and failed mating, or exposure to external stimuli such as lowdoses of H<sub>2</sub>O<sub>2</sub> or acetic acid.

Various morphological and biochemical events observed in apoptotic cells are chromatin fragmentation and its condensation (margination), externalization of phosphatidylserine to the outer leaflet of the plasma membrane, mitochondrial fragmentation, cytochrome *c* release, cytoskeletal perturbations and histone H2B[8]. Yeast strains lacking factors for 5' to 3' mRNA decapping and decay (*DCP2* and *LSM1*), mutants defective in 3' to 5' cytoplasmic exosome function (*SKI2*) or deadenylation (double deletion of *CCR4* and *PAN2*) were found to exhibit various biochemical and morphological features of apoptosis such as increased cellular reactive oxygen species levels, externalization of phosphatidyl serine, chromatin fragmentation, enhanced caspase gene (*YCA1*) expression and protein activity in mid-log phase cultures.

The characteristic feature of these strains apoptosis (*lsm1Δ*, *dcp2Δ*, *ski2 Δ*, *ccr4Δ* and double mutant *ccr4Δpan2Δ*mutants) is clear-cut stabilization of multiple mRNAs. Ccr4p is the predominant deadenylase subunit in yeast and *ccr4* mutants are known to exhibit accumulation of all mRNAs tested with 3' poly(A) tails of an intermediate length (~25–45 adenosines). Double mutants of *CCR4/PAN2* were reported to be deficient in cytoplasmic deadenylation and accumulate all mRNAs tested thus far with longer poly(A) tails (>55 adenosines) suggesting longer poly(A) tail length of the accumulated mRNAs contribute to enhanced cell death in *ccr4Δpan2Δ* strain than *ccr4Δ* strain. But the wild type strain and *pan2Δ* mutant do not exhibit cytoplasmic deadenylation defects as well as characteristic features of metazoan apoptosis [8]. RNA oxidation also dictates chronological life span. In mammals, RNA oxidation was described as an early event preceding cell death and neuronal deterioration, not merely a consequence of dying cells [9]. In the yeast decapping *Klism4Δ1* mutant, which accumulates oxidized mRNAs, has shorter life span than the wild type strain and undergoes regulated cell death. In addition, in this mutant the capacity to handle oxidised RNAs in yeast declines with aging. These phenotypes can be reversed to the wild type situation by the addition of antioxidants to cell cultures [10].



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## CONCLUSION

Moreover the cellular mRNA decay factors Pat1p, Lsm1p, and Dhh1p are required for the replication of wide range of positive-strand RNA [(+)RNA] viruses including the plant Brome mosaic virus (BMV), the animal Flock House virus, the human Hepatitis C virus (HCV) and the emerging West Nile virus (WNV) and therefore are potential targets for new antiviral drugs. The Lsm1-7-Pat1 hetero-octameric specifically binds to *cis*-acting regulatory sequences of Brome mosaic virus (BMV) RNA and the 1a protein in yeast to promote viral RNA translation and subsequent recruitment out of the host translation machinery to the viral replication complexes [11]. The upregulation of crucial mRNA decay factor Lsm1p contributes to human cancer making it a potential target for human cancers. It is not yet known how mRNA perturbations contribute to apoptosis in yeast and cancer, autoimmune and neurodegenerative disorders in mammalian cells. Beside defects in mRNA turnover, defects in the RNA synthesis and processing are associated with disease-specific alterations in RNA-binding proteins as well in miRNAs, tRNAs and lncRNAs that may represent potential diagnostic biomarkers [12]. *Saccharomyces cerevisiae* represents a well-established model system for understanding of the complex regulatory networks operating in higher organisms since RNA decay pathways and decay factors are well conserved in all eukaryotes from yeast to mammals. Dcp2 is the major mRNA decapping enzyme in eukaryotic cells and is regulated by interactions with several activators, including Dcp1, Edc1, and Edc3, as well as by an autoinhibition mechanism (Figure 4).

Deregulation of the Dcp1/2 activity, crucial for the quality control and turnover of RNA, may lead to the onset of serious diseases [13]. In mammalian cells, Dcp2 seems to be linked to the spinal muscular atrophy, the innate immunity pathway and the interferon response [14, 15]. With respect to this, Dcp2 inhibitors should be helpful in the study of RNA decapping and may provide novel therapeutic tools [16]. Yeast can be used to study the effects of the increase or decrease of mRNA stability through the modification of cap structures, an argument that has great potential for use in gene therapy and for the construction of new cap-based molecular probes [17]. Under nitrogen starved conditions, autophagy is induced, and the bulk RNA is first cleaved to 3' nucleotides by the vacuolar ribonuclease Rny1 [18]. A conserved process of stress-induced tRNA and rRNA cleavage exists in eukaryotes, possibly extending to prokaryotes. It is presumed that enhanced tRNA and rRNA cleavage during stress conditions are activation of a general cytosolic nuclease or stress-induced cytosolic release of vacuolar nucleases. The activation of endonucleolytic cleavage of tRNAs correlates with the progression of cancer and understanding the mechanism behind tRNA cleavage might provide a useful therapeutic target [19]. In addition, the frog-derived RNase known as Onconase has been shown to enter cells and trigger apoptosis in a manner correlated with tRNA cleavage and consequent translational inhibition and is currently in clinical trials as an anti-cancer therapy [20].

In addition, studies on yeast have shed light on human diseases such as prion biology, virus-host interactions, metabolic diseases, neurodegenerative disorders, cancer, or aging. Yeast apoptosis and its regulation is structurally and functionally conserved in yeast and yeast has even served to uncover pathways involved in apoptosis and other controlled cell death subroutines involving the AAA-ATPase Cdc48/VCP, the BAX inhibitor-1, the implication of metacaspases as cell death regulators, the role of cathepsin D in non-autophagic mitochondrial degradation. The understanding of yeast cell death and its putative modulation may improve industrial and biotechnological applications, provide insights into mRNA turnover, and help develop the fight against fungal and other diseases [21].

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Table 1: Enzymes involved in mRNA decay

Protein	Properties	Function	Significant interactions
Pab1p	Contains four N-terminal RRM domains and a proline-rich C terminus	Major protein associated with poly(A) tail. Blocks mRNA decapping and stimulates translation. Primary coupler of deadenylation and decapping.	eIF-4G, eRF3, Pan2/3p
eIF-4E	Cap-binding protein	Component of the eukaryotic translational initiation complex, eIF-4F. Blocks mRNA decapping by competing with Dcp1/2p for access to the cap.	Lsm7p, eIF-4G, eIF-4A, eIF-4B, Pab1p
Lsm1-7p	Sm-like proteins	Required for the efficiency of decapping in vivo. Forms a heteroheptameric ring complex and interacts with the mRNA after deadenylation. May facilitate the assembly of the decapping complex.	Dcp1p, Dcp2p, Dhh1p, Pat1p, Xrn1p, Upf1p
Pat1p	88kDa protein with no recognizable sequence motifs	Interacts with both polyadenylated and deadenylated transcripts. Required for efficiency of both decapping and formation of P bodies in vivo. May "seed" the decapping complex on the mRNA.	Dcp1p, Dcp2p, Lsm1-7p, Dhh1p, Xrn1p, Crm1p
Dhh1p	Member of the ATP-dependent DExD/H box helicase family	Required for the efficiency of decapping in vivo. Homologs across species are required for translational repression during mRNA storage events.	Dcp1p, Dcp2p, Lsm1-7p, Ccr4p, Pop2p, Caf17p, Pbp1p, Edc3p
Edc1p, Edc2p	Small, basic proteins with weak homology to each other	Required for efficient decapping in vitro. Directly binds to the mRNA substrate.	Dcp1p, Dcp2p
Edc3p	Contains five conserved domains	A general and mRNA-specific regulator of decapping. Regulates the decapping of the RPS28a mRNA.	Dcp1p, Dcp2p, Dhh1p, Crm1p, Rps28ap, Nup157p, Lsm8p
Puf3p	Pumillo-like protein, contains eight PUF repeats	Messages specific activator of mRNA deadenylation and decapping. Homologs facilitate translational repression. Regulates the decapping of the COX17 mRNA.	
Upf1p, Upf2p, Upf3p	Upf1p is an ATP-dependent RNA helicase	Required for non-sense-mediated decapping.	eRF1, eRF3, Dcp2p, Upf2p, Lsm1p





Table 2: Enzymes involved in mRNA decay

Protein	Function	Features
<b>Deadenylation</b>		
Ccr4p	Catalytic subunit of the deadenylase	Homology to Mg <sup>2+</sup> dependent endonucleases
Pop2p	Regulator of deadenylation, may also have deadenylase activity	Homology to RNaseD
Pan2p/Pan3p	Minor deadenylases, required for poly(A) length control	Pan2p has homology to RNaseD
PARN	Mammalian deadenylase	Homology to RNaseD. Can bind to 5' cap, which stimulates deadenylase activity
<b>Decapping</b>		
Dcp1p	Major component of decapping holoenzyme	EVH1/WH1 domain
Dcp2p	Catalytic subunit of decapping holoenzyme	NUDIX motif, conserved Box A and Box B motif
<b>Exonucleases</b>		
Xrn1p	Major cytoplasmic 5'→3' exonuclease	
Rat1p	Nuclear 5'→3' exonuclease	
Rrp4, Rrp40p, Rrp41p, Rrp42p, Rrp43p, Rrp44p, Rrp45p, Rrp46p, Mtr3p, Csl4p	A complex of 3'→5' exonucleases termed the exosome	Domain organization similar to that of bacterial PNPase

Annu. Rev. Biochem. 2004. 73:861-890. Downloaded from www.annualreviews.org



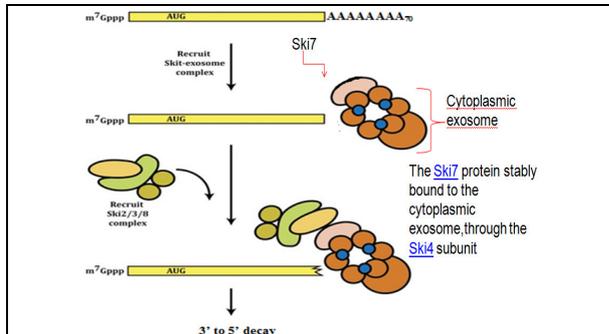


Figure 1: 3' to 5' decay mediated by exosome and Ski complex (Ski7 with Ski2/Ski3/Ski8). The Ski2/3/8 complex interacts with Ski7, and this interaction, which appears to occur between Ski7 and the Ski3 and Ski8 proteins, is required for 3' to 5' degradation of mRNAs.

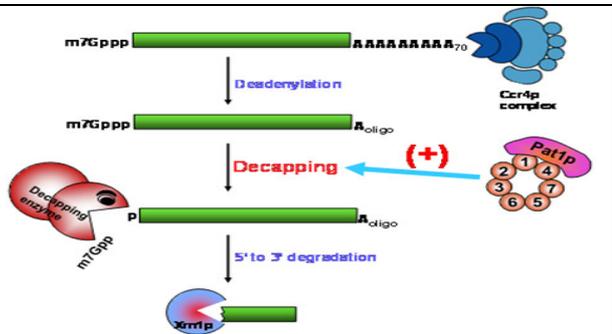


Figure 2: Lsm1p-7p-Pat1p complex is an activator of decapping *in vivo*. Deadenylation dependent decapping and 5' to 3' mRNA decay by Xrn1p is illustrated.

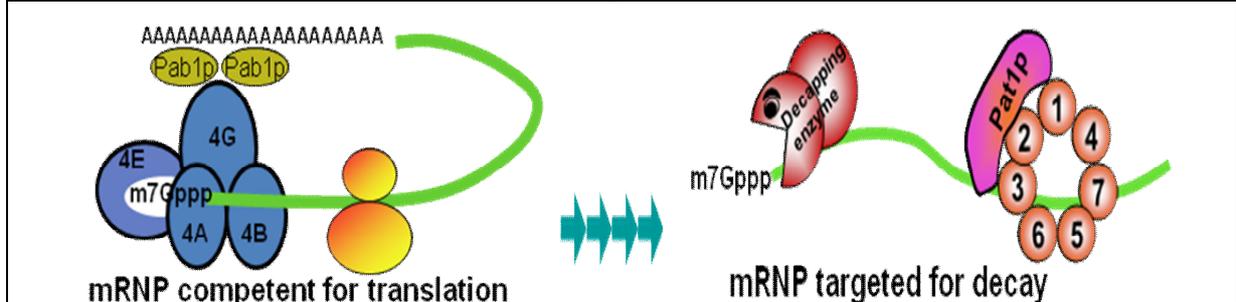


Figure 3: An mRNP transition from a translation competent status to degradation competent form.

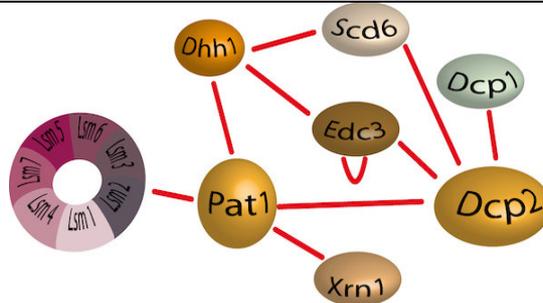


Fig 4: The decapping protein interaction network





## Biology and Lifecycle of *Henosepilachna vigintioctopunctata* FABRICIUS, a Serious Defoliator of Bittergourd in Gajapati Districts of Odisha

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### ABSTRACT

*Henosepilachna vigintioctopunctata* (Fabricius), commonly known as Hadda beetle, is a polyphagous pest of various economically important agricultural crops in India. It is a serious pest of cucurbit crops, especially, bitter gourd (*Momordica charantia*). The present study was carried out during June-July, 2019 and the studies on its biology indicated that a gravid female laid 182 to 356 eggs on an average in 6-7 batches during her life span. The duration of different stages of life cycle viz. eggs, larvae and pupa lasted for an average of  $4.1 \pm 0.33$  days,  $20.8 \pm 3.35$  days and  $3.2 \pm 0.72$  days, respectively. The adult male and female survived for an average period of  $29.8 \pm 3.10$  days and  $34.4 \pm 2.37$  days, respectively. The whole body of the adults is covered with fine short hairs. Adults are copper brown coloured mottled with black spots. The present study can help the researchers in understanding the biology and behaviour of this particular pest, which can help in taking proper management strategies.

**Keywords:** *Henosepilachna vigintioctopunctata*, *Momordica charantia*, Biology and Life Cycle.

## INTRODUCTION

Cucurbits, belong to Family Cucurbitaceae, constitute the largest group of summer vegetables grown all over the world. Bitter gourd is the most popular crop of the cucurbitaceae family grown in low and mid-hills of Jammu & Kashmir. Fruit juice of bitter gourd is used as a traditional medicine to cure diabetes and also used to treat acidity, indigestion, constipation and ulcers. Its seeds are also powerful antihelminthics. Bitter gourd is infested with a variety of insect pests right from the primordial stages of the crop to harvest of the products. Besides the direct damage, many pests act as vector for viruses. Insect pests of cucurbits of serious concern are Red pumpkin beetle, Fruit flies and Melon ladybird beetles. (Gupta, 2004).





*Henosepilachna vigintioctopunctata* (Fabricius) or melon ladybird beetle or spotted leaf-eating beetle, belongs to the Family-Coccinellidae or ladybird beetles, of Order- Coleoptera. *Henosepilachna* is an oligophagus, multivoltine, coccinellid beetle, infesting crops in mid-hills and plains of India (Kumar and Kumar 1998). Both grubs as well as adult beetles feed voraciously on the green matter of the leaf and skeletonize it leaving the upper epidermal tissue intact (Rath *et al.*, 2002; Mohasin and De, 1994).

## MATERIALS AND METHODS

In order to study the lifecycle of melon ladybird, the adults were collected from the fields of cucurbits, by using entomological nets, during the months of June-July, and were kept in rearing cage, under laboratory conditions. They were continuously fed on the leaves of cucurbits (bitter gourd). The adults were allowed to copulate and each pair was observed for pre-mating, mating and oviposition behavior and duration. The adult female laid eggs in batches. Eggs were counted and after hatching the grubs were reared and the morphometric measurements for each instar were recorded. Observations regarding the pre-pupal and pupal stages and adult longevity were also recorded. Data gathered during the experiment was analyzed statistically for calculating mean, standard deviation and standard error.

## RESULTS AND DISCUSSION

The results of present investigation presented in table1 revealed that the incubation period ranged from 3 to 4 days with mean duration of  $4.1 \pm 0.33$  days. showed complete metamorphosis with four different stages; Egg, Grub (Larva), Pupa and Adult (Beetle). The female laid as many as 182 to 356 eggs during the life span with an average of  $265.8 \pm 52.49$  eggs. Hatching % of the eggs were 56.60 %. Similar results were obtained by Indu and Chatterjee (2006). While 272.32 eggs were reported by Verma and Anandhi (2008) and 302.5 by Qamar *et al.*, (2009). Newly hatched 1st instar larvae were yellowish in color and had six rows of long branched spines. The duration of first instar larva ranged from 3-5 with a mean of  $5.8 \pm 0.62$  days. The range of second instar period varied from 4-6 days with mean duration  $5.6 \pm 0.41$  days. The third instar larva was 4-5 days ranged with a mean of  $4.3 \pm 0.45$  days. The fourth instar larva was observed 6-7 days ranged with the mean of  $7.2 \pm 0.63$  days. The total larval period ranged from 17 to 23 days with a mean of  $20.8 \pm 3.35$  days. The full grown 4th instar grub stopped feeding and roaming for 10-15 min to locate suitable site for pupation. The colour of the grub gradually faded and the body shrank. Verma and Anandhi (2008) observed the larval period as  $15.1 \pm 4.90$  days while  $14.9 \pm 0.43$  days was reported by Qamar *et al.*, (2009).

The full fed grubs spent 1 -3 days in the pre-pupal stage with an average of  $1.6 \pm 0.89$  days. The average pre-pupal length was  $5.32 \pm 0.42$  mm and breadth was  $3.26 \pm 0.32$  mm where as the mean pupal period was  $3.2 \pm 0.72$  days and ranged from 2 to 5days. Similar results were obtained by Verma and Anandhi (2008) and Qamar *et al.*, (2009). The average pupal length was  $6.15 \pm 0.24$  mm and breadth was  $3.73 \pm 0.38$  mm. The mean adult male beetle longevity was  $29.8 \pm 3.10$  with the range from 27 to 32 days. The mean lifespan of female beetle of *E. vigintioctopunctata* was observed  $34.4 \pm 2.37$  with the range from 31-39 days. The results further showed that the duration of life cycle varied from 49 to 75 days with mean duration of  $65 \pm 6.23$  days. The mean fecundity was recorded as  $56.8 \pm 6.62$  eggs/female with a range of 38 to 69 eggs/ female.

### Nature of damage

*Henosepilachna vigintioctopunctata* is a serious pest of cucurbits especially *Momordica charantia* (Bitter gourd). Both adults and larvae(grubs) are often found on the lower surfaces of the leaves, scrapping and feeding voraciously on the parenchyma and the lower epidermis between the veins and skeletonize it in a characteristic manner leaving intact the upper epidermis as well as the tougher tissues (veins, etc.) in the form of "window".





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The affected leaves become translucent, take a grayish color and dry up. In cases of severe attack, the young plant can dry up completely and die. Adults are fliers can damage large crop areas during their peak activity (Nagia *et al.*, 1992).The adults are not responsible for as great level of injury as are the larvae

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**Table-1 : The results of present investigation**

BIOLOGICAL EVENTS	RANGE	MEAN±SE
Fecundity	38- 69	56.8 ± 6.62
Incubation Period (days)	3-4	4.1 ± 0.33
Larval period (days)		
Instar-I	3-5	5.8 ± 0.62
Instar-II	4-6	5.6 ± 0.41
Instar-III	4-5	4.3 ± 0.45
Instar-IV	6-7	7.2 ± 0.63
Total larval period(days)	17-23	20.8 ± 3.35
Total pupal period(days)	2-5	3.2 ± 0.72
Adult longivity		
Male	27-32	29.8 ± 3.10
Female	31-39	34.4 ± 2.37
Total life cycle(days)	38-69	56.8 ± 6.62





## A Review on Fish Processing Wastes Generation in India and Its Further Utilization Prospects into Different Value Added Compounds

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### ABSTRACT

In India, the matter of fish waste has concerned considerable attention to the food producers, processors, retailers, and consumers because the waste from fish generated during a huge amount from the fish processing industries, retail markets and also from the by-catch at the fishing harbour. The continuous increase in global fish resources leads to 25% of wastage among total fish catch annually. During 2006-07, an estimate of the, 02,750 tones of waste was generated from fish processing (both processing and pre-processing taken together) industries of India alone. Non-utilization or underutilization of those waste products not only cause negative externalities to society but also cause environmental pollution and ecological onus. To secure from pollution and to scale back waste, it's now become important to possess a comprehensive understanding about the recycle and/or conversion of those fish wastes into useful products of higher nutritive value and betterment of human society. Thus, the effective utilization of fish processing waste materials from the fish processing sectors has been reviewed here-in India, the problem of fish waste has concerned considerable attention to the food producers, processors, retailers, and consumers because the waste from fish generated during a huge amount from the fish processing industries, retail markets and also from the by-catch at the fishing harbour. Non-utilization or underutilization of these waste products not only cause negative externalities to society but also lead to environmental pollution and ecological onus. To secure from pollution and to scale back waste, it's now become important to possess a comprehensive understanding about the recycle and/or conversion of those fish wastes into useful products of higher nutritive value and betterment of human society. Thus, the effective utilization of fish processing waste materials from the fish processing sectors has been reviewed here.

**Keywords:** Fish, waste, utilization, pollution, enzyme, fish meal.





## INTRODUCTION

Aquaculture is one of the fastest growing food sectors providing an ultimate livelihood option to a millions of peoples across the world. In the last three decades, capture fisheries production increased from 69 million to 93 million tons; during an equivalent time, world aquaculture production inflated from 5 million to 63 million tons. Globally, fish currently represents about 16.6 percent of animal protein supply and 6.5 percent of all protein for human consumption (FAO, 2012). The continuous increase in global fish resources results in 25% of wastage among total fish catch annually (FAO, 2012). Fisheries generate large amount of solid wastes such as whole fish waste, fish head, viscera, tails, skin, bones, blood, liver, gonads, guts and some muscle tissues and also liquid wastes consisting of wastewater used during fish processing.

Every year, enormous amount of these processing wastes are discarded from seafood processing plants and fish markets. Because of the specificity of certain raw material and its processing in relation to a specific product, surplus and waste food processing co-products are not readily used by the parent processors. During 2006-07, an estimate of 3, 02,750 tonnes of waste was generated from fish processing (both processing and pre processing taken together) industries of India alone. The maximum waste was generated from processing of shrimps followed by fin fishes and cephalopods. On the context of environmental pollution, waste generation from fish processing is of great concern today. This waste may be a superlative staple for the preparation of high value added products including proteinaceous foods. These are also a valuable source of raw material for recovery of bioactive compounds. Additionally, inappropriate disposal is a major cause of environmental pollution.

The utilization of fish waste succours to eliminate detrimental environmental aspects and revamp quality in fish processing. However, recent advances in industrial biotechnological processes have paved way for economical and highly serviceable utilization of these wastes for mankind. The recovery of chemical components from seafood waste materials & fish processing units, which may be utilized in other segments of the food industry, may be a promising area of research and development for the use of fish waste by-products. These wastes cause a serious problem of environmental pollution and make the environmental atmosphere unhygienic prone to various kinds of diseases. So there is a problem remains what to do with these wastes. One best alternative way is to convert these wastes to value-added bioactive and different products for the use of mankind and other animals. The valuable products that would be developed from of these fish processing waste materials are described below in short.

### Fish waste as a material for enzyme production

The major fish wastes usually found within the market are fish viscera, head, tail, scales etc. Fish viscera is consists of different types of food materials, have the property of enzymatic hydrolysis of different types of proteolytic enzymes that secreted to the gut. Enzymes and bioactive peptides are often attained from fish waste and used for fish silage, fish feed or fish sauce production. An alternative thanks to convert the fish processing wastes into more marketable products is to isolate and purify proteolytic enzymes which are abundant in fish viscera. Proteases or the proteolytic enzymes that are found within the gut might be helpful in fish protein hydrolysate production. Proteolytic enzymes like alkaline, a-chymotrypsin, neutralise, papain, pepsin, trypsin, pancreatin, flavourzyme, bromelain, pronase E, protamex, orientase, thermolysin, validase, protease A amano, protease N amano and cryotin F that derived from plant, animal, and microbial sources are successfully tested for the assembly of antioxidative peptides from fish protein sources.

Protease is a group of enzyme that makes proteolysis known as hydrolysis of the peptide bonds, which link amino acids together in the polypeptide chain forming the protein. Proteases represent one among the most important groups of commercial enzymes and are mainly derived from animal, plant, and microbial sources. Today, there's an increasing demand for fish proteolytic enzymes thanks to their wide selection of applications. Proteases play an



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important role in industries due to their multifarious applications in leather and detergent industry, food and pharmaceutical industries and also in bioremediation processes.

### **Fish waste as a material for fish protein hydrolysates (FPH) production**

FPH is a liquefied product but different from silage. FPH may be defined as fish proteins that are broken down into peptides of various sizes. These products are produced by employing commercially available proteolytic enzymes for isolation of enzymes from fish waste. By selection of suitable enzymes and controlling the hydrolysis conditions, properties of the end product can be selected. Hydrolysates find application in milk replacers and food flavourings. According to the WHO's recommendation, fish protein also serves as a significant source of essential amino acids (about 30% by weight). That is the rationale why fish protein hydrolysates are getting more popular. The degradation can be carried out either chemically (using acid or alkali) or biologically (using enzymes).

Such processes not only maintain a high essential aminoalkanoic acid content but also generate many improved functions for food or pharmaceutical application. For example, improved capacities of oil-binding and emulsifying are required for meat products and spread texture food respectively. Similarly, natural anti-oxidants like FPH could be used for improved anti-oxidation and anti-hypertension activities and to control high blood pressure, in addition, to replace synthetic products which may have negative side effects. So the production of fish hydrolysates from fish processing waste will reduce the pollution due to the accumulation of fish waste in the environment from the fishery based industries [1]. Most hydrolysates are bitter in taste after the time of production. Therefore flavouring agents are like cocoa, and sugar should be used during the fortification in food preparation to mask the bitter taste [2].

### **Fish waste as a material for fish meal production**

Fish meal is that the most vital products obtained from fish waste, by-catch, and other abundant species. It is highly concentrated dry nutritious feed supplement consisting of high-quality protein (70%), minerals (10%), fat (9%) and water (8%). It can have different compositions and qualities, in terms of amino acid profile, digestibility, and palatability, depending on the raw material used for its production and the type of process employed for obtaining the meal. Fish meal is usually used as an ingredient in food for fish and crustaceans. Differences in organic quality can affect the expansion and feed efficiency ratios of the organisms fed. Fresh staple and rancid staple can produce significant differences within the content of biogenic amines like cadaverine within the organic and high-quality organic with low biogenic amine content.

These differences affect certain nutritionally important parameters within the organisms fed with those particular fish meals, like feed intake and feed efficiency, both being reduced within the case of the poor quality fish meal [3]. Traditionally fishmeal production was from the sundried fish collected from various drying centres and therefore the product was mainly used as manure, but now each day, the organic can be produced by two general processes like dry rendering and wet rendering. Process conditions also affect the meal quality. Superior quality fish meals are a prominent item of export from the very beginning of the industry. BIS has brought out the specifications for fish meal as livestock feed for facilitating proper quality control [4].

### **Fish waste as a material for fish silage production**

Viscera of fish include the digestive tissues (stomachs, pyloric caeca, intestines, liver, pancreas, etc.) and other organs like spleen and gonads. Viscera waste was used to obtain fish silages. Almost any low-cost species of fish can be used to make silage, though cartilaginous species like sharks and rays liquefy slowly. Fish silage are often defined as a product made up of whole fish or parts of the fish to which no other material has been added aside from an acid and in which liquefaction of the fish is brought about by enzymes already present in the fish [5]. The rate at which the liquefaction takes place depends upon the temperature and pH of the mixture. Fatty fish liquefy sooner than white fish and cannon fodder liquefy sooner than stale fish and previously chilled or frozen fish. Since the nutritional value of aquaculture, fish diet is decided basically by the aminoalkanoic acid composition of the feed and it's concluded



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that silages made up of fish waste materials are adequate for use as an ingredient in balanced diets. So the ensilage can be used as for fish meal replacement for the production of feeds <sup>[6]</sup>.

**Fish waste as a material for fish oil production**

Fish oils are often extracted from the entire fish, skin or liver (in the case of some species). Fish oils are rich sources of polyunsaturated fatty acids, especially Eicosapentaenoic acid (EPA) and Docosa hexanoic acid (DHA). These two compounds have shown different interesting bioactivities. Among the properties of omega-3 fatty acids, the best known are the prevention of atherosclerosis, reduction of blood pressure and protection against arrhythmias. Squalene is a lipid found in large quantities in shark liver oil. The large by-catch of shark within the fishing industry round the world provides a useful source of fish oils whose value are often substantially increased by processing them to obtain fractions such as squalene. Squalene is interesting bio-active oil and their applications have been reported in the treatment of diabetes, cancer, and tuberculosis. It also has antifungal and anti-oxidative properties. At present, the medicinal values of fish oil are very well known <sup>[7]</sup>.

**Fish waste as a material for collagen and gelatin production**

Skin, bones, and fins represent around 30% of fillet processing waste and are produced as a consequence of the preparation of various fishery products like fillets and sashimi (sliced raw fresh fish). Fish skin, therefore, is a crucial by-product of the fish-processing industry, causing wastage and pollution. Collagen is the major structural protein found in the skin and bones of animals and gelatines are their degradation products. The collagen obtained has potential use for a spread of applications like edible casings for the meat processing industries, cosmetics (because it's good moisturizing properties) and biomedical materials or pharmaceutical applications, which include the production of wound dressings, vitreous implants or carriers for drug delivery. Some reports also show that collagen may evince high anti-radical activity. It is well established that the amount of gelatin used in the food industry worldwide is increasing annually. It has been also demonstrated that fish gelatin can stabilize emulsions, remaining moderately stable to droplet aggregation and creaming, even after being subjected to changes in temperature, salt concentration, and pH. Gelatin from marine source can be a possible alternative to bovine gelatin in future days <sup>[8]</sup>. The amount of gelatin obtained from fish and other species increased consistently from 2003 to 2005 with a growth of 0.7% to 1.3% of total world production <sup>[9]</sup>.

**Miscellaneous uses****Fish calcium**

Filleting waste of bigger fishes are very good sources of calcium which can be used for the pharmaceutical purpose.

**Pearl essence**

Pearl essence is the suspension of crystalline guanine in a solvent. It is the iridescent substance located in the epidermal layer of the scales of pelagic fishes. This is used for coating the objects to give them a lustrous effect.

**Fish glue**

Fish glue is made from fish skins (better quality glue) and fish heads (lesser quality glues). A sequential cooking of fish skin with acid and alkali yields fish glue.

**Fish maws and isinglass**

Sturgeon fish's air bladder or swim bladder is usually referred as isinglass. In India, air bladder of eels and catfishes are used for the production of isinglass. The air bladders are separated from fish and temporarily preserved in salt during the time of transport. On reaching the shore, they are split open, thoroughly washed and outer membrane are removed by scraping and then air dried <sup>[10]</sup>. Then cleaned, desalted, air dried, and hardened swim bladders are called fish maws. Isinglass is used as clarifying agents for beverages, wines, beer, and vinegar by enmeshing the suspended impurities in the fibrous structure of swollen isinglass.





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### **Bioactive compounds**

New biologically active compounds have been isolated from fishery discards. One example is the discovery of the antifungal and antibacterial properties of the epidermis, epidermal mucus of different fish species, liver, intestine, stomach, and gills of some fish species and the blood and shell of some crustaceans. Fish mucous is known to have significant biological functions, acting as an immunological barrier. A variety of biologically active compounds, proteinases, peptides, or polypeptides with high molecular weight are responsible for these functions.

### **Antifreeze proteins**

Antifreeze proteins (AFPs), which are found in diverse species of marine fishes, are characterized by their ability to stop ice formation by cooling below the melting point. This is a protection method of polar fishes against freezing. It is found that snail fish skin tissue shows antifreeze activity which will be purified by chromatography techniques. Some work has also been carried out on the extraction of AFPs from winter flounder (*Pseudopleuronectes americanus*), cunner (*Tautoglabrus adspersus*), sea raven (*Hemitripterus americanus*), and short horn sculpin (*Myoxocephalus scorpius*). The main application of AFPs is as cryoprotectants since they will prevent freezing damage by their capacity to lower melting point and inhibit ice recrystallization. Some studies revealed that the addition of AFP to meat or injection into animal reduces the damage caused by frozen storage of meat.

### **Pigments**

Valuable pigments are found during a sort of fish raw materials, especially in seafood waste. Various studies have reported the presence and recovery of pigments like astaxanthin and its esters,  $\beta$ -carotene, lutein, astacene, canthaxanthin and zeaxanthin in crustacean waste. Carotenoids are a group of fat-soluble pigments that can be found in many plants, algae, microorganisms, and animals, and are responsible for the colour of several shellfish. Carotenoids have been extracted using shrimp waste, from processing head and shell of *Penaeus indicus*, applying different organic solvents. Carotenoids were also extracted from fish eggs and from fish scales waste also. These valuable pigments would be cheaper alternative applicable to a good sort of industrial needs like colouration of some surimi-based products or aquaculture feed formulation. Furthermore, some pigments like astaxanthin are important in medical and biomedical applications due to their high antioxidative effects and to the fact that they are precursors of vitamin A.

### **Chitin and Chitosan**

Chitin, a polysaccharide and one of the major components of crustacean shell waste, has been found to be a potential source of antimicrobial substances, due to the high percentage that shrimp wastes represent on a global scale. Chitosan has strong antimicrobial activity against a variety of microorganisms, and it is non-toxic, biocompatible and biodegradable properties make it adequate for applications as a food ingredient and in medical applications. It has also certain antitumor properties revealed both in vitro and in vivo. Chito-oligosaccharides also exhibited scavenging activity on hydroxyl and superoxide radicals, this being dependent on their molecular weight.

This property makes them potential additives for the inhibition of lipid oxidation in food, but also can prevent certain pathological processes related to radical modification of cellular compounds, such as atherosclerosis, arthritis, diabetes, inflammatory disorders, and neurological disorders such as Alzheimer's disease. Other applications of chitin and chitosan are their use as ingredients of toothpaste, shampoo, hand and body cream, for cell immobilization, and as materials for the production of contact lenses. Chitosan finds extensive applications in food industries, pharmaceutical applications, chemical industries, dental and surgical uses as a hemostatic agent, wound healing, biodegradable films as a substitute for artificial skins for removing toxic heavy metals, agriculture, photography, and textiles [11].





### Bio-oil

Fish oil, a fish powder by-product, was pre-treated by filtration, placed during a reactor with two catalysts (iron oxide and phosphate monobasic) and mixed with ozone bubbling (about 8000 ppm) for one hour temperature which is named primary ozone treatment. Some scientists evaluated the ozone treated fish waste oil as a transportation diesel oil. Then the sample was filtered again and treated with ozone at the same conditions for 30 min, but without the presence of catalysts called as secondary ozone treatment. The oil manufactured from fish waste was tested for its density, flash point, pour point, heating value, distillation test, and sulphur content. The yield of the produced fuel was 95–96%, after filtration, primary and secondary treatments. The method of production of bio-diesel from fish source is also reported by Arvanitoyannis and Kassaveti (2007) [12]. The obtained oil was found to have suitable properties for use in diesel engines, such as almost identical higher heating value compared with commercial diesel fuel, no production of sulphur oxides, lowered or any soot, poly-aromatic and carbon dioxide emissions. These properties suggested that the obtained oil had better properties than methyl-esterified oil waste and was suitable for diesel engines, especially at coldness.

### CONCLUSION

Instead of dumping, the utilization of unwanted fish wastes as a low-cost feedstock along with traditional fishery by-products a better option for production of value-added products and also as health supplement can be considered. It may not only cause the control of solid waste generated from fish industries but also helps in improving fish industry economy. Hence more research and public awareness are required to explore the likelihood and potential of fish processing waste closer to the assembly of value-added commodities for the betterment of human society.

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## Influence of Weed Management Practices on Weed Density, Weed Control Efficiency and Yield of Sweet Corn (*Zea mays* L Saccharata) under Rainfed Condition

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### ABSTRACT

The results of the field experiment revealed that pre emergence application of atrazine @1.0 kg/ha supplemented with hand weeding at 20 days after sowing (DAS) significantly reduced the weed population and dry weight during the initial period of crop growth up to 40 DAS along with enhancement in weed control efficiency. During later stages of crop growth, manual method of weed control by combined hand hoeing, weeding and earthing up markedly reduced the weed population and dry weight and increased the weed control efficiency which remained at par with pre emergence application of atrazine followed by hand weeding at 20DAS. The maximization of yield components like cob length, cob girth and number of grains per cob were recorded in integrated use of pre emergence application of atrazine @1.0 kg/ha with hand weeding at 20 DAS being at par with combination of hand hoeing, weeding and earthing up done at 20 and 40 DAS. The same pre emergence application of atrazine with hand weeding at 20DAS produced the highest green cob yield (34.75 t/ha) and fresh kernel yield (12.61t/ha) that did not differ significantly from manual method of weed control performed with combination of hand hoeing, weeding and earthing up at 20 and 40 DAS.

**Keywords:** weed, method, application, grains, control, yield



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## INTRODUCTION

Sweet corn is gaining popularity among nutritive and health conscious urban masses in India with an immense potential in domestic and international market. Due to its extra sweetness (14-20% sugar) and short duration, sweet corn is cultivated as a remunerative crop for the farmers. A wide spaced crop like sweet corn suffers from heavy weed infestation due to slow initial growth particularly during kharif season. The yield losses in sweet corn due to season long weed infestation ranges from 30 per cent to complete crop failure (Pandey *et al.*2001) [4]. The choice of weed control methods largely depend on effectiveness and economics. Due to increased cost and non-availability of manual labour in required quantity and time for hand weeding, the use of pre and post emergence herbicides to manage the weeds play an important role.

Use of chemical method would make weed control more acceptable to farmers which will not only change the existing agronomic practice but also will allow for satisfactory control of weeds. As the weeds interfere during aftercare operation and the harvest of crop, post-emergence use of herbicides may help in avoiding the problem of weeds at later stages. Under such situation, managing weeds through pre and post-emergence herbicide will be an ideal means for controlling the weeds in view of economics and effectiveness of sweet corn cultivation. Even though the farmers use pre-emergence herbicide in many instances, early weed control are not sufficient because the weed flourishes even after critical period of crop-weed competition. So the mechanical and manual weeding method has to be given priority in Indian agriculture scenario. Keeping primarily this aspect in foresight, the present experiment has been undertaken to devise an appropriate weed management practices for enhancing the productivity of sweet corn during kharif season.

## MATERIAL AND METHODS

The field experiment was carried out in randomized block design with eight treatments and three replications at Agronomy Main Research Farm, Orissa University of Agriculture and Technology, Bhubaneswar, Orissa during the kharif season of 2017. The treatments were comprised of atrazine @ 1kg /ha as pre-emergence at 1day after sowing (DAS) followed by hand weeding at 20 DAS, tembotrione @ 125g/ha at 20 DAS as post emergence, atrazine @ 0.5kg /ha + tembotrione @ 60g /ha as tank-mix at 20 DAS, power weeder at 20 DAS, cycle hoe at 20 DAS, hand weeding at 20 DAS and 40 DAS, hoeing followed by weeding and earthing-up at 20 DAS and 40 DAS and control (Weedy check). The soil characteristics were sandy loam in texture, acidic in reaction with pH of 5.73 and medium in organic carbon content (0.66%) with low in available N (158.96 kg/ha), medium in P<sub>2</sub>O<sub>5</sub> (20.36 kg/ha) and low in K<sub>2</sub>O (104.56 kg/ha). The sweet corn variety NS 680 was sown in the month of 31st July, 2017 with a spacing of 60cm from row to row and 30cm from plant to plant. Half the dose of N i.e. 60 kg/ha, full dose of P<sub>2</sub>O<sub>5</sub> (60 kg/ha) and half dose of K<sub>2</sub>O i.e. 20kg/ha were applied as basal and remaining N and K<sub>2</sub>O doses were applied at 20 and 40 DAS in two equal splits. The weed count and weed dry weight were recorded from an area of quadrant size of 1m×1m at 20, 40 and 60DAS. The crop was sprayed with monocrotophos @ 0.2% at 20 and 40 DAS to save the crop from various insect attacks. At harvest, yield attributing characters like cob length and cob girth along with fresh cob yield and fresh kernel yield were recorded from all the plots.

## RESULTS AND DISCUSSION

The experimental site was infested with all total 19 weeds comprised of seven grasses, two sedges and ten broad leaved weeds. Amongst the grasses, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Digitaria ciliaris*, *Eleusine indica*, *Panicum maximum*, *Paspalum scrobiculatum*, *Sporobolus diander* and *Cyperus iria* and *Cyperus rotundus* in sedges and *Ageratum conyzoides*, *Boerhavia diffusa*, *Celosia argentea*, *Cleome rutidosperma*, *Cleome viscosa*, *Commelina benghalensis*,



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*Melochia corchorifolia*, *Oldenlandia corymbosa*, *Portulaca oleracea* and *Sida acuta* under broad leaved weeds were observed.

### Effect on weed population

The data pertaining to weed population at 20, 40 and 60 DAS presented in the Table 1 indicated that weed population was remarkably reduced with weed management treatments. Significantly the lowest weed population was observed in atrazine + hand weeding (9.01/ m<sup>2</sup>) at 20 DAS. The next best result was obtained in hand hoeing followed by weeding and earthing-up (12.19/ m<sup>2</sup>) atrazine (@ 0.5 kg /ha) + tembotrione (@ 60 g /ha (12.31/ m<sup>2</sup>) and hand hoeing (12.93 / m<sup>2</sup>) at 20 DAS. During 40 DAS, weed density was reduced with atrazine + hand weeding (8.99 / m<sup>2</sup>) followed by hand hoeing combined with weeding and earthing-up (10.84 / m<sup>2</sup>), hand weeding ( 10.99 / m<sup>2</sup>) and atrazine (@ 0.5 kg /ha + tembotrione (@ 60 g /ha (12.65/ m<sup>2</sup>) which were at par.

At 60 DAS, the minimum weed population was observed in hand hoeing followed by weeding and earthing-up (11.30 / m<sup>2</sup>) which was at par with all the weed management treatments except cycle weeder and unweeded check. At 20, 40 and 60 days after sowing (DAS), the treatment atrazine + hand weeding recorded the lowest weed population which was possible due to application of pre emergence spray which acts as a inhibitor of photosystem-II leading to death of the weeds at early stage of crop followed by hoeing performed at 20 DAS controlled all types of weeds. The results are in line with Kolage *et al.* (2004) [2] who showed that atrazine applied as pre-emergence spray reduced the weed intensity substantially at 15 days of crop growth.

Afterwards the hand weeding at 20 DAS resulted in removal of left over weed population thereby providing weed free condition during critical period of crop weed competition during 15 to 45 DAS. Patel *et al.* (2000) [5] reported that pre-emergence application of atrazine @ 1.0 kg a.i./ha in combination with hand weeding at 35 DAS was most effective in reducing the total number of weeds. Similar favourable results were obtained by Deshmukh *et al.* (2008) [1] who reported that pre-emergence application of atrazine @ 0.75 kg /ha followed by one hand weeding at 45 DAS was most effective way of weed control. The efficiency of cycle hoe operation in management of weeds in rainy season was not effective as the dense rooting pattern of weeds along with spacing provided in between the tynes of cycle hoe did not uproot the weeds properly. Tank mix application of atrazine + tembotrione also failed to give desired yield due to lesser weed control because of only single application and the results are in line with Williams *et al.* (2011) [10]

### Effect on weed dry weight

The data presented in Table 2 indicated the significant influence of weed management treatments on weed dry weight at different stages of crop growth. The lowest dry weight was recorded in atrazine + hand weeding ( 1.87g/m<sup>2</sup>) being at par with weeding done by power weeder ( 2.13g/m<sup>2</sup>) at 20DAS. At 40 DAS, atrazine + hand weeding (3.18g/m<sup>2</sup>) was the single best treatment in reducing the weed dry weight. It was followed by hand hoeing combined with weeding and earthing-up (4.09 g/m<sup>2</sup>) which remained at par with weeding done by power weeder ( 4.43g/m<sup>2</sup>) at 40 DAS. During 60DAS, the significant reduction in weed dry weight was observed in the hoeing followed by weeding and earthing up at 20 and 40 DAS (2.81g/m<sup>2</sup>). It was resulted in due to imposition of most effective and efficient manual method of weeding in combination of hoeing, weeding and earthing up operations performed at 20 and 40 DAS. This was closely followed by hand weeding (3.68g/m<sup>2</sup>) which did not differ significantly from atrazine + hand weeding (4.18 g/m<sup>2</sup>). Similar kind of result was obtained by Nagalakshmi *et al.* (2006)[3] who reported that hand weeding twice at 3 and 6 weeks after sowing recorded significantly the lower weed dry matter.

The reduction in weed dry weight in pre emergence application of atrazine followed by hand weeding is attributed to the cumulative effect of herbicides and hand weeding which resulted in reduced dry matter production of weeds





by lowering the weed population. This result is in agreement with Sunitha *et al.* (2012) [8]. Power weeder which has high efficiency failed to contribute towards weed control due to single treatment imposition and lesser skilled weeder operator. This result is corroborated with Sekhar *et al.* (2010) [7]. The maximum weed dry weight was recorded in unweeded control were 3.39, 7.49 and 8.88 at 20, 40 and 60 DAS respectively. It is mainly due to higher and uninterrupted growth of weeds which made depletion of growth resources like solar radiation, moisture and nutrient.

### Effect on weed control efficiency (WCE)

The weed control efficiency (WCE) was remarkably affected by various weed control treatments (Table 2). At 20 DAS, the weed control efficiency was significantly increased in atrazine + hand weeding (48.39%) over all other weed management treatments. During 40 DAS, the same treatment atrazine + hand weeding was found superior in recording the maximum WCE (57.50 %). The next best result was recorded in hand hoeing followed by weeding and earthing-up at 20 DAS and 40 DAS (45.26 %). The increase in weed control efficiency at initial period crop growth at 20 DAS upto knee high stage (40 DAS) is due to reduction in weed population and dry weight by pre emergence application of herbicides followed by later manual weeding at 40 DAS. The results are also in conformity with Sunitha *et al.* (2012) [8] who reported that pre-emergence application of atrazine 0.5 to 1.0 kg *a.i./ha* in combination with hand weeding at 30 DAS recorded the highest weed control efficiency due to the lowest weed dry weight. Significantly the highest WCE was observed in hand hoeing followed by weeding and earthing-up treatment (68.35 %) at 60 DAS. It was followed by hand weeding at 20 DAS and 40 DAS (58.55 %) and atrazine + hand weeding (52.86 %). This was possible due to imposition of most effective manual method of weed control at 20 and 40 DAS that resulted in smothering of weed growth thereby improved weed control efficiency. The efficiency of tembotrione in reducing weed dry weight is far lesser due to it's effectiveness confined only to monocot grassy weeds.

### Effect on yield components and yield

The perusal of data presented in Table 3 revealed the significant effect of weed managements treatments on yield attributes like cob length, cob girth and number of grains/cob along with green cob yield and fresh kernel yield. The data regarding length of cob showed that the highest cob length was recorded in atrazine + hand weeding (25.55 cm) which was at par with hoeing + weeding + earthing up (22.59 cm) and hand weeding (20.88 cm). The lowest cob length was recorded in unweeded control (16.66 cm) followed by atrazine and tembotrione tank mix (17.44 cm). The maximum girth of cob was observed in atrazine + hand weeding (18.11 cm) closely followed by hoeing + weeding + earthing up (17.78 cm) and hand weeding (16.80 cm) which were at par with each other. The highest number of grains per cob was recorded in pre emergence application of atrazine with hand weeding (573.48) which was at par with combination of hand hoeing weeding and earthing up (556.70). The lowest number of seeds per cob was recorded in un weeded control (389.76) followed by atrazine and tembotrione tank mix (409.79).

The yield attributes of crop are influenced by genetic traits as well as agronomical practices out of which management of weed is one of the common agronomic practices. Pre emergence application of atrazine at early stages of crop growth reduced the weed population and dry weight thus, eliminated the crop weed competition giving an edge to crop over weeds which was concreted by hand weeding at 20 DAS. Similar favourable results were obtained by Sanodiya *et al.* (2013) [6] and Swetha *et al.* (2015) [9]. The improvement in yield attributes was resulted in manual methods due to it's effectiveness in reducing the weed population and dry weight and gave the opportunity for greater availability of crop growth resources. The green cob yield was the highest in atrazine + hand weeding (34.75 t/ha) being at par with manual hoeing followed by weeding and earthing up at 20 and 40 DAS (30.70 t/ha) and hand weeding at 20 and 40 DAS (29.74 t/ha). The lowest fresh cob yield was obtained in weedy check treatment (13.57 t/ha) followed by atrazine and tembotrione tank mix (17.30 t/ha). The fresh kernel yield followed the similar trend as observed in green cob yield. The pre emergence application of atrazine with hand weeding at 20 DAS combination of hand hoeing, weeding and earthing up at 20 and 40 DAS and hand weeding at 20 and 40 DAS were superior over all other treatments recording the fresh kernel yield of 12.61, 11.03 and 10.80 t/ha, respectively.



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Sweet corn yield is greatly influenced by dry matter accumulation in different parts. Weed as a biotic stress causing factor has a prominent role in it. The enhancement in green cob yield and fresh kernel yield with pre emergence application of atrazine supplemented with one hand weeding at 20 DAS and manual weeding in combination of hoeing, weeding and earthing up at 20 and 40 DAS is ascribed to increase in weed control efficiency and yield components in these weed management treatments. Similar favourable results on improvement in yield of corn with pre emergence application of atrazine followed by hand weeding was obtained by Sunitha et al. (2012) [8] and manual method of hand weeding at 20 and 40 DAS was reported by Sanodiya et al. (2013) [6] and Swetha et al. (2015) [9].

## CONCLUSION

Pre emergence application of atrazine @1.0 kg/ha at 1 day after sowing supplemented with one hand weeding at 20 days after sowing is the most effective and efficient method of weed control in reducing the weed population and dry weight along with enhancement in yield components, green cob yield and fresh kernel yield of sweet corn under rainfed condition.

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S.K. Lenka *et al.***Table 1. Effect of weed management treatments on total weed population (number of weeds /m<sup>2</sup>) in sweet corn.**

Treatment	20DAS	40DAS	60DAS
Atrazine (Pre-em) @ 1.0 kg /ha) + hand weeding at 40 DAS	9.01* (80.68)	8.99 (80.32)	12.91 (166.16)
Tembotrione (PoE) @ 125 g/ha)	13.63 (185.27)	12.43 (154)	13.63 (185.27)
Atrazine (Pre-em) @ 0.5 kg /ha) + tembotrione (PoE) @ 60 g /ha)	12.31 (151.03)	12.65 (159.5)	13.31 (176.65)
Power weeder at 20 DAS	13.87 (191.87)	12.84 (164.36)	13.87 (191.87)
Cycle hoe at 20 DAS	13.93 (193.54)	14.39 (206.57)	15.26 (232.36)
Hand weeding at 20 DAS and 40 DAS	12.93 (166.68)	10.99 (120.28)	11.93 (141.82)
Hand hoeing, weeding and earthing-up at 20 DAS and 40 DAS	12.19 (148.1)	10.84 (117)	11.30 (127.19)
Un weeded control (Weedy check)	14.21 (201.42)	16.06 (257.42)	17.88 (319.19)
SEm (±)	0.49	1.27	0.94
CD(P=0.05)	1.43	3.70	2.74

\*The data are  $\sqrt{X+0.5}$  transformed. The figures in parentheses are the original values**Table 2. Total weed dry weight and weed control efficiency (WCE) as influenced by weed management treatments in sweet corn**

Treatment	Weed dry weight (g/m <sup>2</sup> )			WCE (%)		
	20DAS	40DAS	60DAS	20DAS	40DAS	60DAS
Atrazine (Pre-em) @ 1.0 kg /ha) + hand weeding at 40 DAS	1.87 (2.99)	3.18 (9.61)	4.18 (16.97)	48.39	57.50	52.86
Tembotrione (PoE) @ 125 g/ha)	2.86 (7.67)	6.41 (40.59)	7.23 (51.77)	15.54	14.23	18.49
Atrazine (Pre-em) @ 0.5 kg /ha) + tembotrione (PoE) @ 60 g /ha)	3.15 (9.42)	5.91 (34.42)	7.02 (48.78)	8.34	21.03	20.78
Power weeder at 20 DAS	2.13 (4.03)	4.43 (19.12)	6.03 (35.86)	37.13	40.85	32.01
Cycle hoe at 20 DAS	2.70 (6.79)	6.49 (41.62)	7.83 (60.8)	20.40	13.31	11.69
Hand weeding at 20 DAS and 40 DAS	2.77 (7.17)	5.00 (24.5)	3.68 (13.04)	18.16	33.14	58.55
Hand hoeing, weeding and earthing-up at 20 DAS and 40 DAS	2.47 (5.6)	4.09 (16.22)	2.81 (7.39)	27.15	45.26	68.35
Un weeded control (Weedy check)	3.39 (10.99)	7.49 (55.6)	8.88 (78.35)	0.00	0.00	0.00
SEm (±)	0.11	0.20	0.20	3.2	2.63	2.32
CD(P=0.05)	0.31	0.58	0.59	9.37	7.68	6.77

\*The data are  $\sqrt{X+0.5}$  transformed. The figures in parentheses are the original values

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Table 3. Effect of weed management treatments on yield components grains/ cob and yield in sweet corn

Treatment	Cob length (cm)	Cob girth (cm)	Green cob yield (t/ha)	No of grains/ cob	Fresh kernel yield (t/ha)
Atrazine (Pre-em) @ 1.0 kg /ha) + hand weeding	25.55	18.11	34.75	573.48	12.61
Tembotrione (PoE) @ 125 g/ha)	20.07	15.30	20.13	436.83	9.07
Atrazine (Pre-em) @ 0.5 kg /ha) + tembotrione (PoE) @ 60 g/ha)	17.44	14.16	17.33	409.79	8.22
Power weeder at 20 DAS	19.41	15.03	21.45	447.25	8.51
Cycle hoe at 20 DAS	16.87	14.27	19.33	423.76	8.56
Hand weeding at 20 DAS and 40 DAS	20.88	16.80	29.74	507.96	10.80
Hand hoeing, weeding and earthing-up at 20 DAS and 40 DAS	22.59	17.78	30.70	556.70	11.03
Un weeded control (Weedy check)	16.66	13.13	13.57	389.76	4.98
SEm (±)	1.85	1.28	3.69	8.69	0.68
CD (P=0.05)	5.40	3.75	10.80	25.43	2.00





## Studies on Genetic Diversity in Blackgram (*Vigna mungo*(L.)Hepper) Genotypes

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### ABSTRACT

The present investigation was conducted to examine the genetic diversity existing among 36 genotypes of blackgram, during *kharif-2015* under randomized block design with three replications. The data was recorded for thirteen quantitative characters to obtain estimates of variability, heritability, genetic advance and divergence. Analysis of variance showed significant differences between genotypes for all the 13 characters studied. High estimates of GCV and PCV were observed for clusters per plant followed by plant height, seed yield per plant and biological yield per plant. High heritability coupled with moderate genetic advance was recorded for seed yield per plant. The 36 genotypes were grouped in to seven heterogeneous clusters. Among these clusters, cluster II have a maximum number of genotypes (10). On the basis of mean performance genotypes VALLABH URD- 01 followed by KPU 12-133 were found to be the best genotypes in Allahabad agro-climatic conditions. The characters such as plant height and seed yield per plant which should be given top priority for effective selection. Percent contribution towards the total divergence was maximum through seed index followed by seed yield per plant and biological yield. The present investigation revealed that cluster II and VI are most diverse to each other and the genotypes constituted in these clusters may be used as parents for future hybridization programme.

**Keywords:** Blackgram, genetic advance, GCV, PCV, heritability, genetic advance and quantitative traits.

### INTRODUCTION

Blackgram is basically a tropical crop but it is grown in both *Kharif* and *Zaid* season in India. Since the crop is grown in various agro-ecological condition and cropping system with diverse cultural practices, No single plant type is appropriate for all production system, this is a need for collection of existing genotypes for potential utilization in

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development of appropriate plant type, exploitation of hybrid vigour, widening the genetic base, multiple resistance, remunerative cropping systems and intercrop besides matching production and protection technologies can help to realize the long cherished goal of making country pulses efficient especially. Lack of stable varieties for higher yield is a major bottleneck for growing of this crop Therefore for increasing the productivity of Blackgram collection and characterization of germplasm from different regions of cultivation need specific emphasis. In order to step up the production potential, it is necessary to launch a dynamic breeding programme to develop improved blackgram varieties suitable for different agro-climatic regions. For planning and execution of a successful breeding programme, the most essential pre-requisite is the availability of substantial desirable genetic variability for important characters in the genotype collections of the plant species. The available variability in a population can be partitioned into genetic parameters such as coefficients of variation, heritability and genetic advance to serve as basis for selection of desirable genotypes than existing ones.

A successful breeding programme in blackgram would need information on the nature and degree of genetic divergence in the available stock for choosing the right parents for further improvement. Subsequently, heterosis is directly proportional to genetic divergence and to dominance square and is also associated with adaptation (Falconer, 1981). The accurate estimation of genetic diversity can be invaluable in the selection of diverse parental combinations to generate segregating progenies with maximum genetic variability (Barrett and Kidwell, 1998) and Introgression desirable traits from diverse germplasm in to the available cultivars with respect to plant varietal protection and germplasm maintenance by removing the duplicity and misidentify in the core accessions. Quantitative traits provide an estimate of genetic diversity and numerical taxonomic techniques including principle component and cluster analysis have been successfully used to classify and measure the pattern of genetic diversity in germplasm, as in blackgram (Ghafooret al., 2001). Mahalanobis's  $D^2$  statistics is a very sensitive tool for measuring genetic divergence based on quantitative traits and is also widely used by many breeders for selection of divergent parents for hybridization programme.

## MATERIALS AND METHODS

The material for the present study comprised 36 blackgram genotypes accessions along with one check (SHEKAR-2), evaluated in a randomized block design with 3 replications at Research Farm of Department of Genetics and Plant Breeding, SHIATS, Allahabad during *Kharif* season, 2015. All the standard cultural practices and packages were followed to raise a good and healthy crop. In each entry, five competitive plants were selected randomly, data recorded on thirteen traits *viz.*, days to 50% flowering, days to 50% pod setting, plant height, number of branches per plant, number of clusters per plant, number of pods per plant, pod length, number of seeds per pod, days to maturity, biological yield per plant, harvest index, seed index and seed yield per plant. The analysis of variance was carried out for all the characters and then data was analyzed following multivariate analysis of Mahalanobis, (1936) and genotypes were grouped into different clusters following Tocher's method (Rao,1952).

## RESULTS AND DISCUSSION

A wide range of variation was observed among 36 blackgram (*Vigna mungo* L. Hepper) genotypes for thirteen quantitative characters. The perusal of data revealed that variance due to treatment was highly significant for all the characters exhibited by the genotypes. Significant genetic variation in various component characters might be effective.

### Genetic Parameters

The analysis of variance revealed significant differences among the genotypes for all the characters studied (Table 1). Close relationship between GCV and PCV was found in all the characters and PCV values were slightly greater than



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GCV, revealing very little influence of environment for their expression. On an average, the higher magnitude of GCV and PCV were recorded for cluster per plant, plant height, seed yield per plant, biological per plant, seed index and harvest index suggesting sufficient variability and thus scope for genetic improvement through selection for these traits, similar findings were also reported by Neelavati and Govindarasu, (2010). It indicates that the existence of wide spectrum of variability for these traits and offer greater opportunities for desired traits through phenotypic selection. High heritability coupled with moderate genetic advance was registered for plant height (Table-2) suggesting predominance of additive gene action and non additive gene action in the expression of this trait. Therefore, this character can be improved by mass selection and other breeding methods based on progeny testing.

### Genetic divergence

The 36 diverse genotypes were grouped into seven cluster using Mahalanobis  $D^2$  statistic (1936) and Tocher's methods. Clustering pattern indicate that II is the largest comprised 10 out of 36 genotypes. On the other hands cluster I and VI comprised 6 genotypes, cluster III comprised 5 genotypes and cluster IV and V comprised 4 genotypes and cluster VI comprised 1 genotype respectively. The pattern of group constellation proved the existence of significant amount of variability. Appreciable genetic divergence in blackgram has been earlier reported by number of workers. The inter cluster  $D^2$  value was maximum between cluster II and VI (421.92) followed by I and V (326.24) and I and VI (309.93) Suggesting that the genotype present in these clusters may be used as a parents for hybridization programme to develop desirable type as heterosis can be best exploited and chance of getting transgressive segregants are maximum when generating diverse lines are crossed (Lal et al., 2001).

Hybridization programme involving genetically diverse parents belonging to different clusters would provide an opportunity for bringing together gene constellation of diverse nature, promising hybrid derivatives probably due to complementary interaction of different genes in parents (Murty and Anand, 1968). The selection and choice of parents mainly depends upon contribution of characters towards divergence. Contribution towards genetic divergence is presented in table 4. The highest contribution in manifestation of genetic divergence was exhibited by seed index (35.24) followed by seed yield per plant (25.71), biological yield per plant (20.95), pods per plant (7.78) and days to 50% maturity (3.02) Suggesting scope for improvement in these characters. In other words, selection for these characters may be rewarding. Similar results were reported by Pandey and Anurag, (2010). for biological yield and test weight.

### CONCLUSION

On the basis of results the genotypes VALLABH URD 01 followed by KPU 12-133, KPU 406 and KPU 12-219 were identified as the genotypes for seed yield at Allahabad region. The present investigation registered high heritability along with high genetic advance as a 5% of mean for seed yield per plant which should be given top priority for effective selection the present investigation further revealed that cluster II and VI are most diverse to each other. Therefore, genotypes present in these cluster are suggested to provide a broad spectrum variability in segregating generations and may be used as parents for future hybridization programme to develop desirable genotypes.

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Table 1. Analysis of variance for different 13 quantitative characters in Blackgram.

S. No.	Characters	Mean sum of squares		
		Replication (d.f.= 2)	Treatments (d.f.= 35)	Error (d.f.= 70)
1.	Days to 50 % Flowering	4.08	14.64**	3.64
2.	Days to 50 % Pod Setting	0.71	20.19**	5.40
3.	Plant Height	6.28	256.91**	69.05
4.	Number of Branches/Plant	0.03	0.36**	0.11
5.	Clusters/ Plant	37.47	28.41**	15.22
6.	Pods/ Plant	0.78	15.87**	2.20
7.	Pod Length/ Plant	0.0032	0.036**	0.0091
8.	Seeds/ Pod	0.033	0.142**	0.08
9.	Days of Maturity	0.65	4.43**	1.32
10.	100 weight of seed	0.018	0.20**	0.0069
11.	harvest Index	4.87	17.77**	3.12
12.	Biological Yield/ Plant	0.11	22.77**	0.93
13.	Seed Yield/ Plant	0.21	4.81**	0.18

\*, \*\* Significant at 5% & 1% level of significance.

Table 2. Genetic parameters for 13 quantitative characters of 36 blackgram genotypes.

S. No.	Characters	Genotypic Coefficient of variation (GCV)	Phenotypic Coefficient of variation (PCV)	Heritability (h <sup>2</sup> )	Genetic Advance (GA)	Genetic Advance as a percentage of mean
1.	Days to 50 % Flowering	4.60	6.49	50	2.80	6.71
2.	Days to 50 % Pod Setting	4.43	6.42	48	3.16	6.31
3.	Plant Height	11.27	16.34	48	11.24	16.00
4.	Number of Branches / Plant	7.36	11.39	42	0.38	9.79
5.	Clusters/ Plant	11.79	24.29	22	2.05	11.50



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6.	Pods/ Plant	3.40	4.14	67	3.61	5.74
7.	Pod Length/ Plant	1.98	2.80	50	0.14	2.88
8.	Seeds/ Pod	2.36	5.45	19	0.12	2.12
9.	Days of Maturity	1.48	2.23	44	1.39	2.02
10.	Seed Index	5.76	6.06	90	0.50	11.29
11.	Harvest Index	5.50	7.04	61	3.56	8.85
12.	Biological Yield/ Plant	7.65	8.12	89	5.23	14.83
13.	Seed Yield/ Plant	8.78	9.28	89	2.42	17.10

Table 3: Distribution of the 36 genotypes of blackgram into different clusters.

SI. No.	Cluster numbers	Number of genotypes	Genotypes included
1.	I	6	KPU12-1728, KPU12-188, KPU400, KPU12-45, KPU12-1732, KPU11-51
2.	II	10	KPU11-46, RBU 1012, KPU 11-43, KPU 405, KPU 10-01, Pratap Urd 01, RBU 38, KPU 12-133, KPU 15-128, KPU 12-1734
3.	III	5	KPU 210-89, KPU 406, Shekar -2 (Check), KPU (M) 222, KPU 10-26
4.	IV	4	KPU 11-40, KPU96-3, KPU1714-146, KPU532-57
5.	V	4	KPU 11-39, PU19, KPU12-219, KPU11-42
6.	VI	1	KPU 12-330
7.	VII	6	Vallabh Urd -01, PU 31, KPU 11-41, KPU 522-67, KPU 58-81, KPU 12-393

Table 4: Intra (diagonal) and inter cluster average distances ( $D^2$ ) for different quantitative characters in blackgram

	I Cluster	II Cluster	III Cluster	IV Cluster	V Cluster	VI Cluster	VII Cluster
I Cluster	40.10	91.48	90.69	160.32	204.56	309.93	99.26
II Cluster		41.34	93.63	196.28	326.24	421.92	190.16
III Cluster			40.64	82.40	143.08	225.73	74.41
IV Cluster				43.08	69.67	150.34	86.32
V Cluster					25.12	125.16	72.75
VI Cluster						0.00	181.76
VII Cluster							41.41





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**Table 5. Percent contribution of different quantitative characters towards genetic divergence in blackgram genotypes**

S. No.	Source	Contribution %
1.	Days to 50 % Flowering	0.79
2.	Days to 50 % Pod Setting	0.79
3.	Plant Height	0.16
4.	Number of Branches/Plant	2.06
5.	Clusters/ Plant	0.16
6.	Pods/ Plant	7.78
7.	Pod Length/ Plant	0.95
8.	Seeds/ Pod	0.16
9.	Days to Maturity	3.02
10.	Seed Index	35.24
11.	Harvest Index	2.22
12.	Biological Yield/ Plant	20.95
13.	Seed Yield/ Plant	25.71





## Evaluation of Exotic Rice Germplasm for Yield and Its Component Traits

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### ABSTRACT

The present investigation consists of 25 rice genotypes. The study was conducted for yield and yield contributing traits in randomized block design (RBD) with three replications, at Field Experimentation Centre, Department of Genetics & Plant Breeding, SHIATS, Allahabad (U.P.). The data were recorded on 13 characters to study the analysis of variance, Coefficient of variation, heritability, Genetic advance and coefficient of correlation. Based on the mean performance among 25 genotypes of rice NDR359 genotype was found to be superior in grain yield. The analysis of variance revealed significant differences for all the characters indicating sufficient variability among the genotypes. Highest genotypic and phenotypic coefficient of variations were recorded for harvest index. The characters viz., number of spikelets per panicle and biological yield per hill exhibited high heritability coupled with high genetic advance. The perusal of genotypic and phenotypic correlation coefficients indicated that harvest index, biological yield per hill, tillers per hill, panicles per hill and test weight were significantly and positively associated with grain yield.

**Keywords:** Genetics, variation, number, harvest, biological, genotypic, phenotypic

### INTRODUCTION

India is the largest rice growing country in world. However, its productivity per unit area by world standard is low. In order to increase rice productivity, high yielding and disease resistant varieties should be developed. Knowledge on the genetic architecture of genotypes is necessary to formulate efficient breeding methodology. It is essential to find out the relative magnitude of additive and non additive genetic variances, heritability and genetic gain with regard to the characters of concern to the breeder. Breeding strategies is chiefly influenced by the choice of germplasm.



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The systematic breeding program involves the steps like creating genetic variability practicing selection and utilization of selected genotypes to evolve promising varieties. Selection of high yielding varieties based only on grain yield will not be much effective unless adequate information on genetic parameters are available to formulate hybridization and selection program for further improvement because the estimate of the mean serves as a basis for eliminating the undesirable genotypes. Whereas genetic variability (GCV and PCV) help to choose the potential genotypes. Heritability along with genetic advance would be more useful tool in predicting the resultant effect from selection of the best genotypes for yield and some of its components in rice. It is very difficult to judge whether observed variability is highly heritable or not. Moreover, knowledge of heritability is essential for selection based improvement as it indicates the extent of transmissibility of a character into future generations. (Kumar and shukla,2002). The grain yield is the primary trait targeted for improvement of rice productivity in both favorable and unfavorable environments from its present level. Heritability estimates can anticipate improvement by selection of useful characters. Hence, objectives of the present study is to evaluate the 25 rice germplasm for yield and its component traits and to estimate the genetic variability among 25 rice germplasm and to study the interrelationship among the characters with seed yield

## MATERIALS AND METHODS

The experiment was laid out with 25 rice genotypes in a Randomized Block Design with 3 replications at the field experiment center of the Department of Genetic and Plant Breeding, School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Science (Formerly Allahabad Agriculture Institute), Deemed to be University Allahabad During kharif. Recommended packages of practices were followed for superior crop growth. The data were recorded five randomly selected plants from each replication leaving the first two border rows from all the four sides, in order to avoid the sampling error. The observations were recorded as per the following procedure. Readings from five plants were averaged replication wise and the mean data was used for statistical analysis for the 13 characters. Analysis of variance was done according to procedure given by Panse and Sukhatme (1967). The formula used to calculate PCV and GCV were given by Burton (1952). Heritability was calculated by the formula given by Lush (1949) and Burton and Devane (1953).

## RESULT AND DISCUSSION

Analysis of variance showed highest significant difference among 25 rice genotypes for all the characters under study, suggesting that the genotypes were genetically variable and indicating the presence of substantial genetic variability. A perusal mean performance revealed that genotype NDR359, has highest mean performance for yield per plant (22.92 g) and genotype HHZ10-DT7-51 has maximum number of spikelet's (262.67). Genotype HHZ10-DT7-51 recorded highest mean performance for harvest index (53.33%) and genotype NDR359 recorded highest mean performance for plant height (99.40cm). on the basis of mean performance for yield the genotypes NDR359 (22.92g), BP1620F-BB-17-BB8 (22.83 g),HHZ10-DT7-51 (21.70 g), BHS825 (19.83 g), HHZ1-DT3-Y1-Y1 (19.66 g) were regarded as the best genotypes for grain yield per hill.

Less difference in the estimates of genotypic and phenotypic variance and higher genotypic values compare to environment variances for all the character suggested that the variability present among the genotype were mainly due to genetic reason with minimum influence of environment and hence heritable. The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters are presented in (table 1) the result are in conformation to the findings of Deosarkaret al., (1989). PCV was higher than GCV for 13 character studied, indicating little role of environment on the expression of this characters. Maximum phenotypic coefficient of variation (PCV) was observed for harvest index (43.38) followed by grain yield per plant (31.92) and lowest PCV observed in days to maturity (3.84).



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The maximum genotypic coefficient of variation (GCV) was observed for harvest index (43.30) followed by grain yield per plant (29.84) and lowest GCV observed days to maturity (3.77). Heritability estimates revealed that character like harvest index (99.00), spikelet's per panicle (99.00), and flag leaf length (99.00) followed by biological yield (97.00), days to 50% flowering (96.00), days to maturity (96.00), test weight (94.00), plant height (91.00), seed yield per plant (87.00) flag leaf width (80.00), panicles per plant (75.00), panicle length (74.00), and tillers per plant (56.00). Estimates of genetic advance revealed that character number of spikelet's per panicle (92.27) and lowest genetic advance for flag leaf width (0.19). Estimates of genetic advance as percent of mean revealed that highest for harvest index (89.04%) followed by seed yield per plant (57.48%) and lowest for days to maturity (7.61%).

Relatively high differences between genotypic coefficient of variation and phenotypic coefficient of variation for observed for flag leaf width seed yield per plant number of tillers per plant panicles length and days to maturity. These findings suggested that greater influence of the environmental in the expression of these traits similar results were also reported by Mohammad *et al* (2002) that the high magnitudinal difference between phenotypic coefficient of variation and genotypic coefficient of variation for flag leaf width and number of panicles per hills, where as environmental coefficient of variation contributed more in the expression of these characters.

Heritability is a measure of the extent of phenotypic variation caused by the action of genes. It is evident that the heritability (broad sense) was estimated for 13 quantitative characters under study, ranged from 56% (number of tiller per plant) to 99% (harvest index). Mhandarkaret *al* (2002), Patilet *al* (2003), Viveket *al*. (2004) and Elayarajaet *al*. (2005) registered high estimated of heritability for grain yield per plant. Genetic advance for all the characters under study was ranged from 7.61% (Days to maturity) to 89.04% (Harvest index). High heritability along with high genetic advance as percent of mean was registered for harvest index, spikelet's per panicle and seed yield per plant. Suggesting preponderance of additive gene action in the expression of these characters. This type of character could be improved by mass selection and breeding methods based on progeny testing.

**Correlation Coefficient**

Correlation coefficient is a statistical measure which is used to find out the degree and direction of relationship between two or more variable. Seedyield per hill showed positive significant association with harvest index (-0.879\*\*\*), spikelet's per panicle (0.653\*\*\*), tillers per plant (0.359\*\*\*), test weight (0.227\*\*), and panicles per plant (0.225). It showed positive non-significant association with panicle / length (0.028\*) and days to 50 % flowering (0.004\*). The correlation of grain yield per hill showed negative significant association with days to maturity (-0.246\*\*) and plant height (-0.132\*\*) and. It showed negative non-significant association with biological yield (-0.087\*), flag leaf width (-0.072\*) and flag leaf length (-0.025\*) at genotypic level. Seed yield per hill showed positive significant association with harvest index (0.820\*\*\*), number of spikelet's per panicle (0.607\*\*), tillers per plant (0.316\*\*), panicles per plant (0.224\*\*) and test weight (0.200\*\*) It shows positive non-significant association with panicle length (0.028\*) and days to 50% flowering (0.012\*) It shows negative significant association with plant height (-0.127\*) and days to maturity (-0.211\*). It showed negative non-significant association with flag leaf width (-0.097\*), biological yield (-0.077\*) and flag leaf length (-0.023\*) at phenotypic level.

Simultaneous expression of character may be either due to pleiotrophy or genetic linkage. If the relationship is due to manifold effect on gene or genes, it is difficult to separate those effect by selecting a particular character.

Hence, the investigation it could be concluded that among the 25 rice genotype evaluated under Allahabad condition, on the basis of per se performance NDR359 genotype was found to be superior in the yield followed by BP10620F-BB-17-BB8 and HHZ10-DT7-51 spikelet's per panicle and BP12816F-KN-7-1 test weight.





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**Table 1: Estimation of components of variance and genetic parameters for 13 characters in rice germplasm**

Si.No.	Characters	VG	VP	GCV	PCV	h <sup>2</sup> (bs)%	GA	GA as %of mean
1	Days to 50% Flowering	23.03	23.87	5.05	5.14	0.96	9.71	10.21
2	Plant Height (cm)	24.24	26.37	5.49	5.73	0.92	9.72	10.85
3	Flag Leaf Length	13.57	13.66	12.58	12.62	0.99	7.56	25.83
4	Flag Leaf Width	0.01	0.01	7.37	8.24	0.8	0.19	13.57
5	Tillers/ Plant	1.46	2.58	12.27	16.33	0.56	1.87	19.01
6	Panicles/ Plant	1.43	1.89	14.27	16.42	0.75	2.14	25.53
7	Panicle Length cm	2.54	3.44	6.49	7.55	0.74	2.83	11.51
8	Spikelet's/ Panicle	2026.96	2047.68	27.09	27.23	0.99	92.27	55.52
9	Days to Maturity	23.92	24.86	3.77	3.84	0.96	9.88	7.61
10	Biological Yield	85.35	87.77	17.59	17.84	0.97	18.77	35.74
11	harvest Index	165.72	166.3	43.3	43.38	0.99	26.47	89.04
12	Test Weight	7.49	7.97	12.4	12.79	0.94	5.47	24.77
13	Seed Yield/ Plant	21.22	24.27	29.84	31.92	0.87	8.87	57.48

VG= Genotypic Variance, VP=Phenotypic Variance, GCV=Genotypic Coefficient of Variation, PCV=Phenotypic Coefficient of Variation, h<sup>2</sup>(bs)= Heritability(broad sense), GA= Genetic Advance

**Table 2 :Genotypical correlation matrix**

No	Character	Days to 50% Flowering	Plant Height (cm)	Flag Leaf Length	Flag Leaf Width	Tillers / Plant	Panicles / Plant	Panicle Length cm	Spiklets / Panicle	Days to Maturity	Biological Yield	harvest Index	Test Weight	Seed Yield/ Plant
1	Days to 50% Flowering	1.0000	0.2997	0.2027	0.0832	0.3566	0.3758	0.2206	0.0770	0.7592	0.1680	-0.0659	0.1611	0.0049
2	Plant Height (cm)		1.0000	0.6813	0.2305	0.2706	0.2736	0.0211	-0.0703	0.2092	0.6054	-0.4458	-0.0397	-0.1326
3	Flag Leaf Length			1.0000	0.3485	0.3921	0.3665	0.3234	-0.1498	0.2425	0.6095	-0.3345	-0.0285	-0.0256
4	Flag Leaf Width				1.0000	-0.4219	-0.3972	-0.3168	0.0592	0.2548	-0.0885	-0.1471	0.0347	-0.0727
5	Tillers/ Plant					1.0000	0.9108	0.5045	-0.1099	-0.0034	0.5976	0.0990	0.2999	0.3597
6	Panicles/ Plant						1.0000	0.4905	-0.1229	0.1061	0.7531	-0.0728	0.2463	0.2253
7	Panicle Length cm							1.0000	-0.1788	0.0934	0.2724	-0.0971	0.4514	0.0287
8	Spiklets/ Panicle								1.0000	-0.0821	-0.1673	0.6074	-0.0892	0.6534
9	Days to Maturity									1.0000	0.0765	-0.1980	0.1159	-0.2460
10	Biological Yield										1.0000	-0.4945	0.1315	-0.0876
11	harvest Index											1.0000	0.0557	0.8795
12	Test Weight												1.0000	0.2274
13	Seed Yield/ Plant													1.0000

**Table 3: Phenotypical correlation matrix**

No	Character	Days to 50% Flowering	Plant Height (cm)	Flag Leaf Length	Flag Leaf Width	Tiller s/ Plant	Panicle s/ Plant	Panicle Length cm	Spiklets / Panicle	Days to Maturity	Biological Yield	harvest Index	Test Weight	Seed Yield/ Plant
1	Days to 50% Flowering	1.0000	0.2822	0.2012	0.0782	0.2763	0.3461	0.1757	0.0723	0.7358	0.1638	-0.0649	0.1526	0.0125
2	Plant Height (cm)		1.0000	0.6506	0.1964	0.1528	0.2200	0.0303	-0.0702	0.1986	0.5717	-0.4277	-0.0315	-0.1276
3	Flag Leaf Length			1.0000	0.3055	0.2846	0.3101	0.2775	-0.1511	0.2382	0.6014	-0.3332	-0.0236	-0.0237
4	Flag Leaf Width				1.0000	-0.2392	-0.2587	-0.2273	0.0552	0.2025	-0.0839	-0.1287	0.0321	-0.0974
5	Tillers/ Plant					1.0000	0.6820	0.3537	-0.0685	0.0171	0.4285	0.0777	0.2066	0.3166
6	Panicles/ Plant						1.0000	0.3647	-0.1010	0.0743	0.6235	-0.0624	0.1792	0.2244
7	Panicle Length cm							1.0000	-0.1430	0.0818	0.2668	-0.0900	0.3541	0.0289
8	Spiklets/ Panicle								1.0000	-0.0802	-0.1623	0.6035	-0.0875	0.6079
9	Days to Maturity									1.0000	0.0791	-0.1947	0.1074	-0.2113
10	Biological Yield										1.0000	-0.4885	0.1266	-0.0772
11	harvest Index											1.0000	0.0509	0.8208
12	Test Weight												1.0000	0.2000
13	Seed Yield/ Plant													1.0000





## Climate Resilience and Its Effects on Indian Rice Germplasm – A Review

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### ABSTRACT

Climate change has evolved from a topic of future speculation to an inconvenient reality of the present. It gives about the inseparable link between agriculture and climate variables, the impact of climate change on agriculture and food security which has been at the forefront of research and on the political agenda in recent times. Climate change in India is becoming quite evident, and the changes are much more evident than in other parts of the country. Due to changing weather, extreme abiotic factors such as high and low temperatures, drought, salinity, osmotic stress, heavy rainfall, floods, frost damage poses a serious threat to rice production and is also harmful to farmer and sustainability for rice cultivation. There is a great need to frame strategies against these problems. Crop improvement will help to find a sustainable and effective solution against negative impact of climate change. Advances in molecular breeding will help and exploit the inherent potential of wild species through transferring potential genes of abiotic/biotic tolerance through introgression. It must be done with the help of molecular markers to identify the underlying QTL / genes with the development in the techniques including DNA microarray, mass spectrometry, RNA sequencing or other modern high performance using genomic strategies. It is now possible to decipher the underlying metabolic pathways through the top-down approach. The present review provides an overview of recent evidence, the potential impacts of climate change on rice and it also offers its mitigation strategy by improving productivity of rice of different germplasm in India.

**Keywords:** Climate Change; Rice Production; Abiotic Stress; Biotic Stress; Molecular Breeding





## INTRODUCTION

The Indian subcontinent has a rich diversity in rice germplasm that includes terrestrial races, wild *Oryza* species, related genera, natural hybrids between wild relatives and germplasm resources generated through breeding programs. The large-scale dissemination of modern, high-yielding varieties and changes in cultural practices are leading to a narrowing of the genetic basis of rice cultivation. Wild rice species are in danger of extinction due to environmental deprivation. The value of rice germplasm collected and stored in terms of useful economic characteristics has been demonstrated in many screening tests. Recently, a network project launched in the country has evaluated more than 12,000 accessions and identified adhesions with tolerance / resistance to pests and pathogens and various abiotic stresses (Paroda, R.S. and S.S. Malik 1990). The characterization and evaluation of germplasm, complemented by biosystemic studies that use wild species and also molecular studies of genetic diversity, is generating the information base for a more efficient use of these precious resources.

Genetic improvement has become a necessary of all rice breeding activities. However, a large number of germplasm accesses are awaiting an appropriate evaluation and characterization. A systematic evaluation and improvement must be carried out in a way related to the mission of time, with the participation and association of all parties involved in the development of stable and durable varieties with resistance / tolerance multiple. Breaking the yield limit through genetic improvement becomes the priority in rice research (Ashraf et al. 1994). The exploitation of heterosis through the hybridization of rice provides a brilliant opportunity to increase the yield potential of rice in the tropics. The hybrids of the indica tropical elite varieties and the new type of tropical japonica plant are under development. The ideological approach to the selection of plants is also required, using physiological attributes as selection criteria. Improving the productivity of rice cultivation involves selecting the germplasm available for biotic and abiotic stress tolerance and the intensification of research in genetics. The physiological mechanisms of tolerance to this stress would be important (Evans, 1990). To meet diversified needs, varieties compatible with the consumer on a time scale would be desirable.

The germplasm evaluated should only be used if there is an adequate documentation system to consolidate and disseminate the information generated. Furthermore, in view of existing and rapidly emerging IPR regimes, it is essential to ensure easy access to genetic resources for uninterrupted varietal improvement (Donald, 1968). In an IPR regime based on subsidies, access cannot be facilitated unless there is a fair and equitable distribution of benefits due to the materials used in the developed products and the benefits of their commercialization. To fully utilize diversity, germplasm centers must have a genetic resources unit (GRU) in which accessions are maintained and provided to breeders. In addition, the molecular characterization of the released varieties and genetic reserves of the elite should be taken gradually (Evanson, 1994). Biotechnologically improved germplasm improvement provides a path for collaboration between the public and private sectors with a proportional distribution of benefits. However, ecological risks should always be assessed on a case-by-case basis to understand potential and probable problems, if any.

In this direction, climate is changing beyond the average atmospheric condition through natural factors such as the orbit of the terrestrial revolution, volcanoes and movements of the crust from artificial factors such as the increase in the concentration of greenhouse gases such as CO<sub>2</sub>, methane, etc. In fact, agriculture is often considered as the most time-dependent human activity (Hansen, 2002). Global climate change can have possible consequences on global agricultural production (Berg et al., 2013) and can alter the food availability, decrease access and impact the quality of food (USDA 2015). The estimated increase in temperatures, fluctuations in precipitation patterns, the occurrence of extreme weather events and the lower availability of water can lead to a reduction in agricultural productivity. The general circulation on climate change, due to the increase in the concentration of greenhouse gases (GHG), the global average temperature of the surface will increase between 1.5 and 4.5 ° C during the next 100 years (Senapatiet al., 2013).





India is also one of the largest exporters of cereal crop rice. Rice is an important crop that represents approximately one third of the caloric consumption of third world populations. The largest rice producers are China, India and Indonesia. Rice cultivation is the main activity and source of income for more than 100 million families in developing countries in Asia, Africa and Latin America (Desirajuet *et al.*, 2009). China and India play an important role in the production and consumption of rice (Alias Bin *et al.*, 2006). Approximately 2.5 million tons of ground rice is required each year to support the current level of food adequacy. In India, rice contributes 43% of total cereal production and 46% of total cereal production (Nandhini *et al.*, 2006). High projected temperatures can cause a significant reduction in world rice production. The productivity of rice crops depends to a large extent on climate change, in which it is necessary to maintain it at the highest level in order to meet future food demands for the growth of the population in India (Hundal and Prabhjyot, 2007).

Agronomic studies in India, suggest that a temperature increase of 4 ° C would result in a drop in grain yields of 25-40% (Rosenzweig and Parry, 1994). In developing countries, adaptation options such as changes in crop management or breeding practices or improvements in irrigation are more limited. Kumar (2009) reported an estimated decrease of approximately 3% of the company's annual net income in India for a scenario that predicts a temperature variation of + 2 ° C and a variation in the precipitation equal to + 7%. According to Cline (2007), agricultural productivity in India will seriously affect. Southern India will have to face a reduction in crop yield in the range of 15 to 25%, but in northern India it will be more than 25% between 2003 and 2080. Kumar *et al.* (2016) highlighted that soil productivity decreases with the increase in maximum annual average temperature. Using simulations, it was predicted that climate change would result in decrease of 48.63% land productivity by 2100 and a loss of income for farmers in India.

Climate change would threaten the agricultural sector in developing countries, causing serious problems for production and food security, with a greater influence on marginal farmers (Thornton *et al.*, 2013). In India, forecasts on the impact of climate change on rice production began in the 1990s. There are experiments conducted in different parts of India to assess the effect of climate change on rice production in India using different models. It will be very useful in predicting the impact of climate change on future agricultural rice production in India.

### Diversity

The availability of different germplasm should be ensured through the systematic collection and conservation of local varieties and the wild species that provide the genetic bricks for plant breeding. Populations of local varieties, although predominantly self-fertilized, are genetically heterogeneous. They also differ in varieties, showing a high rate of genetic differentiation. Traditionally, there were a large number of such varieties in each location before the expansion of high-yielding varieties (HYV). Together with wild rice and weeds, these primitive varieties could be highly active in the evolutionary aspect. The diversity of rice genetic resources is running out (Richharia1979). The large-scale dissemination of modern, high-yielding varieties and the replacement of traditional varieties, particularly in the irrigated rice ecosystem, are leading to concern that the genetic basis of rice cultivation has become too small. Changes in cultural practices in which flood risk systems are being replaced by irrigation systems will eventually lead to the loss of several deep-water races. Wild paddy rice species are in danger of extinction due to environmental degradation. This genetic erosion is occurring at a time when new tools of biological research allow scientists to focus on both the diversity of genes and the diversity of genotypes. Although there has been considerable success in protecting and conserving rice biodiversity in recent decades, much remains to be done (Boje-Klein, 1986)

India has abundant resources of wild rice in particular *O. nivara*, *O. rufipogon*, *O. officinalis* and *O. granulata*. Wild rice species can be found in many different natural habitats, from shade to full sunlight, and can be annual or perennial in nature. Some wild species appear as weeds in and around rice fields and even hybridize naturally with cultivated forms. This complex association between cultivated and wild forms can increase the diversity of rice crops in traditional farming systems, where farmers often grow mixtures of varieties to provide a buffer against the risk of total crop loss due to biotic and abiotic stresses. The complex association between cultivated and wild forms can



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obviously improve the diversity of rice crops in traditional agricultural systems (Jackson and Huggan1993). Different ecological situations in rice growing areas have given rise to the following main eco-specific rice varieties with seasonal, situation and system specificity:

- The group Aus: early maturation, photosensitive types: it can be grown in all seasons, except in winter.
- The group Aman: late types are mostly sensitive to the photoperiod and flower during a specific period, regardless of when they are sown or transplanted.
- The Boro group: be the best as summer harvest. When sown during the winter, they tolerate better the temperature of the cold in the early vegetative phase than the other groups.
- The Gora group: of short duration, can support a certain degree of water stress during its growth period.
- The Basmati group: specific to the regions of the northern regions of the Indian subcontinent, with extremely valuable quality traits such as elongation, aroma, flavor, etc.

**Germplasm Collections**

According to an estimate, around 50,000 rice breeds should exist in India. A total of 66,745 accesses have been collected so far from various parts of the country. Assuming that almost 50% of the total germplasm is doubled, about 17,000 land races of rice still remain to be harvested. Therefore, a serious effort must be undertaken in this direction. The exploration and collection of native rice cultivars began at the end of the century. The establishment of the agricultural research station in Dhaka in 1911 and the breeding station of Paddy in Coimbatore in 1912 and the central rice.

The Research Institute (NRRI) in Cuttack in 1946 strengthened these activities. This led to the recommendation of 394 varieties for general cultivation, such as selections of pure lines, of the collected germplasm. Systematic exploration programs were initiated between 1955 and 1960 by the Jeypore Botanical Survey, which led to the collection of 1,745 cultivars in southern Orissa and adjacent areas of Madhya Pradesh. About 900 Manipur cultivars were harvested between 1965 and 1967. Between 1965 and 1972, the Indian Agricultural Research Institute (IARI) collected 6630 accessions, which became known as the Assam rice collection. The varieties grown in the Madhya Pradesh region have been harvested and the 19,116 collections collected make up the Raipur Collection (Govindaswami and Krishnamurthy1959). A special initiative for varieties of mountain rice fields grown in Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Uttar Pradesh, Orissa and West Bengal led to the collection of 1,938 cultivars. The National Plant Genetic Resources Office (NBPGR) increased the collections in the period 1983-1989 with 4,862 accessions. In addition, the joint explorations of NBPGR in collaboration with the State Agricultural Universities (SAU) during 1978-1980 and the NRRI in 1985 led to the collection of approximately 7000 and 447 accessions (respectively from Sikkim, South Bihar and parts of Orissa). VPKAS Almora explored germplasm in the mountainous region of Uttar Pradesh and 1,247 primitive cultivars were collected (Gupta and Tomar 1994).

The wild rice collections were started in the NRRI between 1948 and 1955. Subsequently, the collections were collected in IARI from West, North, Center and East of India. There have also been many joint explorations with other countries. The French team of IRAT and ORSTOM collaborated with ICAR for the collection, in particular on *O. nivara*, *O. rufipogon* and *O. officinalis* of Goa, Karnataka, Maharashtra and Gujarat in 1986 (Malik and Dikahit1990). During 1987-1989, ICAR scientists and IRRI has undertaken an intensive harvest of wild rice in South India and West Bengal (Krishnamurthy and Sharma1987).

**Germplasm Evaluation**

Rice diversity has been well used in efforts to solve current food problems. Local rice varieties have been harvested over several decades to become donors of high-yield, pest-resistant and well-adapted varieties that have led to unprecedented increases in rice yield. The cost of rice for millions of consumers is now about half of what it was in the 1960s. The value of germplasm preserved from rice has been demonstrated in many tests of useful economic characteristics. Thousands of accesses have been tested to resist eight pests and five rice diseases and tolerance to various abiotic stresses (Sharma et al. 1987). Resistance to some pests and diseases such as brown unemployment and





rice explosion is quite common in cultivated rice. The characterization and evaluation of germplasm, complemented by biosystemic studies that use wild species and molecular studies on genetic diversity, is generating the information base for a more efficient use of these valuable resources.

The first purely intensive selection of germplasm collected locally allowed the release of about 400 improved cultivars, obtaining 10 to 20% more of the traditional cultivars and adapted to several agroclimatic regions. The japonica-indica hybridization was launched after 1950 by ICAR to introduce a non-accommodation reactivity and non-lodging fertilizer responsiveness in indigenous tall indica, released variety ADT 27 (Roy *et al.* 1979). In the 1960s, hybridization programs widely used semi-native genotypes of Taiwan in possession of Dee-gee, the woo-gene and several semi-dwarf and high-yielding varieties have been developed. The intensive cultivation of these semi-dwarf hybrids has caused problems of diseases and parasites and, consequently, research has been redirected towards the collection and evaluation of indigenous germplasm, and many donors of resistance have been identified mainly in NRRI and IIRR. ICAR in association with the United Nations Development Program, launched a national hybrid rice project that led to the creation of 12 hybrid research centers in a strategic position. Through this effort, India has launched 14 tropical rice hybrids through public institutions and private seed companies.

In the IIRR, Hyderabad, a large number of germplasm accessions have been evaluated for their agronomic characteristics, including against pests and insect diseases and several promising accessions have been identified. This was a coordinated program for rice improvement in India. All the main rice research centers including NRRI, IARI, TNAU, IGKV, KAU, AAU, NEH Research Complex and others, have participated in this effort. In addition, ICAR approved a network project for the period 1993-1998 in IIRR to evaluate the available germplasm against the main insects and diseases. The network was with two main centers i.e., NBPGR and IGKV, and 13 hot spots namely Almora (UP), Aduthurai (TN), Kapurthala (PB), Sambalpur (OR), Raipur and Jagadpur (MP), Maruteru and Srikakulam (AP), Mandya and Ponnampet (KAR), Moncompu (Kerala) and Pondicherry (UT). Until 1997, more than 15,000 accessions were projected in several hot spot locations and a catalog for 12,000 accessions with 21 characters was developed.

The evaluation efforts have led to the identification of useful features, i.e., resistance or tolerance to tropical strains of bacterial rust, tungro virus, grassy stunt virus, tungro virus, green grasshopper of rice, brown planthopper, stem borer and rosette; and tolerance to salinity, alkalinity, flood and submersion. The list of collection sections for which promising subscriptions / donors have been identified is shown in Table 3.

### Rice production in India

India already devotes more than its precious territory to rice from any other country: up to 42 million hectares. Planting more land for rice is definitely out of the question. The solution must come from squeezing more grain from each plant through the proper exploitation of the diversity of germplasm. By 2025, the world could be required to produce around 765 million tonnes of raw rice compared to 519.63 million tonnes produced in 1995. More than 90% of the additional production needed must come from Asia, where Most live the poorest people in the world. This increase must come from higher productivity on a long-term sustainable basis. The production environment in the future will be very different (Malik and Vaughan 1989). Rice should be grown with less water, less work and much less land. Yields must be increased considerably, even those that could be subject to greater biotic and abiotic pressures. The yield potential of irrigated rice in the tropics has remained stagnant at around 10 t/ha since 1966, when the first Indica semi-dwarf variety, IR8, was launched. Rain-fed rice accounts for approximately 45% of the total area planted with rice in Asia (Roy 1979). Its current average yield of 2.0 t ha<sup>-1</sup> should increase to around 4.0 t ha<sup>-1</sup> over the next 30 years. This increase is also essential to release the pressure on the irrigated rice. The tensions related to water and soils are the limits to increase the production of rain rice (Evanson 1994).

India is one of the largest rice producers in the world and accounts for 20% of world rice production. Rice is the pre-eminent crop of India and represents staple foods in many parts of India. Rice accounts for 23.3% of total cultivated



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area and 43% of total cereal production and 46% of cereal production (Singh, 2009). From 1950 to 2015, rice production in India increased along with the rice growing area and the irrigation system (Fig. 2). The country has the largest area cultivated with rice. Rice is basically a kharif (planted during the June-July period and harvested in November-December) which represents 84% of the country's rice crop. Follow the summer rice (planted in November-February and harvested in March-June) to 9% and the autumn rice (planted in May-August and harvested in September-October), which represents 7% of the rice harvest. Rice crops require an optimum temperature of around 25 degree Celsius and rainfall greater than 100 cm. Rice is also cultivated through irrigation in areas that receive less rain. Although due to the occurrence of drought and other extreme events, we can see fluctuations in rice yield in India, there is an increase in yield of up to 400% from 1950-2015 (Fig. 3). However, the yield in rice (kg/hectare) is lower than in other countries. In recent years, in 2009-10, the yield of rice has been reduced due to the severe drought that has affected almost half of the country. In the future, climate change will also affect rice production in India. As the population of India continues to grow, it is a challenge for the agricultural sector in India to increase rice production by fighting the consequences of climate change. Therefore, it is important to study how climate change will affect rice production in India.

**Impact of climate change on rice production**

Studies suggest that rising temperatures, rising sea levels, and changes in precipitation and predicted distribution as a result of global climate change could lead to substantial changes in land and water resources for production and productivity. Rice crops grown in different parts of the world (Nguyen 2002). Studies using the DSSAT models have shown that the increase in temperature can reduce the yield of rice by 12% and the change in precipitation will be responsible for reducing yield up to 31.3%, until 2030. The increase in temperature In the future, the concentration of CO<sub>2</sub> in the atmosphere could also improve the growth of plants through the effect of fertilization because CO<sub>2</sub> is an essential component of photosynthesis (Watanabe and Kume, 2009). When C3 plants, such as rice, are exposed to high concentrations of CO<sub>2</sub>, the speed of photosynthesis of their leaves is accelerated due to both the enrichment of the CO<sub>2</sub> substrate and the inhibition of photorespiration by high concentrations of CO<sub>2</sub>. However, the stimulating effect of the high concentration of CO<sub>2</sub> gradually decreases with the prolongation of the exposure time (Gen-Yun Chen *et al.* 2005). In rice, photosynthetic acclimation is related both to the limitation of RuBP carboxylation and to the limitation of RuBP regeneration (Gen-Yun Chen, 2005).

**Projections about change in rice yield due to climate change in India during 2011-2016**

Geethalakshmi *et al.* (2011) projected climate change in the Cauvery Basin of Tamil Nadu, the results showed that rice production increases with higher and lower temperatures and rainfall. The ADT 43 rice yields simulated by a decision support system for the transfer of agricultural technology with fertilization effect showed a reduction of 135 kg per hectare per decade to provide regional climate results for impact studies (PRECIS), while there was an increase in yield of 24 kg per hectare per decade for the production of model 3 of the regional climate system (RegCMS). If we consider only the effect of the increase in temperature, the increase in temperature of 2°C could reduce rice yields by 15-17 % (Jayaraman, 2011). Kumar *et al.* (2016) affirmed that climate change has altered climatic conditions. It affects seasonal crops and decreases the growth time of available rice in Uttarakhand and Uttar Pradesh. Gupta *et al.* (2012) noted that climate change is likely to reduce rice yields in 16 large and agriculturally intensive Indian states. The slightly positive impact of increased precipitation on rice yields has been overshadowed by the negative impact of rising temperatures on yield, both in wet and dry areas. The expected decrease in rice yield is 1.21% in the wettest areas and 0.92% in the drier areas.

Evaluation of the impact of rice on climate change in ecologically sensitive areas, namely the Western Ghats (WG), the coastal districts and the northeastern states of India, using the simulation model Info Crop, variable effects expected from the climate position, climatic scenario, type of culture and its management (Kumar *et al.* 2016). It is likely that the irrigated rice in the western Ghats region will change from + 5% to -11% in the PRECIS A1b 2030 scenario depending on the location. In the case of rainy rice, the yield can be affected between 35% and 35%, however, a large area can lose yield up to 10%. The results indicate that rice can benefit from CO<sub>2</sub> fertilization in



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some places. As for irrigated rice, more fertilizers are supplied than rain rice, which may result in higher yields due to the effect of CO<sub>2</sub> fertilization. Rice is likely to be watered in parts of southwestern Karnataka and in the northernmost districts of Kerala.

During the Kharif season, the 1°C increase did not have a negative impact on performance. The increase in temperature above 1°C has led to a reduction in rice yields. On the contrary, the increase in temperature is showing a positive effect on rice yield during the Rabi season. There is a gradual increase in groundwater flow, percolation, soil water and water yield. The rice yields of the Kharif season with changes in temperature, precipitation and CO<sub>2</sub> are decreasing over time from the current to the end of the century. In the case of Rabi rice, yield levels are not significantly affected over time (Lakshmanan et al. 2011). Auffhammer et al. (2011) used data from India at the state level and, according to statistical analyzes, showed that during 1966-2002, drought and extreme rainfall events had a negative impact on rice yield, especially in rainy areas. Drought causes greater loss than extreme rainfall. Using the simulation, they found that rice yield would have been 1.7% higher in the absence of drought. Hundreds of millions of rice producers and consumers in India are affected by climate change.

The International Rice Research Institute predicted a 20% drop in production per degree of temperature increase in percent. Rice becomes sterile if it is exposed to temperatures above 35 degrees for more than an hour during flowering and, consequently, does not produce wheat (Senapatiet al. 2013). Pattanayak and Kumar (2013) estimated that, in the absence of climate change, rice production in India in 1969-2007 would have been 8% higher. Naresh Kumar et al. (2013) declared the reduction in yields of irrigated rice fields of 4, 7 and 10% during the scenarios of 2020, 2050 and 2080, respectively in India. Saravanakumar (2015) used panel data from 13 districts during the period 1971-2009 to assess the impact of climate change on crop production in Tamil Nadu. The empirical results showed a quadratic relationship (in the form of an inverted U) between the yield of the rice and the climatic variables. As the temperature and precipitation increase, the yield of the crop initially increases to a threshold level and, therefore, decreases. Following the projections of RegCM4 that continue to observe heating and precipitation anomalies, this could result in a significant loss of crop productivity. Projections suggest that there may be a 10% drop in rice yield by the end of the 21st century compared to average yields in the period 1971-2009. A plausible reason to increase the yield can be the effect of the interaction of the temperature with a high concentration of carbon dioxide.

The possible future impacts of climate change on the yield of irrigated rice were evaluated using the Land and Water Assessment Tool and the climate change scenario generated by the MIROC global climate model. The simulation showed a positive impact with an increase in annual rice production between 5.5-6.7, 16.6-20.2 and 26-33.4% during 2020, 2050 and 2080, respectively (Abeysingha et al. 2016). By 2030, throughout India, the average temperature should rise by at least 0.5°C in both summer and winter. In northern India and northwestern India, the temperature should rise by 1°C during the winter. According to the RCP 6.0 projection, in all regions of India, the temperature is likely to increase between 1 and 1.5°C by 2050, but in northern India, including rice production centers such as Punjab and In Uttar Pradesh, the average temperature is likely to increase by 2°C. By 2080, summers and warmer winters are likely to be seen in the northern regions of India such as the Punjab and Uttar Pradesh, with rising temperatures. At 3°C, while in the rest of the rice producing regions of India, the temperature should increase by at least 2°C. There will be more days of interruption and fewer days of monsoons and variation of precipitation. The increase in the frequency of extreme weather events, such as floods and droughts, will cause a decrease in the production of rice crops that will affect food security and the cost of living and, ultimately, worsen rural poverty in India (Teng et al. 2016).

The simulation analysis for the development of strategies for adapting rice to the climate change scenario highlighted low-cost adaptation strategies that included a better variety of crops, a change in variety and better crop management, a change in the time of sowing, an efficient use of irrigation and fertilizers, greater substitution of seeds by farmers and an increase in the application of fertilizers. Adverse changes in meteorological parameters and the decrease of potential yields should be considered as an indication of future problems. Farmers' yields must be



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constantly monitored for their stability. Breeders must develop new truths with improved germplasm and be more adjustable in climate change. Scientists working in soil and agronomy must find ways to improve the efficiency of the use of inputs. People in planning and policy development should plan ways to make technology circulate among farmers. Regular monitoring of crops and climatic factors in the effective agricultural area would help to predict problems and allow taking measures to improve productivity.

**CONCLUSION**

The impact of climate change on rice production is of particular interest due to its importance as a food source throughout the world, in Asia and particularly in India. Several studies reveal changes in predictions about the impact of climate change on rice production. Changes in temperature, radiation, precipitation and carbon dioxide levels can affect rice yields through its direct effect and indirect effects. While climate models have done a good job of capturing large-scale aspects of the current climate, they still contain systematic errors of the model that add uncertainty to the future projection. Proud projections of future crop yields lead to a decrease in food self-sufficiency rates in other regions. The impact of high CO<sub>2</sub> emissions and temperature on rice crops is not yet clear. The uncertainty in forecasts is derived from climate models, spatial resolution, and crop models and to add an additional level of complexity, rice cultivation depends on management skills, rice variety, crop model, the infrastructure, etc. Most studies on the impact of climate change on rice production have a negative effect on overall performance. The increase in temperature can shorten the duration of the growth period and, therefore, reduce the yield if management practices are not modified. It can be concluded that a high increase in CO<sub>2</sub> and a low increase in temperature can increase rice yields, while a high increase in temperature and a low increase in CO<sub>2</sub> can lead to a decrease in rice yield to negative effects on the growth of crops. Proactive measures for adaptation to climate change can significantly reduce the negative impacts and, therefore, increase the security of the livelihoods of the rural population at risk. In a scenario of climate change and evolving technologies, it is necessary to introduce crops capable of withstanding fluctuating temperatures and other natural factors.

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**Table 1: lists several collection missions and collections. The source material deposited as the base collection is mentioned in Table 2.**

SI. No.	Agency/ Area	Year	No. of collections
1.	Base collection from Coimbatore (AC)	1911-47	2,000
2.	Jeypore Botanical Survey (JBS)	1955-59	1,745
3.	Manipur Collection (MNP)	1965-70	904
4.	West Bengal Collection		
	Chinsurah, Bankura and Kalimpong	1960-71	5,550
5.	Assam Rice Collection (ARC)	1968-71	6,630
6.	Dr. Richharia's Collection from M.P.	1971-81	19,000
7.	Collection from various states (Upland)	1976-77	1,431
8.	National Collaborative Program (NCS)	1978-80	6,439
9.	U. P. Hill collection by Pantnagar Univ. and VPKAS, Almora	1978-90	2,580
10.	Lowland and saline types from Orissa	1980-82	300
11.	Collection by NBPGR from different parts of India	1976-84	8,353
12.	Collection by P. A. U., Kapurthala	1982-84	1,178
13.	Collection by H. A. U., Kaul	1982-86	960
14.	Collection by NBPGR/ CRRI from Goa, Gujarat, Karnataka, Sikkim, Mizoram, Arunachal Pradesh and Orissa	1984-88	3,092
15.	Collection from Rajasthan and Maharastra	1980-90	3,489
16.	Collection by NBPGR from Orissa, W.B.	1986-95	3,122
17.	Collection by CRRI from Orissa Wild rice Collection by NBPGR/ IRRI/	1990-95	717
18.	IGKV/ CRRI	1984-97	840
	Total		68,330

Source: MangalaRai (1998).

**Table 2: Number of Germplasm Accessions deposited in National Gene Bank.**

CENTER	NO.OF ACCESSIONS
NBPGR, TRICHUR	1,086
NBPGR, CUTTACK	1,299
NBPGR, SHILLONG	1,270
NBPGR, BHOWALI	270
NBPGR, NEW DELHI	15
IARI NEW DELHI	20
ICAR RES.COMP.,TRIPURA	60
DRR, HYDERABAD	3,900
CRRI CUTTACK	21,874
IGKV, RAIPU	8,712
MSSRF, CHENNAI	43
IRRI PHILIPPINES	3,455
Total	42,004

Source: MangalaRai (1998).



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**Table 3: Traits for which germplasm has been evaluated and donors identified among the various collections in the country.**

COLLECTION	TRAITS	
NRRRI (old collection)	Abiotic stresses	Upland with adequate moisture, Upland with moisture stress,
		Saline and alkaline soils, low-lying areas with waterlogging flood and deep water conditions
	Biotic stresses	Blast, Helminthosporiosis, Bacterial leaf blight, Stem rot, Stem borer, Gall midge
NRRRI (JBS collection)	Agronomic / yield	High no. of grains per panicle, high 1000-grain weight, Early and good tillering, Scented kernel
	Biotic stresses	Blast, Bacterial blight, Gall midge, RTV
ARC	Agronomic / yield	Dwarf with Indica type grain, Dwarf with Japonica type grain, Javanica plant habit, Glaberrima type plant habit
	Abiotic stresses	Tolerant to flood
	Biotic stresses	Blast, Bacterial blight, Stem rot, Stem borer, Gall midge, RTV, WBPH, brown plant hopper, Multiple resistance to-GM,SB, BLB, BLS, BL, RTV
IIRR / ARC	Biotic stresses	Blast, Bacterial leaf blight, Stem borer, Gall midge, RTV, Green leaf hopper
IIRR	Biotic stresses	Blast, Bacterial leaf blight, Sheath blight, RTV, Green leaf hopper, Stem borer, WBPH, Brown plant hopper, Gall midge, Leaf folder, Yellow stem borer
ICAR Research	Agronomic / yield	Rainfed upland, lowland, earliness, Non-lodging tall habit, fine grain, glutinous rice, scented rice, Suitable for high altitudes (1300m), Suitable for medium altitudes (800-1300m), Suitable for low altitudes (<800m)
Complex for NEH Region	Abiotic stresses	Drought tolerance, tolerance to cold at flowering, tolerance to iron toxicity,
	Biotic stresses	Blast
Raipur	Abiotic stresses	Drought
	Biotic stresses	Bacterial blight, Panicle midge, Stem borer, Gall midge, WBPH, Brown plant hopper, Brown spot
Assam	Agronomic / yield	High protein content, High aromatic oil content
	Abiotic stresses	Drought tolerance, flood, submergence, low light
	Biotic stresses	Blast, Bacterial leaf blight, Sheath blight, Root knot nematode, Brown plant hopper

Source: MangalaRai (1998).





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**Table 4: Projections about change in rice yield due to climate change**

Area	Prediction about Change in Yield of rice	References
India	Highest yielding areas -0.75 t/ha for 1 °C increase in temperature Low yielding areas -0.04 to -0.08 t/ha for 1 °C increase in temperature	Sinha and Swaminathan (1991)
	At Climate change scenario of 2040-49 - 0 to 4% in NW India + 3 to 5% Central India + 5 to 17% South India	Rathoreet al. (2001)
Punjab	- 5.4 % for 1 °C increase in temperature - 7.4 % for 2 °C increase in temperature - 25.1 % for 3 °C increase in temperature	Hundal and Kaur (1996).
	-3 % with every 1 °C increase in temperature -9% with every 1 °C increase in temperature and decrease in solar radiation by 5%	Hundal and Prabhjyot (2007)
	- 4.9 % for 1 °C increase in temperature - 8.2 % for 1.5 °C increase in temperature - 8.4 % for 2 °C increase in temperature	Saseendranet al. (2000)
North westIndia	+15 and + 28% for a doubling of CO <sub>2</sub> +4% for enhanced CO <sub>2</sub> and increased temperature	Lalet al. (1998)
Indo-Gangetic plains	Declining trends of potential simulated yield	Pathak et al. (2003)
Kerala	Positive change upto 5°C increase but then for every 1°C decrease upto 6%. - 8% per 2 mm/day decrease in rainfall	Mathaudaet al(2000)
Upper Ganga basin	-23% in 2080s	Aggarwalet al., (2010)
Eastern regions of India	-7.20 and -6.66 % with every 1 °C increase in temperature	Krishnan et al. (2007)
W.Bengal	+ 6% per increase CO <sub>2</sub> level by 100 ppm	Swain and Yadav (2009)
Bihar	+ 2.7% 2020s - 0.3% 2050s - 31.3% 2080s	Harisset al., (2010)
Tamil Nadu	Decreasing trend in yield	Srivani et al. (2007)

Source: MangalaRai (1998).



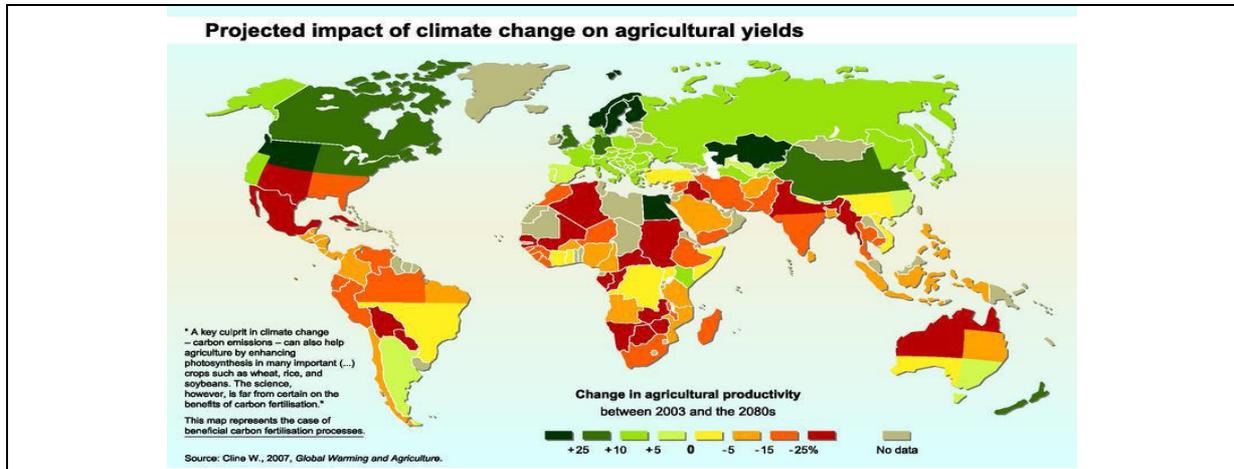
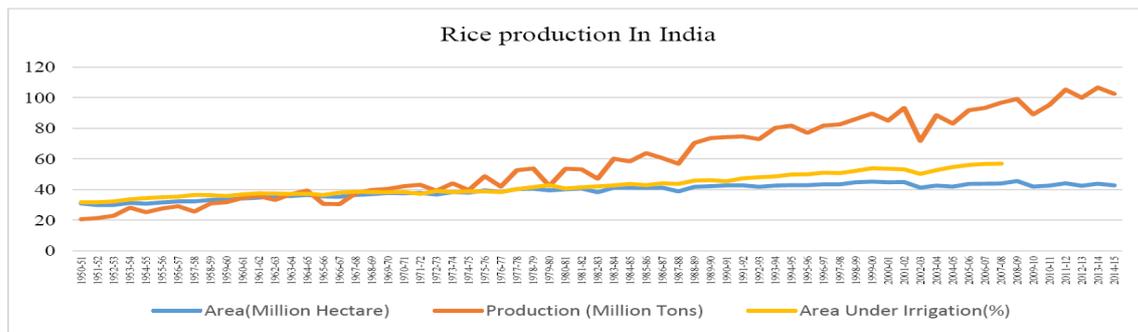
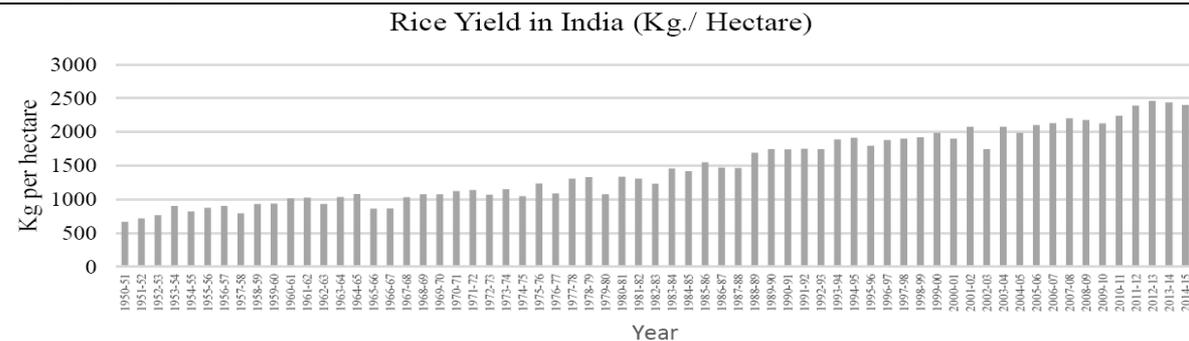


Fig.1 Impact of climate change on agricultural yields globally (Source Cline, 2007)



(Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, India)

Fig.2. Rice cultivated Area (Million hectares), rice production (Million Tons) and area under irrigation (%) in India (1950-2015)



Source: Directorate of Economics and Statistics, Department of Agriculture and Cooperation, India.

Fig. 3 Rice yield (Kg/hectare) in India (1950-2015)





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## Efficiency of Information and Communication Technology (ICT) tools and their relationship with factors accessing Agricultural information

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### ABSTRACT

Information and communication technology (ICT) are an emerging field for the enhancement and development of the agriculture. ICT tools are the very useful for the dissemination of knowledge to the farmers for the user friendly features. Farmers can easily access agricultural information with help of ICT tools. In this context, we explored the effect of socioeconomic characteristics of farmers on the efficiency of ICT tools. The study was conducted in five villages of Cooch Behar-I and Cooch Behar-II block of Cooch Behar district of West Bengal. Purposive as well as multistage and random sampling procedures were followed in selecting respondents. Farmers' efficiency on ICT tools was considered as dependent variable and the other related social, personal, psychological and communication attributes were considered as the independent variables. The data were collected with the help of the structured interview schedule through personal interview method. The major statistical measures used were coefficient of correlation and multiple regressions. From the coefficient of correlation, it has been found that the variables like educational qualification and asset possession were positively associated with the dependent variable; also age and experience in farming were negatively associated with it. In multiple regression analysis, the variable like family experience in farming and achievement motivation are significantly and negatively contributing towards characterizing the attitude towards ICT tools and the entire explicability is 46%.

**Keywords:** Efficiency, Information and Communication Technology, Educational qualification, Achievement motivation



**Subhrajyoti Panda and Satarupa Modak**

## INTRODUCTION

Access to information is the key to development and creating information-rich societies to poverty alleviation as well as sustainable development. It is necessary to empower poor people to reduce digital divide, implements ICTs projects in local language prioritizing local needs and content, models on utilization of low cost ICTs (Rao, 2009, Saravanan, 2013 and Kamath, 2018). ICTs broadly cover the set of activities that facilitates capturing, storage, processing, transmission and display of information by electronic means. The information communication technology (ICT) through some computer and mobile enabled, analogue and digital tools is the key enabler and vital component of new knowledge based economy and information revolution. ICT and Mobile technology had improved the package of practices and improved the agriculture through knowledge dissemination by e-agriculture. Rural information systems had focused on supplying the information to the rural people about modern agriculture (Jayade, et. al., 2014). Agriculture is moving towards more market oriented than production oriented with the help of market intelligence. These have a significant role in poverty alleviation by empowering rural farmers and other citizens with ICTs to grow their business and create new opportunities and delivery of services to rural areas (Nkwocha, et.al., 2009). With the advancement of technology now the whole world seems comes into our fist. If rural India gets benefited with ICT tools especially youths than we can ensure growth and development of farming and also check migration issues.

## MATERIALS AND METHODS

To study the efficiency and find out the supporting or opposing reasons behind use of ICT tools this study was conducted in five villages of Cooch Behar I & II block of Cooch Behar district, West Bengal. An exhaustive list of ICT tool users particularly for agricultural advisory services was prepared with the help of the local people, local administrators etc and twenty (20) number of ICT tool users were selected. Purposive as well as multistage random sampling procedures were followed in selecting a total of 100 respondents. Efficiency of ICTs (Y) was conceptualized as the efficacy of information sources (digital and analogue) used by the users in case of seeking agricultural information and also acquaintance of handling this ICT tools. A structured interview schedule was prepared by incorporating the construct and content of efficiency in using computer, efficiency in using Internet, efficiency in using Smart Phone, Television, Kisan Call Center (KCC), Information Kiosks, mobile based advisory service, VCD/DVD players and any other digital means. The responses from the ICT tool users were recorded with four point scales to represent the degrees namely 'no knowledge', 'can operate with some assistance', 'have working knowledge', 'proficient/competent in handling' and 0, 1, 2, 3 was the score assigned for the categories respectively. The total score of effectiveness in using ICT tools was obtained by adding the scores of all items in the scale.

Again as a supporting or opposing factor Age ( $X_1$ ), Caste ( $X_2$ ), Experience in farming ( $X_3$ ), Educational Qualification ( $X_4$ ), Family Education Status ( $X_5$ ), Family Annual Income ( $X_6$ ), Family Annual Expenditure ( $X_7$ ), Land Holding ( $X_8$ ), Possession of assets ( $X_9$ ), Livestock possession ( $X_{10}$ ), House Type ( $X_{11}$ ), Social Participation ( $X_{12}$ ), Self Confidence ( $X_{13}$ ), Risk Preference ( $X_{14}$ ), Scientific Orientation ( $X_{15}$ ), Economic Motivation ( $X_{16}$ ), Management Orientation ( $X_{17}$ ), Decision making ability ( $X_{18}$ ), Achievement Motivation ( $X_{19}$ ), Utilization pattern of communication sources ( $X_{20}$ ) were selected.

## RESULT AND DISCUSSIONS

Above figure indicated that majority (53%) of the respondents were under low level of efficiency on ICT tools followed 31 per cent on medium level and 16 percent of the respondents categorized as high level of access. The mean score of total distribution is 22.22, standard deviation is 8.99 and the coefficient of variation 40.46 per cent signifies high consistency level of the distribution for the variable 'efficiency on ICT tools'. Most of the users from the selected study were not efficiently using ICTs to access agriculture information.



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Table (1) reflects the Pearson's coefficient of correlation among the dependent variable, access to ICT tools of the farmers with the twenty casual variables. The result shows that the education ( $X_4$ ) and possession of assets ( $X_9$ ) are positively and significantly associated with the dependent variable, access to ICT tools. On the other hand, the variable age( $X_1$ ) and experience in farming ( $X_3$ ) is negatively and significantly associated with the efficiency of the farmers to the ICT tools.

**Age and Efficiency on ICT tools**

Age is the factor which plays a great role in our society to adopt any modern technology. Mostly the young aged people are more interested towards the new technologies to do their work more efficiently. In this study, it is found that the young farmers are using ICT tools more effectively due to their feeling of wanting to know about the mobile and computer based technology to get the information easily and quickly. This may be the reason that young farmers have more efficient in handling ICT tools than the elder farmers. Due to this age is significantly and negatively correlated with efficiency on ICT tools.

**Experience in farming and efficiency on ICT tools**

Experience means more practical knowledge about something. In this study most of the farmers are experienced. They are more skilful in handling the agricultural practices without using any modern technology. The less experienced farmer who are recently doing the agriculture practices are given more emphasis towards using ICT as they are more efficient in adopting new technologies to do it more efficiently than the more experienced farmer. More experienced farmers have less efficient in handling the ICT tools than the less experienced farmer. More experienced farmers are traditional and their mind set up is towards the traditional agriculture. This is the main possible cause that experience in farming is significantly and negatively correlated with efficiency on ICT tools.

**Education and Efficiency on ICT tools**

Education is the process through which one individual can gather knowledge and use this knowledge in their situation to solve their problems. In other words education makes an individual perfect through the manifestation of different positive traits prevailed within an individual. The perfection of any activity need risk assimilation and creativity. The formal education always tries to help the human being to become innovative and creative. Education helps the farmer to learn about ICT tools more quickly and efficiently. That is why education is significantly and positively correlated with efficiency on ICT tools.

**Possession of assets and efficiency on ICT tools**

In our society possession of assets signifies the farmer's socio-economic condition. The farmers having more assets indicate that they are more advanced in taking new technologies in their farming situation. They collect the information on agriculture through the modern technologies by using mobile, computer as their possession of asset is more. They can effectively give effort towards ICT tools for their information needs in agriculture. This may be the possible reason that possession of assets is significantly and positively correlated towards the variable efficiency on ICT tool. From the table (2) it is observable that the variable experience in farming and achievement motivation are significantly and negatively contributing in case of characterizing the predicted variable efficiency on ICT tools. Other variable like education is significantly and positively contributing towards characterizing efficiency on ICT tools.

**Experience in farming and efficiency on ICT tools**

Experience in farming reflects the time period regarding farmer's involvement in agriculture and allied sectors. Mostly it was observed that the aged persons in rural areas are more experienced and knowledgeable regarding various farm practices. Although the aged persons are more experienced compared to the young farmers but they are less aware about the application of modern information technology. At present, youth in rural areas are much acquainted with the latest information technologies due to increased mass media exposure and computer literacy. In



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this study area, majority of the respondents are young aged farmers who are practising farming for not more than five years. Almost all the young farmers are having smart phones and they are familiar with the application of other software but not aware about the efficient utilization of ICT tools in agriculture due to their less experience in farming. That is why the variable 'experience in farming' is significant and negatively contributing towards the predicted variable 'efficiency on ICT tools'. The variable experience in farming is directly contributing 47.90% in case of characterizing efficiency on ICT tools. One unit change of the variable is delineating 0.576 unit change in the predicted variable efficiency on ICT tools.

**Education and Efficiency on ICT tools**

Education acts as a crucial factor in determining the knowledge level of farmers. Education helps in developing the capabilities of a farmer towards the modern technologies and new initiatives taken in agriculture. Education not only increases the knowledge but it also helps in increasing the efficiency of a farmer in the modern farming. In the present study most of the farmers are young aged. They are also educated enough to know about modern technologies used for agricultural information. They have mainly taken training for how to use computers and internet. They are efficient to handle the ICT tools. Without education one cannot effectively use the ICT tools. That is why the variable 'education' is significantly and positively contributing towards characterizing efficiency on ICT tools. The variable education is directly contributing 16.70% in case of characterizing efficiency on ICT tools. One unit change of the variable is delineating 1.801 unit changes in the predicted variable efficiency on ICT tools.

**Achievement Motivation and Efficiency on ICT tools**

Achievement means a person's present proficiency, mastery, and understanding of general and specific areas of knowledge. Achievement is the measures of efficiency of instruction and learning. In the present study area most of the persons have given importance to agriculture. They are more interested to achieve more profit from the agriculture by giving more concentration towards the production and marketing of the product. They do not think that ICT tools are important for agricultural practices because they believe that use of simply ICT tools is wastage their time and it would not help them get information. The farmers are mainly age old persons, so they fear to use ICT tools. That is why the variable 'achievement motivation' is significantly and negatively contributing towards characterizing the predicted variable 'efficiency on ICT tools'. The variable achievement motivation is directly contributing 16.00% in case of characterizing efficiency on ICT tools. One unit change of the variable is delineating 0.777 unit changes in the predicted variable efficiency on ICT tools. The  $R^2$  value being 0.46, it was to infer that the twenty predictor variables put together have explained 46.00% variation embedded with the predicted variable efficiency on ICT tools used by the respondents. Still 54.00% variation embedded with predicted one remains unexplained.

**CONCLUSION**

From the study, we have seen that variables like educational qualification and asset possession were positively associated with the efficient use of ICT tools. As higher education increase the thrust of knowledge and asset possession reflects economic empowerment enable one's purchasing power of technological gadgets. Again, age and experience in farming were negatively associated with it as older age people find it complex to handle ICTs and experienced farmers like to follow conventional farming systems initiated by the forefathers. In multiple regression analysis, the variable like family experience in farming and achievement motivation are significantly and negatively contributing towards characterizing the attitude towards ICT tools.





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**Table 1. Correlation Coefficient of Efficiency on ICT tools (Y) with other variables**

Variables	Coefficient of Correlation (r)
Age(X <sub>1</sub> )	-0.366**
Caste(X <sub>2</sub> )	0.133
Experience in farming (X <sub>3</sub> )	-0.484**
Educational Qualification(X <sub>4</sub> )	0.267**
Family Education Status(X <sub>5</sub> )	0.031
Family Annual Income (X <sub>6</sub> )	0.185
Family Annual Expenditure (X <sub>7</sub> )	0.191
Land Holding (X <sub>8</sub> )	-0.129
Possession of assets(X <sub>9</sub> )	0.337**
Livestock possession(X <sub>10</sub> )	-0.031
House Type (X <sub>11</sub> )	0.131
Social Participation(X <sub>12</sub> )	0.171
Self Confidence (X <sub>13</sub> )	-0.003
Risk Preference (X <sub>14</sub> )	0.127
Scientific Orientation (X <sub>15</sub> )	0.172
Economic Motivation (X <sub>16</sub> )	0.104
Management Orientation(X <sub>17</sub> )	0.131
Decision making ability(X <sub>18</sub> )	0.187
Achievement Motivation (X <sub>19</sub> )	-0.163
Utilization pattern of communication sources(X <sub>20</sub> )	0.222

\*\* Significant at 1% level and \*Significant at 5% level

**Table 2. Multiple regression analysis of Efficiency on ICT tools (Y) with other variables**

Variables	Un-standardized Coefficients		Standardized Coefficients	t-value
	B	Std. Error	Beta	
Age(X <sub>1</sub> )	0.065	0.157	0.070	0.413
Caste(X <sub>2</sub> )	0.909	1.238	0.065	0.734

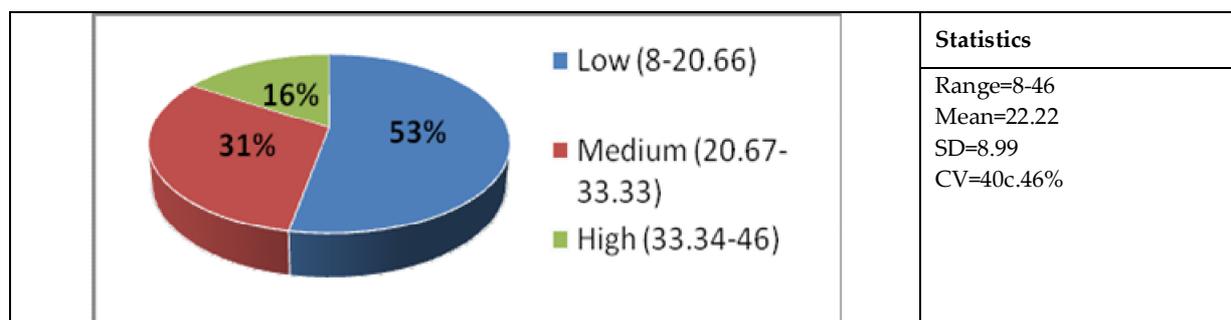




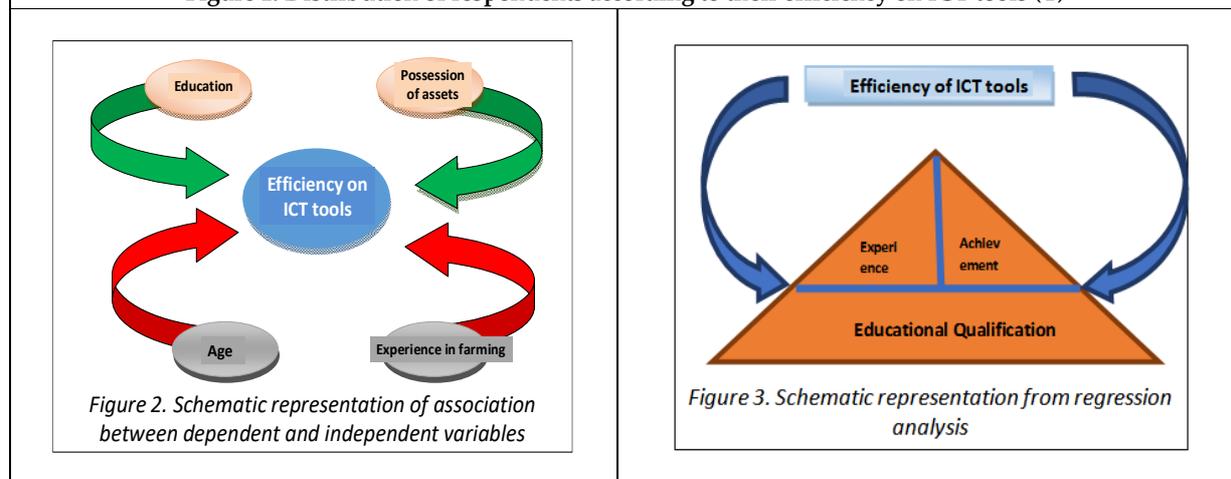
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Experience in farming (X <sub>3</sub> )	-0.576	0.206	-0.479	-2.791**
Educational Qualification(X <sub>4</sub> )	1.802	1.043	0.167	1.727*
Family Education Status(X <sub>5</sub> )	-0.180	0.308	-0.053	-0.585
Family Annual Income (X <sub>6</sub> )	-0.834	4.349	-0.045	-0.191
Family Annual Expenditure(X <sub>7</sub> )	5.836	5.330	0.262	1.094
Land Holding (X <sub>8</sub> )	-0.434	0.584	-0.093	-0.744
Possession of assets(X <sub>9</sub> )	0.068	0.086	0.087	0.792
Livestock possession(X <sub>10</sub> )	0.030	0.155	0.018	0.193
House Type (X <sub>11</sub> )	1.757	1.324	0.128	1.327
Social Participation(X <sub>12</sub> )	2.335	2.121	0.107	1.100
Self Confidence (X <sub>13</sub> )	0.290	0.316	0.085	0.917
Risk Preference (X <sub>14</sub> )	-0.301	0.536	-0.052	-0.560
Scientific Orientation (X <sub>15</sub> )	0.254	0.406	0.059	0.626
Economic Motivation (X <sub>16</sub> )	-0.180	0.554	-0.032	-0.325
Management Orientation(X <sub>17</sub> )	0.091	0.200	0.042	0.452
Decision making ability(X <sub>18</sub> )	0.952	0.662	0.136	1.437
Achievement Motivation (X <sub>19</sub> )	-0.777	0.439	-0.161	-1.77*
Utilization pattern of communication sources(X <sub>20</sub> )	0.344	0.207	0.162	1.656

\*\* Significant 1% level, \* Significant at 5% level and R<sup>2</sup>= 0.46



**Figure 1. Distribution of respondents according to their efficiency on ICT tools (Y)**





## Effects of Irrigation on Potato: a Boon for Its Yield

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### ABSTRACT

Water is the vital source for crop production and is the most limiting factor in Indian agricultural scenario. Though India has the largest irrigation network, the irrigation efficiency has not been achieved more than 40 per cent. Due to water scarcity, the available water resources should be very effectively utilized through water saving irrigation technologies. Economic use of water is a vital problem which confronts farmers and agricultural scientists in irrigated areas of arid and semi-arid regions. The limited groundwater reserve is the major constraint for irrigation water supply. Improper irrigation water operation accounts for significant water losses in large area in our country. Consequently, the use of modern irrigation systems in irrigation operation and scheduling is essential for the reduction of irrigation water demands. Various research works have been conducted by many workers to find out optimum irrigation level of potato, so as to minimize the cost of cultivation. The relevant literature available on these aspects in state, country and abroad has been briefly reviewed in this paper.

**Keywords:** Arid region, Semi-arid region, Irrigation

### INTRODUCTION

Potato (*Solanum tuberosum* L.) the so called “papa” of Mayan Civilization is one of the most important crop in the world in terms of its use as human food and as raw material for the starch industry (Fabeiro *et al.*, 2001). The word

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"potato" may refer either to the plant itself or to the edible tuber. Potato is a starchy tuberous crop evolved from the ancestor like perennial nightshade (*Solanum tuberosum*). It is believed to be originated from the Titicaca lake area in Andes mountain now located in Peru, Bolivia and Northern Chile trijunction of South America. This temperate tuber crop is being cultivated in the country for the last more than 300 years which has always been the 'poor man's friend'. Being a crop of foreign origin it acclimatizes itself in the cuisines of countryside so popularly that, it is now put under Public Distribution System in India. Potato is an economical food and is source of low cost energy to the human diet which can substitute the cereals for human consumption to a greater extent. It contains 20.6% carbohydrates, 2.1% protein, 0.3% fat, 1.1% crude fiber and 0.9% ash. It also contains a good amount of essential amino acids like leucine, tryptophan, and isoleucine etc. It is grown in almost all the states of India with a total production of 455.69 lakh million tonnes of potato from an area of 20.63 lakh ha and productivity of 22.09 t/ha (<http://nhrdf.org/pdf/POTATO%20CROP%20REPORT-%2008%20APRIL%202016.pdf>).

Potato is one of the most remunerative and profitable crop for the growers due to its higher yield potential within a limited time. It is a short duration crop, which is responsive to high input use and capable to produce more yield under a wide edaphic situation and adiabatic conditions. Considering its gestation period potato production per unit area per unit time is higher under Indian plains as compared to European countries in general and temperate regions in particular. The wide flexibility in its planting and harvesting dates makes the crop most suitable for inclusion in intensive cropping system. The crop finds an important place in the economy of poor and marginal farmers and plays a significant role in nutritional security producing more food per unit area and time. In Odisha generally *Rabi* crop is planted in November and December months in the plains and the *Kharif* crop is cultivated as rainfed with the onset of rain in June and July months in limited pockets of interior tribal districts like Koraput and Phulbani.

Water, as an universal solvent is the integral part of cell constituents necessary within the plant for different metabolic activities like photosynthesis, respiration and other plant physiological functions such as transport of minerals and photosynthetic products, turgidity of plant cells, transpiration and regulation of leaf temperature. Compared to several other crops, the potato plant is sensitive to both lack of and an excess of water. Lack of water is the most common stress. Water deficit decreased number of leaves, leaf area, plant height, tuber number, growth and yield, canopy radiation interception, harvest index, fresh weight of root and leaves, root number, root dry weight and tuber yield (Hassanpanah, 2009). Even a short period of dryspell drastically affects the yield, especially after tuber initiation. That is why a continuous water supply to meet the crop water demand at different growth stages is highly recommended for better growth from sprout development to maturity (Ierna and Mauromicale, 2006). At the beginning of tuber formation, drought favors attack by *Streptomyces scabies* (common scab). At later stages, drought causing cracks in soil favor tuber infestation by insects, especially tuber moth. Drought influences yield directly by restricting transpiration and photosynthesis. Dry soils form clods that make soil and crop management difficult and cause tuber damage at harvest. Excess water may be caused by heavy rainfall, heavy irrigation, or inefficient drainage. Excess water creates anaerobic condition preventing oxygen to reach the underground parts of the potato plant resulting in poor root development and rotting of the newly formed tubers. Seed tubers are especially susceptible to tuber rot.

Over-irrigation shortly after planting may reduce emergence because of excessive growth of lenticels which allows entrance of parasites and soil surface compaction which increases the production cost. High moisture favors development of late blight (*Phytophthora infestans*). The stomata of potato leaves close quickly upon lack of humidity which leads to reduced transpiration and photosynthesis, heating of leaves and subsequent reduction in yield. Crops sensitive to water stress require a systematic approach for irrigation scheduling. Considering the rates of the crop water requirement is calculated which is used in irrigation scheduling to improve the effectiveness of irrigation. An adequate water supply is required from tuber initiation till the near maturity for higher yield and good quality of potato specially for processing purpose.



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Potato is very sensitive to water deficit due to its sparse and shallow root system (Jefferies, 1993). An adequate supply of water is required by potato plant in all critical stages from the time of emergence to the start of senescence. The amount of water needed by potato varies with soil type, temperature, humidity, air movement, plant and number of shoots per plant, variety and cultural practices (Wiersema, 1987). Correct water management provides sufficient water for potato growth and avoids excessive loss or waste of water (Haverkort, 1982). The yield is greatly influenced by timing, amount and fecundity of irrigation applied (Kashyap and Panda, 2003). The primary goal of potato irrigation management is to minimize both soil water fluctuations and maintain the availability of soil water at the field capacity level.

### Response of Irrigation Levels and growth attributes

Water is essential requirement for plants. Thus reduced availability of water to plants is likely to restrict crop growth. As irrigation is a measure to increase water availability to plants and reduce adverse effects of water deficits in crop. Sood (1986) observed that during pre-monsoon period, supplemental irrigation at 0.5 atmosphere moisture tension stimulated growth and increased potato mean yield by 64 q/ha under rainfed conditions. Tiwari et al. (1998) reported that plant height responded significantly with different irrigation levels of drip irrigation, however, plant height was statistically at par with furrow irrigation and 100% irrigation supply with drip irrigation.

Irrigation levels had no significant influence on number of leaves per plant in okra. Chauhan et al. (2009) studied the effect of method of irrigation on growth, fruit (green and dry) and seed yields of chilli cv Pusa Jwala. Scheduling irrigation through drip at 80% of CPE increased plant height, branches, chlorophyll, fruit and seed yield as compare to surface irrigation method. Ghamarnia and Sepehri (2009) reported that the number of stem per plant and the number of tuber per plant were not significantly affected by different irrigation methods and their results also indicated that regardless to irrigation method, the maximum and minimum yield of potato with 34.46 and 19.17 t/ha were achieved in irrigation water treatment of 100% and 50% tape, respectively. The least per cent of tubers smaller than 35 mm (26.42%) was obtained in tape method with 50% irrigation-water requirement and the highest per cent of tubers smaller than 35 mm (37.99%) was obtained in furrow irrigation method. Pirboneth et al. (2012) reported that among irrigation regimes, the highest plant height produced with six days interval and was 52.3% higher in compare with no irrigation treatment. Farrag et al. (2016) reported that 100% irrigation requirement treatments produced the highest values for vegetative growth parameters followed by the 75% irrigation requirement. Whereas the lowest values for these parameter were recorded under 50% IR.

### Yield and yield attributes

Steineck (1958) found that potato is particularly sensitive to faulty irrigation technique. He emphasized that planning of irrigation at higher tensions and withholding water for 2, 4, 6 weeks period induced yields of 78, 58, and 36 per cent, respectively of the yield of highest yielding treatment. Working on the laterite soils of West Bengal, Perez et al. (1961) observed that yield and per cent of large size tubers increased by increasing frequency of furrow irrigation. They concluded that available soil moisture at 30 cm depth should not be allowed to fall below 50 percent of field capacity. Moolani and Hukkeri (1965) showed that irrigation at lower tension (0.25 to 0.30 atmosphere) increased yield by 6.12 and 34.5 q/ha as compared to yield under 0.6 and 0.9 atmosphere soil moisture tension, respectively. Yadav and Tripathy (1972) reported that in field trail, irrigations given at 25, 50 and 70 per cent of available moisture showed significant improvement in potato tuber yield and 'A' grade tuber with increase in irrigation levels. Doorenbos and Kassam (1979) reported that for higher yield at a given site, the seasonal water requirements of a potato crop with a phenological cycle varying from 120 to 150 days ranged from 500 to 700 mm, depending on climate. Deficient irrigation promoted a reduction of tuber quality and lowered yield due to reduced leaf area and or reduced photosynthesis per unit leaf area (Van Loon, 1981). MacKerron and Jefferies (1986) have shown that increased duration of water stress before tuber initiation reduces tuber set per stem.

Another study by Singh et al. (1988) reported that tuber yield of potato variety "Kufri chandramukhi" irrigated on the basis of IW/CPE ratio of 2.0 was comparable to that irrigated at 0.25 bar soil water tension but saved 12 cm



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irrigation water, resulting in 20-14 per cent higher irrigation water use efficiency. Shrivastava et al. (1994) studied the response of tomato to three levels of water (0.4 PE, 0.6 PE and 0.8 PE) and mulches (black plastic and sugarcane trash) and they found highest yield with the combinations of sugarcane trash and irrigation at 0.4 Pan Evaporation. King and Stark (1995) studied the water management practices on forty five commercial potato fields in southeast Idaho. Potato yield is reduced by both over- and under irrigation.

Efficient irrigation management can increase marketable yield while reducing production costs by conserving water, energy and nitrogen fertilizer, as well as reducing potential ground water contamination. Chandra et al. (2001) observed the performance of potato under limited irrigation in which the IW: CPE 1.20 and 50% ASMD (Available Soil Moisture Depletion) treatments recorded significantly more tuber yield than IW/CPE 0.60 and 75% ASMD. Experimental findings of Kashyap and Panda (2003) revealed that among five irrigation treatments 10% (T1), 30% (T2), 45% (T3), 60% (T4), 75% (T5) maximum allowable depletion of available soil water during non critical stage of crop growth with delayed irrigation, the yield reduced significantly under T4 and T5, which result in minimum fresh tuber yield and total dry matter yield. Erdem et al. (2006) reported that, irrigation regimes influenced tuber yield in 2005 and the highest tuber yield was registered for 30% irrigation regime, reaching 35.13 t ha<sup>-1</sup> in 2003 and 44.56 t ha<sup>-1</sup> in 2005. Kumar et al. (2007) evaluated the performance of two chipping potato cultivars Kufri Chipsona-1 and Kufri Chipsona-2 under different irrigation levels and reported that non-significant variation in number of stems and compound leaves with irrigation levels but observed consistent decline in processing grade and total tuber number ha<sup>-1</sup> under water stress. Like tuber number, processing-grade tuber yield, total tuber yield, biomass yield and average tuber weight also decreased with decrease in irrigation frequency from 15 mm to 35 mm cumulative pan evaporation (CPE).

Kumari et al. (2009) recorded highest water use efficiency (1.37q/kg-mm) with 0.80 IW/CPE under micro sprinkler irrigation. Water application of 257 and 261 mm was found optimal for attaining the maximum yield under micro sprinkler and drip irrigation systems, respectively. Economic analysis revealed that using micro irrigation for potato production in canal irrigated area of semi-arid climate is a profitable alternative of existing irrigation method. Experimental findings of Zaman et al. (2009) revealed that the tuber yield recorded under irrigation at IW/CPE of 0.6 (I3) was 27.9% higher than rainfed (I1) and 23.0% higher than splash irrigation (I2). Ati et al. (2010) studied the yield of potato (*Solanum tuberosum* L.), under regular deficit irrigation and results showed that the yield of potato were 34.5, 34.3, 28.2 and 30.2 t/ha for control treatment (irrigate reestablishing field capacity when 60% of the available water was depleted), T1 (no irrigation during vegetative growth stage), T2 (no irrigation during tuberization stage) and T3 (no irrigation during bulking and tuber enlargement), respectively for the first season, while in the second one equaled 36.7, 36.2, 30.0 and 31.2 t/ha. Another experiment was conducted by Amanullah et al. (2010) to study the effect of different irrigation regimes on the yield and yield contributing characters of high yielding potato varieties namely Binella, Cardinal, Chamak and Heera. Five irrigation treatments: no irrigation, irrigation at IW/CPE ratios of 0.25, 0.50, 0.75 and 1.00.

Treatment IW/CPE ratio of 1.00 was found the best among the different IW/CPE ratios tried, yielding maximum which was significantly different from other treatments with 5- rounds of irrigations applied at stolonization, tuberization, bulking and ripening stages of crop growth. On an average application of 41.8 mm irrigation water per event at an interval of around 15 days starting from 20 days after planting yielded the highest (40.5 t/ha) in IW/CPE ratio of 1.00 treatment. Ierna et al. (2011) conducted an experiment with the aim of achieving an appropriate combination of irrigation water and nutrient application in cultivation management of a potato crop in a Mediterranean environment. They concluded that the treatments based on 50% ETM and a medium level of fertilization represent a valid compromise in early potato cultivation management. Compared to the high 14 combination levels of irrigation and fertilization, this treatment entailed a negligible reduction in tuber yield to save 90 mm ha<sup>-1</sup> year-1 of irrigation water, with notable economic savings for farmers compared to the spendings that were usually made.



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Saikia (2011) conducted a field experiment with 4 irrigation schedules viz., irrigation to each furrow at 25 mm CPE (I1), irrigation to alternate furrow at 25 mm CPE (I2), irrigation to each furrow at stolon formation (SF) stage (30 DAP), tuber formation (TF) stage (50-55 DAP) and tuber development (TD) stage (65-70 DAP) (I3), and irrigation to each furrow at stolon formation (SF), tuber formation (TF) and tuber development (TD) stage + 1 extra irrigation after 10 days of irrigation at tuber development stage (I4) and 2 mulching treatments viz., no mulch (M1) and mulching with water hyacinth @ 5t/ha (M2). Tallest plants were recorded when irrigations were applied at SF + TF + TD stage + irrigation after 10 days of TD stage under M1 condition.

Number of shoots/plant was significantly affected by different treatments during both the years. Highest total tuber yield of 14.2 t/ha was recorded when irrigation was applied at each furrow at 25 mm CPE during 2006-07. In case of large size tubers (> 75 g), highest tuber yield (2.21 t/ha) was recorded when irrigation was applied at SF + TF + TD stage + irrigation after 10 days of TD stage under M1 condition during the same cropping season. Singh et al. (2012) conducted an experiment to study the influence of irrigation and mulch on growth, yield and economics of potato. Results revealed that the irrigation given to all furrows with paddy straw mulch @ 5 t ha<sup>-1</sup> produced significantly higher tuber yield (295 q ha<sup>-1</sup>) as well as tuber numbers (605 thousands ha<sup>-1</sup>) in comparison to other treatments tried in main crop season.

In early crop of potato, the irrigation applied at 20 mm CPE with paddy straw mulch @ 5 t ha<sup>-1</sup> gave significantly higher total yield (170 q ha<sup>-1</sup>) than other irrigation treatments. Bisht et al. (2012) conducted field experiment by taking seven treatments i.e., 100% OPE (Open Pan Evaporation) daily (I1), 80% OPE daily (I2), 60% OPE daily (I3), 100% OPE at alternate day (I4), 80% OPE at alternate day (I5) 60% OPE at alternate day (I6) and control (I7) i.e., furrow irrigation given up to 5 cm depth at an interval of 15 days. The maximum number and yield of A (>75 g) and D (0-25 g) grade tubers was recorded in treatment I4 (100 % OPE at alternate day) and I6 (60% OPE at alternate day) respectively while, B (50-75 g) grade in I2 (80% OPE daily) and C (25-50 g) grade under I5 (80% OPE at alternate day). Dry matter content of tuber increased with increase in irrigation levels from 60, 80, 100% OPE respectively, on daily as well as on alternate day basis in comparison to the control i.e. furrow irrigation.

Tyagi et al. (2012) conducted a field experiment comprised of five irrigation levels (irrigation at critical stages of potato (*Solanum tuberosum* L.), irrigation at critical stages of French bean (*Phaseolus vulgaris* L.) and irrigation at 0.8, 1.2 and 1.6 IW/CPE ratio) as main plots and 3 cropping systems (sole potato, sole French bean and potato + French bean in 2:3 row ratio). Irrigation at IW/CPE ratio of 1.6 produced the highest tuber yield followed by irrigation at 1.2 IW/CPE ratio, while the lowest tuber yield was achieved with irrigation at 0.8 IW/CPE ratio. Although the tuber yield with irrigation applied at critical growth stages (CGS) of potato was significantly lower than with IW/CPE ratio of 1.6, but the water use efficiency (WUE) with CGS of potato was higher. Verma et al. (2012) conducted a field experiment to study the effect of irrigation and nitrogen management on productivity of potato (*Solanum tuberosum* L.) and their residual effect on succeeding maize (*Zea mays* L.). Among the irrigation regimes, irrigation at 60 mm CPE recorded significantly the highest growth characters, yield attributes and total tuber and biological yields over irrigation at 80 and 100 mm CPE..

The specific gravity, starch and dry matter contents increased from 40% to 65% field capacity and the lowest under 100% field capacity irrigation treatment. Field experiment was conducted by Admasu et al. (2016) to determine the optimal irrigation regime and NP fertilizer rate of Potato (Local name: Gudene) under five irrigation treatments (Irrigation at +40% ASMDL, +20% ASMDL, ASMDL, - 20% ASMDL and -40% ASMDL) and three NP fertilizer rate levels (25% more on the recommended rate, recommended rate and 25% less from the recommended rate). The lowest tuber yield was found at +40% ASMDL irrigation with a value of 28.77 t/ha and it was comparable to tuber yield found at +20% ASMDL irrigation. An experiment was conducted by Ruttanaprasert et al. (2016), to study the effects of water stress on total biomass, tuber yield, harvest index and water use efficiency in Jerusalem artichoke and to evaluate the differential responses of Jerusalem artichoke (JA) varieties under drought stress. The 3×5 factorial combinations of three water regimes (Field capacity (FC), 50% available soil water (50% AW) and 25%



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AW), and five JA varieties (JA 60, JA 125, JA 5, JA 89 and HEL 65) were arranged in a pot experiment in a randomized complete block design with four replications for two years. Drought reduced tuber dry weight, total biomass, harvest index.

### Physiological properties and nutrient uptake

Sood and Sharma (2002) studied that the effect of irrigation (100, 150, 200 and 230 mm) and nutrient application (50 or 100% recommended NPK, farmyard manure or plant residues) on the yield of potato cv. Kufri Jyoti in potato-based sequential cropping systems viz., potato-cabbage, potato-radish and potato-pea, were determined in a field experiment. Application of 100% recommended NPK+ irrigation resulted in the highest mean yield of potato (408 q/ha), cabbage (340 q/ha), radish (470 q/ha) and peas (111 q/ha), N, P and K uptake of potato, and N and K content in potato tubers. Generally, in most cases, the treatment of the medium or/and highest soil moisture level (60 and 80 % from available water) gave the highest significant values for plant height, dry matter and K content of potato plant at 90 days from planting and potato tuber yield ton/feddan N, P and K contents in tuber in addition to, total soluble solids and protein content in tuber as well as consumptive use. Ahmadi *et al.* (2011) reported that, the irrigation treatments were not significantly different in terms of N uptake in the tubers, shoot, and whole crop of potatoes.

However, there was a statistical difference between the crop grown in different soil texture where plants in the loamy sand had the highest amount of N uptake. Patel *et al.* (2012) conducted an experiment to study the effect of fertigation of nitrogen and potash under different methods of irrigation on yield of potato cv. Kennebec. They reported that growing of potato laying drip with laterals in each pair and applying 75% recommended dose of N and K (206 kg each) as fertigation in five splits resulted into higher tuber yield and uptake of nitrogen, phosphorus and potash, nutrient productivity, net return, net realization and benefit cost ratio. Maralian *et al.* (2014) carried out an experiment by taking irrigation as main plot treatments (I1=full irrigation, I2= 0.8 I1 and I3= 0.6 I1) and three potato genotypes as subplots (B1= Clone 82-10, B2= Clone 97-2 and B3= Agaria cultivar) were allocated to the sub plots. There was no significant differences for RWC, chlorophyll (b) and carotenoid among genotypes.

Chlorophyll content (mg/g.f.w) decreased at 60% irrigation (40% stress) and the highest level observed in 97-2 clone. The highest carotenoid content belongs to 80% applied water and it is decreased significantly at 60% applied water. Clone 97-2 had the highest chlorophyll (a), chlorophyll (b), chlorophyll (a+b) and carotenoid content at 80% full irrigation. According to Rolando *et al.* (2015) after water restriction initiation, a temporary rise of Chl SPAD was observed in the three genotypes of potato. This increased leaf greenness under water restriction coincided with a decrease in leaf growth. They suggested that the highest greenness increase following water restriction in the most drought susceptible varieties is an expression of more conservative strategies under drought. Thus, lower chlorophyll loss rate and later onset of senescence was related to higher yield under water restriction. Farrag *et al.* (2016) reported that 100% irrigation requirement resulted in the highest average values of NPK content in the plant leaves.

### CONCLUSION

To feed the additional two billions of hungry people by 2030 water, a scarce resource need to be used more efficiently. As a biggest consumer, agriculture withdraws 70% of fresh water worldwide entering into a steep competition with industry and domestic use. To combat such alarming situation national slogan “more crop per drop” should be echoed in every corner of the country for a judicious use of water adopting smarter water management practices with alignment of cutting edge technologies on this aspect. We know potato as an winter crop consume a greater part of the ground water reserve as grown only in irrigated condition. In order to quench the thirst of the crop augmenting the exact water requirement we can get the same yield as in the outdated flooding





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irrigation practices. Therefore the genetically engineered drought tolerant cultivars with judicious amount of irrigation water can yield a bumper crop justifying the slogan “more crop per drop”.

There is need to improve irrigation management strategies, which can increase the water-use efficiency (WUE) of the crop. Therefore, irrigation based on cumulative pan evaporation will help to maintain adequate soil moisture without any waste of water. The yield of the potato varieties can be improved to a great extent by optimum application of supplemental irrigation. So we can increase the production under water stress condition. These conditions dictate utilization of a quantitative potato irrigation management for consistent, optimum economic return from potato crop.

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## Rice Bran and Its Potential: An user Prospective

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### ABSTRACT

Rice bran could be a by-product created throughout the method of milling. The bran constitutes nearly 7%-8.5% of the whole grain. The bran consists of the pericarp, tegmen (the layer covering the endosperm), aleurone, and sub-aleurone. Proximate analysis of rice bran by various researchers shows that rice bran is highly enriched with vitamins including vitamin E, thiamine, niacin, also minerals like aluminium, calcium, potassium, sodium, zinc etc. Apart from vitamin and minerals rice bran is also rich in protein, fiber, moisture and ash. Various antioxidants like tocopherols, tocotrienols, oryzanol that inhibits platelet aggregation and prevents cardiovascular diseases are present in the rice bran oil. Rice bran also contains polyphenols (ferulic acid, caffeic acid, salicylic acid), phytosterols ( $\beta$ -sitosterol). These metabolites found in rice bran are likely to work synergistically to contribute to rice bran's functional food properties which make the biochemical composition of rice bran an attractive research platform to work with. This review article shade light upon the probabilities of multiple nutritional therapies and medical application from user prospective.

**Keywords:** Endosperm, Aleurone, Proximate analysis, Functional food

## INTRODUCTION

Rice is now grown in over hundred countries around the world and the global rice production is estimated to be 495.87 million tonnes of milled rice in 2018-2019. Asian countries produce most of the world's rice. India, being an important centre of rice cultivation is the second largest producer and leading exporter of rice with production and export of 115.6 million tonnes and 12,500 tonnes respectively in the year 2017-18. Climate change not only pushes





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farmers of different river basins to adopt new varieties of crops that can resist vagaries of weather but also compels agro-scientists to merge into research works to invent modified better varieties, specially of rice.

### Structure of the rice grain

The rough rice grain or paddy consists of an outer protective covering called the hull or husk and the rice caryopsis or fruit called brown or dehulled or dehusked rice (Juliano and Bechtel, 1985). The brown rice, on the other hand, consists of the outer layers (comprising the pericarp, seed-coat and nucellus), the germ or embryo and the endosperm. The endosperm consists of the aleurone layer and the endosperm proper. The endosperm proper consists of the sub aleurone layer and the starchy or inner endosperm. The aleurone layer encloses the embryo. The hull or husk constitutes about twenty percent of the rough rice weight. The brown rice weight is contributed by pericarp (one to two percent), aleurone plus nucellus and seed-coat (four to six percent), germ (one percent), scutellum (two percent) and endosperm (ninety to ninety one percent) (Juliano, 1972). The aleurone and embryo cells are rich in protein bodies, containing globoids or phytate bodies, and in lipid bodies (Tanaka *et al.*, 1973; Tanaka *et al.*, 1977). The endosperm cells are thin-walled and filled with amyloplasts containing compound starch granules.

### By-products of rice milling and their utilization potential

On milling, the rough rice produces rice, white rice, germ, bran, fine brokens and husk. Each of these components has unique properties and can be used in a number of ways. The utilization pattern of these components directly or as derivatives decides the extent of value addition in rice. There are many more ways in which the by-products of rice milling can be considered as value added products rather wastes. Different by products finds their use in different aspects such as rice husk/straw in paper industry, rice bran as animal feed, rice bran as functional food and nutraceutical, rice bran as source of enzymes. Rice bran is wealthy source of essential nutrients like carbohydrates, proteins, fats, dietary fibers and antioxidants like tocopherols, tocotrienols, phytosterols and oryzanol. The nutritional composition of rice bran confirms its potential for the development of food product. Premakumari *et al.* (2012) develop breakfast/dinner recipes by subbing cereals with microwave stabilized rice bran at completely different levels. The results revealed that the recipes with 25% incorporation of rice bran had a good acceptability in par with standard recipe. The studies on different types of bran revealed that the volume of bread and cookie spread decreased while muffin volume increased with the increase in bran levels (Sekhon *et al.*, 1997). The acid and dry heat stabilized rice bran was used by Younas *et al.* (2011) to prepare the highly nutritious cookies. They conclude that moisture, crude protein, fat and mineral contents, average width, thickness and spread factor of cookies increased with the increase in percentage of rice bran.

Defatted rice bran conjointly possesses distinctive function and biological process properties. Keeping in sight, the nutritional importance of defatted rice bran, Charunuch *et al.* (2014) made an attempt to prepare ready-to-eat breakfast cereals enhanced with defatted rice bran. Production of corn flakes and tortillas chips, by supplementation of gelatinized corn flour with rice bran from 10 to 30% was studied the viscosity and color quality was affected. The sensory parameters decreased while protein percentage was increased depending on the level of rice bran (Al-Okbi *et al.*, 2014). With the utilization of stable rice bran, a source of dietary fiber, frozen pizza was prepared by De delahaye *et al.* (2004).

### Chemical and nutritional aspects of rice bran

The outer layer of brown rice is bran which comprises the pericarp, seed-coat and nucellus. It also includes part of aleurone layer and the germ which get removed during the milling process. Rice bran contains one of the most nutritionally superior oil ranging from eighteen to twenty two percent (Cicero and Derosa, 2005) and serves as an excellent source of an array of nutrients (Moldenhauer *et al.*, 2003). Rice bran as a waste product of paddy milling contained protein, carbohydrate, dietary fiber, ash, fat, vitamin, mineral and natural antioxidant compounds (Chen *et al.*, 2008; Saenjum *et al.*, 2012). The minerals are mostly concentrated in the outer layers of brown rice or bran fraction. A major proportion of the phosphorus in bran is phytin phosphorus. Potassium and magnesium are also present as



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the principal salts of phytin. Out of the different minerals iron, phosphorous and potassium are more concentrated in the bran fraction while sodium and calcium are evenly distributed in both bran and milled rice (Resurrection *et al.*, 1979; Juliano, 1985). Rice bran oil (RBO) contains antioxidants like  $\gamma$ -oryzanol, tocopherol, tocotrienol and also has a good fatty acid profile for which RBO in the diet significantly reduces LDL cholesterol along with triglycerides, increases HDL cholesterol (good cholesterol), inhibits platelet aggregation and prevents cardiovascular diseases.

Rice bran, a by-product of milling constitutes nearly 7-8.5% of the entire grain. The bran consists of the pericarp, tegmen (the layer covering the endosperm), aleurone, and sub-aleurone (Houston, 1972). Rice bran consists of the pulverized outer layers of the rice kernel and the germ and accounts for 10% of the processed brown rice. The vast majority of nutrients are concentrated in the bran fraction which includes oil, essential fatty acids, proteins, fibers, vitamins, antioxidants and other micronutrients. Presently, rice bran is usually used as cost-effective ingredient for animal feed or as stuff for oil extraction (Orthofer, 2004). But there is an underestimated potential for high-value rice bran products for human nutrition. Researchers have been conducted to produce ingredients from rice bran that are rich in dietary fibers or proteins. Rice bran is the most nutritious part of rice and a good source of bioactive phytochemicals such as  $\gamma$ -oryzanol, tocopherols, and tocotrienols. These phytochemicals have health beneficial properties including antioxidant activity. In recent years, rice bran has been extensively studied for its antioxidative and disease-fighting properties. It is having the ability of lowering the risk of cancer and cholesterol formation (Rohrer and Siebenmorgen, 2004). Anti-inflammatory activity and inhibition cholesterol oxidation are other properties (Akihisa *et al.*, 2000; Xu *et al.*, 2001).

Rice bran is a rich source of oil, protein, fiber and micronutrients. Rice bran proteins have a high nutritional value and are hypoallergenic in nature. These proteins are rich in essential amino acids, especially lysine, hence can be used as an ingredient in food formulations (Fabian and Ju, 2011). Rice bran additionally contains an array of nutraceutical compounds. Ubiquinone-10 is present in rice bran and may provide protective benefits of antioxidant. Epidemiological and biochemical evidence supports the idea that ubiquinol-10 (CoQ10H2) an important cellular antioxidant, inhibits lipid peroxidation as well as regenerates other antioxidants such as  $\alpha$ -tocopherol (Sunesen *et al.*, 2001). The presence of  $\gamma$ -oryzanol and plant sterols attribute to the hypocholesterolemic activity of rice bran (Sheetharamaiah and Chandrasekhara, 1988). Tocotrienols present in rice bran inhibit  $\beta$ -hydroxy  $\beta$ -methyl glutaryl-CoA (HMG CoA) reductase activity which is the rate-limiting enzyme for cholesterol synthesis (Qureshi *et al.*, 2000). Rice bran is rich in nutrients and has a protein content of 14%-16%. The comparatively high nutritional price of rice bran protein is attributable to the high essential amino acid content. The reported protein efficiency ratio (PER) 1.6-1.9, is comparable with the value of 2.5 for casein (Saunders, 1990). Major carbohydrates in rice bran are hemicellulose (8.7%-11.4%), cellulose (9%-12.8%), starch (5%-15%), and  $\beta$ -glucan (1%). Rice bran contains 15%-23% oil. Three major fatty acids, palmitic (12%-18%), oleic (40%-50%), and linoleic (30%-35%), make up 90% of total fatty acids.

Crude rice bran oil contains 3-4% waxes and about 4% unsaponifiable lipids. Oryzanol and tocopherol, the two potent antioxidants are present in rice bran (Saunders, 1985). Rice bran is also rich in B-complex vitamins. The mineral composition of rice bran depends to a large extent on nutrient convenience of the soil within which the crop mature. Rice bran contains Ash (6.72-11.41%), Fe (8.6-43mg/100g), Ca (30-120 mg/100g), Na (13-20 mg/100g), K (1000-2000 mg/100g), P (1100-2500 mg/100g) and zinc (4.6-6.6 mg/100g) (Houston, 1972). Bran contains 80% of rice kernel iron (Lu and Luh, 1991). Bioactive compounds of rice bran include phenolic and cinnamic acids (Laokuldilok *et al.*, 2011), anthocyanins, flavonoids (Jun *et al.*, 2012), steroidal compounds (Miller and Engel, 2006), polymeric carbohydrates (Rondanelli *et al.*, 2011) and proteins (Prakash, 1996). A rice bran protein formulation can provide nourishment to preschoolers (Khan *et al.*, 2011). The protein with a caloric value of 416 kcal/100g and a digestibility of 80.9-84.45% had good acceptability during a short-term infant-feeding trial. These findings suggest that inexpensive rice bran proteins could contribute to food security. Because rice bran is a rich source of dietary fiber and minerals, the effect of incorporation of three levels (5, 10, and 15%) of commercial defatted rice bran on bread quality was examined by Sairam *et al.* (2011). Dietary fiber content, antioxidative activity and shelf life increased with





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increase bran levels. These results suggest that rice bran can serve as a functional ingredient for high-fiber breads with improved antioxidant potential and storage stability.

### Functional properties of rice bran

Rice bran is faint in color, sweet in taste, moderately oily and encompasses a slightly cooked nutty flavor (Tao, 1989). Texture varies from a fine, powder-like consistency to a flake. In addition to flavour, colour, and nutritional properties (protein extractability and solubility), other properties such as water and fat absorption, emulsifying and foaming capacity are important factors determining the potential use of rice bran in food. Stabilized rice bran is a rich source of both soluble and insoluble dietary fiber (25-35%). Insoluble fiber functions as a bulking agent, whereas soluble fiber lowers steroid alcohol (Wise, 1989). Soluble fiber might hamper texture, jelling, thickening, and emulsifying properties (Olson *et al.*, 1987). Additional insoluble fiber in rice bran leads to sensible water-binding capability. According to James and Sloan (1984), the defatted extruded rice bran absorbs most of the water and fat. It has greater foaming capacity and stability compared to wheat bran in model systems. In baked product, the high water-binding capability of rice bran helps maintain wetness and freshness.

Rice by-products might serve as important sources of raw material that could be used as ingredients of functional food and nutraceuticals. Texture of rice bran varied from a fine, powder-like consistency to a flake, depending on the polishing and stabilization process. High fat absorption capability in extruded rice bran would be fascinating in product like meat extenders to assist maintain succulence and improve mouthfeel. The full fat extruded rice bran with less fat permeability could be best for foods like donuts and pancakes that are baked in fat and for which absorption of fat isn't desirable (James and Sloan, 1984). Rice bran protein concentrate has shown sensible emulsifying activity, stability, and capacity. The foaming capability aids in air incorporation, leavening, and texturization in baked products, meringues, and whipped toppings. Extruded defatted rice bran with 115.5% foaming value could be the best bran for achieving the above functions in food systems (James and Sloan, 1984). A high level (20%) of rice bran in bakery product affects overall look, volume, taste, and structure.

### Phytochemicals and antioxidant activity of rice bran

All phytochemical mixes for the most part amass in the pericarp and testa or bran of the rice seed. One advantage of rice bran was that it was a wellspring of bioactive phenolics. These phenolic mixes have intense antioxidant and free radical scavenging properties, which avoid incessant illnesses, for example, malignant growth, diabetes, heftiness and cardiovascular maladies (Okarter and Liu, 2010). Madhujith and Shahidi (2009) observed that there were higher measures of solvent conjugate than free phenolics in grain. Moreover, dissolvable conjugate phenolics, once discharged from ingested nourishment by microscopic organisms in the microbiota, may assume a basic job in conveying antioxidants to the colon in a way like bound phenolics. Rice bran was utilized as a waste result of paddy processing contained protein, sugar, dietary fiber, fiery debris, fat, nutrient, mineral and characteristic antioxidant mixes (Chen *et al.*, 2008; Saenjum *et al.*, 2012). They revealed that rice bran likewise contained phytochemical mixes in critical sum and these mixes had been considered as common antioxidant.

The antioxidant movement for settled rice bran was 65µg/g of vitamine-C equivalent. Moko *et al.* (2014) revealed that DPPH hindrance percent was extended from 51.02-73.8. Canan *et al.* (2012) revealed that rice bran contained 6.4 mg/100g of phytate P. Chotimarkorn *et al.* (2008) observed that methanolic rice bran separates delivered solid outcomes with DPPH free radical scavenging 38-74%. The better action of methanol extract, might be clarified by the likelihood of progressively polar phenolic mixes and lipids eluted in the methanol than in the ethyl acetic acid derivation extricate. All phytochemical mixes would collect in the pericarp and testa or bran of the rice bit. Among rice assortments there were rice assortments that contained shading colors. These mixes were shade containing identified with particular hues, for example, red, purple and dark. Antioxidant activities of paddy assortments containing shading colors, for example, red Thai, dark rice, red darker and dim purple had been seriously examined by Yodmanee *et al.* (2011). They revealed that rice with non shading colors contained lower phenolic substance and



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antioxidant action. Numerous investigations have revealed that dark rice contained anthocyanin and other polyphenolic mixes more bounteously than white rice (Ryu *et al.*, 1998; Zhang *et al.*, 2006).

The convergences of lipophilic antioxidants of vitamin E (tocopherol and tocotrienols) and  $\gamma$ -oryzanols were 319.67 to 443.73 and 3861.93 to 5911.12 $\mu$ g/g respectively on dry weight (DW) basis, and were not related with bran shading. The complete phenolic, absolute flavonoid, and antioxidant limits of ORAC (oxygen radical absorbance limit), DPPH (1, 2-diphenyl-1-picrylhydrazyl) radical searching, and iron-chelating in the free division were connected with the force of bran shading, while varieties of these in the bound portion were not exactly those in the free part among bran. Mixes in the bound portion had higher antioxidant limit of ORAC than DPPH, in respect to those in the free part. The bound portion of light-shading brans contributed as a lot to its complete ORAC as the free part. All out proanthocyanidin fixation was the most elevated in red rice bran, while complete anthocyanin was most astounding in purple brans. The dominating anthocyanin was cyanidin-3-glucoside. Red and purple bran had a few crease higher complete phenolics and flavonoids just as ORAC and DPPH, from both free and bound portions, than stop dried blueberry and broccoli. Their outcomes show that rice bran were normal wellsprings of hydrophilic and lipophilic phytochemicals for use in quality control of different nourishment frameworks just as for nutraceutical and practical sustenance application.

Rice bran had been perceived as an amazing source of vitamins and minerals, yet had been under-used as human sustenance and had customarily been utilized essentially in creature sustains. Research led over the most recent two decades had demonstrated that it contained an exceptional complex of normally happening antioxidant mixes (Moldenhauer *et al.*, 2003). Past research about antioxidant properties in shaded rice bran showed that rice bran with certain shading that contained anthocyanin had a reductase catalyst inhibitory and hostile to diabetic action (Kim *et al.*, 2008; Park *et al.*, 2008). Further investigations detailed that dim purple rice assortment had higher iron, polyphenol and antioxidant properties than the red rice assortment, while red rice contains higher phenolic mixes. It had additionally been accounted for that dark rice had a searching exercises higher than red rice assortment, while non shaded rice had phenolic substance and antioxidant activity which were lower than the hued rice assortment (Muntana and Prasong, 2010; Yodmanee *et al.*, 2011).

### Health benefits and anti-nutritional factors of rice bran:

Nutritional studies in animals and humans have shown a cholesterol lowering potential for rice bran and rice bran fractions (Newman *et al.*, 1992; Hegsted *et al.*, 1993). Among compounds whose hypocholesterolemic activity has been demonstrated in animal and/or human subjects are rice waxes, oryzanols (ferulic acid esters of triterpene alcohols), hemicelluloses, neutral-detergent fiber fractions, proteins, and oil components (Saunders, 1990). Diets high in unsaturated fatty acids such as oleic, linoleic, and linolenic acid, which are present in rice bran oil, lowered LDL-cholesterol when replacing saturated fat (McDonald *et al.*, 1989). Rice bran extracts inhibited the growth of the following bacteria isolated from patients suffering diarrheal disease: *Vibrio cholerae*, *Vibrio vulnificus*, *Salmonella spp.*, *Shigella spp.*, *Escherichia coli*, and *Staphylococcus aureus* (Kondo *et al.*, 2011). The nutritional composition of rice bran shows the presence of several compounds which possesses significant anti-oxidant activity to prevent chronic diseases. The incorporation of dietary fiber into the functional food have reported to decrease the risk of coronary heart disease, reduction of blood cholesterol levels and improvement of insulin sensitivity (Mellen *et al.*, 2008). The oryzanol component acts as protective agent against UV light and is used in cosmetics as sunscreen agent. The ferulic acid esters of gamma oryzanol act as anti-ageing compounds as they stimulate hair growth. Rice bran also prevents high blood pressure, hyperlipidemia and hyperglycemia. Both Type I and Type II Diabetes Mellitus also controlled by nutraceuticals developed from fiber fraction of rice bran (Qureshi *et al.*, 2002). Food supplemented with rice bran also lead to reduced bone loss in women suffering from postmenopausal osteoporosis (Heli and Shanna, 2005).

Cereal brans have not been used to their maximum capacity as a sustenance source because of the presence of antinutritional factors out of which the phytic acid, phenol and tannins fill in as the real constituents that limit the immediate usage of brans in the eating regimen. Rice bran has the higher phytic acid substance than other cereal





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bran. Phytic acid (PA) is a viable chelator of numerous basic mineral supplements, for example, iron, zinc, and calcium which comprises around one to five percent of the dry matter of numerous cereals and eatable vegetables thus consequently presenting genuine negative effects on the usage of mineral supplements and lead to ailment health in people (Jacobsen and Slotfeldt-Ellingsen, 1983). Rice bran is wealthy in lipids and serious lipase movement within the sight of endogenous lipoxygenase causes quick crumbling of these lipids by rancification (Pauca-Menacho *et al.*, 2007). Due to lipid susceptibility, the commercial utilization of rice bran requires enzymatic inactivation following bran division to maintain a strategic distance from unsaturated fat, expand its timeframe of realistic usability and permit its commercialization for human utilization. Rice bran oil has a few one of a kind healthful properties. Be that as it may, just a little division of this profitable oil is utilized for palatable oil generation. The principal reason is that the oil is exposed to rice bran lipase catalyst after rice processing which causes rapid hydrolysis of the triglyceride of oil into glycerol and free unsaturated fats. These free unsaturated fats become substrates of lipoxygenase and result in deterioration of rice bran oil quality. All the more explicitly, the subsequent unsaturated fats cause an increase in bran acidity and decrease in pH.

### Food use of rice bran

Luh and Liu (1980) revealed that rice bran was exceedingly nutritious and consequently utilized as a nourishing substance. Hossain *et al.* (2012) examined on nutritive estimation of polished rice and revealed that in most of the nations, out of all the harvest deposits, this was one of the least expensive and biggest source of metabolizable energy with as much as crude protein. Rice bran supplementation essentially improved the dietary fiber, mineral and protein substance of the treats. Besides, cost of generation was additionally decreased with proportionate increment of supplementation. As of late, the utilization of rice bran is picking up significance in numerous studies because of the way that, amid the preparing of entire rice, a lot of the grain's external layers are expelled, raising the centralization of supplements in the bran and rendering it a vital source of supplements for the nourishment purpose and human utilization (Imsanguan *et al.*, 2008; Parrado *et al.*, 2006).

### CONCLUSION

Rice bran obtained during milling of rice is getting commercial importance in the world due to the fact that it contains nutritionally superior oil and a number of health beneficial compounds. Despite of the massive scientific proof on rice bran bioactivity, it still remains underutilized in human health and nutrition as a result of its thought of as animal feed and is understood to undergo hydrolytic rancidity after processing from whole grain rice. GC-MS, UPLC-MS/MS (ultra-performance liquid chromatography-tandem mass spectroscopy) and metabolomics analysis of rice bran revealed a huge number of metabolites that were clustered into several metabolic pathways including amino acids, carbohydrates, cofactors, vitamins, lipids, nucleotides, peptides, secondary metabolites, xenobiotics etc. Although rice bran is a good nutritional food source, rapid rancidity from the activity of enzymes such as lipase and lipoxygenase deteriorate the nutritional values in rice bran and limits the wide usage of rice bran as a food ingredient. The effective utilization of rice bran is possible only by deactivating the lipolytic enzymes such as lipase, lipoxygenase responsible for the hydrolytic rancidity since this phenomenon severely affects the nutritive value and palatability of rice. This problem creates a future line of work to look forward to for getting maximum benefits out of the milling by-product of rice.

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## Rainfall Runoff Analysis by Advanced Hydrological System and Artificial Neural Network

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### ABSTRACT

The main objective of the present study is to conduct laboratory experiment for the generation of rainfall runoff data using rainfall simulator (Advanced hydrological System). AHS is embedded with Armsoft Educational Software S12MKII-306 hydrological systems. A graphical record of flow and time resulting from rainfall over catchment is called a hydrograph. The sand tank should be set to different slope of maximum 3.5% and minimum 1.5 % before carrying the test. For the validation of observed data, a model is established for estimating observed runoff data using Artificial Neural Network (ANN) technique. The ANN model for the runoff discharge evaluation was developed using MATLAB Software. The MATLAB tool used for the creation of ANN model is Neural Networks tool. ANN model behaviour during training, testing, validation gave a good comparison with overall R value 0.98. Error in observed and predicted volume were found as 6.66 % and 7.89 % respectively at 3.5 % and 2.5 % slope whereas error in peak discharge were estimated as 7.40 and 3.07 respectively at 3.5 % and 2.5 % slope. Nash-Sutcliffe Efficiency was calculated as 91.3 % and 92 % respectively at 3.5 % and 2.5 % slope.

**Keywords:** Rainfall simulator, ANN, MATLAB, Hydrograph, Nash-Sutcliffe efficiency

### INTRODUCTION

Rainfall-runoff models are conventionally assigned to one of three broad categories :*deterministic* (physical), *conceptual* and *parametric* (also known as analytic or empirical)[1] [2] which plays a vital role in the hydrological cycle. A number of models i.e. Artificial Neural Networks (ANNs), physically based, black box and conceptual models have been used to simulate the complex hydrological processes such as rainfall runoff process which shown a useful



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tool in water resources. However, due to its complexity and spatio-temporal variation, a few models can accurately simulate this highly non-linear process. Incomplete, noisy and ambiguous data can be handled theoretically by ANN [3]. Neural network research has evolved in three distinct phases [4]. ANNs are often cheaper and simpler to implement than their physically based counterparts [5]. They are also well suited to dynamic problems and are parsimonious in terms of information storage within the trained model [6]. An ANN is a massively parallel-distributed information processing system that has certain performance characteristics resembling biological neural networks of the human brain [7].

Distributed models can be considered as an assemblage of sub catchments arranged either in series or as a branched network [8]. ANNs have been developed as a generalization of mathematical models of human cognition or neural biology. Their development is based on 1. Information processing occurs at many single elements called nodes, also referred to as units, cells, or neurons. 2. Signals are passed between nodes through connection links. 3. Each connection link has an associated weight that represents its connection strength. 4. Each node typically applies a nonlinear transformation called an activation function to its net input to determine its output signal. A neural network is characterized by its architecture that represents the pattern of connection between nodes, its method of determining the connection weights, and the activation function. The application of ANNs in many fields, including financial management, manufacturing, control systems, design, environmental science and pattern recognition for geographical and hydrological study [9] [10]. Extraction of hydrological rules from ANN weights and on the development of standard performance measures that penalize unnecessary model complexity [11]. Data cleansing techniques have not been widely applied in ANN rainfall-runoff modelling, so there is much scope for development in this area [3].

Advanced Hydrologic System (AHS) enables to demonstrate the physical processes found in hydrology, including rainfall-runoff process; well abstractions, formation of river features. Realistic results can be obtained from this small-scale apparatus, which can be conveniently located in a laboratory and requires no special services. Thus, the apparatus is useful to study the part of hydrological cycle bounded by the arrival of net rainfall on ground surface and catchment runoff either by surface streams or well abstraction. AHS is embedded with Armsoft Educational Software S12MKII-306 hydrological systems. The software is split into three parts to suit the different exercises associated with S12-MKII. Part 1 of this software is used to determine the Sand Factor (voidage) of the sand used in the sand tank. Part 2 of the software is used for continuous logging of the Outflow from the collecting tank and any change in mass, allowing rainfall hydrographs, sediment yield etc. to be monitored continuously throughout an exercise. Part 3 of the software is used for manual entry of results obtained from the bank of manometer tubes allowing water table profiles, draw-down at wells etc to be recorded and graphically presented. The software also allows all relevant settings to be manually entered for future reference. Zeroing the Height Over Weir reading, Zeroing the Mass reading and rainfall intensity pattern can be set as per requirement. In the present investigation, the simulated rainfall intensity pattern is used having different pattern of rainfall intensity. For each value of rainfall intensity different overland plane slopes of 1% to 4% were used. MATLAB software is used to test and validate the results through ANN. The objective of the study is to identify single storm runoff hydrograph at different bed slopes and rainfall intensity. Study also validate results using ANN with MATLAB software and further validated by Nash- Sutcliffe Criteria.

## MATERIALS AND METHODS

The present study has been carried out with the help of Advanced Hydrological system (Fig.1). This system is sensor based which shows runoff, sediment yield, volume of discharge with respect of change in bed slope, rainfall intensity, river flow in graphical or tabular forms. The system is based on the concept of watershed which has a single drainage outlet. This also consist confined and unconfined aquifer concept. In the present study, focus is on to find out runoff discharge and volume with changing slope and rainfall intensity. Tamilnadu sand without vegetation has





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been used for the purpose of quick discharge. The time taken for the water to reach the point of concentration depends on the horizontal distance it has to travel and also on the velocity. The greatest time taken for rain falling on the catchment (the far corners) is called time of concentration. A graphical record of flow and time resulting from rainfall over catchment is called a hydrograph. The sand tank should be set to different slope of maximum 3.5% and minimum 1.5 % before carrying the test. Smooth the sand in the tank to give a smooth surface parallel to the top edge of the tank, then use the sand scoop to create a channel of rectangular cross section centrally down the length of the tank between the river inlet and the deep outlet at the foot. The channel should be approximately 4 cm wide and 2 cm deep. Connect the flexible piping from the overhead spray nozzles to the quick release connector on the 3 l/min flow meter. As per the guidelines of Armfield AHS for stream flow for a short duration storm (Fig.3) and stream flow from a long duration storm (Fig.4). Spray nozzles are turned on to simulate rainfall and select a rainfall flow rate of between 1 and 3 l/min. Rainfall is allowed long enough to give a steady runoff value. Flow is turned off and recession limb of hydrograph is recorded. Stopwatch is started (zero time) at commencement of rainfall and weir discharge is read as frequently as necessary to show the hydrograph form. This is also done for same catchment of short duration with slope.

Hydrograph peak discharge in short Duration high intensity is increased for short time because of less time of concentration. While in the case of high duration low intensity rainfall as the time proceed because of high time of concentration it will account for infiltration losses. It is clearly showing that discharge of any catchment depends up on slope of catchment as well as duration and intensity of rainfall. Hydrographs for various rainfall intensity with various slopes collected using AHS are shown in Fig. 5, 6 and 7. The ANN model for the runoff discharge evaluation was developed using MATLAB R2012b software. The MATLAB tool used for the creation of ANN model is nntool (neural networks tool). We collected some data for runoff discharge at the laboratory using advanced hydrological systems. These recorded data were taken for model development using various input variables (slope, rainfall intensity, rainfall duration) and output runoff discharge, the data base used for the ANN model generation.

The behaviour of model during training, testing and validating which shows its capability to predict the process input output relation. As much as the correlation coefficient value (R) is higher, better the model will predict [11]. The training process of ANN was terminated when the overall error on the testing data set was minimal. The main function of training process is to reach an optimal solution based on some performance measurements such as overall error; coefficient of determination known as R value. The validation sets are usually used to select the best performing network model. In this project ANN was the optimal at 100 iterations with 7 hidden nodes. It was found that training and validation phases gives the good agreement with the coefficient of determination value as shown in figure below. Note that the data pairs closer to the diagonal line (also known as the line of agreement) in model behaviour plot gives excellent prediction. The Nash-Sutcliffe efficiency criteria is used to estimate the model performance which can be expressed by the following equation (1);

Nash-Sutcliffe Efficiency (NES) in (%),

$$NES = \left( 1 - \frac{\sum_{i=1}^n (Y_o - Y_c)^2}{\sum_{i=1}^n (Y_o - Y_m)^2} \right) \times 100$$

..... equation (1)

Where,  $Y_o$  = Observed flow (Experimental rainfall flow) value at time t,

$Y_c$  = Predicted flow (kinematic flow) value at time t,

$Y_m$  = Mean of observed values.

Error in Computational Runoff Volume:

The error in runoff volume for the present study was estimated by equation (2)





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$$\text{Volumetric error, in \%} = \left( 1 - \frac{Y_c}{Y_o} \right) \times 100$$

..... equation (2)

Where,  $Y_o$  = Runoff volume observed and  $Y_c$  = Runoff volume predicted

## RESULTS AND DISCUSSION

Each experiment has been done 10 times and average value has been taken into consideration. Hydrograph resulting from short duration of 10 minute with high intensity rainfall of 3 litre per minute at 3.5 % bed slope showed a runoff volume, runoff depth and discharge with sand factor (voidage) 0.610 kg as 23 l, 11.5 mm and 3.06 l/min respectively. Similarly, hydrograph resulting from long duration of 30 minute with low intensity rainfall of 3 litre per minute at 3.5 % bed slope showed a runoff volume, runoff depth and discharge with sand factor (voidage) 0.610 kg as 15 l, 7.5 mm and 0.54 l/min respectively. Hydrograph resulting from short duration with high intensity rainfall showed a higher peak discharge value at 20 minute elapsed time while long duration with low intensity rainfall showed at lower peak discharge at 32 minute elapsed time. Hydrographs are also shown in Fig.5,6 and 7 which has been taken at different slopes with same rainfall intensity showed peak discharges as 2.52, 2.56 and 2.64 lit/min respectively at 1.5 %, 2.5 % and 3.5 % bed slope respectively. Thus, it is revealed that peak discharge changes with varying slopes.

Observed hydrographs by AHS at 3.5 % slope with rainfall intensity 1.5 litre per minute has been compared with predicted hydrographs by MATLAB incorporated in ANN with same slope and rainfall intensity. The observed and predicted hydrographs showed closer resemblance at 3.5 % and 2.5 % slope. The predicted hydrographs using ANN model showed that the model performed better estimation with observed runoff data which is also useful for decision making in the area of water resources management and planning, flood forecasting etc. The comparison of observed and predicted runoff hydrograph using ANN model. ANN model behaviour during training, testing, validation gave a good comparison with overall R value 0.98. Pertinent characteristics of observed and predicted hydrographs for 1.5 lit/min rainfall intensity has been shown in Table 1: Error in observed and predicted volume were found as 6.66 % and 7.89 % respectively at 3.5 % and 2.5 % slope whereas error in peak discharge were estimated as 7.40 and 3.07 respectively at 3.5 % and 2.5 % slope. Nash-Sutcliffe Efficiency was calculated as 91.3 % and 92 % respectively at 3.5 % and 2.5 % slope.

## CONCLUSIONS

The validation of collected data sets were analysed and found that the ANN model estimate in better way to model rainfall runoff process. ANN technique is useful to handle the complex problems as compared to other techniques. Further, the results illustrated clearly ANN is capable to simulate rainfall runoff relationship which might help in confirming the general enhancement archived in other fields of hydrology. In addition, results and comparative analysis indicate that ANN is more suitable to predict river runoff of a catchment than other classical regression model. Modelling can assist in rural and urban planner to undertake the necessary measures to deal with the river bed predictions. Hence, it can help to avoid losses due to ecological hazards.

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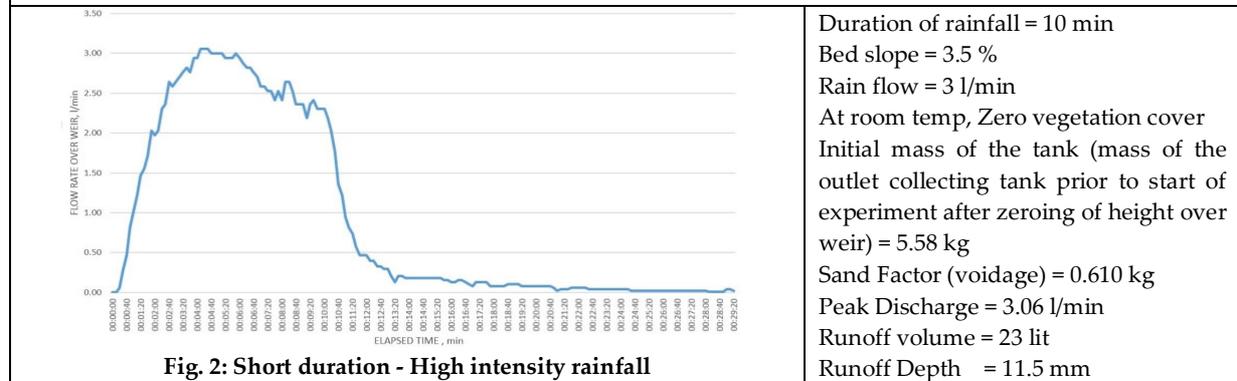
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**Table 1: Appropriate characteristics of observed and predicted data**

Sl.No	Slope (%)	Observed volume (litre)	Predicted volume (litre)	Error (%)	Observed time to peak (sec)	Predicted time to peak (sec)	Error (%)	NSE (%)
1	3.5	75	70	6.66	1080	1000	7.40	91.3
2	2.5	76	70	7.89	650	630	3.07	92



**Fig.1: Armfield Advanced Hydrological System (AHS)**



**Fig. 2: Short duration - High intensity rainfall**

Duration of rainfall = 10 min  
 Bed slope = 3.5 %  
 Rain flow = 3 l/min  
 At room temp, Zero vegetation cover  
 Initial mass of the tank (mass of the outlet collecting tank prior to start of experiment after zeroing of height over weir) = 5.58 kg  
 Sand Factor (voidage) = 0.610 kg  
 Peak Discharge = 3.06 l/min  
 Runoff volume = 23 lit  
 Runoff Depth = 11.5 mm





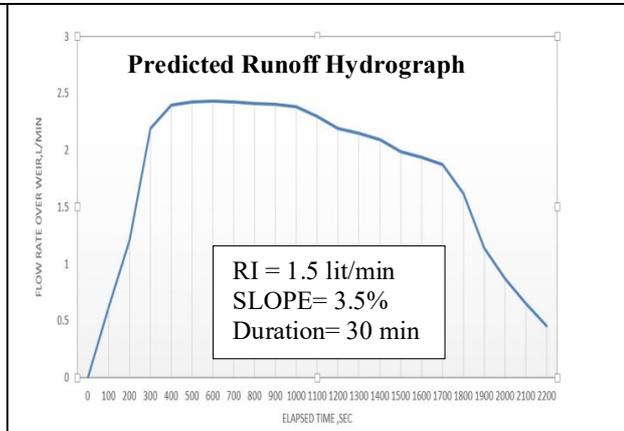
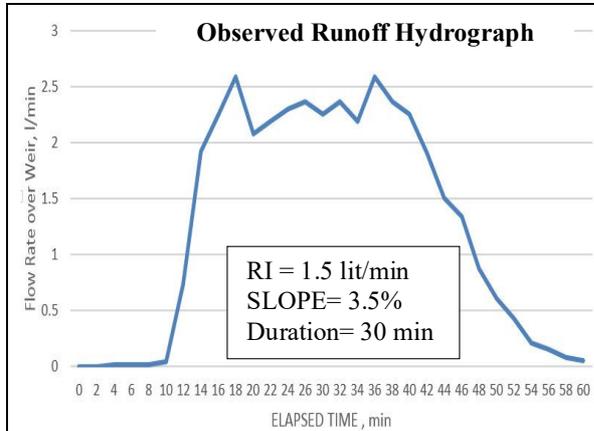
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<p style="text-align: center;"><b>Fig.3: High Duration – low intensity rainfall</b></p>	<p>Duration of rainfall = 30 min                  Bed slope = 3.5 %                  Rain flow = 1.5 l/min                  At room temp, Zero vegetation cover                  Initial mass of the tank (mass of the outlet collecting tank prior to start of experiment after zeroing of height over weir)= 5.8 kg Sand Factor (voidage) = 0.610 kg                  Peak Discharge = 0.54 l/min                  Runoff Volume = 15 lit                  Runoff Depth = 7.5 mm</p>
<p style="text-align: center;"><b>Fig.4: Hydrograph for 1.5lit/min Rainfall with slope 1.5 %</b></p>	<p>Duration of Rainfall= 30 min                  Rainfall Intensity=1.5 lit/min                  Bed Slope=1.5 %                  Zero Vegetation cover and at room temperature                  Initial Mass of the tank=5.54 kg                  Peak Flow=2.52 lit/min                  Runoff Volume=75 lit</p>
<p style="text-align: center;"><b>Fig. 5: Hydrograph for 1.5 lit/min Rainfall with 2.5 % Slope</b></p>	<p>Rainfall Intensity=1.5 l/min                  Bed Slope=2.5 %                  Initial Mass of the tank=6.25 kg                  Zero vegetation cover                  at room temperature                  Peak Flow=2.64 l/min                  Runoff Volume=76 l</p>
<p style="text-align: center;"><b>Fig.6: Hydrograph for 1.5lit/min Rainfall with 3.5 % Slope</b></p>	<p>Rainfall Intensity = 1.5 l/min                  Bed slope=3.5 %                  Rainfall Duration=30 min                  Initial Mass of the tank=5.63 kg                  Zero vegetation cover                  at room temperature                  Peak Flow=2.56 l/min                  Runoff Volume=75 l</p>



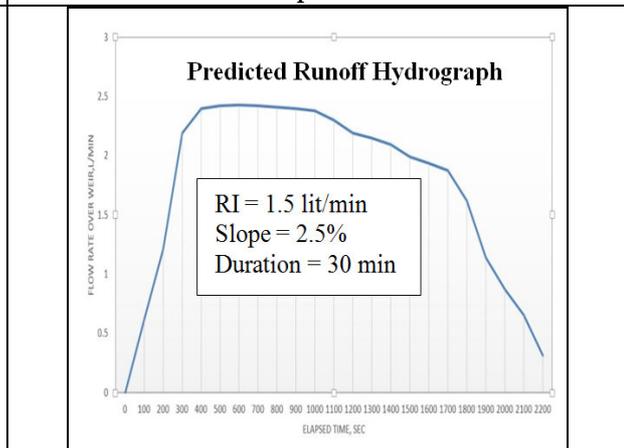
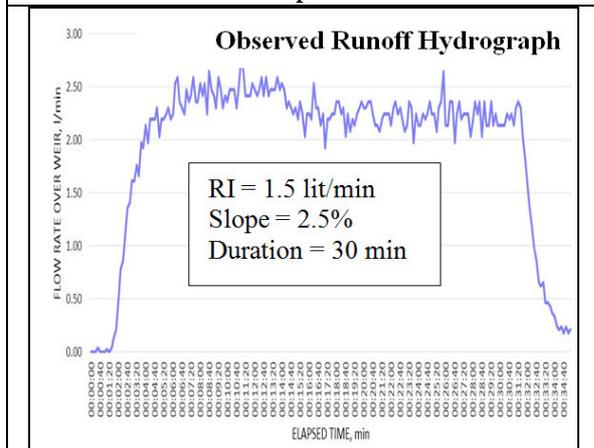


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**Fig.7: Observed runoff hydrograph for 1.5lit/min rainfall with 3.5% bed slope**

**Fig.8: Predicted runoff hydrograph for 1.5lit/min rainfall with 3.5% bed slope**



**Fig. 9: Observed runoff hydrograph for 1.5lit/min rainfall with 2.5% bed slope**

**Fig. 10: Predicted runoff hydrograph for 1.5 lit/min rainfall with 2.5% bed slope**





## Caspase Dependent Rapid Cell Death in *Bordetella bronchiseptica*

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### ABSTRACT

*Bordetella bronchiseptica* is a small, Gram-negative, rod-shaped bacterium known to cause infectious bronchitis in dogs and other animals, but rarely infects humans. Results of the present study showed that *Bordetella* was found to exhibit a nutrition stress-related postexponential rapid cell death (RCD). The RCD in this bacterium is accompanied by typical markers of eukaryotic apoptosis such as loss of cell viability in the post-exponential phase, enhanced biosynthesis of caspase-3 like protein. The affinity purified fraction cross reacted with human caspase-3 polyclonal antibody.

**Keywords:** eukaryotic, cell death, animals, infectious, antibody.

## INTRODUCTION

In eukaryotes, programmed cell death (PCD) is a genetically regulated self destruction process for the elimination of damaged or unwanted cells. It plays an important role in the development and maintenance of the integrity of organisms. Cells undergoing PCD exhibit a number of biochemical, physiological, and morphological features [1, 2]. Similarly to eukaryotes, PCD in bacteria is a complex and regulated process that is essential for bacterial communities' survival, differentiation, and spreading. The similarities observed between cell death systems of animals, plants, and bacteria suggests endosymbiotic acquisition of bacteria by eukaryotes [3, 4, 5]. PCD in a cell is induced by a certain signal(s). The end point of the signaling activity is the induction and activation of caspases (cysteine-specific proteases), the proteases that finally execute PCD [1, 2]. Several investigators have reported the occurrence of PCD in bacteria regulated by chromosomal and extrachromosomal toxin-antitoxin pairs of molecules. In *Escherichia coli*, such chromosomal toxin-antitoxin systems include *mazEF*, *chpBIK*, *relBE*, *yefM-yoeB*, and *dinJ-yafQ* [3, 4, 5, 6]. Earlier studies in *Xanthomonas campestris* pv. *glycines* (Xcg), a plant pathogen and the etiological agent of bacterial pustule disease of soybean (*Glycine max*), was found to exhibit a nutritional stress-related postexponential rapid cell death (RCD). The RCD in *Xanthomonas campestris* pv. *glycines* was found to display certain



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molecular features similar to those of the programmed cell death (PCD) of eukaryotes such as increased cellular reactive oxygen species levels, externalization of phosphatidyl serine, Biosynthesis of catalytically active caspase-like protein in the mid-log phase cultures. . The amino acids glycine and L-alanine as well as the D isomers of valine, methionine, and threonine were found to induce the synthesis of an active caspase-3-like protein that was associated with the onset of RCD. Addition of pyruvate and citrate to the culture medium induced both the synthesis of active caspase-3-like protein and RCD [7]. Computational analysis of the already sequenced genomes revealed that the apoptosis-related domains in bacteria typically form complex multi-domain architectures. These multi-domain proteins contain fusions between apoptosis-related domains, such as apoptotic ATPases fused with a metacaspase or a tollinterleukin-receptor (TIR) domain [8, 9]. Consistent with this bacterial caspase was found to interact functionally and physically with poly(ADP-ribose) like protein (PARP) like protein in the observed modulation of genetically programmed RCD [10]. Purification and further characterization of caspases to electrophoretic homogeneity from *xanthomonas* is challenging due to exopolysaccharide Xanthan that promotes protein aggregation in cell free systems. The present study was undertaken to search for a new bacterial species that undergo post exponential RCD akin to Xcg and eventual purification and characterization of this novel and uncharacterized cell death protein called caspase. *Bordetella bronchiseptica* is a small, Gram-negative, rod-shaped bacterium of the genus *Bordetella*. It can cause infectious bronchitis in dogs and other animals, but rarely infects humans [11, 12]. Based on genome serach *Bordetella* was found to have caspase-like domain and found to exhibit post exponential RCD similar to Xcg with the synthesis of catalytically active caspase-3 like protein that cross reacts with human caspase-3 antibody. This 80± 2 kDa in vivo affinity purified protein lost a majority of its activity.

**MATERIALS AND METHODS****Media and culture conditions**

Inoculation was carried out by the addition of a single isolated colony of *Bordetella* to the Luria-Bertani (LB) medium and was incubated for 24 h on a rotary shaker (150 rpm) at ambient temperature (26±2 °C). The 24 h grown culture was incubated further under static conditions at the ambient temperature, in order to observe PCD. For viable cell counts aliquots of the culture broth were withdrawn and serially diluted using sterile saline (0.85%) and transferred to LB-agar using spread plate technique. Plates were incubated at ambient temperature for 72 h. Viable cell counts were obtained at the end of the incubation period by counting colonies. To induce RCD, metabolites such as alanine (Ala), pyruvate (Pyr) and citrate (Cit) were added to the LB medium at the start of incubation in 100mM, 100 mm and 50 mM respectively

**Caspase-3 assay**

A single colony of *Bordetella* was transferred to 10 ml of medium and incubated overnight (~18 h) on a rotary shaker (150 rpm) at ambient temperature. A one ml (~10<sup>8</sup> cfu/ml) aliquot of the culture was centrifuged at 10,000 g for 10 min. The pellet was washed once with phosphate buffered saline (PBS, 10 mM, pH 7.4), suspended in 500 µl of caspase assay buffer [HEPES (20 mM, pH 7.6), NaCl (100 mM), CHAPS (0.1%), DTT (10 mM), EDTA (100 µM), and glycerol (10%)] [7, 10], and the cells lysed by freeze-thaw (freezing under liquid nitrogen and thawed at 37 °C) followed by sonication on ice for 15 s. Protein equivalent to 25 µg was mixed with 200 µM of synthetic colorimetric substrate, Ac-DEVD-pNA [N-acetyl-Asp-Glu-Val-Asp-pNitroanilide], prepared in dimethyl sulfoxide (DMSO) as 10 mM stock and incubated at 37 °C for 30 min in 1 ml caspase assay buffer. After incubation the absorbance at 405 nm was measured using a spectrophotometer. The protein concentration was determined by the standard Bradford method [13].

**SDS-PAGE**

Overnight grown *Bordetella* cells were harvested by centrifuging at 10,000 g for 10 min, the pellet washed twice with phosphate buffered saline (PBS, 10 mM, pH 7.5) and suspended in sterile milli-Q water. The cell suspension was mixed with an equal volume of 2X gel loading buffer [Tris (100 mM pH 6.8), SDS (4%), glycerol (20%), bromophenol



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blue (0.002%), and  $\beta$ -mercaptoethanol (200 mM)]. The mixture was heated at 95 °C for 10 min, immediately chilled on ice for 5 min, and centrifuged at 12,000 g for 10 min. A 50  $\mu$ l aliquot of the supernatant was loaded on 10% (w/v) SDS-polyacrylamide slab gel, which was run vertically at 35 mA constant current on a PAGE system (Techno Source, India).

**Silver staining of SDS PAGE**

The gel was left overnight in the fixative solution, removed and washed thrice in 100 ml of 50% ethanol, each washing for 15min. The gel was then treated with sodium thiosulphate (20 mg/100 ml) for 1 min. After treatment with sodium thiosulphate, the gel was rinsed 4X with distilled water, each for 30 s. The gel was immersed in a solution containing 200 mg / 100 ml of AgNO<sub>3</sub> and 1 $\mu$ l formaldehyde / ml and left for 30 min with gentle shaking. It was then rinsed 4X with distilled water; each for 30 s. Silver stain was developed by adding developer on the gel. When proper contrast was visible, the over development of gel was stopped by adding 100 ml of stopping solution on the gel. Finally, the gel was stored in 50% methanol.

**Western blotting**

After completion of the SDS-PAGE run, electro-blotting was performed using a hybond-P membrane in a transfer buffer [25 mM Tris, 192 mM glycine (pH 8.3); 20 % methanol] employing 50 mA constant current overnight at 4°C. The blotted membrane was air dried for 1 h, suspended in methanol for 5 min and equilibrated in TBS buffer (20 mM Tris pH 7.6, 0.5 M NaCl) for 30 min. The equilibrated membrane was subjected to blocking with 3% gelatin (3g of gelatin in 100 ml TBS), washed twice with TTBS (TBS containing 0.05% Tween-20) and hybridized with 10  $\mu$ l (0.5 mg/ml) of the affinity purified biotin-conjugated polyclonal rabbit anti-active human caspase-3 antibody for 18 h at ambient temperature as described previously [7, 10]. After primary antibody hybridization the blot was washed twice with TTBS and later subjected to secondary hybridization with 50  $\mu$ l of streptavidin-horseradish peroxidase conjugate for 1.5 h. Both the primary and secondary antibody reactions were performed in TTBS buffer having 1% gelatin. After secondary hybridization the blot was washed once with TBS-Tween-20 (0.05%) and once with TBS for 5 min, respectively and the band detection was performed by using enhanced chemiluminescence method [Tris pH 8.5 / 4-chloro-1-naphthol / H<sub>2</sub>O<sub>2</sub> / p-coumaric acid].

**Affinity chromatography and immunoprecipitation**

Overnight alanine fortified LB grown culture (1000 ml) was harvested by centrifugation (10,000 g for 10 min.), washed once with PBS and the cells lysed by freeze-thaw and sonication on ice for 5 min in a caspase assay buffer containing protease inhibitors PMSF 1mM, 10  $\mu$ g each of pepstatin, leupeptin and aprotinin. The cell debris was removed by centrifugation (10,000 g for 20 min), and the supernatant was subjected to sequential ammonium sulfate precipitation. The caspase active fraction (15-40 % ammonium sulfate precipitate) was dialyzed overnight in the caspase assay buffer and incubated with commercially available biotinylated form of single specific potent inhibitor of caspase-3 (1  $\mu$ M biotinylated DEVD-CHO) for 30 min [14]. The incubated protein was captured onto a streptavidin-agarose gel. The column material was washed with 20 volumes of the caspase assay buffer containing 0.5M NaCl. The protein was eluted with 200  $\mu$ M free caspase inhibitor (Ac-DEVD-CHO). After blotting the partially purified fractions onto a polyvinylidene difluoride (PVDF) membrane, the caspase protein bands were visualized by means of ponceau-S stain and the blots were probed separately with caspase antibody.

For immunoprecipitation the caspase active fractions after ammonium sulphate precipitation were incubated overnight at 4°C with biotin conjugated caspase-3 antibody in the incubation buffer (TBS buffer containing 1mM EDTA, 1mM PMSF, 10  $\mu$ g each of protease inhibitors pepstatin, leupeptin and aprotinin) and the protein was captured onto a streptavidin-agarose column (1.5 ml). Later the column was washed with 50 ml of the incubation buffer. The protein was eluted with 100  $\mu$ l SDS-gel loading buffer and the eluted protein was analyzed by silver staining and Western blotting.





## RESULTS AND DISCUSSION

### Survival of *Bordetella* in LB fortified media

Viable cell counts in stationary-phase cultures of *Bordetella* grown for 24 and 96 h in different culture media are shown in Figure 1. In media such as LB fortified with alanine, pyruvate and citrate, rapid declines in the viable cell numbers were observed between 24 and 96 h of incubation. The cell count was reduced from 8 log<sub>10</sub> CFU/ml at the onset of the stationary phase (24 h after the start of incubation) to 5 log<sub>10</sub> CFU/ml at the end of stationary phase (96 hrs from the start of incubation) in LB media fortified with metabolites. While in LB untreated control (without addition of metabolites) the cell count remained stable at the onset of the stationary phase (24 h after the start of incubation) to the end stationary phase (8 log<sub>10</sub> CFU/ml). RCD in the presence of previous reported inducer(s) suggested occurrence of a conserved RCD mechanism in *Bordetella* similar to Xcg.

### In vivo caspase activation during RCD

In order to confirm expression of active caspase in the presence of RCD inducers such as alanine, pyruvate and citrate, the protein lysate fraction was subjected to caspase activity. Nearly 3-fold higher caspase activities were observed when compared to LB grown control cultures (Table 1). All the three metabolites (alanine, pyruvate and citrate) showed increased expression of caspase-3 like protein over the untreated LB controls (Figure 2). This clearly indicated that the genetic regulation of PCD in *Bordetella* correlated positively with the caspase-3 like activity.

### Affinity purification and immunoprecipitation

An affinity purification strategy followed for caspase purification was also employed to purify the caspase-3 like protein from *Bordetella* [14]. The partially purified caspase protein after affinity elution gave a strong hybridization signal with the caspase antibody (Fig. 3A & 3B). After elution of this protein from streptavidin agarose column, the 80± 2 kDa protein lost a majority of its activity. Previously reported that intracellular accumulation of metabolites such as pyruvate and citrate in *Xanthomonas campestris pv. glycines* was found to result in a caspase dependent stationary phase rapid cell death (RCD) [7, 10]. Pfam domain architecture analysis combined with operon identification revealed wide and scattered distribution of bacterial metacaspase sequences, and with a potentially intriguing evolutionary role. These metacaspases imply roles in programmed cell death, cellular signaling, various enzymatic activities and protein modification [15]. At the moment, neither the nature of the caspase nor the putative gene caspase domains is clear in *Bordetella*. Western analysis of the cellular lysate revealed that it cross-reacted with the caspase, a feature that needs to be understood. Understanding RCD features in bacteria will help future characterizations of death pathways in prokaryotes.

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**Table 1. Caspase activity of *Bordetella* when grown in LB medium alone and also fortified with Alanine, Pyruvate and Citrate. Approx. 20 µg of the total protein was used for each assay with a specific colorimetric caspase-3 substrate (Ac-DEVD-pNA) and the absorbance (A<sub>405</sub>) was recorded after 30 min.**

Treatments	Caspase activity
LB	0.040±0.005
LB+Alanine	0.125±0.002
LB+Pyruvate	0.126±0.001
LB+Citrate	0.114±0.003

Numbers after (±) symbol denoted SD from three replicates.



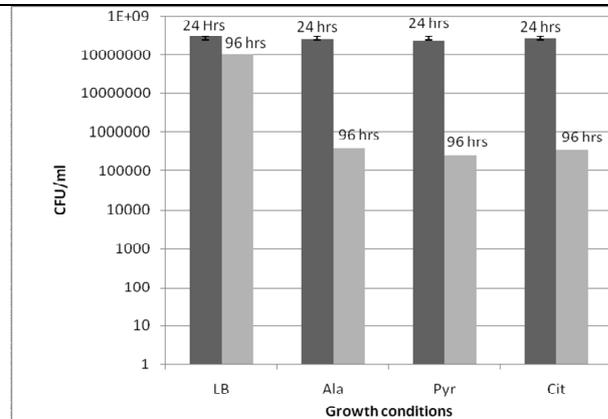


Fig. 1. Viable cell count in stationary phase cultures of Bordetella grown in different media. The medium was inoculated and the viable cell count was determined at the onset of stationary phase (24 h) and during PCD phases (96 h from the start of incubation) as described in the text. The mean and SD of three replicates were plotted as colony forming units (CFU)/ml.

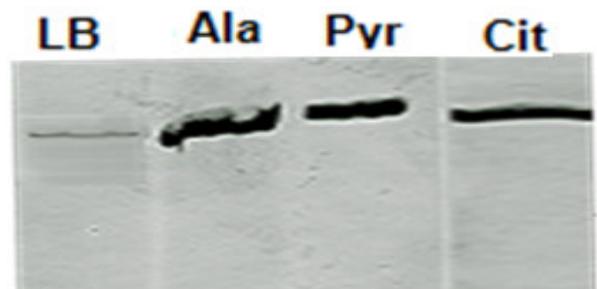


Fig. 2. Induction of caspase-3 synthesis when different concentrations of metabolites (Alanine (100 mM), Pyruvate (100 mM) and citrate (50 mM) respectively) added to LB medium and the control without the addition. Protein equivalent of 200 ul of overnight grown culture was loaded into each well, separated on a 10-15 % gradient SDS-PAGE and subjected to Western analysis with polyclonal rabbit human anti-active caspase-3 antibody.

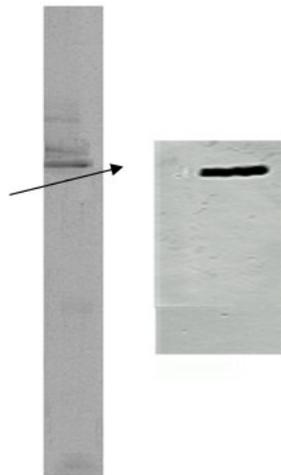


Fig. 3A Fig. 3B

Fig. 3A. Silver stained 8-12 % gradient SDS-polyacrylamide gel showing affinity eluted main active caspase band (upper arrow) with predicted size of 80±2 kDa.

Fig. 3B. Western blot showing cross reactivity of the affinity eluted caspase protein with human polyclonal biotin conjugated caspase-3 antibody.





## An Overview on the Diversity of Edible and Therapeutic Insects of Northeast India

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### ABSTRACT

Edible insects are suitable sources of supplement food items that could meet the present and future wants of humans. Insects are used for human meals in a few elements of the arena while being taboo in other locations and cultural agencies of the globe. Insects are considered as a rich source of proteins (20-70%), amino acids (30-60%), fats (10-50%), fatty acids, carbohydrates (2-10%), minerals (calcium, iron, zinc, phosphorous), nutrients (nutrition A, B complicated and C) and different activated elements that promote human health. They are natural renewable aid that provides meals and economic protection to many ethnic classes in Northeast India, particularly to some of the tribes of Arunachal Pradesh, Assam, Manipur, Nagaland, Meghalaya and Mizoram. Among these, the best consumption of edible insect species belongs to the order Coleoptera (34%), followed by Orthoptera (24%), Hemiptera (17%), Hymenoptera (10%), Odonata (8%), Lepidoptera (4%) and Isoptera (2%). The use of insect species for the remedy of sickness is appeared as a secret and passed on from generation to generation among these tribes. A wide array of studies in recent years has attracted the attention of humans toward the healing and medicinal values of different species of insects and their merchandise. Edible insects can constitute an important part of the diet of developing countries and help to combat various global issues, predominantly malnutrition and food insecurity. Therefore, attention should be given on the studies related to insects as food or to encourage documentation of potential edible insects including their nutritional values and mode of consumption by indigenous groups of Northeast India.

**Keywords:** Edible, *entomophagy*, Northeast India, therapeutic insects





## INTRODUCTION

*Entomophagy* generally refers to the consumption of insects or bugs by human beings. The word *entomophagy* is derived from Greek words, *entomon* meaning “insects,” and *phagein* meaning “to eat”. Entomophagy is known to have played a vital role in providing human nutrition in different regions around the globe including Africa, Asia and Latin America and has a long-standing experience (Aletor, 1995). It is estimated that edible insects are part of the diet of atleast two billion people and more than 1900 insect species are currently used as food (Jongema, 2012). The United Nation’s Food and Agriculture Organization (FAO) in 2004 have reported numerous species of lepidopteran caterpillars as rich sources of potassium, calcium, magnesium, zinc, iron, and vitamins B (Fromme, 1995). Evidence on the emission of greenhouse gases and ammonia at lesser concentrations are also present when compared with livestock (Ooninx *et al.*, 2010).

Thus, insect rearing has been suggested as a promising alternative to the conventional production of livestock (Huis, 2013). The direct or indirect utilization of insects and their products is being known since time immemorial in the medical systems among different cultures throughout the globe (Costa-Neto, 2002) and have shown immunological, antibacterial, analgesic, diuretic, anesthetic and antirheumatic properties (Yamakawa 1998) which in turn have been proven useful in manufacturing modern drugs. Exploiting insects to manufacture folk medicine is a common practice in China and in the State of Bahia in Brazil (CostaNeto, 2002; Feng *et al.*, 2009) and other countries including Mexico, India, Africa and South Korea (Pemberton, 1999; CostaNeto, 2005; Dossey, 2010). A rough estimate shows about 300 species of insect are utilized to prepare 1700 traditional Chinese medicines whereas 42 species are utilized in preparing Bahian Folk Medicine (Costa-Neto, 2002; Feng *et al.*, 2009). Thus, insects can be considered as an inexhaustible source for pharmaceutical substances of the future (Ratcliffe, 2011).

The Northeast India is known as one of the mega-diversity hotspots as out of the nine vegetation types of India, it alone represents six types and covers various endemic as well as rare species of flora and fauna since time immemorial that still remains unexplored. Edible insects are a natural renewable resource that provides not only provides food but also economy to different indigenous ethnic communities in Northeast India. Besides farming, the various tribes make use of insects as their source of income generation. As far as Northeast India is concerned, the full potential of insects as food or raw material for medicines is still far from being appreciated. A perusal of the literature has revealed fragmentary information about edible insects in this region. Thus in this review the authors have tried to discuss the indigenous traditional knowledge related to the practice of consumption of different insect species as food by various ethnic groups of Northeast India along including their cultural values and their role in preparation of traditional medicines.

### Nutritional value of edible insects

The nutrient content of insects varies considerably between species. Depending upon the stages of the insect, their habitat and food habits, the nutritional values of edible insects may vary within the same group. Methods of preparation and processing including drying, boiling or frying that are undertaken before consumption may also influence nutritional composition of the edible insect. Insects have rich sources of proteins (20-70 %), amino acids (30-60 %), fats (10-50 %), fatty acids, carbohydrates (2-10 %), minerals (calcium, iron, zinc, phosphorous), vitamins (vitamin A, B complex and C) and other activated elements that helps in promoting the health of human beings (Chen *et al.*, 2009). Insect proteins are known to be highly digestible proteins that accounts between 77% and 98%. Insects can also be used as a source of fibre due to their high chitin content, accounting for about 10% of the whole dried insect. Insects also have high vitamin and mineral content. 100 grams of bugs would yield 55 grams of protein and 18 grams of fat. They also contain Omega 3 and 6 acids and have a healthy lipid profile. The nutritional compositions of major orders of edible insects (% dry weight) are mentioned in Table 1.





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### Entomophagy in Northeast India

Entomophagy is a common practice among the ethnic communities of Northeast India, more particularly among the tribes of Arunachal Pradesh, Assam, Manipur and Nagaland. Some extent of entomophagy can also be observed among the tribes of Meghalaya and Mizoram. The edible insects in the order Coleoptera (34%) are preferred more followed by Orthoptera (24 %), Hemiptera (17 %), Hymenoptera (10 %), Odonata (8 %), Lepidoptera (4 %) and Isoptera (2 %) (Sangma *et al.*, 2016). In Arunachal Pradesh, a total of 158 species of edible insects has been enlisted (Singh *et al.*, 2007, Singh and Chakravorty, 2008, Chakravorty *et al.*, 2011 and Chakravorty *et al.*, 2013). Nyishi and Galo, two famous tribal communities are known to consume about 102 species of edible insects (Chakravorty *et al.*, 2013). The highest number of insects under the order Orthoptera is preferred by the tribes of Arunachal Pradesh as compared to other tribes of India (Singh and Chakravorty, 2008). 51 insect species are being recorded and documented as edible and consumed as delicacy by six tribes namely Nocte, Wangcho (Wancho), Singpho, Tangsa, Deori and Chakma of Eastern Arunachal Pradesh (Meyer-Rochow and Chakravorty, 2013).

In Manipur, altogether 41 edible insect species have been recorded under 8 orders, 24 families and 36 genera. The highest number of edible insect species (10) has been recorded in the order Hemiptera whereas the lowest number has been recorded in the orders Dictyoptera and Isoptera. The highest number of species (28-30) is known to have been consumed by Meitei, Taro, Tangkhul, Chothe and Thadou tribes as compared to the other ethnic groups in Manipur (Shantibala *et al.*, 2012). Studies revealed that the ethnic groups of Manipur preferred to consume edible insects belonging to the order Hemiptera and lepidopteran insects are not preferred by the Meitei community. People inhabiting the hilly regions in Manipur usually consider the preparation of curry with bees as the most delicious food item among their delicacies. They also prefer aquatic beetles (Prasad, 2007). In Nagaland, two researchers Meyer-Rochow and Changkija identified and provided vernacular names to 42 species of insects used for eating by AoNagas in 1997. They have documented 11 species under the order Orthoptera, 9 species each under Coleoptera and Lepidoptera, 8 species under Hemiptera with species distributed under the remaining orders with Mantodea and Odonata as leading orders.

An early record of an edible insect species of pentatomid bug (*Ochrophora montana*) as a delicacy among the people of Mizo hills was mentioned by Sachan *et al.* in 1987 and termites serving as sources of proteins and carbohydrates was mentioned by Paul and Dey in 2011. Over 60 species of edible insects was enlisted by Meyer-Rochow in 2005 that were popular among the Meitei and Khasi tribes of Manipur and Meghalaya respectively. Entomophagy among the people of Mishing tribes of Dhemaji district of Assam was investigated by Doley and Kalita in 2011. The researchers recorded a total of 15 edible insect species under 15 genera and 12 families. Order Hymenoptera (4 species) was preferred mostly followed by Lepidoptera (3 species), Orthoptera (3 species), Hemiptera (2 species), Coleoptera (2 species) and Isoptera (1 species) respectively. The giant water bugs (*Lethocercus indicus*), eri silkworm (*Samia ricini*), muga silkworm (*Antheraea assama*) and house cricket (*Acheta domesticus*) were recorded to be the most liked edible insects among them. The green weaver ant (*Oecophylla smaragdina*) is a famous edible insect species that is consumed by the Mishing tribe and the Ahom Community of Assam in the month of April during the Assamese Bohag Bihu festival (Chakravorty *et al.*, 2011). A total of 16 terrestrial edible insect species under 6 orders *viz.*, Lepidoptera (3 species), Isoptera (1 species), Blattodea (1 species) and Hemiptera (1 species) was documented by Dutta *et al.*, in 2016 from Dhemaji district of Assam.

The locals usually prefer to consume edible insect species namely cicada (*Pomponia* sp.), short horned grasshopper (*Eupreponotus* sp. and *Choroedocus* sp.), long horned grasshopper (*Mecopoda elongate elongate*), adult cricket (*Tarbinskiellus* sp.) and the mole cricket (*Grylotalpa* sp) for their delicacy. Consumption of termites (*Odontotermes* sp.) in alate stage is also preferred by them due to their high nutritive values and anti-microbial properties (Lamberty *et al.*, 2001). The practice of entomophagy is also seen among the Tiwa community of Assam. They prefer to eat 15 species of edible insects under 6 orders namely Hemiptera (3 species), Coleoptera (2 species), Orthoptera (4 species), Hymenoptera (3 species), Odonata, Lepidoptera and Isoptera (1 species each) and 14 families (Rahman *et al.*, 2018). Among the species, the highest amount of protein was recorded in giant water bug (19.8%), highest amount of





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carbohydrate content was recorded in cricket (5.1%) and highest amount of lipid content was observed in giant water bug (8.3%) (Rahman *et al.*, 2018). 32 species of edible insects are known to be consumed by the ethnic tribes – the Karbis and the Rengma Nagas based on their seasonal availability (Ronghang and Ahmed, 2010). A total of 23 species of edible insects belonging to orders *viz.*, Hemiptera, Coleoptera, Hymenoptera, Orthoptera, Lepidoptera, Isoptera and Odonata was considered as edible among the people of Bodo tribe (Hazarika and Goyari, 2017). The larvae of *Oecophylla Smaragdina* are being eaten during the time of their famous festival Bwisagw.

### Therapeutic values of insect

The exploration and utilization of insect species for treatment of different diseases have been regarded as a secret that is passed on only to family members from generation to generation among the tribes of Northeast. In recent years, a wide array of studies has attracted the attention of people towards the therapeutic values of various insect species along with their products (Antonio, 1994; Oudhia, 2002; Padamanbhan and Sujana, 2008). The tribes Galo and Nyishi of Arunachal Pradesh, utilizes several insect species that are deemed medically important in home remedies for different ailments (Chakravorty *et al.*, 2011). The Garo tribe also utilizes insects with therapeutic values (Ghosh and Deka, 2015). The mole cricket, *Gryllotalpa africana* has been used as a therapeutic food for healing certain childhood diseases and the orb-weavers, *Nephila* is exploited in preparation of folk medicines. Crushing and mixing of the hind legs of grasshoppers with water is practiced as a treatment of kidney diseases and also said to have refreshing properties and reduces swelling (De asis, 1982).

As a treatment of violent headaches, the dry grasshoppers are crushed by the healer and mix with the ashes of the grasshopper with a little organic salt and makes incisions on the nape and front of the patient thereby applying the solution to the incisions (Antonio, 1994). The formic acid of the green weaver ant (*Oecophylla smaragdina*) has been utilized for treating scabies, malaria, toothaches, stomach disorders, blood pressure anomalies, nose infection, sinus and throat infections (Chakravorty *et al.*, 2011). The insect is simply dried under the sun, ground and mixed with mustard seeds before inhalation. In preparing traditional medicines, termites are the most commonly used insects (Alves *et al.*, 2011; Solavan *et al.*, 2006; Coutinho *et al.*, 2009; Lima *et al.*, 2010). e.g., for treating diseases like asthma, whooping cough, bronchitis, influenza, flu a species of termite namely *Microcerotermes exiguous* is used (Alves *et al.*, 2009 and 2011). Another species of termite *Nasutitermes macrocephalus*, is commonly used to treat diseases like asthma, bronchitis, 'catarrh in the chest' coughs, influenza, sore throat, sinusitis and tonsillitis (Lima *et al.*, 2010; Alves *et al.*, 2008). Treatment of constant itching and soreness of the throat, is also done by using pupae and larvae of mulberry silkworm (*Bombyx mori*) and muga silkworm (*Antherea assama*) (Dutta *et al.*, 2016). For detoxification and treating the bacterial infections that causes sore eyes, swollen throat and loss of speech, silkworm are being prescribed in Chinese medicine (Ratcliffe *et al.* 2011).

Infection of mouth and tongue in small children, also known as "dudmur", can be treated by using larvae and pupae of eri silkworm (*Samia cynthia ricini*) in Assam (Dutta *et al.*, 2016). The silkworm pupae are also known to increase the immunity; protects the liver and prevent cancer in human (Chowdhury *et al.*, 2015). A prominent ethnic community of Meghalaya and Assam, the Garo tribe utilizes honey as a remedy against dudmur" disease (Ghosh and Deka, 2015). The treatment of stomach problems can be done with the help of larvae and eggs of yellow jacket wasp (*Vespa orientalis*, *Vespa magnifica*) and the "nest" of potter wasp (*Eumenus* sp.). The eggs and larvae of honey bee (*Apis* sp.) and its product honey can be utilized for curing whooping cough (Dutta *et al.*, 2016) as honey has healing properties (Ratcliffe *et al.* 2011). Cockroach (*Periplaneta americana*) has also been exploited for treating asthma in both children and adults (Dutta *et al.*, 2016). A list of insect species having both edible and therapeutic values is given below (Table 2).





## CONCLUSION

To meet the demands of the ever-increasing population with limited availability of agricultural land and resources, an urgent need has aroused to identify an alternate source of food for humans. The future estimates show the world population would soon reach 9 billion approximately which would result in additional demand and need for nutrition as well as health facilities as compared to the current needs. Thus, entomophagy can serve as an innovative alternate solution as edible insects can constitute a vital part of the diet of developing countries to combat issues like food insecurity and malnutrition and therapeutic insects can be further exploited in preparing medicinal products. The results of various studies revealed that there are differences in preferences in consuming edible insects among the different tribes and regions. Thus, to popularize and adopt entomophagy as well as therapeutic insects in a true sense, further studies should be carried out on key factors including ecology, management and conservation implications, industrialization and marketing of edible insects and therapeutic insects which will help in promoting the commercial development of these insects and widening of the market.

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**Table 1. Nutritional compositions of edible insect orders (% dry weight) (Rumpold and Schlüter, 2013)**

Order	Protein		Amino acids		Fat		Carbohydrate	
	High	Low	High	Low	High	Low	High	Low
Odonata	65.45	46.37	51.70	36.10	41.28	14.23	4.78	2.36
Orthoptera	65.39	22.80	57.51	20.23	34.60	2.2	3.90	1.20
Homoptera	57.14	44.67	53.19	32.59	30.60	24.85	2.80	1.54
Hemiptera	73.52	42.49	59.68	38.09	44.30	9.73	4.37	2.04





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Coleoptera	66.20	23.20	62.97	13.27	35.86	14.05	2.82	2.79
Lepidoptera	68.30	14.05	61.84	13.27	49.48	5.0	16.27	3.65
Hymenoptera	76.69	12.65	81.27	21.0	55.10	7.99	7.15	1.95

Table 2. List of insect species having nutritional and therapeutic values in North east India

Order	Family	Common name	Scientific name	Disease/ailment for which insect is used/food value
Lepidoptera	Bombycidae	Mulberry silkworm	<i>Bombyx mori</i>	Constant itching & soreness of throat
	Saturniidae	Muga Silkworm	<i>Antherea assamensis</i>	Constant itching and soreness of throat
	Saturniidae	Eri silkworm	<i>Samia cynthia ricini</i>	Infection of tongue & mouth
	Crambidae	Bamboo worm	<i>Omphisa fuscidentalis</i>	Food value
	Erebidae	Bihar hairy caterpillars	<i>Spliosoma obliqua</i>	Food value
	Lasiocampidae	Tent caterpillars	<i>Malacosoma sp.</i>	Food value
Orthoptera	Acridoidea	Short horned Grasshopper	<i>Eupreponotus sp.</i>	Food value
	Acrididae	Short horned Grasshopper	<i>Choroedocus sp.</i>	Food value
	Acrididae	Rice grasshopper	<i>Oxya hyla hyla</i>	Food value
	Tettigoniidae	Long horned Grasshopper	<i>Mecopoda elongate</i>	Food value
	Tettigoniidae	Grasshopper	<i>Acrida gigantea</i>	Food value
	Gryllidae	Cricket	<i>Tarbinskiellus sp.</i>	Food value
	Gryllidae	Field cricket	<i>Acheta bimaculatus</i>	Food value
	Gryllidae	Common cricket	<i>Brachytrupes achatinus</i>	Food value
	Gryllidae	Spotted cricket	<i>Liogryllus bimaculatus</i>	Food value
	Gryllidae	Blackhead caicket	<i>Grylloides melanocephalus</i>	Food value
	Gryllotalpidae	Mole cricket	<i>Gryllotalpa sp.</i>	Food value
Dictyoptera	Mantidae	Praying mantis	<i>Mantis religiosa</i>	Food value
	Mantidae	Praying mantis	<i>Heirodula sp.</i>	Food value
Hymenoptera	Formicidae	Weaver ant	<i>Oecophylla smaragdina</i>	Nose infection, sinus & throat infection
	Formicidae	Red ant	<i>Crematogaster dohni</i>	Food value
	Formicidae	Ant	<i>Formica indica</i>	Food value
	Vespidae	Giant hornet	<i>Vespa orientalis</i>	Stomach problems
	Vespidae	Wasp	<i>Vespa magnifica</i>	Food value
	Vespidae	Potter wasp	<i>Eumenes sp.</i>	Stomach problems
	Apidae	Honey bee	<i>Apis cerana</i>	Whooping cough
	Apidae	Giant honey bee	<i>Apis dorsata</i>	Whooping cough
	Vespidae	Paper wasp	<i>Polistes sp.</i>	Food value
	Vespidae	Yellow jacket wasps	<i>Vespula vulgari</i>	Food value
	Vespidae	Common wasp	<i>Eucaria artifix</i>	Food value
	Apidae	Stingless bee	<i>Tetragonula sp.</i>	Cough, Acne





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Coleoptera	Scarabaeidae	White grub	<i>Lepidiota mansueta</i>	Food value
	Cerambycidae	Cashew stem girgler	<i>Analeptes trifasciata</i>	Food value
	Hydrophilidae	True water beetle	<i>Hydrous olivaceus</i>	Food value
	Hydrophilidae	Water scavenger beetles	<i>Hydrous indicus</i>	Food value
	Curculionidae	Bamboo beetle	<i>Cyrtotrachelus dux</i>	Food value
	Scarabaeidae	Rhino beetle	<i>Oryctes rhinoceros</i>	Food value
	Cerambycidae	Long horned beetle	<i>Anoplophora glabripennis</i>	Food value
	Cerambycidae	Pink woodborer	<i>Xystrocera globosa</i>	Food value
	Cerambycidae	Wood borer	<i>Neocerambyx paris</i>	Food value
	Cerambycidae	Wood borer	<i>Coelosterna scabrata</i>	Food value
	Curculionidae	Palm weevil	<i>Rhynchophorus signaticollis</i>	Food value
	Dytiscidae	Diving beetle	<i>Dytiscus Marginalis</i>	Food value
Isoptera	Termitidae	Termite	<i>Odontotermes sp.</i>	Food value
	Termitidae	Termite	<i>Macrotermes natalensis</i>	Food value
Blattodea	Blattidae	Cockroach	<i>Periplaneta americana</i>	Asthma
Hemiptera	Cicadidae	Cicada	<i>Pomponia sp.</i>	Food value
	Cicadidae	Cicada	<i>Cicada verides</i>	Food value
	Belostomatidae	Giant water bug	<i>Lethocerus indicus</i>	Food value
	Belostomatidae	Water bug	<i>Diplonychus rusticus</i>	Food value
	Nepidae	Water scorpion	<i>Laccotrephes maculatus</i>	Food value
	Nepidae	Water scorpion bug	<i>Ranatra sp.</i>	Food value
	Pentatomidae	Stink bug	<i>Udonga montana</i>	Food value
	Corixidae	Water boatmen	<i>Micronecta sp.</i>	Food value
	Notonectidae	Backswimmer	<i>Notonecta sp.</i>	Food value
	Hydrometridae	Water measurer	<i>Hydrometra greeni</i>	Food value
	Pentatomidae	Painted bug	<i>Bagrada picta</i>	Food value
	Pentatomoidea	Bamboo bug	<i>Dolycoris indicus</i>	Food value
	Largidae	Giant red bug	<i>Lohita grandis</i>	Food value
Gerridae	Water slider	<i>Gerris spinolae</i>	Food value	
Odonata	Libellulidae	Scarlet skimmer	<i>Crocothemis servilia</i>	Food value
	Libellulidae	Wandering glider	<i>Pantala flavescens</i>	Food value
	Libellulidae	Asian pintail,	<i>Acisoma panorpoides</i>	Food value
	Aeshnidae	Mosaic darners	<i>Aeschna sp.</i>	Food value
	Libellulidae	Dragon fly	<i>Crocothemis servilia</i>	Food value
	Libellulidae	Blue-tailed forest hawk	<i>Orthetrum triangulare</i>	Food value
	Libellulidae	Common picture wing	<i>Rhyothemis variegata</i>	Food value
	Libellulidae	Chalky percher	<i>Diplacodes trivialis</i>	Food value

Source: Dutta et al., 2016; Narzari and Sharmah, 2015; Hazarika, 2018; Rahman et al, 2018; Shantibala et al., 2012; Meyer-Rochow and Changkija, 1997)





## Marker-Assisted Selection: a Potential Tool for Genetically Improvement of Fishes

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### ABSTRACT

A fish breeder faces the challenge of how to more effectively and efficiently perform selection and accelerate the breeding progress to satisfy the requirements of changing markets for fish cultivars. Molecular marker-assisted breeding (MAB), the application of molecular biotechnologies (DNA markers) to practical breeding and selection, is a novel strategy and a powerful methodology for fish performance improvement. However, improvement of performance traits through traditional phenotype-based selection needs several generations to optimise these performance characters. Other problems associated with the traditional breeding programme is the maintenance of each generation and complexity of the measure qualitative trait such as meat quality. Marker-Assisted Selection (MAS) can be the best alternative to solve these problems. Marker-Assisted Selection (MAS) is a type of indirect method of selection of better performing breeding individuals. MAS depends on identifying the link between a genetic marker and Quantitative traits loci (QTL). After identifying the markers linked to QTL, they can be used in the selective breeding programme to select the brooders having better genetic potential for the targeted trait. Improvement of performance traits through MAS is fast and more accurate and allows us to understand the genetic mechanism affecting performance traits.

**Keywords:** Quantitative traits loci, Marker-assisted selection, Selective breeding, Genetic improvement

### INTRODUCTION

Molecular markers have been extensively used for identification of strains and species, detection of inter and intra-specific hybridization, parentage and kinship analysis, estimation of effective population size and level of inbreeding, assessment of parental contribution in mass spawning, preventing inbreeding, mapping of quantitative trait loci (QTLs) and selective breeding. Marker-Assisted Selection (MAS) is a kind of indirect way of selection of well

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performing breeding individuals (Liu et al., 2004). MAS depends on identifying the link between a genetic marker and Quantitative traits loci (QTL). The important economic traits like resistance to diseases, body growth, meat quality, etc. highly affect the profitability of the fishes. The main aim of every selective breeding programme is to produce improved offspring for these traits. However, enhancement of performance traits through phenotype-based selection requires numerous generations to optimise these traits. Another limitation associated with the traditional breeding programme is the looking after of each generation of fishes and complexity in the measure qualitative trait such as fish meat quality. Marker-Assisted Selection (MAS) can be used as the best alternative to solve these problems.

The main restrictive factor for the realization of genotype based selection potentials in fishes is the unavailability of a molecular marker for fishes. However, the marker discovery becomes very easy through the next generation sequencing methods like Illumina, Ion torrent, and 454 GS FLX platforms. So, the researchers are now capable of identifying a large number of molecular markers in the genome of any fish species (Al et al., 2015). Thus MAS finally become a reality by using the markers to detect linkage with the traits of interest. In aquaculture, genetic mapping has been done for tiger shrimp, rainbow trout, atlantic salmon, kuruma prawn, catfishes and tilapia. Now genetic map needs to be for the other commercially important fish to overall increase aquaculture in developing country like india. Recently MAS become the very popular method of indirect selection for production of the genetically improved offspring in aquaculture selective breeding programme. As most of the performance traits are controlled by multiple genes and therefore inherited as quantitative traits, and analysis of their associated quantitative trait loci (QTL) is a crucial part of aquaculture genomics. QTLs are largely unknown genes that affect performance traits (growth or disease resistance) of the fishes.

#### The significance of MAS in selective breeding programme

The rate of the genetic gain through MAS can increase when there is a continuous identification of new QTL for the targeted traits. The extra genetic gain through the MAS may decrease very quickly in successive generation of selection for the same QTL and also the rate of identification of new QTL is hard to predict. The information developed from the detected QTL in the selection needs developing some selection criteria to connect this molecular information with phenotypic variation (Sakamoto et al., 2000). MAS can be powerfully used to detect the major QTLs for a trait and for a phenotypic which is costly to measure. Till date, QTL for traits such as growth and disease resistance, cold and salinity, sex determination have been mapped in fishes. Such studies can provide essential information about outlines and the rate of evolutionary changes besides may use as tools for marker assisted selection in selective breeding. Mapping genes and QTLs is of fundamental and applied concern in aquaculture species. The purpose of QTL mapping is to assist in selective breeding by understanding the effect and quantity of genes determining a trait. QTL analysis for important traits like thermal tolerance, spawning time, embryonic development, growth traits, stress, salinity tolerance, infectious hematopoietic necrosis and bacterial cold-water disease have been conducted for more than 20 aquaculture species including finfish, mussels and crustaceans (Haldar et al., 2018b). Table 1. Shows the number of studies has been conducted on marker assisted selection in fishes.

#### Advantages and limitations of marker-assisted selection in fish breeding

Over conventional selection methods, MAS is profitable for the aquaculturist for a low heritability trait like growth in fish. It assists to detect the existing genetic variation in brooder stock and can be used to improve desirable traits in target fish species. Improvement of performance traits through traditional selection integrated with molecular tools is more accurate, fast and allows us to recognize the genetic mechanism controlling performance traits. The main constraint in MAS is the lack of complete genotype information of the fishes and increasing sample collection cost for genotyping. There is very limited study has been directed on MAS in fisheries in India (Haldar et al., 2018a). Genotyping the whole population is also tough in commercial fish populations. But the dramatic development of molecular genetics, has introduced a new generation of molecular markers like microsatellite and single nucleotide polymorphisms (SNPs) for use in the genetic improvement of farm animals.



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These markers provide more accurate genetic information and a better understanding of the animal genetic resources. Traits that are expressed late in life, expensive or difficult to measure (disease resistance), is very tough to optimize using traditional breeding programme. Selection programme requires numerous progenies to optimise traits and the progeny testing scheme in some case needs a long generation interval and also very expensive (Haldar et al., 2018b). MAS is a very useful tool to select those traits which are restricted to only one sex and to reduce generation interval through early selection, even before maturity of the fish. To decrease genotyping costs, the researcher is now concerned on the identification of the most informative individuals based on phenotypic information, segregation analysis or combining the phenotypic and genotypic information in breeding (Groenen et al., 2000). The choice of the marker information is not totally reliable due to the possibilities of overestimation of QTL effects in QTL position in the fish population. The discrepancy is also a major problem in QTL detection in fish because the QTL effect is not expressed similarly over the years or when it is used in a different population or stock. The main targeted traits in aquaculture for MAS are body growth, disease resistance, meat quality, feed efficiency and maturation.

**CONCLUSION**

The use of genetic markers with the phenotypes in a process called marker-assisted selection. Combined with traditional selection techniques, MAS has become a valuable tool in selecting organisms for desirable traits. MAS is expected to increase genetic gain compared to traditional breeding programs and reduce the cost of progeny testing by early selection of the potential fishes. The application of MAS in breeding programmes depends on the knowledge of breeders about variable marker information from fish to fish and the different effects on multiple traits and his ability to spend in genotypic information that helps in improve their commercial breeding activities (Montaldo et al., 1998). MAS also provides an apparently possible approach to selection for higher growth and genetic disease resistance animals. In the future to make MAS significant in commercially important aquaculture breeding populations, the accessibility of large-scale genotyping approaches and infrastructure that allows the generation of hundreds of thousands of molecular data at a reasonable cost will be necessary.

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**Table: 1 Numbers of studies conducted on MAS in fisheries**

Research	Species	Target traits
Marker assisted selection for spawning date and co-variation among economically important fitness traits in a commercial strain of rainbow trout ( <i>Oncorhynchus mykiss</i> )	Rainbow trout ( <i>Oncorhynchus mykiss</i> )	Co-variation between spawning date and developmental rate
Mapping QTL for resistance against viral nervous necrosis disease in Asian seabass	Asian seabass	Viral nervous necrosis disease (VNN)
Screening and characterization of sex-linked DNA markers and marker-assisted selection in the Nile tilapia ( <i>Oreochromis niloticus</i> )	Nile tilapia ( <i>Oreochromis niloticus</i> )	4 sex-linked markers (Marker-1 from RAPD and Markers-2, -3, and -4 from AFLP)
Three EST-SSR markers associated with QTL for the growth of the clam <i>Meretrix meretrix</i> revealed by selective genotyping.	Clam ( <i>Meretrix meretrix</i> )	Growth- traits
Quantitative genetics of taura syndrome resistance in pacific white shrimp ( <i>Penaeus vannamei</i> ): a cure model approach	Pacific white shrimp ( <i>Penaeus vannamei</i> )	Taura syndrome virus resistance
Marker-assisted breeding of a lymphocystis disease-resistant Japanese flounder ( <i>Paralichthys olivaceus</i> )	Japanese flounder ( <i>Paralichthys olivaceus</i> )	Lymphocystis disease-resistant
Identification of genetic markers associated with Atlantic salmon Salmosalar in Atlantic salmon Salmosalar	Atlantic salmon Salmosalar	Atlantic salmon Salmosalar
A genomescan reveals a QTL for resistance to infectious salmon anaemia in Atlantic salmon (Salmosalar)	Atlantic salmon (Salmosalar)	Infectious salmon anaemia
Identification of a novel chromosomal region associated with infectious hematopoietic necrosis (IHN) resistance in rainbow trout <i>Oncorhynchus mykiss</i>	Rainbow trout <i>Oncorhynchus mykiss</i>	Infectious hematopoietic necrosis (IHN) resistance





## NiCoT Transporters from Microorganisms for Metal Transporter Studies-Mini Review

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### ABSTRACT

The content of bacterial cells (cytoplasm) is surrounded by a lipid bilayer, called the cell membrane that protects the cell from outside influences and makes it possible to carefully control the composition of the cytoplasm. In Gram-positive bacteria the cytoplasm is bordered by a single phospholipid bilayer, the cell membrane, and a peptidoglycan layer, the cell wall, which supports firmness of the cell. Gram-negative bacteria possess an additional outer membrane creating a periplasmic space. The outer membrane of Gram-negatives is permeable, allowing small molecules to enter the periplasm. In contrast, the cytoplasmic membrane forms a selective barrier especially for bulky hydrophilic compounds that cannot easily pass the hydrophobic membrane. To get trace metals, nutrients into and breakdown products out of the cell, membrane embedded proteins, called transport proteins, mediate the translocation of trace metals, solutes across the cell membrane. Most transport proteins are very selective and only carry one or a few related compounds (metals, nutrients) from one side to the other. Not all metal or nutrient transport systems need to be present at the same time, since usually limited numbers of different essential metals are present in particular habitats or growth media.

**Keywords:** metals, nutrients, products, numbers, cytoplasm.





## INTRODUCTION

To prevent unnecessary consumption of energy and matter for the synthesis of (transport) proteins, bacteria have evolved mechanisms to sense the presence of substrates and to react on their availability. In this way, specific transport systems and associated catabolic enzymes are synthesized only when their substrates are present and other preferred carbon and energy sources are lacking. The synthesis of the transport systems and enzymes is regulated at the level of transcription of the coding genes and operons. In the presence of substrate the expression of the respective genes is activated by a mechanism called induction. When more than one substrate is present, bacteria decide which one to utilize first, primarily the one that provides the most energy for growth. Then, only the (transport) proteins required for metabolism of the preferred substrate are synthesized, while synthesis of the proteins required for metabolism of the less favored substrate is unwanted even though the inducer is present. Transport of molecules across the cell membrane is a fundamental process of all living organisms. It is essential for understanding growth, development, nutrition as well as uptake and excretion of exogenous or synthesized molecules. Microbes represent general and basic functional systems where many transport processes have been studied on a molecular basis. Knowledge of the microbial transport processes will provide new perspectives to treatments by inhibitors, drugs, antibiotics, vitamins, growth promotion compounds, activators and toxic compounds of various kinds.

Metal ions are essential for life, for instance as structural or catalytic co-factors in metalloproteins. For this reason bacteria make use of various transport systems for the uptake and subsequently, usage of metals from the environment. Besides uptake systems for free metal ions, bacteria also possess specific transport proteins that mediate the uptake of metals complexed to so-called chelating agents (Paulsen and Saier, 1997; Thomas *et al.*, 1998; Krom *et al.*, 2000). Most of the bacteria (*B. subtilis*) contain both types of transport systems to acquire essential elements, like calcium and magnesium (Silver *et al.*, 1975; Silver and Lusk, 1999; Krom *et al.*, 2000).

### Metal ions in biological systems

Metal ions are vital and essential life elements that play very critical role in numerous metabolic functions in every living cell. The interaction between metal ions and functional constituents of living cells is powerful and specific. Approximately one out of three proteins requires a metal ion cofactor for structure and/or function (Rosenzweig, 2002). These metal ions can transfer electron flow in a substrate or enzyme, thus effectively controlling an enzyme-catalyzed reaction. They can serve to bind and orient substrate with respect to functional groups in the active site. They also provide a site for redox activity if the metal has several valence states. In some cases metal ions are required for a reporter of structure and functional relation of metalloenzymes: they are like Zn in dehydrogenase (Braden *et al.*, 1975), and Co in alcohol Phosphoglucomutase, carboxypeptidase (Warren *et al.*, 2002). Metal ions are required for the formation of concentration gradients across the membrane required for the transport process, osmotic responses and structural integrity. They also function as essential cofactors in oxidative phosphorylation, gene regulation and free radical homeostasis. Metal ions are currently included in formulations used for applications such as diabetes, anti-inflammatory, rheumatoid arthritis, psychiatric and anti-ulcer medications using compounds of cadmium, vanadium, copper, zinc, gold, lithium, and bismuth, respectively.

Many of the metal ions, which are required relatively in larger quantities like Ca, Mg, Na and K are designated as essential or 'macro elements' whereas some are not required for growth such as Hg, Pb and Ag, are designated as non-essential or toxic metal ions due to their toxicity at very low concentrations. In between are the metals that are required only in minute quantities by microorganisms such as Co, Cu, Ni, Fe, Mn and Zn, which are designated as 'trace elements'. All metal ions whether essential or non-essential, exhibit toxicity above certain threshold concentrations. Hence their homeostasis is crucial for all living organisms.



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Transition metals are essential for many metabolic processes. Aberrations in the cellular metal ion concentrations may lead to cell death and severe diseases. Excess metal ions can bind to proteins and nucleic acids and alter the activities of these biomolecules (McRee, 1998). In addition, high concentrations of redox-active metal ions can result in undesired Fenton chemistries, which produce reactive oxygen species that can damage biomolecules (Wink *et al.*, 1994). Conversely, lower than optimal levels of metal ions can result in metal ion deficient stress conditions which often results in low growth rates and possibly cell death. Consequently, intracellular metal ion concentrations must be maintained within a narrow range (Kaim and Schwederski, 1991) and all cells utilize a great deal of energy (ATP) maintaining optimal metal ion concentrations within the cell (Nelson, 1999). This process is called homeostasis, a term derived from the Greek *homoios* (same like, resembling) and *stasis* (to stand, posture).

Metal ion transporters play a major role in maintaining the necessary concentrations of the various metal ions in the different cellular compartments. The studies of yeast metal ion transporters helped to unravel the molecular mechanism of macrophage defense against bacterial infection and hereditary diseases. Most of the control of metal ion concentrations is accomplished by regulating metal ion flow across lipid membranes surrounding the cytoplasm or individual organelles. As the cell becomes deficient in certain metal ions, transporters (importers) can be activated at the transcriptional level to bring more ions across the inner-membrane and into the cell. Similarly, when intracellular metal ion concentrations are too high, metal sequestration proteins/molecules or efflux systems are expressed to maintain homeostasis.

**Metal Transport**

Metal ion uptake in microorganisms is often biphasic. The two distinct phases of metal uptake are: 1. Biosorption- a rapid phase of metal binding to surface cell wall fraction, which is energy-independent 2. Bioaccumulation- a slower phase of metal ion accumulation into the cell mediated by transport proteins of the membrane requiring inputs of energy. Biosorption mostly involves the functional groups present in the cell wall and a recent study from our laboratory has shown that toxic metal ions compete with  $\text{Ca}^{2+}/\text{Mg}^{2+}$  for binding groups. There appears to be unique pattern for binding of  $\text{Ca}^{2+}/\text{Mg}^{2+}$  that are not competed either by toxic metal ions or in between themselves (Sowjanya and Mohan, 2009).

The mechanism of binding of essential metal ions appears to be predominantly by complexation, while toxic metal ion binding appears to be primarily by electrostatic interactions with ensuing competition among themselves. Several metal-resistant strains of *N.crassa* and one cobalt- sensitive mutant characterized earlier showed both transport block and over accumulation patterns of metal uptake. Cobalt uptake was shown to be biphasic, energy-dependent and increased with temperature and decreased with increase in pH. Magnesium inhibited cobalt uptake but iron could not do so. However in a cobalt resistant strain, a passive mode of transport was shown (Venkateswerlu and Sastry, 1970, 1973). A cobalt-sensitive mutant (CSM) of *N. crassa* is 5-fold more sensitive to cobalt and 4-fold more sensitive to nickel compared to wild type *N.crassa*. The mechanism for increased sensitivity is shown to be due to an accumulation of cobalt in CSM that is five fold higher than that observed in the wild type (Rashmi *et al.*, 2004).

Nickel transport in wild type and three Ni-resistant mutants of *N.crassa* was studied (Maruthi Mohan and Sivarama Sastry, 1984). Two of the nickel- resistant mutants were shown to be hyperaccumulators, while a third mutant has a transport block in comparison to wild type *N.crassa*. The above mutants were also resistant to cobalt, with similar patterns of uptake (Maruthi Mohan and Sivarama Sastry, 1983). Cobalt and nickel transport was also studied in a wall-less mutant of *N.crassa* and a corresponding cobalt-resistant strain. Both of these mutants did not show biosorption due to absence of cell wall and the mechanism of resistance was shown to be similar to those described above for the normal wall containing *N.crassa* strains (Sri *et al.*, 2003; 2004).





### Classification of membrane transporters

The availability of a large number of membrane transporters from diverse organisms and also a better understanding of the fundamental mechanisms involved paved the way for a systematic classification system. The Transport Classification (TC) system represents a systematic approach to organize transport systems according to the mode of transport, energy-coupling mechanism, molecular phylogeny and substrate specificity (Saier *et al.*, 1999; Saier, 2000). Based on the above, a relational transporter database was designed for describing the cellular membrane transport proteins in organisms whose complete genome sequences are available. Till date there are a total of 394 organisms whose transporter protein complement is available in transport database.

Transport systems are classified on the basis of five criteria, and each of these criteria corresponds to one of the five numbers or letters within the TC # for a particular type of transporter. Thus TC # normally has five components as follows: V.W.X.Y.Z.V (number) corresponds to the transporter class (i.e., channel, carrier (porter), primary active transporter or group translocator); W (a letter) corresponds to the transporter subclass which in the case of primary active transporters refers to the energy source used to drive transport; X (a number) corresponds to the transporter family (sometimes actually a super family); Y (a number) corresponds to the subfamily, and Z corresponds to the substrate or range of substrates transported. Any two transport systems in the same subfamily of a transporter family that transport the same substrate(s) are given the same TC#, regardless of whether they are orthologues (arose in distinct organisms by speciation) or paralogues (arose within a single organism by gene duplication). The transporter classification system by Saier, demarcates 5 different classes of transporter genes based on the mode of transport and energy coupling mechanisms as shown below:

Primary active transporters (ATP-dependent): The transport process is coupled to a primary source of energy such as ATP hydrolysis, exothermic flow of electrons from reduced substrate to an oxidized substrate and utilization of light energy to drive transport of a solute. Ion channels: Channels are energy-independent transporters that exhibit higher rates of transport and lower stereo specificity. This class includes both channels and pores consisting of  $\alpha$ -type channels,  $\beta$ -barrel porins, pore-forming toxins and non-ribosomally synthesized channels. Secondary transporters: They utilize ion or solute electro-chemical gradient to drive the transport process across the cytoplasmic or internal membranes of the biological cells. According to Saier's classification there are 84 gene families for this transporter class (Sobczak and Lolkema, 2005). Amino acid residues that are rare in transmembrane helices (K, R, H, Q, D, E, N, F, W, and Y) help in the formation of channel in secondary transporters (Kalinina *et al.*, 2003). The first 3-dimensional crystal structure of a secondary transporter is reported in 2002 i.e., *Escherichia coli* AcrB transporter of RND family (Murakami *et al.*, 2002).

Unclassified: This class mainly includes transporters of unknown biochemical mechanism; putative but uncharacterized transport proteins and functionally characterized transport proteins with unidentified sequences. Group Translocators: They modify the substrates during transport. Transport systems of the bacterial phosphoenolpyruvate: sugar phosphotransferase systems are the major group translocators.

### Ni-Co homeostasis

#### Role of Ni-Co in biological systems

Ni is an essential component of several metalloenzymes involved in energy and nitrogen metabolism (Ragsdale, 2009). In prokaryotes, the major Ni-binding enzymes include urease, Ni-Fe hydrogenase, carbon monoxide dehydrogenase, acetyl-coenzyme A, decarbonylase/synthase, superoxide dismutase SodN, methyl-coenzyme M reductase and glyoxalase I. In eukaryotes, urease is the only characterized Ni-dependent enzyme (Baird and Garber, 1981). Additional candidate Ni-containing proteins or compounds have also been described in different organisms including humans (Denkhaus and Salnikow, 2002). Because natural environments contain only trace amounts of soluble Ni<sup>2+</sup>, attaining sufficiently high intracellular nickel concentrations to meet the demand of the nickel enzymes



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requires a high affinity nickel uptake system(s) (Rodionov *et al.*, 2006), molecular and metallochaperones (Quiroz *et al.*, 2007) and sensors and regulators of the levels of enzymes involved in nickel homeostasis (Iwig *et al.*, 2006; Phillips *et al.*, 2008). Co is mainly found in the corrin ring of vitamin B12 (also known as cobalamin), a group of closely related polypyrrole compounds such as cyanocobalamin, methylcobalamin and deoxyadenosyl cobalamin (Michihiko and Sakayu, 1999; Warren *et al.*, 2002; Banerjee and Ragsdale, 2003). Vitamin B12 is a complex organometallic cofactor and is mainly present in three classes of enzymes in prokaryotes (classified based on different chemical features of the cofactor): adenosylcobalamin-dependent isomerase, methylcobalamin-dependent methyltransferase, and B12-dependent reductive dehalogenase. Besides, a few proteins containing non-corrin Co are present in methionine aminopeptidase and nitrile hydratase.

### Ni-Co transporters in living systems

The average concentration of Ni is as low as 2 ppb in sea water and 0.3 ppb in fresh water, corresponding to a molarity of approximately 30 nM and 5 nM, respectively. The most commonly occurring oxidation state of Ni is Ni (II) and thus Ni<sup>2+</sup> ion is the substrate for transport. Under artificial conditions, i.e. at concentrations that are much higher than in the natural environment, Ni<sup>2+</sup> can be taken up by microbial Mg<sup>2+</sup> transport systems (Smith and Maguire, 1995; Eitinger and Friedrich, 1997; Kehres *et al.*, 1998; Eitinger and Mandrand Berthelot, 2000). Since Mg<sup>2+</sup> is a competitive inhibitor of Ni<sup>2+</sup> transport by these systems and since the natural concentration of Mg<sup>2+</sup> is at least three orders of magnitude higher than that of Ni<sup>2+</sup>, Mg<sup>2+</sup> transport systems probably contribute little to Ni<sup>2+</sup> uptake under physiological conditions. It is intriguing how the living systems acquire nickel for their metabolic needs. Transport assays have identified Ni<sup>2+</sup> uptake in a variety of bacteria and archaea in the presence of several thousand-fold excess of Mg<sup>2+</sup> (Hausinger, 1993). These studies took advantage of the radioactive isotope <sup>63</sup>Ni, a low-energy (67 keV) β–emitter that decays with a radioactive half-life of 100 years to the stable isotope <sup>63</sup>Cu.

The characterization of Ni-deficient mutants of *E. coli* and *Ralstonia eutropha* (formerly *Alcaligenes eutrophus*) were milestones for the analysis of the underlying transport mechanisms (Eitinger and Friedrich, 1991). Complementation of the mutants and sequence analysis of the genes revealed that a transporter of the ATP-binding cassette family is responsible for Ni<sup>2+</sup> uptake in *E. coli*. An unrelated single-component permease that probably acts as a uniporter operates in *R. eutropha*. These two major types of bacterial high-affinity Ni<sup>2+</sup> transport systems are discussed in detail below.

### The nickel-specific ABC transporters

The discovery of a highly specific Ni transport system in *E. coli* originates from the characterization of a novel category of mutants isolated by *MudI* transposon mutagenesis that were totally impaired in hydrogenase activity (Wu and Mandrand-Berthelot, 1986). These mutants contain significantly reduced levels of H<sub>2</sub>-related activities, fermentative formate hydrogenlyase and respiratory fumarate-dependent H<sub>2</sub> uptake. Interestingly, addition of high concentrations (0.5 mM) of Ni salts leads to a complete recovery of hydrogenase activity and to the concomitant restoration of normal H<sub>2</sub> uptake activities. This strictly Ni-dependent restoration was taken as the first suggestion of a defect in Ni transport. Structure and mechanism of ABC transporters was reviewed earlier (Schmitt and Tampe, 2002).

Further investigation of the mutants was performed using both biochemical and genetic approaches. When grown in a nickel rich medium, the cellular Ni content of the Nik mutants was found to be abnormally low, less than 1% of that of the parental strain (Wu *et al.*, 1989). Therefore these mutants were unable to acquire sufficient Ni for hydrogenase biosynthesis during normal growth. However, gradually increasing external Ni concentration increases both cellular Ni content and hydrogenase activity to attain normal wild-type levels. Under these circumstances, Ni can be readily taken up by the low-affinity high-capacity magnesium transport system CorA (Smith *et al.*, 1998). This behavior was further substantiated by the fact that the *nik* hydrogenase phenotype can be fully suppressed by growth in media containing very low (0.01 mM) added magnesium, which would reduce Mg competition for Ni entry by the Mg uptake system (Wu *et al.*, 1989). Finally, a direct demonstration for a defect in Ni uptake came from examination of the ability of the Nik mutants to take up <sup>63</sup>Ni<sup>2+</sup> (Navarro *et al.*, 1993).





### The NiCoT family

The first structural gene for a Ni<sup>2+</sup>-specific permease was identified by sequencing a fragment of *R. eutropha* DNA that restores Ni deficiency of an *R. eutropha* mutant (reviewed by Eitinger and Friedrich, 1997). This strain was unable to grow on hydrogen as the energy source, and produces only low activity of urease under standard conditions. The deduced amino acid sequence revealed an integral membrane protein (HoxN) that did not show any similarities to available database entries. Transport assays indicated that HoxN has an extremely high affinity for Ni<sup>2+</sup> ion, but a very low capacity. The K<sub>t</sub> value for Ni<sup>2+</sup> was estimated to 20 nM and the maximal velocity was 1.5 pmol Ni<sup>2+</sup> × min<sup>-1</sup> × (mg total cell protein)<sup>-1</sup>. These values represent, however, a rough estimation rather than an exact determination, because it is very difficult to distinguish transport from binding to the cell envelope at very low substrate concentrations. Expression of *hoxN* in *E. coli* allowed the reproducible measurement of HoxN activity using a physiological assay system (Wolfram *et al.*, 1995). Accumulation experiments with recombinant *E. coli* growing in the presence of <sup>63</sup>Ni<sup>2+</sup> indicated that HoxN concentrates its substrate only tenfold (Wolfram *et al.*, 1995; Degen *et al.*, 1999). This result suggested a very slow uniport mechanism. The membrane topology of HoxN was analyzed by fusing N-terminal segments to alkaline phosphatase and β-galactosidase, which serve as reporters for periplasmically and cytoplasmically located sites, respectively. These studies revealed that the N- and C-termini of the Ni permease are located in the cytoplasm and that the protein contains eight membrane-spanning segments (Eitinger and Friedrich, 1994; Eitinger *et al.*, 1997).

In addition to the common topology of HoxN-type Ni permeases, a few amino acid sequence motifs are conserved (Fig 1.1). Four of these motifs are located within transmembrane segments. Site-directed mutagenesis experiments were performed to obtain more detailed information on the significance of these residues for affinity and specificity of the permeases. In a study with HoxN of *R. eutropha* (Eitinger *et al.*, 1997; Olaf and Eitinger, 2002), replacements were introduced into the HX<sub>4</sub>DH motif, located in the unusually polar transmembrane segment II. This motif is fully conserved among the HoxN-type permeases, but is also present in the unrelated NikC, one of the two integral membrane proteins of the *E. coli* ABC-type Ni<sup>2+</sup> transporter. In the latter case, however, the signature is located in the first periplasmic loop connecting the putative transmembrane segments II and I. In summary, these results suggested that the conserved signature sequence in TMD II is a critical part of the selectivity filter of nickel/cobalt permeases (Degen and Eitinger, 2002).

A very important point in the analysis of membrane transporters is the question regarding how substrate specificity is mediated. Members of the HoxN-type permease differ in ion selectivity. HoxN, for instance, is highly specific for Ni<sup>2+</sup> and unable to transport Co<sup>2+</sup>. Ni<sup>2+</sup> uptake is not inhibited by a ten-fold excess of divalent Co, Mn, and Zn ions (Degen *et al.*, 1999). The NiCoT member of *Rhodococcus rhodocrus* (RrNhlF) is less selective and transports both Ni<sup>2+</sup> and Co<sup>2+</sup>. Ni<sup>2+</sup> uptake is strongly inhibited by ten-fold excess of Co<sup>2+</sup>, but not by Mn<sup>2+</sup> and Zn<sup>2+</sup> (Degen *et al.*, 1999). Ni<sup>2+</sup> transport by HpNixA of *Helicobacter pylori* is moderately sensitive to the presence Co<sup>2+</sup> (Fulkerson *et al.*, 1998, 2000). Compared with its bacterial relatives, Nic1p has a unique specificity (Eitinger *et al.*, 2000). Nic1p seems to be a third type of nickel permease, since Co<sup>2+</sup> was an inhibitor but, if at all, only a weak substrate for transport. Understanding the molecular basis of the differences in ion selectivity is a challenging problem.

Over the last two decades, sequences related to HoxN of gram-negative and gram-positive bacteria were reported. The list includes: *Bradyrhizobium japonicum* (BjHupN; Fu *et al.*, 1994), *Helicobacter pylori* (HpNixA; Mobley *et al.*, 1995), *Mycobacterium tuberculosis* (MtNicT; Cole *et al.*, 1998) and *Rhodococcus rhodochrous* (RrNhlF; Komeda *et al.*, 1997). The role of BjHupN, HpNixA, and RrNhlF has been experimentally investigated. In the absence of BjHupN, *B. japonicum* produces only low levels of hydrogenase activity under Ni limitation (Fu *et al.*, 1994). HpNixA plays a crucial role in *H. pylori*, a human pathogen that is dependent on a highly active urease for initial colonization of the gastric mucosa. At very low concentrations of noncomplexed Ni<sup>2+</sup>, reflecting the situation in human serum, HpNixA is essential for urease activity (Harry *et al.*, 1995). A K<sub>t</sub> value of 11 nM Ni<sup>2+</sup> was determined for this permease (Mobley *et al.*, 1995; Wolfram and Bauerfeind, 2002). RrNhlF was originally identified as a Co<sup>2+</sup> transporter in the actinomycete *R. rhodochrous* J1 (Komeda *et al.*, 1997). This organism produces two types of Co-containing nitrile hydratases, which are



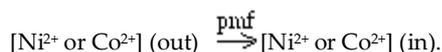


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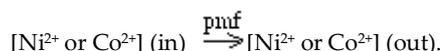
used as industrial catalysts for the kiloton scale production of acrylamide and nicotinamide (Kobayashi and Shimizu, 1998). A reinvestigation of its substrate specificity demonstrated that RrNhlF is able to transport Ni<sup>2+</sup> with high affinity, although a slight preference for Co<sup>2+</sup> ion was observed (Degen *et al.*, 1999).

A Ni<sup>2+</sup> transport system was reported for the thermophilic *Bacillus sp. strain TB-90* (Maeda *et al.*, 1994). It is encoded by the two distal genes (*ureH*, *ureI*) of the urease operon. When the operon was expressed in *E. coli*, urease activity was strongly diminished in the absence of UreH or UreI. UreH shows approximately 15% amino acid sequence identity to members of the HoxN family, but contains most probably less than eight transmembrane segments. UreI consists of only 65 amino acid residues and has no counterparts in the databases. The *Methanococcus jannaschii* genome-sequencing project revealed an ORF (ID number MJ1092) that is related to the *Bacillus* UreH. Two similar sequences were also reported for the plant *Arabidopsis thaliana* (ID numbers AL022023 and AC005825). *M. jannaschii* requires Ni for methanogenesis, and *A. thaliana* for incorporation into urease. Nevertheless, the available data do not allow additional conclusions on the mechanism of Ni<sup>2+</sup> transport in these organisms.

The overall reaction catalyzed by the proteins of subclass 1 of the NiCoT family is:



The overall reaction catalyzed by proteins of subclass 2 of the NiCoT family is probably:



### Other transporters of Ni-Co

Microorganisms have developed a number of devices to maintain appropriate intracellular concentrations of transition metal ions. Fig 1.2 schematically illustrates uptake and export systems, which are involved in Ni homeostasis in different bacteria. At high extracellular concentrations, Ni<sup>2+</sup> enters the cells by Mg<sup>2+</sup> transport systems. Under physiological conditions, Ni<sup>2+</sup> uptake is mediated by the Nik system in *E. coli*, and by members of the HoxN family in many other organisms. Metal resistance determinants like the *Cnr* and *Czc* export systems of *Alcaligenes* and *Ralstonia* species (Silver and Phung, 1996) or the P-type ATPases of *H. pylori* (Melchers *et al.*, 1998) export either excess Ni<sup>2+</sup> or other transition metal cations.

Certain ABC systems, consisting of three (CbiMQO) or four (CbiMNQO) components and encoded within prokaryotic coenzyme B12 biosynthesis gene clusters are implicated in cobalt uptake (Roth *et al.*, 1993). Since cognate extracellular binding proteins, pre-requisites for substrate uptake by prokaryotic ABC permeases, have not been identified, the mechanism of cobalt uptake by CbiM (N) QO remains elusive. Homologs of CbiMQO were identified adjacent to urease genes in *Streptococcus salivarius* (Chen and Burne, 2003) and *Actinobacillus pleuropneumoniae* (Bosse *et al.*, 2001), and shown to be important for urease activity in cells grown under nickel limitation. These ABC systems are confined to the prokaryotes; no homologues are reported in eukaryotes. Distant homologues of the NiCoT family (subfamily 2) have differing predicted topologies: 4, 5, 6, 7 and 8 TMSs. One such homologue, RcnA (YohM) of *E. coli* (274 aa) has 6 putative TMSs in a 3+3 arrangement with a large hydrophilic loop between putative TMSs 3 and 4. This protein is believed to catalyze Ca<sup>2+</sup> and Ni<sup>2+</sup> efflux (Rodrigue *et al.*, 2005). A putative Mg<sup>2+</sup> transporter from *E. coli* was identified (Silver, 1969; Nelson and Kennedy, 1972) and its transport properties described. The locus was named CorA because the phenotype of the mutant is resistance to growth inhibition by Co<sup>2+</sup> (cobalt resistance). Overexpression of the *Saccharomyces cerevisiae* magnesium transport system conferred resistance to aluminum ion (MacDiarmid and Gardner, 1998). The CorA gene was cloned from *S. typhimurium* and the protein characterized



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(Szegegy and Maguire, 1999). CorA was the first  $Mg^{2+}$  transport locus identified at the molecular level (Hmiel *et al.*, 1986). A novel family of magnesium transport genes in *Arabidopsis* was identified (Li *et al.*, 2001). The Mrs2p was identified as an essential component of the major electrophoretic  $Mg^{2+}$  influx system in mitochondria (Kolisek *et al.*, 2003). In keeping with the unique biological chemistry of the  $Mg^{2+}$  (Maguire and Cowan, 2002; Ronald and Michael, 1998), CorA has no homology to any other type of transporter or membrane protein. The crystal structure of CorA indicates a channel like structure (Lunin *et al.*, 2006). CorA mediates the influx of  $Mg^{2+}$ ,  $Co^{2+}$ , and  $Ni^{2+}$  (Snavey *et al.*, 1989). The uptake of  $Co^{2+}$  and  $Ni^{2+}$  by CorA is unlikely to be of great importance physiologically since the affinity of CorA for  $Ni^{2+}$  and  $Co^{2+}$  is within the toxic range for these bacteria. Nonetheless, since the requirement of a cell for  $Co^{2+}$  and  $Ni^{2+}$  is small, their "leakage" through CorA might provide some or all of the cell's requirements under many environmental situations.

**Metabolic role of cobalt**

Life is dependent on a number of chemical elements. Besides common elements, several trace elements are utilized, including certain metals and metalloids. Because these elements play important roles in cellular metabolism, efficient mechanisms of uptake, storage and utilization are required for many of them. Among biometals, cobalt (Co) is utilized at particularly low levels but play important roles in several biological systems. Cobalt in small amounts is essential to many living organisms, including humans. Having 0.13 to 0.30 mg/kg of cobalt in soils markedly improves the health of grazing animals. Biosynthesis of Ni and Co enzymes is dependent on high-affinity uptake of metal ions from natural environments. Co is mainly found in the corrin ring of vitamin B12 (also known as cobalamin), a group of closely related polypyrrole compounds such as cyanocobalamin, methylcobalamin and deoxyadenosyl cobalamin. Additionally, a few proteins containing non-corrin Co were reported, such as methionine aminopeptidase from *Salmonella typhimurium*, prolidase from *Pyrococcus furiosus* and nitrile hydratase from *Rhodococcus rhodochrous* (Kobayashi *et al.*, 1998). However, most of these proteins are not strictly Co-specific and may also use other metals (such as iron, zinc and manganese) in place of Co.

**Cobalt History**

Cobalt was known in ancient times through its compounds, which would color glass a rich blue. George Brandt (1694-1768) is credited with the discovery of cobalt (1730-1737). He was able to show that cobalt was the source of the blue color in glasses, which previously had been attributed to the bismuth found with cobalt. During the 19th century, cobalt blue was produced at the Norwegian Blaafarveværket (70-80 % of world production), led by the Prussian industrialist Benjamin Wegner. In 1938, John Livingood and Glenn Seaborg discovered cobalt-60. The word cobalt comes from the German kobalt or kobold, meaning evil spirit, the metal being so called by miners, because it was poisonous and troublesome (it polluted and degraded the other mined elements, like nickel). Some also think the name may derive from Greek kabalos, which means 'mine', and which may have common roots with kobold, goblin, and cobalt. Naturally occurring cobalt is composed of 1 stable isotope, 59-Co ( $^{59}Co$ ). 22 radioisotopes have been characterized with the most stable being  $^{60}Co$  with a half-life of 5.2714 years,  $^{57}Co$  with a half-life of 271.79 days, and  $^{56}Co$  ( $^{56}Co$ ) with a half-life of 77.27 days, and  $^{58}Co$  ( $^{58}Co$ ) with a half life of 70.86 days.

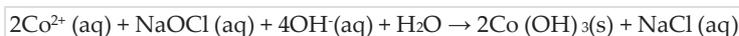
**Chemistry of cobalt**

Cobalt is a chemical element in the periodic table that has the symbol Co and atomic number 27. Cobalt is a brittle, hard, transition metal with magnetic properties similar to those of iron. Cobalt is present in meteorites. Ore deposits are found in Zaire, Morocco and Canada. Cobalt-60 ( $^{60}Co$ ) is an artificially produced isotope used as a source of  $\gamma$  rays (high energy radiation). Many ores contain cobalt but not many are of economic importance. These include the sulphides and arsenides linnæite,  $Co_3S_4$ , cobaltite,  $CoAsS$ , and smaltite,  $CoAs_2$ . Industrially, however, it is normally produced as a byproduct from the production of copper, nickel, and lead. Normally the ore is "roasted" to form a mixture of metals and metal oxides. Treatment with sulphuric acid leaves metallic copper as a residue and dissolves out iron, cobalt, and nickel as the sulphates. Iron is obtained by precipitation with lime (CaO) while cobalt is produced as the hydroxide by precipitation with sodium hypochlorite (NaOCl)

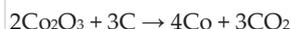
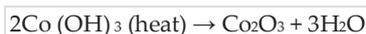




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The trihydroxide  $\text{Co}(\text{OH})_3$  is heated to form the oxide and then reduced with carbon (as charcoal) to form cobalt metal.



### Bioremediation of trace cobalt from radioactive waste of nuclear power reactors simulated effluents

The release of radionuclides into the environment is a subject of global health concern. Significant quantities of radionuclides were released during nuclear weapons testing in the 1960's and from Chernobyl plant in 1986. Globally, about 440 nuclear power reactors (NPRs) of a total generating capacity 360,000 MWe are in operation. In India, 15 units of NPRs are working with a total installed capacity of about 3500 MWe. These are mainly pressurized heavy water reactors (PHWRs) apart from two boiling water reactors. The construction of two units of 1000MWe (which are pressurized light water reactors) is in progress in addition to the construction of four 700 MWe PHWRs and three more 220MWe PHWRs. Nuclear Power Reactors (NPRs) namely the boiling water reactors (BWR's), the pressurized light water reactors (VVERs) and the pressurized heavy water reactors(PHWR's) though generate radionuclides as a part of the fission energy production, yet these fission products are well contained within the fuel elements themselves.

The radioactive waste streams arising at different stages of nuclear fuel cycle vary in the type and content of radioactivity. While the high level radioactive waste generated in the reprocessing plants is vitrified and contained, the intermediate level radioactive waste arising out of operating nuclear power plants, the mining and fuel element preparation activities are processed and the effluents are discharged after suitable dilution so as to conform to technical specifications. Chemical approaches are available for metal remediation, but these lack the specificity required for treating target metals against a background of competing ions. Biological approaches offer the potential for the highly selective removal of toxic metals coupled with considerable operational flexibility: they can be used both *in situ* and *ex situ* in a range of bioreactor configurations. Advances in understanding the roles of microorganisms in such processes, together with the ability to fine-tune their activities using the tools of molecular biology, has led to the development of novel or improved metal bioremediation processes. The aim of this study is to highlight the key steps in the nuclear fuel cycle where biological treatment strategies may augment existing chemical processes. The mechanisms of microbial interactions with key radionuclides in the wastes are discussed alongside the possible antagonistic effects of other organic and inorganic species present in effluents.

### Sources of radioactive waste generation

Radioactive waste generated is separated into three categories depending on its level of radioactivity and the length of time it remains hazardous such as low-level waste (LLW) which consists of processed radioactive waste from the operating nuclear power plants as well as from decommissioning operations exhibiting relatively short-lived radioactivity, Intermediate-level waste (ILW) contains the short-lived and long-lived radionuclides residing in spent ion-exchange resins used in the coolant purification processes (clean-up system) and high-level waste (HLW) consists mainly of highly radioactive and long-lived remnants of the fission process of nuclear fuel cycle.

### Nuclear fuel cycle

The nuclear fuel cycle is a chain of processes, beginning with the mining of uranium, manufacturing and managing nuclear fuel prior to and after its use in reactor (Fig 1.3). Natural uranium contains only small amounts (0.72%) of fissile  $^{235}\text{U}$  and requires enrichment to 3%  $^{235}\text{U}$  in power generation. The aim of reprocessing is to recover, for reuse, the uranium and plutonium which are to be separated from other activation and fission products. All steps in the



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cycle, from mining, fuel enrichment, reprocessing and reactor decontamination, generate waste contaminated with radionuclides (U, Th, Pu (the actinides), Po, Ra (arising from actinide decay), Ba, La, Ce, Ru, Rh, Mo, Tc, Cs, Xe, Kr, I etc (representative fission products) and certain isotopes of Co, Mn, Cr, Fe and Ni (activated corrosion products). These wastes are different at each stage and dictate the approach to be adopted by chemical or biological treatment.

### Mining and milling

The extraction of uranium ore from the earth is conducted by injecting the solvent (water) underground. Milling is the process through which mined uranium ore is physically reduced to a suitable size. Mining wastes contain high concentrations of Uranium, sulfate and lower concentrations of other metals such as molybdenum and selenium. Here contamination of personnel is a problem rather than personnel exposures due to any gamma radiation. Mill tailings contain the daughter elements of  $^{235}\text{U}$  and  $^{238}\text{U}$  and also Th and Ra as well as Po and Pb. Ra is precipitated with  $\text{BaSO}_4$  by the addition of  $\text{BaCl}_2$  and the complex formed  $(\text{Ba,Ra})\text{SO}_4$  is utilized by sulfate-reducing bacteria, releasing  $\text{H}_2\text{S}$ ,  $\text{Ba}^{2+}$  and  $\text{Ra}^{2+}$  (McCready and Krouse, 1980). *Shewanella putrefaciens* (dissimilatory iron-reducing bacteria) also release dissolved  $^{226}\text{Ra}$  from the tailings and is further precipitated using  $\text{Fe}(\text{OH})_3$  (Landa *et al.*, 1991).

### Reprocessing

Reprocessing is the operation by which the unused energy content of spent fuel is recovered and the highly radioactive (hundreds of giga becquerels) long lived fission products are separated, vitrified and contained. Fission reactions results in the production of medium-weight elements including radioiodine, noble gases, and rare earth elements. Neutron capture results in the formation of transuranic elements and their decay products, including various isotopes of plutonium, americium, and neptunium. These products together with the residual uranium dominate the fuel reprocessing waste.

### Decontamination

Decontamination involves the chemical dissolution of oxides formed (during regular operation) on the surfaces of structural materials of the primary coolant system of nuclear power plants (NPPs). Stainless steel, carbon steel, Higher Nickel Alloys in addition to Zircalloys from the main structural materials nuclear power reactors (Fig 1.3). Many of these reactor systems especially those designed and constructed in sixties to eighties employ stellite, a high cobalt (48%w/w) containing alloy especially in areas which experience a high torque such as valve seats, rolling pins etc. During reactor operation, due to the interaction of these materials with high temperature (573K) aqueous coolant, oxide films containing Fe, Ni and Cr in different proportions develop on their surfaces. These oxide films are typically of 2-5  $\mu\text{m}$  thickness on stainless steel surfaces and much higher (40- $\mu\text{m}$ ) on carbon steel surfaces after about 10 years of operation.

The corrosion products released to the coolant get transported through the core, get neutron activated thereby generating activated corrosion products (ACPs) containing radionuclides such as  $^{60}\text{Co}$ ,  $^{58}\text{Co}$ ,  $^{54}\text{Mn}$ ,  $^{51}\text{Cr}$  etc. Ions like  $\text{Co}^{2+}$ ,  $\text{Mn}^{2+}$  and  $\text{Ni}^{2+}$  can exchange with the  $\text{Fe}^{2+}$  ions of the magnetite type of oxide lattice while  $\text{Cr}^{3+}$  ions can exchange with the  $\text{Fe}^{3+}$  ions of the oxide lattice. Thus when the radioactive atoms occupy the lattice positions in the oxide lattice, then there is a buildup of radioactivity which results in the generation of radiation field on the surfaces of the primary system circuit materials of the reactor. The dilute chemical decontamination process referred to as CANDECON, CANDEREM, and CORD (Chemical Oxidation Reduction Decontamination) employ several organic complexing acids like citric acid (Joseph *et al.*, 1996; 1997), ethylene diamine tetra acetic acid (EDTA), oxalic acid) to chemically dissolve oxide films. For nuclear decontamination operations, the order of preference of the major chelating agents is  $\text{EDTA} > \text{NTA} > \text{Citrate}$ , in terms of the relative strengths of their metal complexes and the degree of cleanup that can be achieved. Power-generating nuclear reactors such as boiling water reactors, pressurized light water reactors, and pressurized heavy water reactors require chemical decontamination over a period of operation (Ayres, 1970; Taylor, 1976; Cohen, 1980; Lejon *et al.*, 1994).



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A major source of radiation field arises from the presence of activated corrosion product nuclides such as  $^{51}\text{Cr}$ ,  $^{59}\text{Fe}$ ,  $^{58}\text{Co}$ , and  $^{60}\text{Co}$  on the oxide-filmed inner surfaces of pipes and valves of equipment.  $^{60}\text{Co}$  has proven to be a major contributor for person-sievert budgetary because of its long half-life 5.27 years and its high  $\gamma$ -energies (1.17 and 1.33 MeV), though the equivalent chemical concentration of total cobalt ( $^{59}\text{Co} + ^{60}\text{Co}$ ) relative to that of Fe, Ni, and Cr when the oxide film is dissolved in a chemical formulation is very low (a few nanomolar; Charlesworth, 1971). A dilute chemical formulation consisting of a reducing agent like ascorbic acid, a complexing agent like ethylenediaminetetraacetic acid (EDTA) or nitrilo triacetic acid (NTA), and a pH-maintaining agent like citric acid, all in a few millimolar concentration levels, is employed to dissolve the corrosion-built spinel-inverse spinel oxide film of  $\approx 2\text{--}4\text{-}\mu\text{m}$  thickness in a typical reactor system employing stainless steel as major structural material (Grigoriev *et al.*, 1995). After the chemical decontamination, the concentrations of dissolved iron, chromium, and nickel in the spent decontamination formulation (simulated effluent (SE)) will be of the order of 5–10 mM Fe, 2–3 mM Cr,  $\approx 1$  mM Ni, and total Co  $< 20\text{--}30$  nM ( $< 1\text{--}2$  ppb). Typically, the simulated decontamination effluent (SE) is composed of iron (9.3 mM of Fe as  $\text{FeSO}_4(\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ ), chromium (3 mM of Cr as  $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ ), nickel (0.93 mM Ni as  $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$ ), and cobalt in the concentration range of 8.5–34 nM (0.5–2 ppb) Co as  $\text{CoCl}_2$  traced with  $^{60}\text{Co}$  to yield a solution specific activity of 40 Bq/ml (1.08 nCi/ml) and the tagged cobalt is represented as  $^{60}\text{CoCl}_2$  in the presence of disodium EDTA (13.5 mM) (Fig 1.4).

The spent decontamination solution is normally treated by employing synthetic organic ion-exchange resins of the cation and anion type (Bradbury *et al.*, 1986; Venkateswaran *et al.*, 2003). While the dose rate of the spent decontamination solution itself could be  $\ll 0.1$  Gy/h, the large volume of this solution when treated using ion-exchange columns could yield dose rates of  $\approx 0.1\text{--}1$  Gy/h on contact with the column (Venkateswaran *et al.*, 2003). Removal of cobalt present in trace chemical concentration in the spent decontamination solution has to be achieved in the presence of large excess ( $10^5\text{--}10^6$  fold) concentration of corrosion product ions of complexed Fe, Cr, and Ni. However, due to the nonspecific sorption of metal ions by the ion-exchange resin and due to the soluble complexed metal ions of Fe, Cr, and Ni present in spent decontamination effluent (SE) at  $10^5\text{--}10^6$  fold higher concentration level as compared to that of Co, a large volume of spent resin (solid waste) is generated in waste disposal though the cation-exchange capacities for the metal ions are in the range of  $\approx 50$  g of metal ( $\approx 0.8$  mol) per liter of the resin.

### Bioremediation based on radionuclide-microbe interactions

Microorganisms have the potential for bioremediation of toxic metal ions, as observed both in laboratory studies and in natural environments (Gadd and White 1989; Akthar *et al.*, 1995, 1996; King *et al.*, 1998; Allen *et al.*, 2002; Satinder *et al.*, 2006). Microorganisms interact with radionuclides via several mechanisms as shown below, some of which are used as the basis of potential bioremediation strategies. a) Biosorption b) Bioaccumulation c) Enzymatically catalyzed biotransformations d) Biomineralization via microbially generated ligands e) Microbially enhanced chemisorption of heavy metals. Based on the different types of effluents generated, a single technology cannot be suitable to address the problems. Hence specific bioremediation principles have to be explored to develop a suitable technology studies. Uptake of metals by various microorganisms broadly involves rapid process of biosorption to the cell wall followed by a relatively slower process of bioaccumulation into the cell (Rama Rao *et al.*, 1996; Naveena *et al.*, 2005). The latter process involves both specific and nonspecific transporters located on cell membrane. Further, there are tight homeostatic control mechanisms, which could limit metal uptake or even exclude metals that are accumulated inside the cell.

These interactions could be used for the improvement of bioremediation systems to remove or reduce the concentration of radionuclides from spent decontamination solutions (Gunjan *et al.*, 2005). Till recently, there was no specific metal-binding proteins for heavy metals like cobalt specificity is exhibited. Recent advances in genetic engineering aim to exploit the ability of these biological metal transporters (ABC, secondary, ion channels, phosphate transferases, and unclassified transporters) to assimilate and accumulate metals for bioremediation purposes (Maruthi *et al.*, 2007). The metal membrane transporters are broadly divided into different families.



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A novel cobalt transporter gene was first identified in *Rhodococcus rhodochorus* (*nhlF*; Komeda *et al.*, 1997) and later this was shown to be the NiCoT family of secondary transporters. NiCoT genes have been characterized from various bacterial species, of which *Rhodopseudomonas palustris* CGA009 (RP) and *Novosphingobium aromaticivorans* F-199 (NA) were shown to have preferential uptake for cobalt (Hebbeln and Eitinger, 2004). Recent studies reported from our laboratory involved screening and testing of various wild-type and mutant-type fungal strains and bacteria for the removal of  $^{60}\text{Co}$  ( $^{60}\text{Co}$  with carrier  $^{59}\text{Co}$ ) from simulated spent decontamination effluents (Rashmi *et al.*, 2004, 2007). However, using wild type bacterial strains only up to 1  $\mu\text{g/g}$  biomass,  $^{60}\text{Co}$  removal capacities could be achieved under optimal conditions, while in case of fungi the capacities realized were even lower (20–40 ng/g biomass). These capacities were realized in simulated spent decontamination effluents containing 34 nM of total cobalt (2 ppb). In the present study, an attempt has been made to effect a significant increase in the cobalt removal capacity by using recombinant *E. coli* and *Deinococcus radiodurans* R1 expressing NiCoT transporter genes of *R. palustris* CGA009 and *N. aromaticivorans* F-199. Furthermore, the effects of  $\gamma$ -radiation and chemical toxicity of the simulated effluent were also determined.

**Scope of the present investigation**

The spent decontamination solutions of nuclear power reactors contain high levels of radiation due to cobalt ( $^{60}\text{Co}$ ,  $^{58}\text{Co}$  and  $^{57}\text{Co}$ ) with a very large molar excess ( $10^5$ – $10^6$ ) of non-radioactive metals (Fe, Cr and Ni) (Fig 1.4). Present methods of removal use organic ion exchange resins. Due to the non-specific sorption, a large volume of spent resin is generated which requires tile-holes/trenches for safe burial. Earlier studies from our laboratory screened a number of bacteria and fungi which could significantly reduce the solid waste, with up to 30% removal capacity. In order to enhance the removal capacity and also further decrease biomass, cobalt specific transporter genes were identified using *insilico* approaches. In the present study a remarkable improvement in bioremediation of  $^{60}\text{Co}$  is achieved using recombinant *E. coli* and *Deinococcus radiodurans* R1 expressing NiCoT genes of *R. palustris* CGA009 and *N. aromaticivorans* F-199.

Rapid sequencing of prokaryotic genomes is facilitating the study of comparative genomics. During one such study of cobalamine synthesis gene clusters (*cob/cbi*), a multitude of potential cobalt transporters belonging to various families including the NiCoT family have been identified (Rodionov *et al.*, 2006). In the present study, in order to further improve the efficiency of  $^{60}\text{Co}$  removal over 80-90%, the specific high affinity transporters (Hebbeln and Eitinger, 2004) were cloned and expressed from *R. palustris* CGA009 and *N. aromaticivorans* F-199 in *E. coli*. The genes for the same were cloned and over-expressed in radioresistant *Deinococcus radiodurans* strain R1 which is one of the promising organisms in our study and capable over expressing cobalt transporter protein and transport (bioaccumulation) trace cobalt from simulated spent decontamination solutions of nuclear power reactors (Raghu et al 2008; Gogada et al 2015).

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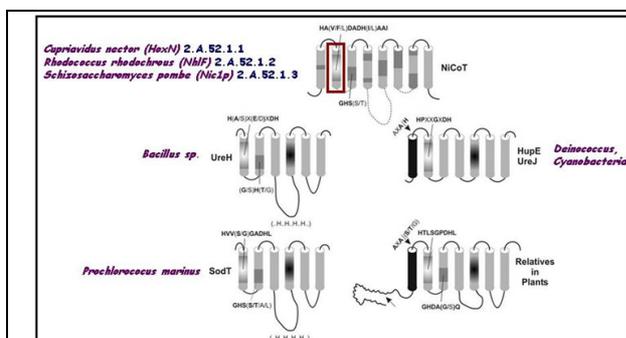


Figure 1: Ni/Co transporters Topology

Conserved segments within the NiCoT family, including the cytoplasmic loop between transmembrane domains (TMDs) IV and V, are highlighted. Dotted lines indicate sequence conservation in cytoplasmic loops. The motif in TMD II with the core sequence  $HX_4DH$  is considered to be a signature sequence for NiCoTs. Very similar signatures in UreH, HupE/UreJ, SodT and in the plant relatives are shown. Another His-containing motif is conserved in TMD III of the NiCoT sequences, and in TMD II of the UreH, SodT and plant sequences (bold letters indicate strong conservation). (Eitinger et al., 2005).

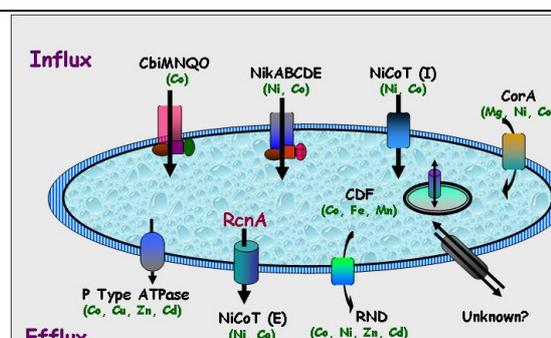


Figure 2: Ni/Co transport in bacteria

The schematic diagram illustrates uptake and export systems involved in Ni homeostasis in different microorganisms. NikABCDE and CbiMNQO are ABC members, their distribution being restricted to prokaryotes. The CorA family includes magnesium transport proteins, which are involved in uptake of Ni-Co at higher concentrations. Nramp members are essential virulent factors of most microorganisms, involved in uptake of manganese and to some extent Ni-Co. NiCoT members are secondary transporters involved in high affinity uptake of Ni-Co, the characterized members being limited to prokaryotes and yeast. The efflux members include P-type ATPases, RND members (Resistance Nodulation and cell Division) and NiCoT efflux members (YohM of *E. coli*).







## Application of Seaweed as a Bio-Fertilizer in Agriculture- Review Study

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### ABSTRACT

Bio-fertilizers offer another eco-friendly innovation which would overcome inadequacies of the conventional based cultivating. In this context seaweed plays a significant and indispensable job in the marine biological system and developing in huge amount in the ocean. Ocean growth can be viewed as an expected wellspring of bio-fertilizer in of dried or new structure; it assists with improving biochemical constituents like sugars, lipids, proteins, strands, debris, phenol, dietary fiber and so forth in plant. The seaweed is a great wellspring of miniaturized scale and large scale components required for plant sustenance. Seaweed extract is effective for improves the quality of soil also act as soil conditioner. This innovation can be actualized in type of natural cultivating for maintainable agribusiness which is better answer for eco friendly approach. The components of seaweed, for example, large scale and smaller scale component supplements, amino acids, nutrients, cytokinin, auxins, and abscisic corrosive (ABA)- like development substances influence cell digestion in offered plants upgrade development and enhance growth and crop yield.

**Keywords:** Biofertilizer, seaweed, nutrient content

### INTRODUCTION

All plants need certain minerals supplements to survive in environment. These minerals happen normally in the soil and are taken up from the soil by the underlying foundations of the plants. Most soil as a rule has enough of these minerals to keep plants solid. Be that as it may, plants are progressively ingested a few supplements or supplements are cleaned out of the soil, and should be supplanted to keep up ideal development and improvement of the plants. Most regular mineral supplements that need supplanting are N, P, K. Composts are fabricated by blends of items that contain N, P, K and other important supplements. The manures are important to include the soil in light of the

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fact that the supplements in the soil get spent because of rehashed development of the plant. The harvest yield likewise begins diminishing along these lines, arranged by restore the fruitfulness of the soil, composts are fundamental. The unnecessary use of chemical fertilizer (synthetic composition) in agriculture are expensive with unfavorable impacts on physico-chemical properties of soils, plant, and human life. Synthetic fertilizer are progressively resistance in the earth which now and again is destructive to the earth particularly, on soil richness and are really causing enormous measure of soil and land corruption (Liu et al., 2009) because of the fact that the vast majority of the microorganism decline following the utilization of substance composts in expanding level (Katsunori, 2003). The ground water sullyng is the greatest issues looked during the utilization concoction composts. In the soil nitrogen manures separates and changes over into nitrates which are water solvent and ventures effectively through the soil and they can stay in that position for a considerable length of time and these collection is causing the issue. These collections of synthetic compounds lead to water contamination both surface and ground water.

Organic manures are derived from natural products, which were collect from living organisms. Organic fertilizers are generally slow-releasing because they have to decompose and to become plant nutrients; however, this also means their benefits are longer lasting. All natural nutrients to soil, increases soil organic matter, improves soil physical properties, reduces soil crusting problems and consistent release of nutrients.

**ROLE OF SEAWEED BIOFERTILIZER**

The term of biofertilizer speak to everything from plant separates or plant extracts. Biofertilizers comprise of N fixers (Rhizobium, Azotobacter, blue green growth, Azolla), phosphate solubilizing microorganisms (PSB) and organisms (mycorrhizae) which increment the flexibly or accessibility of large scale (essential and auxiliary supplement) as well as smaller scale supplements to the host crops. Biofertilizers have demonstrated incredible potential as an, inexhaustible and natural agreeable wellspring of plant nutrient.. Biofertilizers are prepared to utilize and utilized as a live development of helpful microorganisms, when it altered to seed, root or soil, it activates the accessibility and utility of the microorganisms and accordingly the ability to improve the soil wellbeing and beginning to help microbial development and vegetation.

Seaweeds are one of the most important ocean sources of the world. The seaweed extract is available as fertilizer in different forms such as Seaweed liquid fertilizers, liquid fertilizers and powder form of seaweed extracts have been used as a biofertilizer (Table 1). The seaweed extracts are available for several years as fertilizer additives and beneficial results from their use have been reported (Booth, 1969). The components of seaweed such as macro and micro- element nutrients, amino acids, vitamins, cytokinin, auxins, and abscisic acid (ABA) like substances enhance growth and crop yield. The use of natural seaweed as fertilizer has allowed for partial substitution of synthetic fertilizer. Some studies have reported a wide range of beneficial effects of seaweed extract applications (like soil drench, foliar spray, on plants, such as improving soil moisture, water holding capacity and by promoting growth of beneficial soil microbes enhanced soil health. The compositions of different seaweed bio-chemical parameters are described in Table 2.

The treatment of seaweed extract expanded the seed germination, seedling development and yield of harvest. Nerissa Ali et al. (2016) watched the impact on developed under tropical field conditions with a soluble seaweed separate produced using *Ascophyllum nodosum* (ASWE) on tomato plants (*Lycopersicon esculentum* Mill). In this investigation, two field tests and one nursery test were led to assess strategies for application, measurements, the effect of each on plant development boundaries, the quality and yield of natural product. The higher centralization of ASWE brought about a noteworthy increment in plant tallness (37 %) and plant organic product yield (63 %) contrasted with control plants. The comparisons of micro and macro element of different seaweeds are available at table 3.

Rosalba Mireya et al. (2014) have tested the impact of various grouping of (0.2, 0.4, and 1.0 %) fluid ocean growth separates (LSEs) produced using two green kelp viz. *Ulva lactuca*, *Caulerpa sertularioides* and two earthy colored



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ocean growth viz. *Padina gymnospora*, and *Sargassum liebmannii* as biostimulants on the germination and development of tomato (*Solanum lycopersicum*) under nursery and in research facility conditions utilizing two use of foliar splash and soil soak of LSEs. *Ulva lactuca* and *Padina gymnospora* at lower fixation (2%) indicated better germination. The better germination reaction in germination rate related with lower mean germination time, most extreme germination record and germination vitality, and likewise more prominent plumule and radicle length and seedling power. Use of foliar shower was seen as less powerful in plant stature (75cm) than the soil soak (up to 79cm).

Sivasangari Ramya et al. (2015) contemplated the impact on development, biochemical and yield of brinjal by utilizing fluid concentrates of earthy colored marine alga *Stoechospermum marginatum*. The various groupings of fluid concentrates were arranged and applied as foliar splash on the brinjal seedlings, brought up in pots exploratory with kept up under common conditions. Their outcomes uncovered that the quantity of foods grown from the ground weight were expanded at lower focus just (1.5 %). Conversely, fluid concentrates at high focus (5%) was found to have inhibitory impact on brinjal plants when contrasted with the control splashed with water. Sutharsan et al., (2014) were experimented the effect of foliar application of *Sargassum crassifolium* extract at different concentration (concentration (10%, 20%, 50% and 100%) to apply on tomato plants at five times from 3 weeks after transplanting and the results was recorded after two weeks. At 20% of root dry weight (81.57%), shoot dry weight (80.92%), fruit number (57.87%) and fruit yield per hectare (58.70%), along with fruit total acidity (76.95%) and total soluble solids content (25.71%) of fruit significantly increased as compare to control, while all mentioned parameters reduced at 100% of foliar application. Therefore, it concluded 20% concentration of seaweed extract an be used to enhance the growth.

Dogra and Mandradia (2012) was determined the effects of soil applications of different concentrations of seaweed extract from *Ascophyllum nodosum* on growth, yield and downy mildew severity of onion during the Rabi season of 2009. The seaweed granules were applied as the basal dose (1.5, 2.0, 2.5, 3.0 & 3.5 g/m<sup>2</sup>). The highest yield recorded was with application of 2.5g/m<sup>2</sup> followed by 3.0g/m<sup>2</sup> that resulted in 120.8 per cent and 102.5 per cent respectively compared to control. Zodape et al., (2008) found effect of different concentration of (2.5%, 5.0%, 7.5% and 10.0%) to obtain from *Kappaphycus alvarezii* on yield and quality. In the result, significantly increased in length (31.77%) and diameter (18.26%) of fruit, number of fruits (37.47%) and fruit yield (20.47%) per net plot and nutritional quality of Okra (*Abelmoschus esculentus* L.) as compared to control. New research has expanded the arrangement of development stimulant atoms found in seaweed extracts. Firstly, it is rising that brassinosteroids are available in the Kelpak™ E. maxima ocean growth remove (Stirk et al 2014). Furthermore, notwithstanding brassinosteroids, strigolactones have been found in the Seasol™ seaweed separate (Arioli, unpublished information). Be that as it may, another ongoing report by Yusuf et al. (2012) that featured the multifaceted nature of kelp removes makes it hard to attribute the plant reactions to a solitary growth stimulant.

## CONCLUSION

According to the above study considered seaweed can be used as a great wellspring of full scale and smaller scale macro and micro nutrients, phenol, starches and higher substance of plant development hormones. Development advancing substances discharged by biofertilizers improve plant's physiological and biochemical boundaries. In addition to these points of interest, biofertilizers are monetarily encouraging as well. They are likewise nearly less expensive than the other chemical fertilizer.





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Table 1:- The comparison of different seaweeds macro- nutrient content

Name of seaweed	Type	N mg/g	P mg/g	K mg/g
<i>Sargassum wightii</i>	B	174.02	45.56	72.83
<i>Sargassum crassifolium</i>	B	0.4	0.009	1.520
<i>Padina pavonica</i>	B	0.01090	0.00926	0.16013
<i>Dictyota dichotoma</i>	B	175.02	44.56	71.84
<i>Laurencia obtuse</i>	R	3.9	3.8	2
<i>Corallina elongate</i>	R	3.4	3.8	1.6
<i>Jania rubens</i>	R	4	3.5	1.6
<i>Padina pavonica</i>	B	0.07985	0.00069	0.00278
<i>Ulva linza</i>	G	0.05716	0.00120	0.01265
<i>Ulva lactuca</i>	G	0.12609	0.00300	0.01634
<i>Ulva lactuca</i>	G	174.02	45.56	75.83

Whereas, G= Green Seaweed, B= Brown seaweed, R= Red Seaweed, N-Nitrogen content, P-Phosphorus content and K-Potassium content





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**Table 2:- The comparison of different seaweed bio-chemical parameters**

Name of seaweed	Type	P %	C %	L%	F%	A%
<i>Chaetomorpha crassa</i>	G	25.48	26.94	1.50	34.29	26.94
<i>Chaetomorpha linum</i>	G	30.70	26.08	1.30	31.94	26.08
<i>Gracillaria tenuistipata</i>	R	26.13	41.45	0.75	12.21	41.45
<i>Gracillaria fisheri</i>	R	26.71	47.47	0.62	11.78	47.47
<i>Caulerpa racemosa</i>	G	23.42	48.10	0.67	6.68	48.10
<i>Caulerpa branchypus</i>	G	26.34	54.38	1.42	6.04	54.38
<i>Caulerpa lentilifera</i>	G	12.68	27.19	1.09	4.83	27.19
<i>Caulerpa taxifolia</i>	G	33.83	41.24	3.26	7.17	41.24
<i>Ulva rigida</i>	G	13.32	67.84	0.15	5.69	67.84
<i>Ulva lactuca</i>	G	20.12	44.81	4.09	-	22.08
<i>Jania rubens</i>	R	12.93	42.18	2.39	-	39.25
<i>P. capillaceae</i>	B	23.72	50.49	2.71	-	13.02
<i>Enteromorpha intestinalis</i>	G	16.2	24	1.4	-	-
<i>Enteromorpha clathrata</i>	G	11	23	4.5	-	-
<i>Ulva lactuca</i>	G	3	23	1.5	-	-
<i>Codium tomentosum</i>	G	6	20	2.5	-	-
<i>Padina gymnospora</i>	B	17	21	1.2	-	-
<i>Colpomenia sinuosa</i>	B	10.5	22	2.3	-	-
<i>Ulva faciata</i>	G	14.98	39.86	0.21	-	-
<i>Chaetomorpha antennina</i>	G	13.45	34.96	0.34	-	-
<i>Spyridia hypnoides</i>	R	12.87	47.09	0.42	-	-
<i>Amphiroa anceps</i>	R	7.86	25.76	0.21	-	-
<i>Sargassum wightii</i>	B	16.34	54.09	0.51	-	-
<i>Chnoospora maxima</i>	B	9.87	55.86	0.54	-	-
<i>Caulerpa racemosa</i>	G	18.3	83.2	19.1	-	-
<i>Ulva faciata</i>	G	14.7	70.1	0.5	-	-

Whereas, G= Green Seaweed, B= Brown seaweed, R= Red Seaweed, L= Lipid content, F= Fiber content, A= Ash content

**Table 3:- The comparison of micro and macro element of different seaweed**

Name of seaweed	Type	Fe mg/ 100g	Zn mg/ 100g	Cu mg/ 100g	Mg mg/ 100g	K mg/ 100g	Na mg/ 100g
<i>Caulerpa sp.</i>	G	7.14± 0.27	3.41± 0.35	<0.55	949± 2.05	4411± 79.4	7042± 21.8
<i>Ulva lactuca</i>	G	4.65± 0.41	1.87± 0.07	<0.55	560± 4.85	6026± 22.2	3901± 71.6
<i>Sargassum sp.</i>	B	6.83± 0.07	3.74± 0.30	<0.55	953± 2.52	10040± 32.1	4024± 25.1
<i>Eucheuma denticulate</i>	R	6.45± 0.07	6.38± 0.45	<0.55	725± 3.70	3636 ±72.6	4448± 45.1
<i>Gracillaria sp.</i>	R	3.65± 0.26	4.35± 0.34	<0.55	565± 3.51	3417 ±76.3	5465± 27.4

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<i>Gelidiella acerosa</i>	R	10.60± 0.34	5.25± 0.21	<0.55	657± 7.60	30.34 ±41.6	3976± 18.1
<i>Kappaphycus alvarezii</i>	R	5.47± 0.17	5.09± 0.14	<0.55	639± 2.90	3877 ±25.1	3944± 52.0
<i>Stoehospermum marginatum</i>	B	0.50	1.58	3.014	17.31	0.107	5.77
<i>Ulva pertusa</i>	G	-	0.8± 0.2	1.0± 8.3	3670± 533	1224.1± 349.2	376.7 ±63.3
<i>Ulva intestinalis</i>	G	-	1.5± 0.2	0.9± 0.3	3098±1 157.2	2538.6 ±320.3	1064.5 ±489.1

Whereas, G= Green Seaweed, B= Brown seaweed, R= Red Seaweed





## A Perspective on Role of Different types of Nanoparticles in Plant Defense

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### ABSTRACT

Plant pathogens are becoming destructive to the crops in recent years and controlling them is one major problem faced by the farmers. The use of chemical pesticides and herbicides are showing lots of harmful effects towards the environment which is ultimately hampering human health as well as the animals. Thus to reduce these toxins from our habitat continuous efforts are being done to find beneficial alternatives and therefore emerges nanotechnology to treat the crops. Nanoparticles are very small particles ranging in size between 1 and 100 nanometres and are mainly classified into two categories viz. hard nanoparticles which are the metallic nanoparticles and the soft nanoparticles which comprises of the polymeric nanoparticles, liposomes etc. Though nanoparticles are used in various domains but they also have a high impact to control stress in plants, both abiotic and biotic. Metallic nanoparticles have largely shown antifungal inhibition against dangerous pathogens like *Alternaria* sp., *Sclerotinia* sp., *Fusarium* sp., *Rhizoctonia* sp. etc. Soft nanoparticles like chitosan have been used to control the plant fungi viz. *Fusarium* sp., *Alternaria* sp., among many. But the most effective nanoparticle formulation is the combination of both metallic and polymeric component which highly inhibited the phytopathogens as well as helped in growth of plants.

**Keywords:** Metallic nanoparticles, chitosan nanoparticles, plant pathogens, anti-fungal activity.





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## INTRODUCTION

Huge loss is occurring nowadays per year in crop yield and production due to plant pests and pathogens attack [1]. Currently the management of pests and pathogens depends on the application of fungicides, insecticides and herbicides which are having lots of harmful side effects inspite of fast action, high availability and reliability [2]. Thus there is an urgent need for the development of pesticides which will cause less harm to the environment apart from being cost efficient and high performing.

To control this menace nano sized particles of different materials have been developed which range in the size of 1-100 nm and shows completely different properties in comparison to its macro size. The use of nanoparticles (NPs) are less utilised in agricultural applications and development than in other fields such as medicine, engineering etc. [3] In agriculture nanotechnology has the ability to conserve and exploit natural resources, production and protection of crops, utilisation as nanosensors, and for transferring desired genes. Nanoparticles can be synthesized of different shapes, sizes and properties for target specific delivery of an active pesticide [4]. The utilisation of nanoparticles to protect the plants can occur by two different mechanisms: (a) nanoparticles itself acting for crop protection, or (b) nanoparticles acting as carriers of active pesticides which can be applied by sprays or seed/ root treatment. The nanoparticles that are mainly used to control the pest attack in plants are the metallic nanoparticles viz. copper NPs, silver NPs, zinc NPs etc and the soft nanoparticles mainly chitosan NPs.

### Metallic nanoparticles controlling plant pathogens

The attention on application of copper nanoparticles (CuNPs) are highly increasing due to their low cost, high thermal and electrical conductivity, and catalyst [5]. In comparison to other inorganic antimicrobial agents, the copper ones are widely used in agriculture field as fungicide [6], pesticide [7], algicide [8], and herbicide [9]. In an experiment carried out by Kanhed et al. (2014) copper nanoparticles (CuNPs) showed high affectivity than commercial fungicide Bavistin against four plant pathogenic fungi such as *Phoma destructiva*, *Curvularia lunata*, *Alternaria alternata* and *Fusarium oxysporum* [10]. The zone of fungal growth inhibition (mm) was high in CuNPs in comparison to bavistin and almost similar in case of CuNPs+ bavistin treatment. Maximum inhibition was found in the growth of *Fusarium oxysporum* fungal mycelia. The promising antifungal activity of the CuNPs was mainly because of their high surface area to volume ratio.

Efficacy of silver nanoparticles (AgNPs) has also been studied to reduce fungal infection in plants. Kim et al. performed antifungal assay with AgNPs on eighteen different fungi in different concentration of the formulation. The results obtained showed that silver NPs can inhibit the fungi efficiently; though the concentration of AgNPs had an impact on pathogens. Most of the fungi was highly inhibited at 100 ppm concentration of NPs and mainly on PDA media [11]. Lamsal et al. (2011) used AgNPs to manage pepper anthracnose caused by *Colletotrichum* sp. AgNPs were applied in different concentrations and 100 ppm concentration produced maximum fungal growth inhibition in vitro as well as in field condition [12]. Mesoporous alumina nanoparticles were synthesized by Shenashen et al. (2016) with active surface sites, and large surface area to volume ratio, which exhibited high antifungal activity against *Fusarium root rot* of tomato [13]. Magnesium oxide, titanium dioxide and zinc oxide nanoparticles reduced the radial growth of fungal mycelium of *Fusarium oxysporum* f. sp. *betae*, *Sclerotium rolfsii*, and *Rhizoctonia solani* which causes Damping-off and Root Rot of Sugar Beet [14].

### Polymeric nanoparticles restricting phytopathogen growth

Chitosan is a bio-polymer used for its antimicrobial activities and nanoparticles are synthesized from chitosan because of its biocompatibility, biodegradability, high permeability, cost-effectiveness and non-toxic property [15, 16, 17]. Chitosan nanoparticles have been extensively used to control the proliferation and growth of plant pathogens. Experiments performed by Sathiyabama et al. (2016) showed the antifungal activity of chitosan nanoparticles against devastating pathogens such as *Pyricularia grisea*, *Fusarium oxysporum* f. sp. *ciceri*, and *Alternaria solani* and it also act as





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a growth promoter of seedlings. Maximum hyphal growth inhibition was seen in *P. grisea* than other two pathogens [18]. Chitosan NPs inhibited the growth of fungi like *Alternaria alternata*, *Macrophomina phaseolina* and *Rhizoctonia solani* when applied at different concentrations ranging from 0.001 to 0.1% [19]. Oleoyl-chitosan (O-chitosan) nanoparticles were synthesized by Xing et al. (2016) to investigate its antifungal activity against phytopathogenic fungi viz. *Nigrospora sphaerica*, *Botryosphaeria dothidea*, *Nigrospora oryzae*, *Alternaria tenuissima*, *Gibberella zeae* and *Fusarium culmorum*. The first four pathogens were sensitive to chitosan NPs and their growth inhibited along with increase in concentration of NPs [20].

### Combination of metallic-polymeric NPs to inhibit phytopathogens

Though chitosan has been found to be highly effective in reducing the pathogen growth both in vitro and in vivo but blending it with other components like metal increases its efficiency. Copper-chitosan nanoparticles (Cu-CNPs) inhibited mycelial growth and also spore germination in *Alternaria solani* and *Fusarium oxysporum* in in vitro condition. In field experiments the Cu-CNPs showed antifungal activity in tomato plants and also promoted the growth of plants [21]. *Fusarium oxysporum* was treated with silver-chitosan NPs (Ag-CNPs) as well as chitosan NPs in in vitro conditions. Ag-CNPs showed higher radial growth inhibition of the fungus in comparison to chitosan NPs and it also changed the morphology of the pathogen, therefore recommending as a good antifungal agent [22].

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## Effect on Structural and Dielectric Study of Copper Doped SrTiO<sub>3</sub>

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### ABSTRACT

The strontium titanate ((Sr<sub>0.5</sub>Cu<sub>0.5</sub>TiO<sub>3</sub>)) perovskite sample is prepared by solid state reaction method. After Cu doped Strontium with STO; its crystal structure, particle size and lattice parameter were analysed. Structural studies of this perovskite were studied using x-ray diffraction (XRD). The morphology study were performed by scanning electron microscopy. Dielectric loss and dielectric constant of this material at room temperature were analysed for different frequency ranges.

**Keywords:** Solid state reaction; Modulus; Impedance; AC conductivity;

## INTRODUCTION

ABX<sub>3</sub> chemical formula refers to a perovskites structure, where A, B represents two cations with different sizes and X represents for anion which makes a strong bonding with cations. Perovskite material have many applications like ferroelectricity, grain boundary barrier layer capacitor, epitaxial growth, oxygen - gas sensor for superconductor thin films [1]. STO possesses insulating behaviour, conductivity, photo electricity capabilities with dopants such as Mg at cations side[2]. STO uses as an optoelectronic device and plays a vital role in oxide electronics [3]. When SrTiO<sub>3</sub> is compared with BaTiO<sub>3</sub> there are many differences found in their dielectric properties[4]. STO is used for passive devices like filters and antennas, active devices like tuneable rf filters and phase switches [5]. The multi-layered STO sensors have been found high potential for lean hydrocarbon sensing [6].

### Experimental

The sample of Cu doped SrTiO<sub>3</sub> was prepared using high-temperature solid state reaction technique using high-purity stoichiometry ingredients. The structure weighed stoichiometrically was carefully blended, first for 2 hours in an air atmosphere and then for another 1 hour in alcohol. Then the mixed powders were calcinated at an optimized temperature of 950°C for 4hr in a high purity alumina crucible. At first 0.025g of (Sr<sub>0.5</sub>Cu<sub>0.5</sub>)TiO<sub>3</sub> was taken in a crucible and heated it for two hours with a temperature of 150°C. Then the powder was grinded for 30 mins. Then





20ml of N, N-Dimethylformamide was taken in a conical flask and 5g of PMMA was added to it. The mixture is left at ambient temperature for 20 minutes under continuous magnetic stirring until a homogenous mixture is formed. Then to the above mixture stoichiometric (0.025g) amount of ceramic powder ((Sr<sub>0.5</sub>Cu<sub>0.5</sub>)TiO<sub>3</sub>) was added. Again, the mixture was stirred for 1hr and a homogeneous mixture was obtained. Then the homogeneous mixture was casted on glass Petridis and heated in a hot air oven at 120°C for 4-5 hours. Finally, the polymer film was obtained.

## RESULT AND DISCUSSION

### Structural Study

Fig 1 shows the XRD patterns of Cu doped SrTiO<sub>3</sub> at room temperature. The diffraction pattern shows sharp and noisy defined single diffraction peaks, which are different from those of the ingredients. This confirms the good homogeneity and crystallization of the prepared compound [7]. The cubic crystal structure has been confirmed for material. The chosen unit cells ' lattice parameters are refined using a conventional "POWD" computer program package. A strong agreement is found between observed (obs) and calculated (cal) interplanar spacing and is well aligned with interplanar spacing ( $\Delta d = d_{obs} - d_{cal} = \text{minimum}$ ). Cu doped SrTiO<sub>3</sub> crystallite size is roughly estimated from the expansion of XRD peaks (wide 2 ranges) using Scherer's equation  $P = KA / (\beta_{1/2} \cos \theta_{hkl})$  [17]. where K= constant= 0.89,  $\lambda = 1.5405 \text{ \AA}$ ,  $\beta_{1/2}$  =width of the reflection at half intensity). The composites ' average crystallite size (P) is 21 nm.

### Microstructural Study

Fig 2 Shows the Scanning Electron Microscope of Cu doped SrTiO<sub>3</sub>. From the image it can be seen that there is presence of amorphous phase in the composite. The grains are spread more or less homogeneously with less porosity throughout the sample surface. The shape of the grains is spherical. It is found that the average grain size is 200  $\mu\text{m}$ . It is noted that the size of the grain is greater than the size of the crystallite acquired from the Scherer equation. Thus, several crystallites can consist of a single grain.

### Dielectric Study

The variation of dielectric constant ( $\epsilon_r$ ) with frequency is shown in the graph. 3(a). From the graph it can be seen that with increase in the frequency, the dielectric constant decreases. The dielectric constant has a large value at lower frequency range which is a due to the occurrence of various types of polarization in this region like atomic, ionic, interfacial, and electronic polarization while in the high frequency region only the electronic polarization takes place which affects the value of dielectric constant [8]. Again, we can see the variation of dielectric loss ( $\tan \delta$ ) with frequency as shown graph 3(b). For lower frequency range, it shows high loss. As the frequency increases, the value of  $\tan \delta$  reaches a saturation value and after 20 KHz it starts to decrease on further increase in the frequency. The decreases till a certain point and increases on further increase in frequency and almost reaches a sturation value from 450 kHz 1000 kHz after which its value may affect the dielectric loss. The high value of  $\tan \delta$  at lower frequency may result in the high resistivity of grain boundary. As we know, the dielectric constant of the materials is linearly proportional to the average value of grain size, hence, the decrease of dielectric constant and  $\tan \delta$  as a function of Cu doping is due to the decrease of grain size which means that doping of Cu has affected the fabrication of SrTiO<sub>3</sub> ceramics as the mobility of grain boundary decreases because of the separation of defects created due to doping near the grain boundary [9]

## CONCLUSION

The ferroelectric composites of Cu doped SrTiO<sub>3</sub> are successfully prepared by high-temperature solid state technique. The composite shows the cubic structure having lattice constant a=b=c=3.903 angstrom. With increasing frequency, the dielectric constant decreases which explain that all types of polarization exist at low frequency and vanishes along with increasing frequency.





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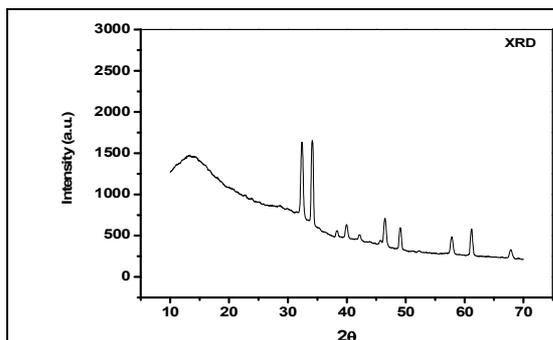


Fig-1. X-ray diffraction patterns of Cu doped SrTiO<sub>3</sub> polymer composites at room temperature

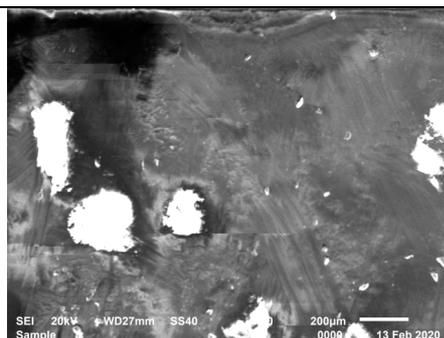


Fig-2. SEM of Cu doped SrTiO<sub>3</sub> polymer composites at room temperature

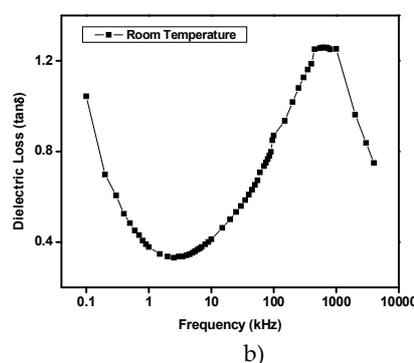
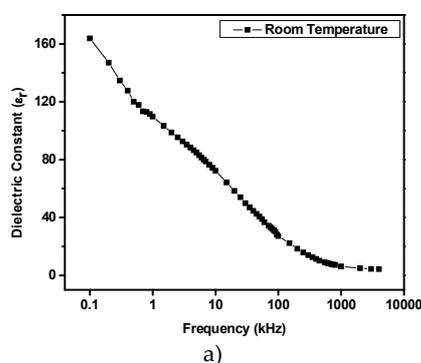


Fig 3(a) and (b): Frequency variation of dielectric constant ( $\epsilon_r$ ) and dielectric loss ( $\tan\delta$ ) of Cu doped SrTiO<sub>3</sub>.





## Structural and Dielectric of Copper Doped Lead Titanate Materials

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### ABSTRACT

Ceramic powders of Cu doped Lead titanate ( $\text{Pb}_{0.5}\text{Cu}_{0.5}\text{TiO}_3$ ) are synthesized through high temperature solid state reaction method. The various weight percentages of ceramic fillers incorporated into the polymer matrix via solution casting techniques. The structural and micro structural studies of this polymer composite were characterized by X-ray diffraction and scanning electron microscopy. Moreover, the dielectric and electrical properties of the composites were measured using an impedance analyzer in a wide range of frequency at room temperature.

**Keywords:** Solid state reaction; Dielectric constant; Impedance; AC conductivity;

## INTRODUCTION

Among ferroelectric materials with perovskite structure ( $\text{ABO}_3$ ), Lead titanate ( $\text{PbTiO}_3$ ) is mostly studied because of their unique physical structure and several other significant properties. Ferroelectric materials are a special type of materials which possess high value of dielectric constant, low dielectric loss, high electrical resistivity and good electrical properties. Because of their excellent piezoelectric and electrical properties these are ideal for various applications in the fields of thin film capacitors, electronic transducers, pyroelectric sensors and nonlinear optics. These materials exhibit spontaneous polarization and can also switch the direction of polarization [1]. It shows relatively low value of dielectric constant (~200) as compared to its other family member like Barium titanate ( $\text{BaTiO}_3$ ) and PZT ceramics.

It has also a high curie temperature of about  $490^\circ\text{C}$  [2]. It has a high value of pyroelectric coefficient and relatively low permittivity which makes it an ideal material for the application of pyroelectric infrared detector. At ambient temperature it shows a strong anisotropy which may be as high as ~1.6 (c/a ratio). A large value of c/a ratio favors the enhanced electrical properties [3]. In this work, we synthesized Lead titanate with Copper as a doping material and then made polymer films of this ceramic powder by solution casting method. Cu doping can increase work function, electrical conductivity, and carrier mobility of these films [4]. Here, we adopted conventional solid-state reaction

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method to synthesize the material i.e. Cu doped lead titanate ( $\text{Pb}_{0.5}\text{Cu}_{0.5}\text{TiO}_3$ ) because most of the chemical-based processing routes require organic or organometallic chemicals of high purity which are much more expensive than the oxides which are widely available also. Here we focus on electrical properties of the polymer films of this ceramic powder. The frequency dependent properties of the material can be studied with the help of complex permittivity ( $\epsilon'$ ), complex impedance ( $Z$ ) and dielectric loss ( $\tan \delta$ ).

### Experimental Technique

The ceramic powders of Cu doped  $\text{PbTiO}_3$  were prepared using high-temperature solid state reaction technique using high-purity stoichiometry ingredients. The samples were carefully blended, first for 2 hours in an air atmosphere and then for another 1 hour in alcohol. Then the mixed powders were calcinated at an optimized temperature of  $950^\circ\text{C}$  for 4hr in a high purity alumina crucible. The ferroelectric ceramic-polymer composites were prepared using solution casting technique. Firstly, the 0.025g of  $(\text{Pb}_{0.5}\text{Cu}_{0.5})\text{TiO}_3$  was taken in a crucible and heated it for two hours with a temperature of  $150^\circ\text{C}$ . Then the powder was grinded for 30 minutes. Then 20ml of N, N-Dimethylformamide was taken in a conical flask and 0.5g of poly (methylmethacrylate) (PMMA) was added to it. The mixture is left at ambient temperature for 20 minutes under continuous magnetic stirring until a homogenous mixture is formed. Then to the above mixture stoichiometric (0.025g) amount of ceramic powder  $[(\text{Pb}_{0.5}\text{Cu}_{0.5})\text{TiO}_3]$  was added. Consequently, the mixture was stirred for 1hr and a homogeneous mixture was obtained. Then the homogeneous mixture was casted on glass Petridis and heated in a hot air oven at  $120^\circ\text{C}$  for 4-5 hours. Finally, the polymer film was obtained.

## RESULT AND DISCUSSION

### Structural Study

Fig 1 shows the XRD patterns of Cu doped  $\text{PbTiO}_3$  at room temperature. The diffraction pattern shows sharp and noisy defined single diffraction peaks, which are different from those of the ingredients. This confirms the good homogeneity and crystallization of the prepared compound [12]. The tetragonal crystal structure has been confirmed for all concentrations. The chosen unit cells ' grid parameters are refined using a conventional "POWD" computer program package. A strong agreement is found between observed (obs) and calculated (cal) interplanar spacing and is well aligned with interplanar spacing ( $\Delta d = d_{obs} - d_{cal} = \text{minimum}$ ).  $\text{PbCuTiO}_3$  crystallite size is roughly estimated from the expansion of XRD peaks (wide 2 ranges) using Scherer's equation  $P = KA/(\beta_{1/2} \cos \theta_{hkl})$  [17], where  $K = \text{constant} = 0.89$ ,  $\lambda = 1.5405 \text{ \AA}$ ,  $\beta_{1/2}$  = width of the reflection at half intensity). The composites ' average crystallite size (P) is 42 nm.

### Microstrutural Study

Fig 2 Shows the Scanning Electron Microscope of Cu doped  $\text{PbTiO}_3$ . From the image it can be seen that there is presence of amorphous phase in the composite. The grains are spread more or less homogeneously with less porosity throughout the sample surface. The shape of the grains is spherical. It is found that the average grain size is  $1 \mu\text{m}$ . It is noted that the size of the grain is greater than the size of the crystallite acquired from the Scherer equation. Thus, several crystallites can consist of a single grain.

### Dielectric Study

Fig.3 (a) shows the variation of dielectric constant ( $\epsilon_r$ ) with frequency. From the graph it can be seen that with increase in the frequency, the dielectric constant decreases. The dielectric constant has a large value at lower frequency range which is due to the occurrence of various types of polarization in this region like atomic, ionic, interfacial, and electronic polarization while in the high frequency region only the electronic polarization takes place which affects the value of dielectric constant [5]. Again, we can see the variation of dielectric loss ( $\tan \delta$ ) with frequency as shown graph 3(b). For lower frequency range, it shows high loss. As the frequency increases, the value of  $\tan \delta$  reaches a saturation value and after 20 KHz it starts to decrease on further increase in the frequency. The





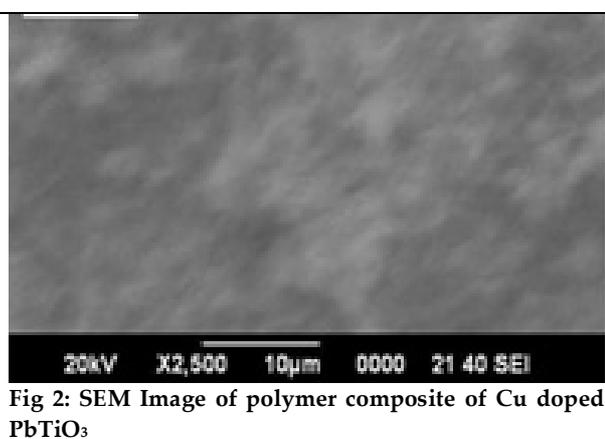
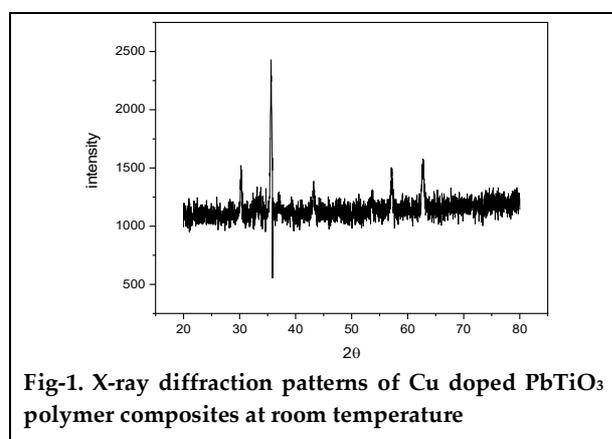
Oriental polarization and the electrical conductivity of material may affect the dielectric loss. The high value of  $\tan \delta$  at lower frequency may result in the high resistivity of grain boundary. As we know, the dielectric constant of the materials is linearly proportional to the average value of grain size, hence, the decrease of dielectric constant and  $\tan \delta$  as a function of Cu doping is due to the decrease of grain size which means that doping of Cu has affected the fabrication of  $\text{PbTiO}_3$  ceramics as the mobility of grain boundary decreases because of the separation of defects created due to doping near the grain boundary [6].

## CONCLUSION

The ferroelectric composites of Cu doped  $\text{PbTiO}_3$  are successfully prepared by high-temperature solid state technique. The resultant composite exhibits tetragonal structures. With increasing frequency, the dielectric constant decrease which explains that all types of polarization exist at low frequency and vanishes along with increasing frequency. We expect that the dielectric properties of the composites can be further improved by optimization of the hybrid particles.

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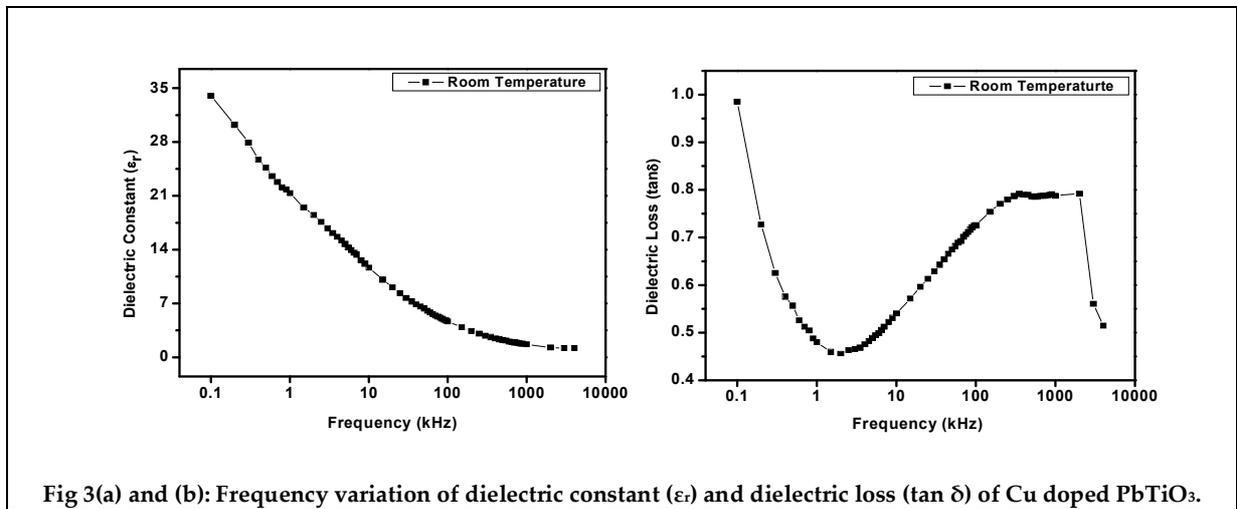


Fig 3(a) and (b): Frequency variation of dielectric constant ( $\epsilon_r$ ) and dielectric loss ( $\tan \delta$ ) of Cu doped  $\text{PbTiO}_3$ .





## Arc Plasma Treatment of Boron Carbide: Preparing Porous Free High Hardness Material

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### ABSTRACT

A high dense boron carbide sample has been prepared by thermal arc plasma melt-cast technique. The high temperature boron carbide was melted within 5-10 min of arc plasma reaction. This melt product exhibits higher hardness with least pore volume. As melting time increases from 5 min. to 10 min., density of product increases. Melt-cast samples were evaluated by X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), transmission electron microscope (TEM), BET (Brunauer-Emmett-Teller) analysis and micro hardness. This work reports a very hard, tough and porous free melt-cast product. Boron carbide prepared by 10 min. of plasma treatment was found to exhibit significantly high hardness (2705 VHN) and Young's modulus (540 GPa) values with almost zero porosity.

**Keywords:** Boron carbide, X-ray diffraction, Microstructure, Hardness

### INTRODUCTION

Ceramic is a solid material comprising of inorganic compound of metal, non-metal or metalloid atoms primarily held in ionic and covalent bonds. Common examples are earthenware, porcelain, and brick. General properties such as high melting temperature, high hardness, and poor conductivity, high moduli of elasticity, chemical resistance and low ductility are the norm, with known exceptions to each of these rules (e.g. piezoelectric ceramics, glass transition temperature, superconductive ceramics, etc.) [1-5]. The modern ceramic materials, which are classified as advanced ceramics, include boron carbide, silicon carbide and tungsten carbide [5-10]. The above carbides are valued for their abrasion resistance and hence find use in applications such as the wear plates of crushing equipment in mining operations. [10-15] Boron carbide has prominent place in ceramic material because of good mechanical, physical and thermal properties, which are described in following sections.





B<sub>4</sub>C is a refractory hard carbide material. It shows superior properties such as low density, high hardness, high melting point, high wear resistance, high thermal and electrical conductivities and a relatively high chemical stability [16]. B<sub>4</sub>C is very commonly used as a neutron absorbent [17]. With such a back drop, the development of B<sub>4</sub>C composites with least porosity has promising applications. [16-18]. These porous free materials have great applications for abrasive, corrosion-resistant and high temperature applications due to their high hardness, high stiffness, good wear resistant and high melting points [16-18].

### Experimental

Arc plasma melting of B<sub>4</sub>C was carried out by using 30 kW (dc) arc plasma reactor. Melting was followed by *in-situ* cooling of reactor / furnace up to room temperature. Ar was used as the plasma generating gas. Melting process was found to complete within 20-40 min. in the 30 kW reactor. Ar gas back up was maintained in the reactor / furnace during the first 1 hour of cooling to prevent oxidation of boron carbide. The dimensions of the ingots are as follows: dia.: 5-6 cm and height.: 1-2 cm. Electrical energy consumption for melt-casting was found to vary in the range 11 - 15.7 kWh / 0.1 kg, which is around 30 times higher than that of iron. This happened due to the common heat loss in the semi-open type of reactor / furnace. Recovery or yield of the composite products prepared in the 30 kW reactor is seen to vary between 86 and 91wt%. The recovery is fairly good in the lab scale operation. Voltage: 50-100 V and I=300-350 A was maintained for preparing different batch samples.

### RESULTS AND DISCUSSION

XRD was employed to study the formation of various phases in such composites. By taking various observed peak positions and the corresponding *d* values into account, the phases and *hkl* indices for various planes were identified by comparison of the observed *d* values with the *d* values in 1999 JCPDS data files (B<sub>4</sub>C: 73-0471, C (graphite-2H): 41-1487. XRD pattern of sample 1 shows major peak of B<sub>4</sub>C and C(G). Following B<sub>4</sub>C peaks are observed: (101), (012), (110), (104), (021) and (024). Carbon is found in graphite form C(G) (002). The major peak of B<sub>4</sub>C is detected at around two theta of 38°. No other impurity is found. The phases were found well defined crystalline phases with following standard FWHM of different peaks. B<sub>4</sub>C crystallizes in rhombohedral lattice with P31m (162) space group and C crystallizing in graphite phase grows in hexagonal lattice (2H polytype) with P6<sub>3</sub>/mmc (194) space group.

Microstructures of all the arc plasma melt-cast samples (mirror polished) were studied under FESEM where typical multiphasic morphologies are observed. Similar microstructure has been observed by other researcher for arc furnace melted and quenched B<sub>4</sub>C samples. In samples multiphasic granular microstructures are observed instead of lamellas. Such a difference in microstructure arises due to slower cooling rate produced in the arc plasma furnace during cooling cycle. Grains of three types of contrast, such as white, grey and dark, are seen in the microstructures. No porous structure is detected in the composite. The dark area is C(graphite). The grey and white phases were found in the melt-cast product. The grey phases were found to plate like structure. The white phase behaves like matrix in the phase. The structure of product was found match with literature. But in sample 3 due to formation of lamellar structure it is difficult to observe grain boundary between grey and white phases. This new kind of structure may have good impact on the mechanical properties of composite. Overall sample 1 and sample 3 are found to free from porosity.

It is evident from TEM image that three types of grains are observed i.e. grey/semi white, white and dark. From the TEM microstructure it observed that the samples are free from microporosity. Microhardness of composites was calculated from the indentation technique by the formula:

$$\text{VHN} = 1.8544 P/d^2 \quad (1)$$

where P is the applied load and d is the average length of diagonals.

No cracks are noticed on the surface, thus suggesting that the melt-cast carbides do not exhibit brittle behaviour at a load of 0.5 kg. At least ten indentations were made per sample and the result reported is the average



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microhardness with standard deviation. Microhardness measurement of samples is presented in Table 3. The microhardness of sample 1 was found to be 2500 VHN. The highest hardness value i.e. 2705 VHN is marked for sample 3. The improved hardness may be due to the presence of less porous (minimum pore value observed from BET analysis) and high melting fluidity during plasma treatment.

## CONCLUSION

Arc plasma melting process was employed to melt-cast B<sub>4</sub>C. The melt-cast products show recovery/yield in the range 78 – 92wt%. Higher value of electrical energy consumed for preparing the material because of high melting point (~27050 °C) of B<sub>4</sub>C. XRD characterization of the melt-cast product shows that B<sub>4</sub>C as major phases and unbound C appear mostly as minor phase. Lattice constants of B<sub>4</sub>C and C (graphite) were determined from *d* values obtained from XRD and found closely match with the corresponding values in JCPDS files. SEM and TEM microstructures reveal that the materials are free from micro porosity. Evaluation of hardness by micro indentation method shows that microhardness occurs in the range 2500-2705 VHN. The increase of hardness value indicates that the materials are not so brittle like common ceramics. The paper presents an elaborate study comprising new results on the preparation and characterizations of B<sub>4</sub>C. SEM image shows granular and lamellar type of structure. SEM and TEM images samples were found to be free from surface defects.

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**Table 1: Electrical energy consumption recorded in arc plasma melting and recovery / yield of B<sub>4</sub>C products.**

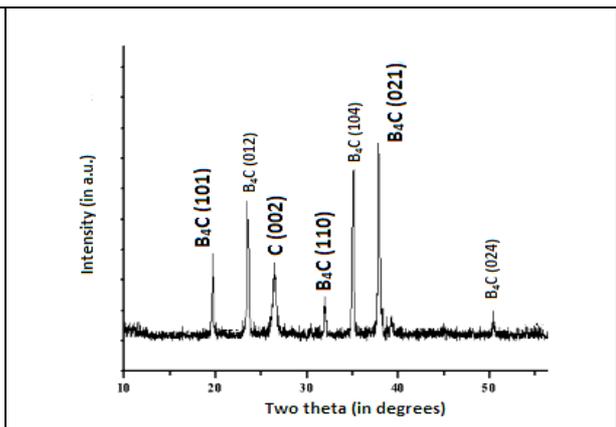
Sample ID	Wt% of sample in charge stage (in g)	Electrical energy consump. recorded for arc plasma melting (kWh/1kg)	Recovery/ yield of product from furnace (wt%)
Sample-1	100	25	88
Sample-2	100	30	78
Sample-3	100	35	92

**Table 2. BET surface area and microhardness studies of the arc plasma melt-cast B<sub>4</sub>C**

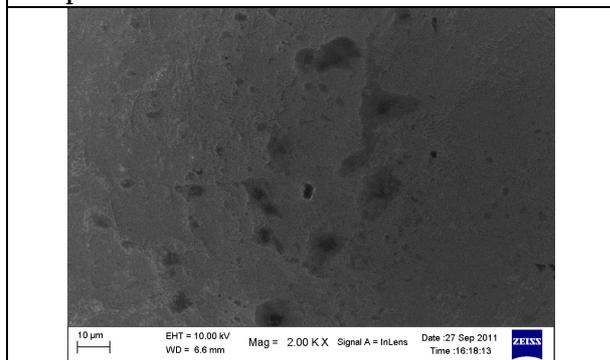
Sample ID	Microhardness (VHN)	Young's modulus	Pore volume determined by BET method (cm <sup>3</sup> /g)
Sample 1	2500 ± 22	400 ± 12	0.005
Sample 2	2440 ± 34	520 ± 14	0.004
Sample-3	2705 ± 28	540 ± 08	0.002



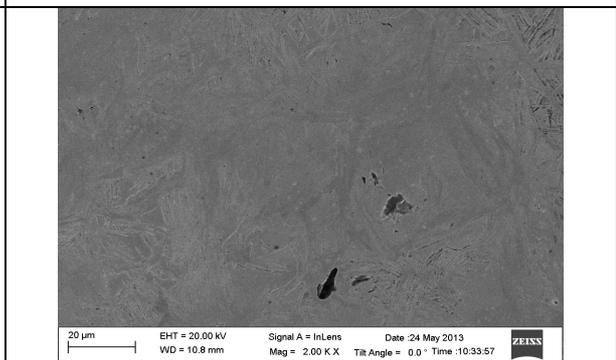
**Fig. 1: Photographic picture of the actual 30 kW (dc) arc plasma reactor used in the melt-casting of WC / its composites**



**Fig. 2: XRD pattern of plasma treated B<sub>4</sub>C**



**Fig. 3: FESEM microstructure observed for B<sub>4</sub>C (Sample 1)**

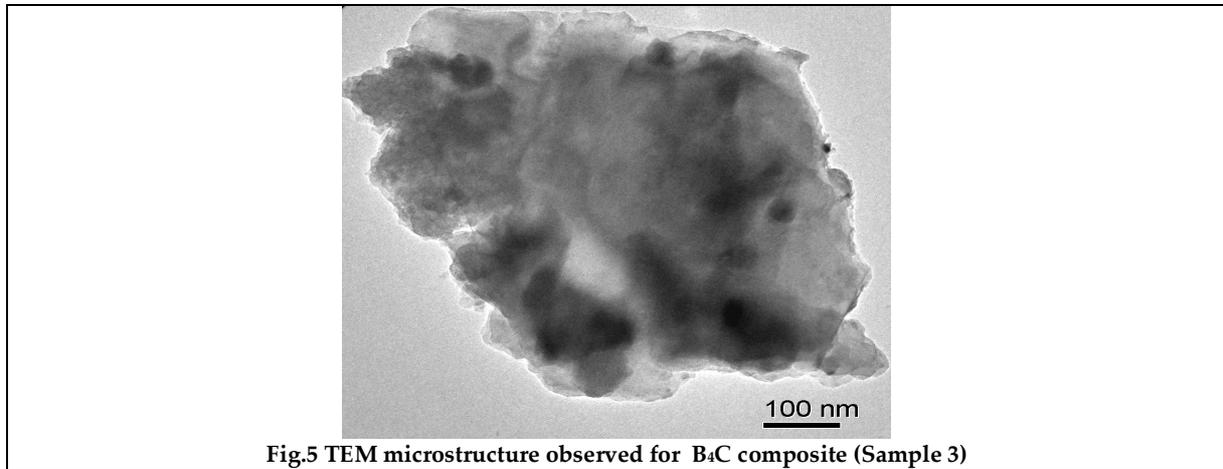


**Fig. 4 FESEM microstructure observed for B<sub>4</sub>C (Sample 3)**





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## Synthesis and Characterization of High Quality Indium Doped ZnO Nanostructures

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### ABSTRACT

Indium doped zinc oxide nanostructures have been synthesized from Zinc acetate dihydrate and indium nitrate dihydrate using sol gel technique. Effect of the dopant (indium) on the structural, morphological, and vibrational modes of zinc oxide nanostructures has been systematically studied using X-ray diffraction, field effect scanning electron microscopy and Raman spectroscopy, respectively. Indium ( $\text{In}^{+3}$ ) being a substitutional dopant in zinc oxide replaces  $\text{Zn}^{+2}$  ions, thus increasing the carrier concentration and affects vibrational modes. The effect of incorporation of indium and the origin of the observed vibrational modes are discussed. So it can be said that indium doped zinc oxide nano structures of desired characteristics can be synthesized using this low cost sol gel technique for its potential applications in numerous fields.

**Keywords:** Indium doping; Sol gel method; Raman Spectroscopy

### INTRODUCTION

Zinc oxide is an abundant, low cost and non toxic n-type material. It is a *II-VI* compound semiconductor and is having a stable wurtzite structure. It has lattice constants of  $a = 3.25 \text{ \AA}$  and  $c = 5.2 \text{ \AA}$  and their ratio  $c/a \sim 1.60$  is same as a hexagonal cell ( $c/a = 1.633$ ) [1]. It has a direct and wide band gap of 3.37 eV [2], and a free-exciton binding energy of 60 meV [2]. Owing to the said physical properties zinc oxide has numerous applications, such as semiconductor devices, transparent conductors, solar cell, varistors, gas sensors, etc. [3-5] and hence large effort has been focused on the synthesis, characterization and applications of zinc oxide nanostructures. These nanostructures can be synthesized by a variety of methods which includes sol-gel technique, wet chemical synthesis route, spray pyrolysis, and so on [6-7]. Undoped zinc oxide shows n-type conductivity due to the presence of donor type intrinsic defects such as oxygen vacancies ( $\text{V}_\text{O}$ ) and zinc interstitials ( $\text{Zn}_\text{i}$ ) [1].

24310





Doping with higher valent impurities further enhances the n-type conductivity of zinc oxide. Hence it is important to understand the influence of dopants on the structural and morphological characteristics of zinc oxide. There are several research papers reporting the doping of zinc oxide with n-type impurities such as aluminium (Al), tin (Sn), iron (Fe) and indium (In) [8-9]. Among all n-type impurities being used, indium is found to be one of the best dopant, as it introduces higher conductivity in zinc oxide. In the present work, we have systematically studied the effect of indium doping on the structural, morphological, and vibrational modes of zinc oxide nanostructures. The possible reasons for the observed characteristics of the synthesized nanostructures are discussed.

### Synthesis of nanostructures

Indium doped zinc oxide nanostructures were prepared by sol gel route using Zinc acetate dihydrate (purity 98%) and indium nitrate dihydrate (purity 99.99%). 1 wt.% of indium nitrate was first mixed with zinc acetate and was dissolved in 2-methoxyethanol. Mono-ethanolamine was added drop by drop into the solution through continuous stirring. The solution was heated at 60 °C and cooled to form a gel. The gel was dried in a vacuum oven kept at 80 °C overnight to form powder. The powder was then crushed in a mortar pestle and sintered at 700 °C for 2 h in air. To study the structural properties of the synthesized nanostructures, X-ray diffraction pattern were recorded using Rigaku Ultima III X-ray diffractometer. The micro structural properties were characterized by field emission scanning electron microscopy (FESEM) using CARL ZEISS SUPRA-40. The vibrational properties of the indium doped zinc oxide nanostructures were characterized by Raman spectroscopy. Possible reasons of the observed properties of the nanostructures were discussed.

## RESULTS AND DISCUSSION

### Structural Characterization

Fig. 1: X-ray diffraction pattern of indium doped zinc oxide nanostructures polycrystalline hexagonal nano structures with peaks at 31.72°, 34.28°, 36.20°, 47.50°, 56.46°, 62.85°, 67.76°, 69.04°, 72.45° and 76.71° are observed corresponding to (100), (002), (101), (102), (110), (103), (112), (201), (004) and (202) planes respectively, similar to a standard hexagonal zinc oxide structure [10]. Presence of these peaks shows that there is no additional phase for indium reflecting the uniformity in phase formation behavior and indicating the substitution of indium in zinc oxide lattice. Fig. 2 shows the energy dispersive X-ray spectroscopy (EDX) of the indium doped zinc oxide nanostructures. It is an analytical technique used to characterize the chemical compositions and purity of the grown samples [11]. As expected the shown spectrum indicates the inclusion of indium in zinc oxide lattice without any impurities.

### Micro Structural Characterization

Fig. 3: FESEM image of indium doped zinc oxide nanostructures. As seen from the figure a random orientation of grains with agglomerated nano structures were formed. This may be attributed to the rapid nucleation and growth of the nanostructures [12]. The random orientation of zinc oxide nano structures is also reflected from the Raman Spectroscopy as outlined below.

### Raman spectroscopy

Raman spectroscopy was performed to study the effect of indium on the vibrational properties of zinc oxide lattice. As reported by E-Morales and Pal, at long and short range orders solids exhibit a correlation between their vibrational properties and the spatial array of the constituent atoms [13]. Fig. 4 shows the Raman spectra of indium doped zinc oxide nanostructures. The spectrum reflects four peaks, located at about 331, 379, 436, and 580  $\text{cm}^{-1}$ . The highly intense peak at 436  $\text{cm}^{-1}$  is attributed to the high frequency mode ( $E_{2H}$ ) and may be due to the involvement of oxygen atoms. The broad LO mode peak at around 580  $\text{cm}^{-1}$  is attributed to the overlapping of two polar modes due to the random orientation of nanostructures, which was also observed from the microstructure of the sample.





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## CONCLUSION

In summary, indium doped zinc oxide nanostructures were synthesized by the cost effective sol gel technique using Zinc acetate dihydrate and indium nitrate dihydrate as the precursor materials. Phase formation behavior was studied from XRD technique and it confirmed the formation of hexagonal zinc oxide. EDX indicated the inclusion of indium into zinc oxide lattice without any impurity. FESEM images revealed the effect of indium doping in zinc oxide. Substitution of indium in zinc oxide is also reflected from the study of vibrational modes of Raman spectroscopy. So using sol gel technique indium doped zinc oxide nano structures with required properties can be synthesized for device applications.

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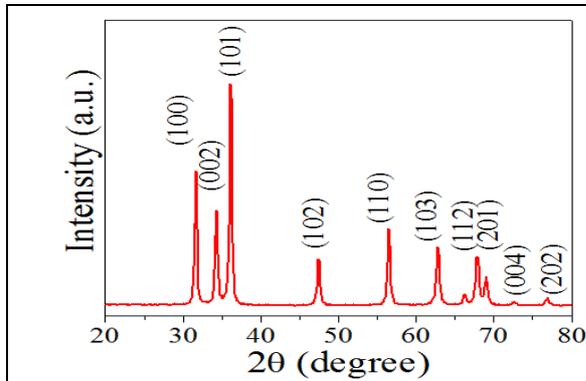


Fig. 1 shows the X-ray diffraction pattern of indium doped zinc oxide nanostructures. From the figure

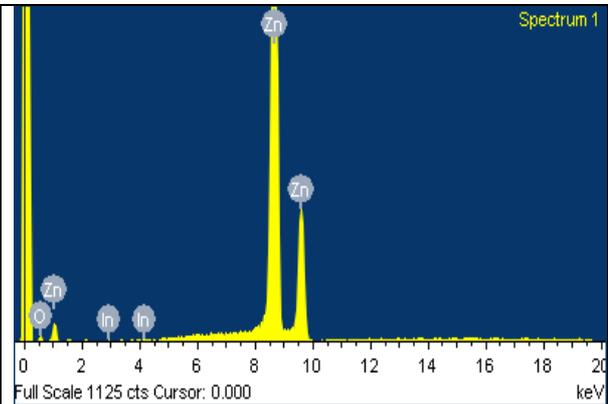


Fig. 2: Energy dispersive X-ray spectroscopy

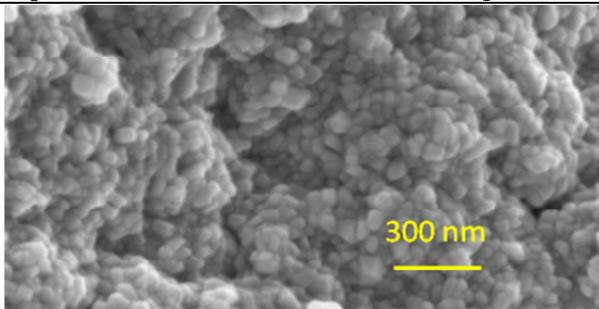


Fig. 3 shows a typical field emission scanning electron micrograph of indium doped zinc oxide nano structures.

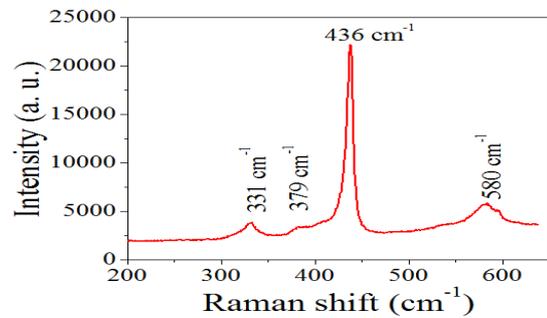


Fig. 4: Raman spectra of indium doped zinc oxide nano structures





## Electrical Transport and Conduction Mechanism of a Europium based Ferroelectric Ceramic

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### ABSTRACT

The article is based on an experimental study. The polycrystalline material  $\text{Na}_2\text{Pb}_2\text{Eu}_2\text{W}_2\text{Ti}_4\text{Ta}_4\text{O}_{30}$  of tungsten bronze structural family has been synthesized using a high-temperature (1100°C) solid-state reaction technique. Preliminary structural studies with X-ray diffraction data show the formation of single phase compound. Electrical properties of the material have been studied using complex impedance spectroscopy technique. It appears that temperature dependent electrical parameters are strongly correlated to the microstructure (i.e., presence of bulk, grain boundary, etc) of the sample. The complex impedance (Nyquist) plot display a single semicircle below 350°C confirming the effect of grain resistance on the electrical behavior. However, in the high frequency range the formed semicircle splits into two suggesting the contributions of both grain and grain boundary effect. The AC conductivity spectra obey Jonscher's universal power law. The activation energy calculated from DC conductivity confirms that the oxygen vacancies play an important role in the conduction mechanism.

**Keywords:** Solid-state reaction; impedance; electrical conductivity.

### INTRODUCTION

There has been rapid progress in search of new ferroelectric materials for industrial and commercial applications such as multi-layer capacitors, transducers, actuators, ferroelectric random access memory, electro-optic switches, pyroelectric detectors, optical modulators, mixers etc.[1–3]. Among all the known ferroelectric oxides of different structural families, oxides of tungsten bronze family have been found promising candidates for wide spread technological applications. The tungsten bronze structure consists of a complex array of distorted  $\text{BO}_6$  octahedral sharing corners in such a way that three different types of interstices ( $A_1$ ,  $A_2$ , and C) are available for cations of a





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general formula  $(A_1)_2(A_2)_4(C)_4(B_1)_2(B_2)_8O_{30}$ . As the smallest interstice C is generally empty, the filled tungsten bronze structure could have a general formula  $A_6B_{10}O_{30}$ . As the dielectric properties of these possible tungsten bronze tantalates are expected to be very interesting, it is an important to search for new low loss dielectric materials in this family for future applications. Detailed literature study reveals that attempts have also been made to develop some ferroelectric niobates, vanadates and tantalates having TB structure [4-9] to enhance some of their properties. One such compound which has drawn our attention is  $Na_2Pb_2Eu_2W_2Ti_4Ta_4O_{30}$  (NPEWTT) and has already been examined elsewhere [10] and some of its properties have been reported. Detail literature survey shows that no work has been reported on the electrical properties of the above compound. In the present work, we report the extensive study to explore the impedance properties of NPEWTT compound. The article is organized into four sections. After the introduction, the second section describes the experimental study process followed by a discussion on the results. The last section provides some concluding remarks.

### Experimental

The polycrystalline sample of  $Na_2Pb_2Eu_2W_2Ti_4Ta_4O_{30}$  (NPEWTT) was synthesized by a solid-state reaction technique using high-purity (AR grade) ingredients:  $Na_2CO_3$  (99%, M/s S.D. Fine Chem. Ltd.),  $TiO_2$ ,  $Ta_2O_5$  and  $WO_3$  (99%, M/s LOBA Chemie Pvt. Ltd. India),  $PbO$  (99.9% M/s E Merk India Ltd),  $Eu_2O_3$  (99.9%, M/s Indian rare earth Ltd). These oxides as well as carbonate were (taken in stoichiometry proportion) mixed in dry (air) and wet (methanol) medium for two hours each in agate mortar. The mixed material was calcined at an optimized temperature ( $1100^\circ C$ ) on the basis of repeated firing and mixing for 4 h in alumina crucible. An X-ray diffraction (XRD) pattern on calcined powder was recorded at room temperature using X-ray powder diffractometer (Rigaku Miniflex). The  $CuK\alpha$  radiation ( $\lambda = 1.5405 \text{ \AA}$ ) was used to collect data in a wide range of Bragg's angle ( $2\theta$ ) ( $20^\circ \leq 2\theta \leq 80^\circ$ ) at a scanning rate of 3 deg/min for preliminary structural analysis. The powder was then pelletized under the uniaxial pressure of 3.5 ton with polyvinyl alcohol (PVA) as binder. The pellets were then sintered at  $1150^\circ C$  for 6 h. The polished sintered pellet was electroded with high purity and quality silver paste and, dried at  $150^\circ C$  for 4 h before taking dielectric and electrical measurements. The surface morphology of a gold-coated pellet sample was recorded by JEOL JSM-5800 scanning electron microscope (SEM). The capacitance, dissipative factor, and impedance parameters on silvered-coated pellet was obtained as a function of temperature ( $29-500^\circ C$ ) in a wide range of frequency (0.1kHz-1MHz) using a computer-controlled impedance meter (Hioki 3532 LCR Hitester) with a laboratory-designed and fabricated sample holder and furnace. To record the temperature at small interval, a chromel-alumel thermo-couple and KUSAM MECO 108 digital milli-voltmeter were used.

## RESULTS AND DISCUSSION

### Impedance analysis

Complex Impedance spectroscopy (CIS) [11] is the most reliable technique to study the electrical properties and process of the materials. The IS technique is based on analyzing the ac response of a system to a sinusoidal perturbation, and subsequent calculation of impedance and related parameters as a function of frequency of the perturbation. Each parameter can be used to highlight a particular aspect of the material. A parallel resistance and capacitance circuit corresponding to equivalent to the individual component of the materials (i.e., bulk and grain boundary) represents a semicircle. Impedance data of materials (i.e., capacitive and resistive components), represented in the Nyquist plot, lead to a succession of semicircle. The electrical properties are often presented in terms of impedance (Z) [12], permittivity ( $\epsilon$ ) [13] and electrical modulus (M) [14]. Measurements of impedance and related parameters of the materials provide us some important data having both real (resistive) and imaginary (reactive) components. These components are calculated using some basic equations: complex impedance  $Z(\omega) = Z' - jZ'' = R_s + \frac{j}{\omega C_s}$ , complex electrical modulus  $M(\omega) = \frac{1}{\epsilon(\omega)} = M' + jM'' = j\omega\epsilon_0 Z$ , complex admittance  $Y^* = Y' - jY'' = j\omega C_p \epsilon^* = (R_p)^{-1} + j\omega C_p$  and complex permittivity  $\epsilon^* = \epsilon' - j\epsilon''$  where  $\omega = 2\pi f$  is the angular frequency;  $C_0$  is the geometrical capacitance,  $j = \sqrt{-1}$  and subscripts p and s are parallel and series circuit components respectively.

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Figure 1. (a) and (b) show the variation of the real part ( $Z'$ ) and imaginary part ( $Z''$ ) of impedance with frequency at various temperatures. It is observed that the magnitude of  $Z'$  decreases with the increase in both frequency as well as temperature indicating an increase in ac conductivity with the rise in temperature and frequency. The values of  $Z'$  for all temperatures merge above 10 kHz. This may be due to the release of space charges as a result of reduction in the barrier properties of material with the rise in temperature, and may be a responsible factor for the enhancement of ac conductivity of material with temperature at higher frequencies. Further, at low frequencies the value of  $Z'$  decreases with rise in temperature showing negative temperature coefficient of resistance (NTCR) type behavior (like that of semiconductors). The variation of  $Z''$  with frequency attains a maximum value ( $Z''_{\max}$ ) at a particular frequency known as electrical relaxation frequency for all temperature. The magnitude of  $Z''_{\max}$  decreases with temperature indicating an increasing loss in the resistive property of the sample. The value of  $Z''_{\max}$  shifts to higher frequencies with increasing temperature. This indicates an increase in the value of the tangent loss of the material. A significant increase in the broadening of the peaks with increase in temperature suggests the existence of a temperature dependence of the electrical relaxation phenomenon in the material. The relaxation process may be due to the presence of electrons/immobile species at low temperatures and defects/vacancies at higher temperatures [15]. The asymmetric broadening of the peaks suggests a spread of relaxation time with two equilibrium positions.

Fig 2. shows complex impedance spectrum (Nyquist plots i.e.  $Z''$  versus  $Z'$ ) with fitted data [16] at different temperatures. The single semicircular arcs of  $Z'' - Z'$  plots at temperatures  $\leq 350$  °C indicate that the electrical processes in the material arises basically due to the contribution from bulk material (grain interior) and can be modeled as an equivalent electrical circuit comprising of a parallel combination of bulk resistance  $R_b$  and bulk capacitance  $C_b$ . At higher temperatures,  $\geq 375$  °C two overlapping semicircular arc have been observed which represents the contribution of both bulk and grain boundary effect. As the temperature increases, the intercept of the semicircles at the  $Z'$  axis shifts towards lower  $Z'$  values, indicating the reduction of the grain (bulk) resistance and grain boundary. The decrease in the value of  $R_b$  is associated with an increase in conductivity with rise in temperature, also the decrease in  $R_{gb}$  values with increase in temperature, suggest a lowering of the barrier to mobility of charge carriers aiding electrical conduction at higher temperature. Further, the depressed semicircles have their centers below the real axis, which indicates the departure from the ideal Debye-type behavior. The values of the electrical or transport parameters corresponding to the equivalent circuit modeled by fitting processes of the measured data at different temperatures are given in Table 1. All the fitted parameters ( $R_b$ ,  $C_b$ ,  $Q$  and  $n$ ) show an anomaly at 375°C due to its ferroelectric to paraelectric phase transition at that temperature [10].

The frequency dependence of imaginary component of impedance ( $Z''$ ) and modulus ( $M''$ ) is shown in Fig. 3. The combine plot of  $Z''$  and  $M''$  as a function of frequency is used to detect the presence of the smallest capacitance and the largest resistance [17]. This plot also helps to distinguish whether relaxation process is due to short range or long range motion of charge carriers. For the short range process, peaks of  $Z''$  and  $M''$  will occur at different frequencies whereas for long range they will occur at same frequency [18-19]. In the studied compound there is mismatch of peaks of different temperatures which suggests short range motion of charge carrier and departure from ideal Debye-like behavior.

### Modulus analysis

Complex modulus formalism is a very important and convenient tool to determine, analyze and interpret the dynamical aspects of electrical transport phenomena (i.e parameters such as carrier/ ion hopping rate, conductivity relaxation time, etc). It provides an insight in to the electrical processes characterized by the smallest capacitance in accordance with the relations :

$$M' = \omega C_0 Z' \quad \text{and} \quad M'' = \omega C_0 Z'' \quad , \quad C_0 = \epsilon_0 A/t$$

( $\epsilon_0$ = permittivity of free space,  $A$ =Area of the electrode surface and  $t$ = thickness of the sample).

Fig 4. shows the variation of  $M'$  and  $M''$  with frequency at selected temperatures.  $M'$  is characterized by a very low value (almost zero) in the low frequency region then a continuous increase with an increase in frequency, having a





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tendency to saturate at a maximum asymptotic value in the high frequency region for all temperatures. The value of  $M'$  approaches to zero at low frequency whereas monotonic dispersion with rise infrequency may be due to presence of conduction phenomenon and short range mobility of charge carriers. This implies the lack of restoring force for flow of charge under the influence of steady electric field [20]. The variation of  $M''$  with frequency shows peaks at a unique frequency that describes the type and strength of electrical relaxation phenomena in the material. The  $M''_{max}$  peak shifts to higher frequency side which suggests the hopping mechanism of charge carriers dominates intrinsically is thermally activated process. Asymmetric broadening of the peak indicates spread of relaxation with different time constants, which suggests non- Debye type [21].

The scaling behavior of the sample was studied by plotting normalized parameters (i.e.,  $M''/M''_{max}$ vers  $\log (f/f_{max})$ ) where  $f_{max}$  corresponds to a value of  $M''_{max}$ at different temperatures (Fig.5). This curve gives an insight into the dielectric processes occurring inside the material as a function of temperature. The coincidence of the curves at different temperature indicates the temperature independentbehavior of dynamic processes occurring in the material [22].This may be due to charge carrier migration by hopping mechanism. The frequency region where the peak occurs indicates the transition from long range to short range mobility [23].

### AC Conductivity

The frequency dependence of ac conductivity,  $\sigma(\omega)$ , at various temperature is shown in Fig. 6. At low temperatures the conductivity increases with rise in frequency, which is a characteristic of  $\omega^n$  ( $n$ =exponential). At high temperatures and low frequencies conductivity shows a flat response while it has a  $\omega^n$  dependence at high frequencies. The phenomenon of the conductivity dispersion in solids is generally analyzed using Jonscher's power law; [24]  $\sigma_{ac} = \sigma_{dc} + A\omega^n$ , where  $\sigma_{dc}$  is the dc conductivity (frequency independent plateau in the low frequency region),  $A$  is the temperature dependent frequency pre-exponential factor and  $n$  is the power law exponent in the range of  $0 \leq n \leq 1$ . The exponent  $n$  represents the degree of interaction between mobile ions with the lattice around them, and the pre exponential factor  $A$  determines the strength of polarizability. The material obeys the universal power law, and is confirmed by a typical fit of the above equation to the experimental data at various temperatures. It is obvious that  $\sigma_{ac}$  increases with rise in frequency but it is nearly independent at low frequency region.

Therefore, extrapolation of this part towards lower frequency side gives  $\sigma_{dc}$ . The increasing trend of  $\sigma_{ac}$  with rise in frequency (in low frequency region) maybe attributed to the disordering of cations between neighboring sites, and presence of space charge. In the high frequency region the curves approach to each other. The nature of conductivity plots reveals that the curves exhibit low frequency dispersion phenomena obeying the Jonscher's power law. According to Jonscher's the origin of the frequency dependence of conductivity lies in the relaxation phenomena arising due to mobile charge carriers. When a mobile charge carrier hops to a new site from its original position, it remains in a state of displacement between two potential energy minima. From non-linear fitting it is found that the motion of charge carriers in the samples is translational one because of small value of  $n$  ( $<1$ ) [25]. In the high frequency domain the conductivity becomes more or less independent of frequency. This typical behavior suggests the presence of hopping mechanism between the allowed states.

### DC Conductivity

Fig. 7.shows the variation of DC conductivity with respect to inverse of absolute temperature. The value of bulk conductivity of the material was evaluated from the complex impedance plots of the sample at different temperatures using the relation  $\sigma_{dc} = t/AR_b$  where  $R_b$  is the bulk resistance,  $t$  the thickness and  $A$  is the surface area of the sample respectively. The dc conductivity increases with rise in temperature confirming the negative temperature co-efficient of resistance (NTCR) behavior. This plot follows the Arrhenius relation:  $\sigma_{dc} = \sigma_0 e^{(-E_a/(K_B T))}$ . The activation energy was calculated from the linear portion of the plot of DC conductivity versus  $10^3/T$  (Fig.7) and was found to be 0.6 eV. Usually, activation energy less than 1.0 eV is connected to singly ionized vacancies and /or electronic mobility in space charge region [26]. So, the conduction process with in this temperature range may be due to the hopping of charge carriers and /or singly ionized oxygen vacancies of the ceramic.





### Concluding Remarks

The complex impedance plots reveal the contribution of both bulk and grain boundary effects in the sample. The material shows NTCR character, temperature dependent relaxation phenomena and polydispersive non-Debye type dielectric relaxation. Modulus analysis has established the possibility of a hopping mechanism for electrical transport processes in the material. The ac conductivity obeys the universal power law and dispersion in conductivity is observed in the lower frequency region. The dc conductivity is observed to increase with increasing temperature further confirming NTCR behavior.

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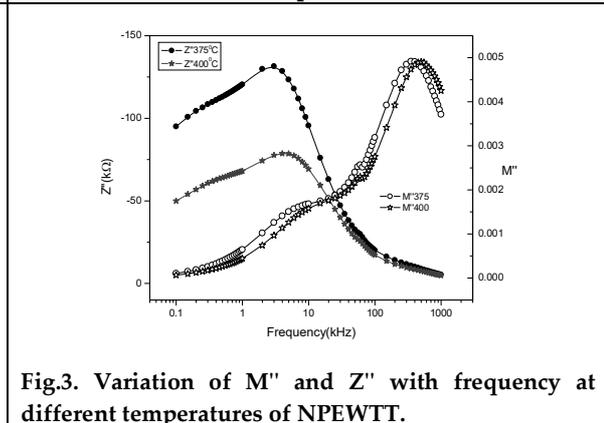
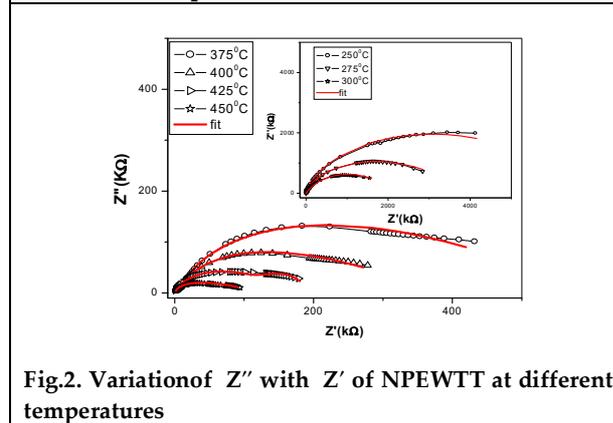
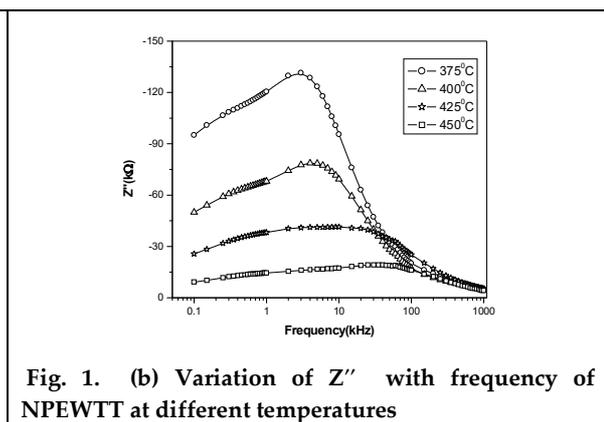
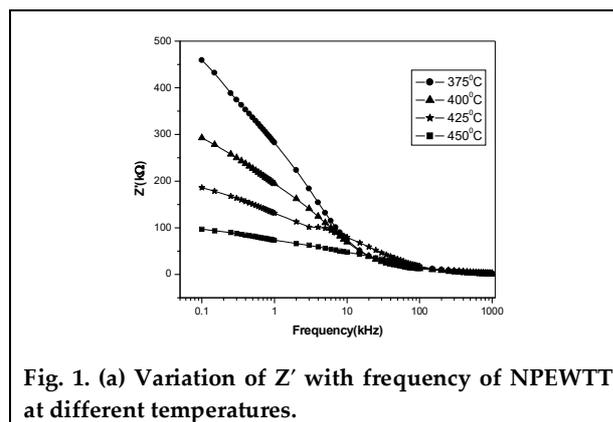


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**Table.1. The values of the electrical or transport parameters in different temperatures**

Temperature(°C)	R <sub>b</sub> in(Ω)	C <sub>b</sub> (in Farad	CPE(Q)	n
250	8.509E6	2.453E11	4.316E9	4.714E-1
275	3.871E6	2.340E11	3.380E9	5.281E-1
300	1.870E6	4.565E11	2.318E9	6.498E-1
375	5.784E5	7.862E11	4.847E8	3.994E-1
400	3.608E5	8.169E11	7.743E8	3.857E-1
425	2.332E5	2.938E11	1.905E7	3.615E-1
450	9.314E4	2.986E11	1.197E7	3.956E-1





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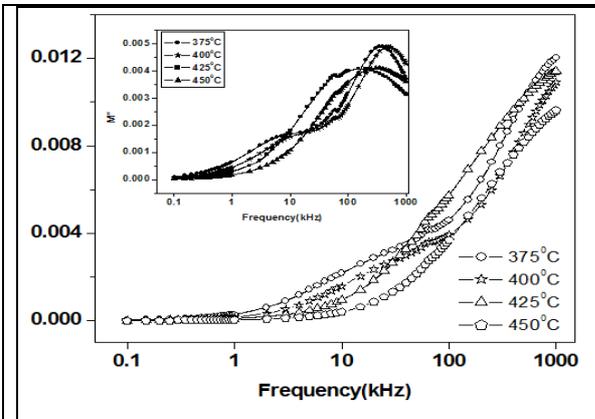


Fig.4. Variation of  $M'$  and  $M''$  with frequency at different temperatures of NPEWTT.

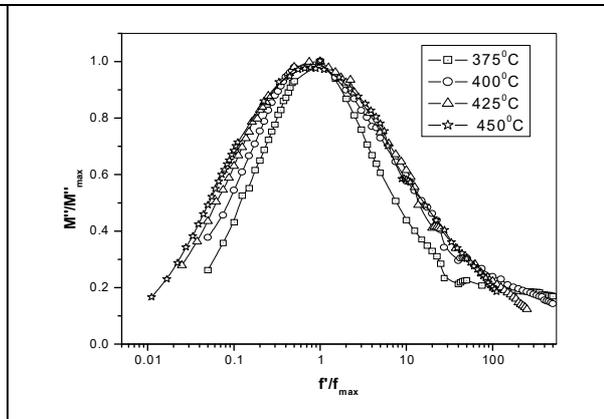


Fig.5. Variation of  $M'/M''_{max}$  with  $\log(f/f_{max})$  at different temperatures of NPEWTT.

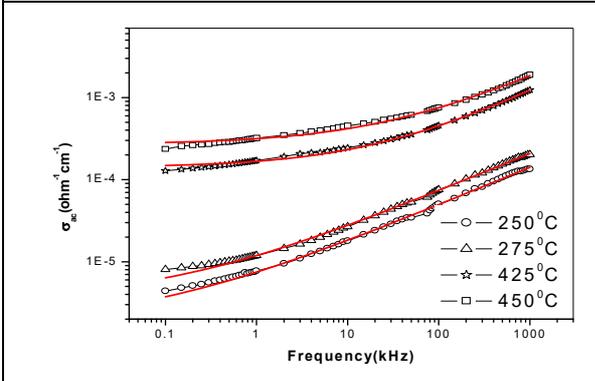


Fig. 6. Variation of ac conductivity with frequency at different temperatures of NPEWTT.

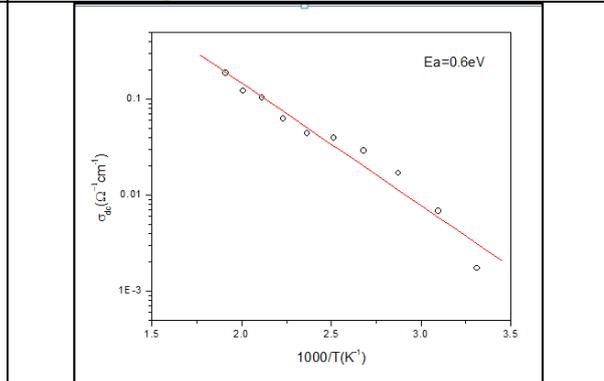


Fig 7. Variation of dc conductivity as a function of temperature of NPEWTT.





## Structural and Optical Characterizations of a Lead Reducing Double Perovskite

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### ABSTRACT

The polycrystalline samples of  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5$  &  $2$ ) were synthesized by low temperature solid state reaction route. Calcination temperature of the studied samples were optimized around  $710^\circ\text{C}$  by repeated firing process. The XRD pattern under room temperature of the samples have been analyzed. It is found that the diffraction peaks are different from that of the ingredients confirming the formation of new compounds. The surface morphology (shape, size and distribution of grains and pores) of the pellet sample was recorded using scanning electron microscope (SEM). For better understanding of structural analysis FTIR spectroscopy technique has been adopted. It is observed bending and stretching vibration are dominating features for affecting the physical properties of the studied compound. The optical band gap calculation and electronic transition of the materials are studied using UV-Vis spectroscopy.

**Keywords:** Double perovskites; SEM; FTIR, UV-Vis spectroscopy

### INTRODUCTION

Ferroelectric perovskites constitute interesting compounds, due to their switching behavior make it potential applications in nonvolatile memories, pyroelectric detector, and their piezoelectric properties are instrumental for transducer, actuators and sensors. Perovskite oxides having a orthorhombic high-symmetry structure in particular a double perovskite represented by the formula  $A_2BB'O_6$  emphasize the long range ordering of B-sites following a rock-salt pattern [1] might be realized experimentally and may have interesting ferroelectric properties. Marginal differences between B and B' cations in either oxidation state or size are conducive for their ordering process. Many double perovskites having two cations with partially filled d-shells exhibit ferro- or ferrimagnetisms and some of them offer magneto resistance effects [2] Again the presence of  $Bi^{3+}$  or  $Pb^{2+}$  ions on A-site favors the appearance of polar structures.





This is due to the  $6s^2$  lone-pair and the strong covalent character of both Bi-O, Ba-O and Pb-O bonds which stabilize a non-centro symmetric distorted environment [3, 4]. Apart from this the double perovskite ( $A_2BB'O_6$ ) is the center of attraction as per as ferroelectric and piezoelectric materials are concerned which is supposed to be a potential candidate for the application in capacitors. Now a day the same scenario was extended from the common perovskite oxides  $ABO_3$  to more complex system such as the ordered Perovskite [5]. These materials are having a large amount of academic interest and have potential applications in catalysis, magnetic media, and electrical conductors and gas sensors, with both the content and the structural distortions of the B/B'O6 octahedral being important factors in determining their physical behavior [6]. Although much work has been done on dielectric and electrical properties of double perovskite [7-11], yet detailed information on structural, optical, dielectric and electrical properties of lead based double perovskite is lacking in literature. In view of this we have synthesized 'Ba' doped lead reducing double perovskite compounds with chemical formula  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5$  &  $2$ ) by solid state reaction method and studied their structural and optical, properties for possible device application.

### Experimental

The polycrystalline samples of  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5$  &  $2$ ) were synthesized by a solid-state reaction technique using high-purity (AR grade) ingredients: PbO (99%, M/s S.D. Fine Chem. Ltd.),  $Bi_2O_3$ ,  $V_2O_5$  and  $BaCO_3$  (99%, M/s LOBA Chemie Pvt. Ltd. India). These oxides as well as carbonate were (taken in stoichiometry proportion) mixed in dry (air) and wet (methanol) medium for two hours each in agate mortar. The mixed material was calcined at an optimized temperature ( $710^\circ\text{C}$ ) on the basis of repeated firing and mixing for 4 h in alumina crucible. An X-ray diffraction (XRD) pattern on calcined powder was recorded at room temperature using X-ray powder diffractometer (RigakuMiniflex). The  $CuK\alpha$  radiation ( $\lambda = 1.5405\text{\AA}$ ) was used to collect data in a wide range of Bragg's angle ( $2\theta$ ) ( $20^\circ \leq 2\theta \leq 80^\circ$ ) at a scanning rate of 3 deg/min for preliminary structural analysis. The powder was then pelletized under the uniaxial pressure of 3.5 ton with polyvinyl alcohol (PVA) as binder. The pellets were then sintered at  $725^\circ\text{C}$  for 6 h. The polished sintered pellet was electroded with high purity and quality silver paste and, dried at  $150^\circ\text{C}$  for 4 h before taking dielectric and electrical measurements. The surface morphology of a gold-coated pellet sample was recorded by JEOL JSM-5800 scanning electron microscope (SEM). The structural and optical characterizations of the synthesized compounds have been carried out with the help of XRD, SEM, EDS, RAMAN, FTIR, and UV-Vis spectroscopy analysis respectively. FTIR spectrometer JASCO, Model-FTIR-4100 is used to study the vibrational analysis.

### Structural and Optical Study

#### XRD analysis

The powder XRD patterns at  $25^\circ\text{C}$  for  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1.0, 1.5, 2$ ) are shown in **Fig.1**. The formation of homogeneous, well crystallized and single phase new compound is conformed from the sharp and well defined peaks [12]. Generally, the structures of double perovskites have monoclinic, tetragonal or orthorhombic. So we have indexed these within the selected systems using commercially available software "POWD" [13]. From the knowledge of best fit data with respect to the observed value and calculated values of inter planner spacing, an orthorhombic unit cell has been selected. The lattice parameters (a, b and c) have been calculated from the peaks position of the peaks in the diffractograms. The observed values of a, b and c have been refined using least-squares fit of the observed positions ( $d_{hkl}$  interplanar spacing) of the peaks so that  $\sum \Delta d = \sum (d_{obs} - d_{cal})$  was found to be minimum. Table 1 represents the standard deviations of the studied samples which indicates the best agreement between the observed and calculated values of interplanner spacing and hence authenticates the correctness of the chosen crystal system and unit cell parameters. The evaluated values of different parameters of the unit cell of the samples are in concurrence with that of earlier report [14]. Primary investigation on the reflections with proper indexing predicts that the materials may have Pmma space group. The average size of the particles in the compounds can be

calculated by using the Scherrer's equation:  $P_{hkl} = \frac{K\lambda}{\beta_{1/2} \cos\theta_{hkl}}$  [15], where K is a constant whose value is equal to



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0.89,  $\lambda=1.5405\text{\AA}$  and  $\beta_{1/2}$ = full width at half maximum (in radians). Orthorhombic distortion is calculated by using  $\delta=[b-a/b+a]$  with 'a' and 'b' are lattice parameters. The refined lattice parameters and average value of particle size are also given in Table 1. The average value of particle size (P) of the above compounds is found to be in between 47 -58 nm using Scherrer's formula [16]. The average particle size found to be small due to the bigger value of full width half maxima (FWHM). The calculated values of lattice parameters are also reflected in table 3.2. As the structure of DP consists of five crystallographic sites as seen fig. 1 so, from the knowledge of the present result, it can precisely determine the  $\text{Ba}^{+2}$  ions (A-site ions) prefer 12-fold coordination [16]. The strongest peaks of different compounds occurring at Bragg angle  $28.77^\circ$ ,  $28.10^\circ$ ,  $27.70^\circ$ ,  $27.54^\circ$ ,  $27.46^\circ$  and the respective miller indices are, (3 0 4), (1 3 ,12), (2 0 2) and (1 1 1) and (10,0 1). This show, the most of the atoms are distributed in the respective planes are different for different  $\text{Ba}^{+2}$  concentrations.

**SEM and EDX Analysis**

Fig. 2 shows the surface morphology of the studied compounds by Scanning Electron Microscope (SEM) device using gold plated bulk pallet sample. The room temperature SEM micrograph confirms highly dense compounds, even distribution of grains and well separated grain boundaries. It predicts that the charge carriers could easily find their path to enhance the leakage current and material may be lossy. The number of well-defined grain boundaries increase as compared to pure lead  $\text{Pb}_2\text{BiVO}_6$ , when  $\text{Ba}^{+2}$  ion is substituted at A-site. Due to this dielectric loss of samples will increase and hence ac conductivity of the sample may be higher [17]. Even though the materials are sintered at high temperature, then also some small voids of irregular shape and size are observed in the compound. Due to the presence of voids, it is expected that charge carriers will show hopping type of motion. The average grain size of the studied samples have been calculated by intercept technique and are found to be 1.785, 1.845, 1.855, 1.734 and 1.725  $\mu\text{m}$  respectively. EDS analysis of the studied compounds are shown in Fig. 3 and it is useful to confirm the purity and percentage of composition. The EDS analysis also suggests that the compound is pure and free from foreign particle.

**RAMAN Spectroscopy study**

In order to characterize materials, measurement of phase transition temperature and to understand the orientation of crystallographic axes of a sample Raman spectroscopy is widely used by material scientists. As we know frequencies of different mode of vibrations are more appropriate to a molecule's chemical bonding and crystal structure, hence Raman and IR spectra are used to estimate the frequencies of vibration on the basis of normal coordinate system. Fig. 4 represents the Raman spectra of the studied samples. Deconvolution using peak-fit software for better understanding of the peak position and FWHM are incorporated in the present study which is represented by red colored lines. The different Raman modes of vibration of the studied samples are reflected in the respective figure. Depending on the doping concentrations it is believed that after doping 'Ba' in  $\text{Pb}_2\text{BiVO}_6$  few 'Ba' are substituted to 'Pb'. The atomic mass of 'Ba' is just smaller than 'Pb' which refers to the larger ionic radius of Pb. The 'Ba' doping will produce compressive stress inside the  $\text{Pb}_2\text{BiVO}_6$  which affects the Raman spectra [18-20]. Hence compressive stress developed is the key factor for different analysis. The other observed bands are also a consequence of 'Ba' doping in the lead based double perovskite. The signature of octahedral phase in PBV is due to the peaks under low frequency range i.e. (200–300)  $\text{cm}^{-1}$ . The higher bands between (650-1057)  $\text{cm}^{-1}$  are due to orthorhombic phase of the PBBV structure [21]. The difference in mass and ionic radius of Ba undoubtedly connected with the shift of Raman bands and its broadening which in turn produce stress inside the matrix due to the phase change. The weaker satellite bands are due the V-O and Ba-O vibrational modes around the main Raman modes of V-Bi, V-Ba, Ba-Bi and Ba-Pb bonds.

**FTIR Analysis**

The FTIR spectrum of the sample was recorded for the wave number from (400 to 4000)  $\text{cm}^{-1}$ . Powder samples were dried before pelletizing to get the sample moisture free before the measurement. The room temperature FTIR spectra of the studied sample in the range of (4000–400)  $\text{cm}^{-1}$  are shown in fig. 5. In the FTIR spectra, different types of





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vibrations are occurring in the studied compounds which are reflected in the respective figures. Generally, the well-defined transmittance bands between 850 - 400  $\text{cm}^{-1}$  are associated with the lattice vibration modes (phonons) having the typical profile expected for an insulating/perovskite material is usually used for the perovskite phase identification [22]. The strongest band at  $\sim 677, 739, 677, 677$  &  $807 \text{ cm}^{-1}$  of the investigated materials is assigned to the anti-symmetric stretching mode of the octahedral  $\text{VO}_6$  and  $\text{BiO}_6$  due to the higher charge of this cation [23]. The IR spectrums at 417, 422, 417, 516 &  $526 \text{ cm}^{-1}$  of the respective samples is assigned to the of O-V-O asymmetric bending modes which are strong in the infrared spectrum. The bands located at 864, 866, 864, 807 &  $858 \text{ cm}^{-1}$  are assigned to C=C stretching mode of vibrations of the samples ( $x=0$  to 2). The bands located in between  $1000\text{-}1800 \text{ cm}^{-1}$  may be attributed as C=O stretching vibration of the studied compounds [24]. The band in between  $3500\text{-}3700 \text{ cm}^{-1}$  is assigned to hydroxyl (OH) stretching vibration obeying mutual exclusion principle as well as hygroscopic nature of the studied compounds [25]. It is observed for Ba composition of  $x=1.5$  & 2 does not show any hygroscopic behavior.

#### UV-Vis Spectroscopy

The diffuse absorbance of the studied compound is shown in Fig. 6. In a typical UV/vis spectroscopy measurement, both transmittance as well as absorbance of photons is measured by the sample. It has been seen that a broad peak near UV range in the transmittance spectra is observed as sample does not absorb strongly whereas in the visible portion of the spectra the reverse effect have been observed. The absorption cut-off wavelength of the samples are within 500-600 nm indicates that the studied compounds could absorb visible light in the wavelength range of 400-600 nm. The optical band gap ( $E_g$ ) of the samples can be calculated using the relation  $\alpha E = A (E - E_g)^n$ , Where  $\alpha$  is absorption coefficient,  $E = hc/\lambda$ , is the photon energy,  $A$  is a constant,  $n$  is an index assumed to have values like  $n=1/2, 3/2$  or 2. For ceramic compounds exhibit direct transition, so the value of  $n$  is assumed as 1/2 and the energy band-gap of sample could be estimated from Tauc plot in fig 6 [26]. The tangent line, which is extrapolated to  $(ah\nu)^2 = 0$ , gives the value of  $E_g$  which are reflected in respective figures.

## CONCLUSIONS

The double perovskite  $\text{Pb}_{2-x}\text{A}_x\text{BiVO}_6$  ( $A = \text{Ba}$  &  $\text{Sr}$ ,  $X= 0, 0.5, 1, 1.5$  and 2) were prepared by cost effective mixed oxide route. The formation of single phase, density and purity behavior in the compound has been verified from experimental analysis like XRD, SEM, and FTIR respectively. The optical and molecular properties of the material were studied by UV Vis which confirms that the material may be used for photovoltaic and LED devices. The band gap calculated from the above study shows that the materials are useful for photo catalytic devices.

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**Table. 1 The average value of particle size**

SL No.	Sample Name	a (Å)	b (Å)	c(Å)	V (Å) <sup>3</sup>	SD	P	D
1	$Pb_2BiVO_6$	10.3313	12.1990	8.4579	1065.9620	0.0044	47	0.082
2	$Pb_{1.5}Ba_{0.5}BiVO_6$	10.6593	12.1165	8.492	1096.6892	0.0037	55	0.063
3	$PbBaBiVO_6$	10.5121	12.8084	8.4963	1143.9688	0.0061	57	0.098
4	$Pb_{0.5}Ba_{1.5}BiVO_6$	10.9441	12.9742	8.8675	1259.1046	0.0063	48	0.084
5	$Ba_2BiVO_6$	10.3523	12.7017	8.1325	1069.3571	0.0055	58	0.101





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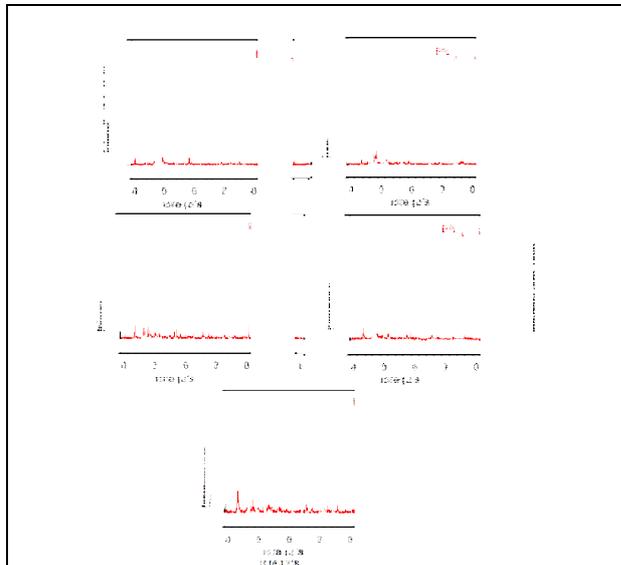


Fig.1 XRD pattern of  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5, 2$ ) at room temperature.

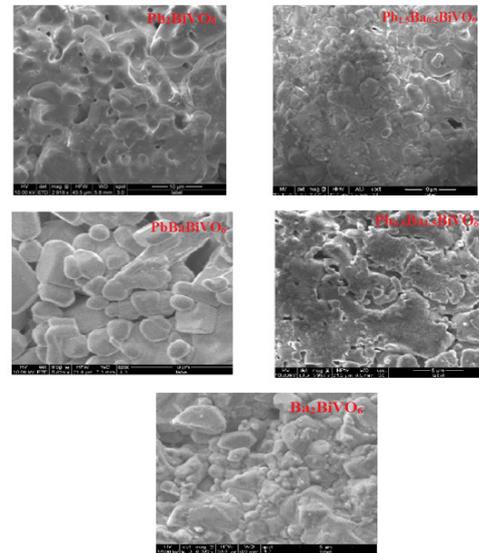


Fig. 2 SEM study of  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5, 2$ )

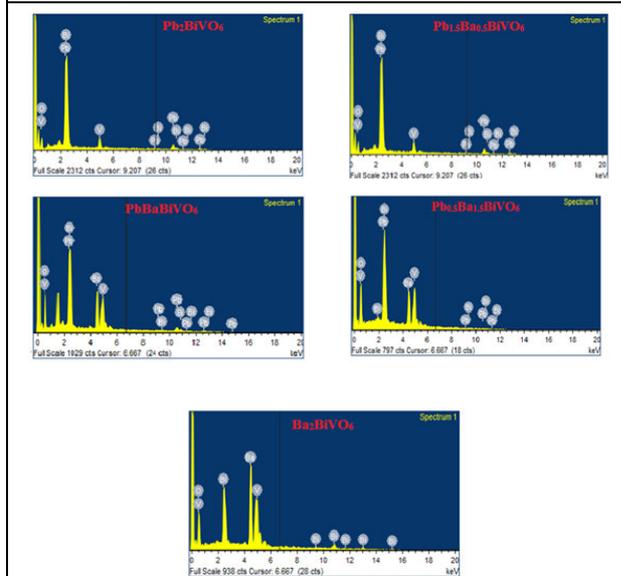


Fig. 3 EDS study of  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5, 2$ )

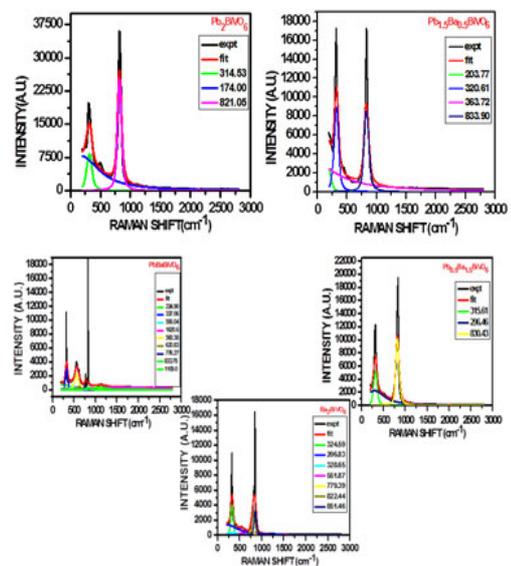


Fig. 4 RAMAN spectra of  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5, 2$ ) at room temperature.





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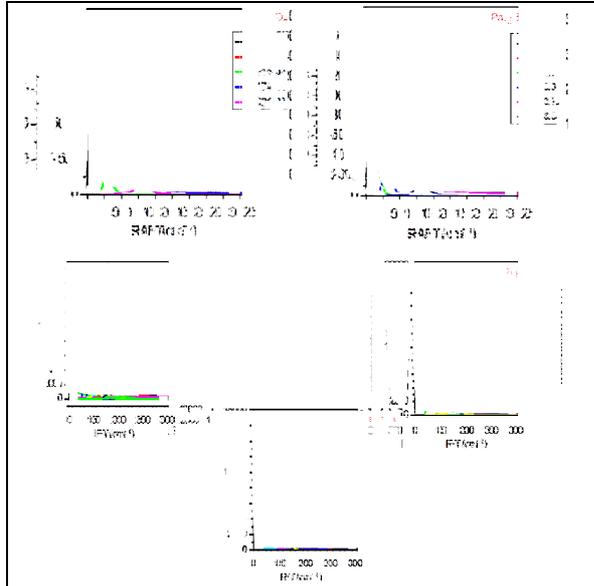


Fig. 4 RAMAN spectra of  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5, 2$ ) at room temperature

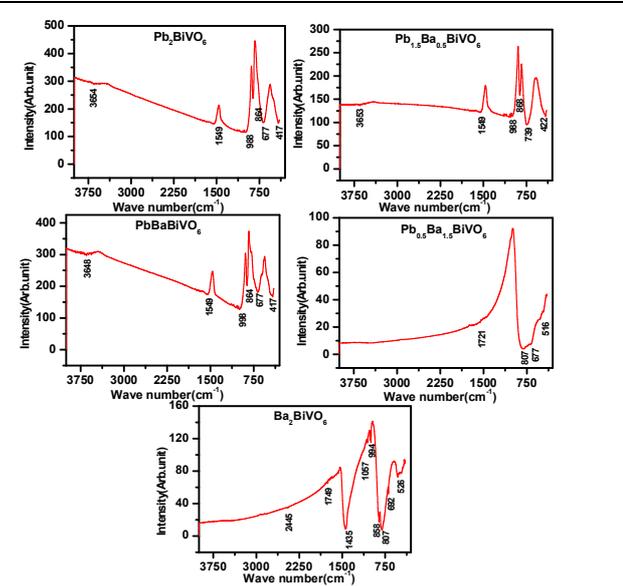


Fig. 5 FTIR spectra of  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5, 2$ ) at room temperature.

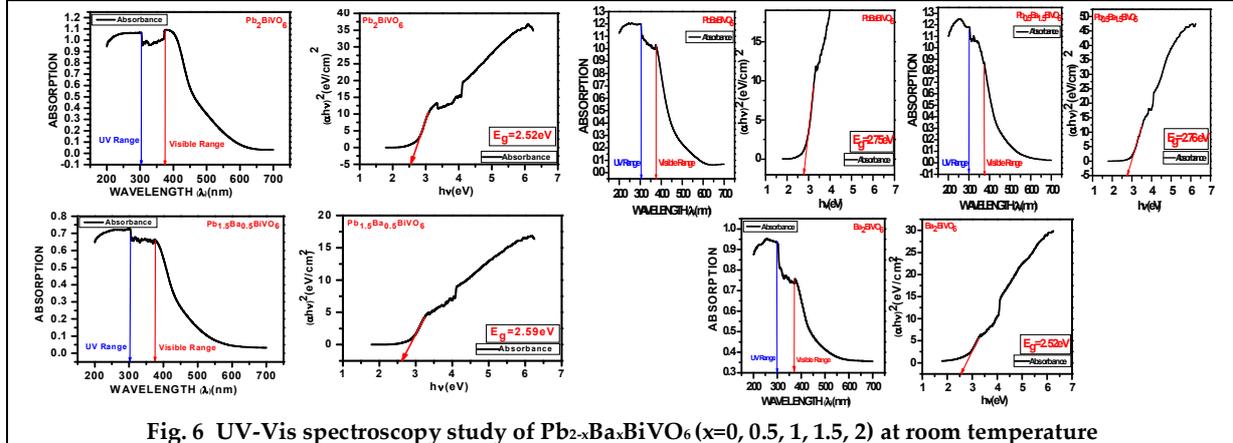


Fig. 6 UV-Vis spectroscopy study of  $Pb_{2-x}Ba_xBiVO_6$  ( $x=0, 0.5, 1, 1.5, 2$ ) at room temperature





## Successful Synthesis and XRD study of Alumina-Reduced Graphene Oxide Composite

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### ABSTRACT

A new alumina ( $\text{Al}_2\text{O}_3$ )-reduced graphene oxide (RGO) composites have been prepared by mechanical ball milling route. X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM) and microhardness measurements have been carried out to optimize the samples. Microhardness of the composites were increased with increasing content of RGO from 1 wt% to 2 wt% in  $\text{Al}_2\text{O}_3$  matrix.  $\text{Al}_2\text{O}_3$ -RGO with 2 wt% RGO shows microhardness of  $1612 \pm 14$  VHN against of microhardness of pure  $\text{Al}_2\text{O}_3$  is  $1420 \pm 05$  VHN.

**Keywords:** Reduced Graphene Oxide, Composite, Microstructural, Mechanical Property

## INTRODUCTION

Alumina ( $\text{Al}_2\text{O}_3$ ) shows good mechanical hardness and chemical inertness, moderate thermal conductivity, high corrosion and wear resistance and Low density ( $3.75$  to  $3.95$   $\text{g/cm}^3$ ). This material has poor fracture toughness which restricts its use. It is used as an attractive ceramic for advanced high temperature structural applications and it is currently used in electronics, aerospace and automotive industries [1-5]. To improve the properties of this material, various reinforcements were used such as WC, B<sub>4</sub>C, TiC and graphene. Among all sample reinforcements in alumina with graphene was found as a best alternative. Graphene which is a single layer of carbon shows outstanding electrical mechanical, thermal, optical and electronic properties [6-7]. The graphene shows outstanding Young's modulus of  $1.0$  TPa, electron mobility of  $15000$   $\text{cm}^2$   $\text{V}^{-1}\text{S}^{-1}$ , 100 times stronger than steel, high electrical and thermal properties [5-10]. It is thought that by addition of graphene (1-5 wt%), properties of composites can be explored. Graphene helps to increase density, mechanical property and toughness of  $\text{Al}_2\text{O}_3$ . But there is also a challenge to prepare such a composite. But in literature it is addressed that by addition graphene in alumina and processing by ball mill route is a novel choice to prepare such super composite. The work successfully reports  $\text{Al}_2\text{O}_3$ -RGO



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composite by ball milling route followed by sintering. The composite nature is evaluated by using X-ray diffraction (XRD), Field emission scanning electron microscopy (FESEM) and Nanoindentation technique.

### Experimental

In this work planetary ball mill was used to prepare composite of alumina+reduced graphene oxide composite. Planetary ball mill is powered by the two motors, one motor is used to rotate the shaft and another one is used to drive both the jars. It is fed with a sample-to-ball charge ratio of 1:8 and the balls taken here are stainless steel balls of diameter 7 mm and 5 mm were put into the hardened steel jar. Then both the jars are rotated simultaneously and separately at a speed of 400 rpm and 150 rpm respectively and due to the this rotation, shaft makes the balls to move strongly and violently, leading to large impact energy of balls on the sample that improves the kinetics of grinding and ultrafine communication results. After ball milling of 8 hrs completed, samples were taken for sintering. The sintering of 4-5 mm dia. samples were carried out at 1500 °C after 7 hrs of sintering. After that the samples were characterized by using various techniques.

## RESULTS AND DISCUSSION

The X-ray diffraction study was used to understand crystalline nature, phase purity of Al<sub>2</sub>O<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub>-RGO (2 wt%) composite samples. The analysis result was done and presented in Fig. 1. The composites having phases and planes are identified by comparing the determined *d*-values (experimentally determined) with the *d*-values of standard powder diffraction data file, C (graphite-2H): 00-041-1487 and Al<sub>2</sub>O<sub>3</sub>: 01-075-1862 supplied in JCPDS-ICDD PDF-2 (2004). The XRD results were taken in 2θ range of 5°-80°. The composite formation of nature of the sample is confirmed from the XRD analysis report. The XRD analysis of only ball milled Al<sub>2</sub>O<sub>3</sub> shows the peaks Al<sub>2</sub>O<sub>3</sub> with different planes of diffraction as (104), (110), (113), (024), (116), (122) and (214). Al<sub>2</sub>O<sub>3</sub> shows two intense major peaks at around 2θ = 40.0° and 2θ = 51.0°. Similar kind of result was observed by other. In case of Al<sub>2</sub>O<sub>3</sub>-RGO composite characteristic peak of C (002) is strongly appeared at 2θ = 30.0° due to the presence of RGO in the Al<sub>2</sub>O<sub>3</sub>-RGO composite. The position and FWHM of the peaks of the different phases with different planes were studied to their standard values which indicate the well-ordered and better crystalline nature of the composite.

FESEM analysis of the typical composites of Al<sub>2</sub>O<sub>3</sub>-RGO with content of RGO 2 wt% is presented in Fig.2. It is understood that uniform distribution of RGO within the Al<sub>2</sub>O<sub>3</sub> grains is very important to prepare superior quality composite for various advanced applications. In Al<sub>2</sub>O<sub>3</sub> with RGO 2 wt% shows regular distribution graphene or RGO grains. The composite is also found to free from micro porosity and any kind of surface defects. Microhardness of Al<sub>2</sub>O<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub>-RGO (1 & 2 wt%) composites determined by micro indentation technique method. Before graphene/RGO is reinforced to Al<sub>2</sub>O<sub>3</sub> phase, it was thought that it may increase the mechanical property of the composites. This is interestingly matching to our expectation that the microhardness value increases with increase in RGO content. Here only alumina shows hardness of 1420 ± 05 VHN. In this work the value of microhardness of Al<sub>2</sub>O<sub>3</sub>-RGO (2 wt%) is found to be higher i.e. 1612 ± 14 VHN. Porosity free nature of the composite along with optimized sintering has some contribution for the development of mechanical property. The above improved microhardness inspires to use the composite for advanced structural applications in aerospace and automotive industries, etc.

## CONCLUSION

In this work, it has been possible to prepare two different compositions of Al<sub>2</sub>O<sub>3</sub>-RGO by varying wt% of RGO from 1-2 wt%. All Al<sub>2</sub>O<sub>3</sub>-RGO composites were ball milled by using a dry planetary ball milling technique for 8 hr. After ball milling, the samples were sintered at 1500 °C for 7 hr. The peaks of Al<sub>2</sub>O<sub>3</sub> and C (graphene/RGO) were observed by XRD analysis in the composites. The composite nature further confirmed from FESEM analysis. Micro free porosity and any kind of surface defects is not observed in FESEM. The uniformity of distribution of graphene/RGO





is found in microstructure. In this work, it is evident that the microhardness and of Al<sub>2</sub>O<sub>3</sub>-RGO composites were found to increase when 2 wt% of RGO is added. Al<sub>2</sub>O<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub>-RGO with 2 wt% RGO has microhardness of 1420 ± 05 VHN and 1612 ± 14 VHN respectively. Such values of microhardness indicate reduced brittleness of the composites. Overall attempt has been taken in the work to correlate RGO content with various microstructural properties and hardness. The composite of Al<sub>2</sub>O<sub>3</sub>-RGO with improved mechanical property has great future scope to prepare advanced ceramic and structural components.

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Table. 1: Microhardness measurement by nanoindentation method

Sample ID	Micro hardness in VHN
Al <sub>2</sub> O <sub>3</sub>	1420 ± 05
Al <sub>2</sub> O <sub>3</sub> -RGO (1 wt%)	1510 ± 22
Al <sub>2</sub> O <sub>3</sub> -RGO (2 wt%)	1612 ± 4

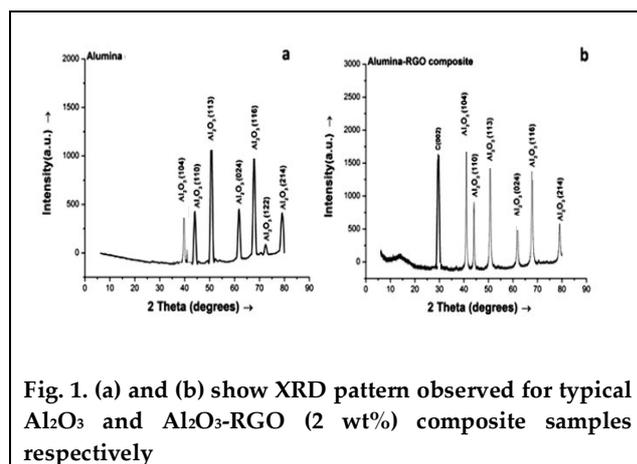


Fig. 1. (a) and (b) show XRD pattern observed for typical Al<sub>2</sub>O<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub>-RGO (2 wt%) composite samples respectively

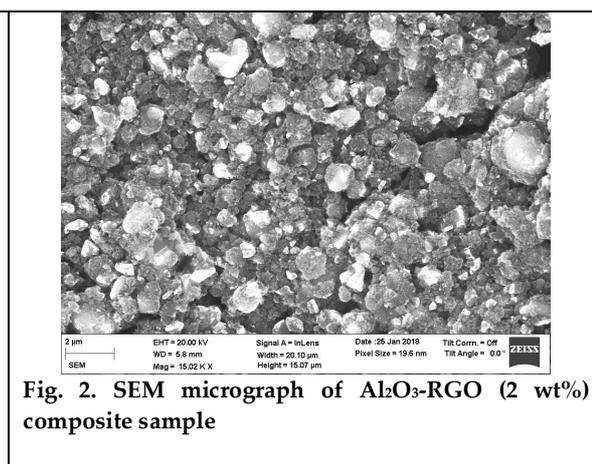


Fig. 2. SEM micrograph of Al<sub>2</sub>O<sub>3</sub>-RGO (2 wt%) composite sample





## Effect of Graphene towards Microstructural and Mechanical Improvement of Aluminium

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### ABSTRACT

A novel method of creating new lightweight aluminium-graphene composite materials is proposed in this work. The aluminum-graphene composite is prepared by reinforcing 1 wt% of graphene in aluminium matrix. Composites of graphene platelets and powdered aluminium were made using ball milling, pressing and sintering. The mechanical properties and microstructure were studied using Vickers hardness and as well as FESEM, X-Ray Diffraction. From FESEM analysis, the composite with 1wt% graphene shows irregular distribution of graphene on the matrix of Al. Grain size was found in the range of 4-7  $\mu\text{m}$ . Al-graphene with 1wt% shows hardness value of 58 VHN. Microstructural and microhardness results indicate that graphene addition improves structural and mechanical property of composite.

**Keywords:** Graphene, Aluminum, XRD, Composite

### INTRODUCTION

Materials are may be more rooted in our culture than we might think. Even the stone, bronze and iron ages are all named after material development of the respective era. In our everyday lives, materials play a big role: metals in everything from electronics to bridges and buildings, ceramics for pottery, knives and as a construction material, polymers in our clothes and plastics and composites in everything from concrete to aerospace applications. In recent years, more advanced materials have been developed for high technology applications; semiconductors, biomaterials, smart materials and nanomaterials. A recent leap in material science was the discovery of a new material which has the potential to alter the future, dubbed a “super material” i.e. Graphene. It is a super strong and stiff, amazingly thin almost completely transparent, extremely light and wonder condition of heat and electricity [1-

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4]. Graphene has emerged as one of the most promising nanomaterials because of its unique combination of superb properties [5-7]. Aluminum is a common used materials used for electrical, aerospace and lightweight materials applications [8-10]. But it has the limited electrical conductivity with conditional mechanical applications. Hence it is supposed that by addition of graphene in aluminium, a super composite can be developed which has great industrial applications. Graphene with has high strength, excellent electrical with high specific surface area improve the application horizon of this material. The work reports aluminum-graphene composite (1 wt%) preparation by 8 hrs of ball milling followed by 560°C for 6 hrs sintering. Properties were studied by employing various characterization techniques such as such as X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), and Microhardness. Al-graphene composite (1 wt%) prepared by 8 hrs of milling shows high microhardness value than pure Al.

## Experimental Details

### Materials

The following materials were used for the synthesis of aluminium-graphene composite:

1. Graphene
2. Aluminium powder

### Pellet preparation

Moreover, we take the sample (aluminium, aluminium-graphene) and ground it for half an hour using a pulveriser machine for the better blending of the samples. Furthermore, we take the powder composites in a mortar and add a small amount of PVA (polyvinyl alcohol) gum into it. Then the PVA gum mixed with the samples properly followed by grinding which is done for 20-25 minutes for diminishing the size of the composites. In addition, by the use of hydraulic pressure machine, for intensifying the pressure up to 50 kg/cm<sup>2</sup>, we get pellets of composites of distinct diameters.

### Synthesis of graphene-aluminium nano composite by ball milling process

To generate the impact and shear forces to particles, the planetary ball mill was designed and have the ability to surmount the contour of gravitational field and to supply a strong acceleration field. In this experiment, the powder-to-ball ratio is kept 1:10 for each jar. Without any solvents, additives, and chemicals, the sample containing jars were placed inside a glove bag. Then the samples for ball milling were weighed for aluminium and graphene in the ratio 99:1 weight percentage and taken in jar-1. Likewise, pure Aluminium was taken in jar-2. Wherein jar-1 contains stainless steel balls having diameter 8mm (300gm) of weight 1kg and similarly, jar-2 also contains the stainless steel balls of weight 1kg having a diameter of 6mm(700gm). These balls were used as a medium of grinding and also to maintain the constant frequency of 26.1Hz for a continuous time period of 8 hours because the motors, which are fixed with the ball mill, rotates with the help of electricity. Finally, all the samples were being cooled down by placing it in a refrigerator and this sample derivatives can be used for different experiments thereafter.

## RESULTS AND DISCUSSION

### Analysis by XRD

Crystalline nature and phase purity of aluminium-graphene composite samples were studied by XRD. The result interpretation with assigned peaks is shown in the fig:1-2. XRD pattern is taken within the range of  $2\theta=5^{\circ}$ - $80^{\circ}$ . The composite formation of aluminium-graphene is confirmed from the XRD analysis report. The XRD analysis of ball milled aluminium shows the peaks of only Al. Different diffracted peaks of Al like (111), (200) and (311) are observed in the ball milled Al sample. The XRD result of Al-graphene (1wt%) interestingly shows the peaks of graphene as C(002) with peaks of Al. So, XRD result confirms the composite formation of Al-graphene. The position and FWHM



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of the peaks of the different phases with different planes were studied and compared to their standard values with JCPDS files which indicate the well-ordered and better crystalline nature of the composite.

**Analysis by FESEM**

Al-graphene (1wt%) composite after sintering was taken for FESEM analysis. FESEM analysis of 1wt% (Fig. 3) shows clearly the presence graphene flakes on the matrix of Al. The grain distribution of graphene found to be irregular. But no defect and porous structure is found in the FESEM microstructures. FESEM it indicates the quality of sample prepared by good sintering condition. The grain size of graphene was found in the range of 4-7  $\mu\text{m}$ .

**Analysis by Vicker's hardness**

The microhardness of sintered Al-graphene products was determined. It is found that microhardness value increases by increasing addition of graphene. Al-graphene (1wt%) shows hardness value of 58 As per the microstructural analysis and hardness values are concerned, it is observed that graphene addition improves structural and mechanical property of composite. Al is very much popular for electrical applications. Further the present works opens a new road of research towards critical application of Al at high temperature with critical load.

**CONCLUSION**

In this present work, successfully Al-graphene (1 wt%) composites were prepared by dry planetary ball milling process followed by sintering. Samples were ball milled by using a dry planetary ball milling for 8 hrs. After ball milling over, the samples were taken for sintering at 560°C for 6 hrs. While XRD of aluminium shows only peaks of Al, aluminium-graphene composite shows peaks due to both Al and graphene. So, XRD confirms the formation of composite of Al and graphene. Al is present in its original metallic form. No oxidation of Al is detected. The composite nature further confirms from FSEM analysis. The composite with 1wt% graphene shows irregular distribution of graphene on the matrix of Al. Grain size was found in the range of 4-7  $\mu\text{m}$ . Al-graphene with 1wt% shows hardness value of 58 VHN. Microstructural and microhardness results indicate that graphene addition improves structural and mechanical property of composite.

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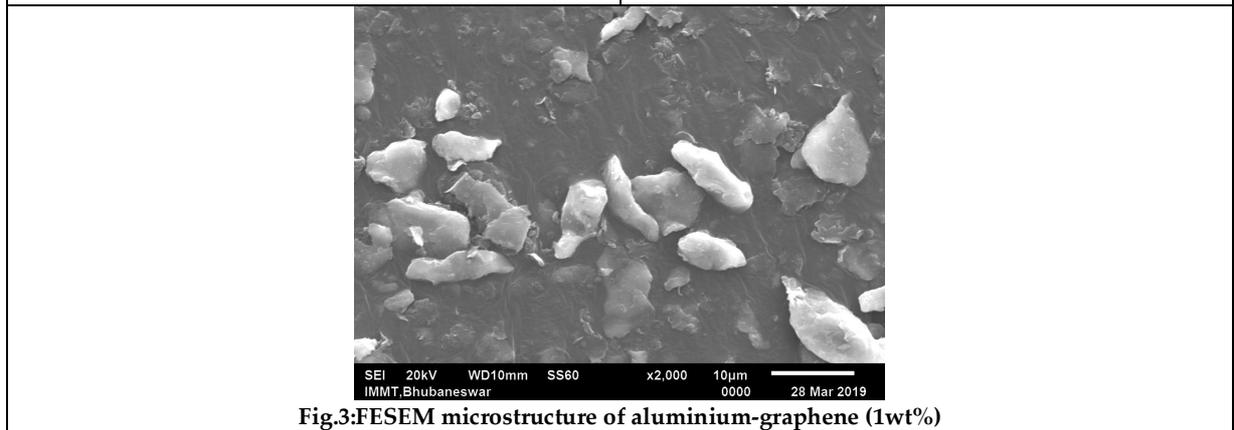
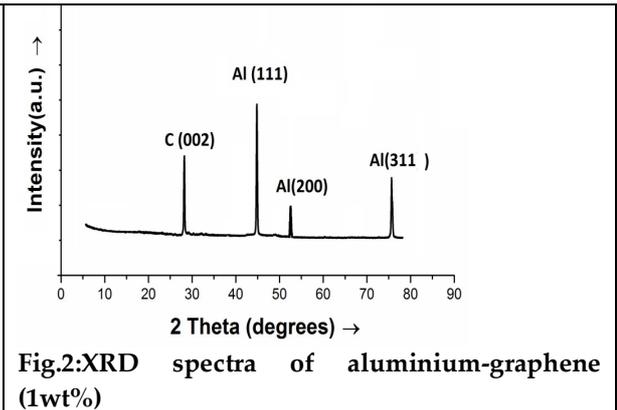
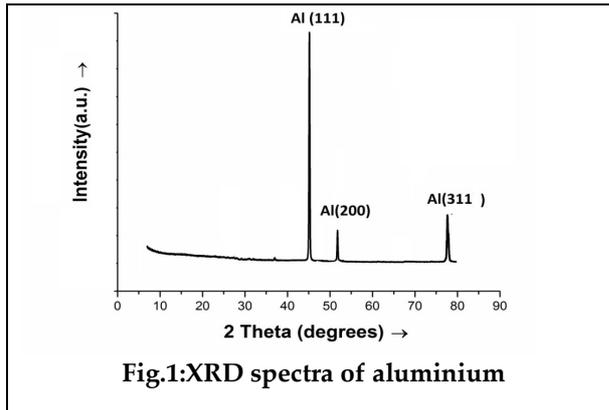




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Table-1:Vickers hardness measurement

Sample ID	Micro hardness in VHN
Al	35 ± 02
Al-Graphene (1 wt%)	58 ± 04





## Synthesis of Alumina - Magnesium Oxide - Graphene Composites: Microstructural Investigation

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### ABSTRACT

In this work the effect of graphene and magnesium oxide (MgO) in alumina (Al<sub>2</sub>O<sub>3</sub>) matrix has been studied. The composites were prepared by using a dry planetary ball milling technique for 8hrs followed by sintering at 1550 °C for 5 hrs. The composite nature was confirmed by XRD study. Composites were found grown with free from micro free porosity and any kind of surface defects. The uniform distribution of graphene and MgO were found in the FESEM microstructure. It is interestingly observed that the microhardness of Al<sub>2</sub>O<sub>3</sub> were found to increase when MgO (2 wt%) and graphene(1 wt%) were reinforced to the composite. The work reports microhardness of Al<sub>2</sub>O<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub>-MgO (2 wt%)-graphene(1 wt%) composites as 1410 ± 04 VHN and 1712 ± 10 VHN respectively. Such high value of microhardness attributes to the improved microstructure with almost zero porosity in the composite.

**Keywords:** Alumina, Graphene, Composite, Ball Milling

### INTRODUCTION

A recent wave in the material science is the discovery of a new material which can show potential application. In this regards a super material i.e. graphene can be considered [1-5]. It is a unique material with super strong and stiff and at the same time amazingly thin & optically transparent, extremely light weight and having high heat and electricity conductivity. There is no wonder regarding its drastic implications for various industrial applications. Above properties and its various functionalities, make it super demandable for a wide spectrum of applications

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ranging from electronics to optics, sensors and bio devices [4-5]. Now researchers are applying this material with other materials (such as plastics, metals and ceramics) to make composites that are stronger and tougher. Alumina ( $\text{Al}_2\text{O}_3$ ) is known as an attractive ceramic for advanced high temperature structural applications and it is currently used in electronics, aerospace and automotive industries [5-10].  $\text{Al}_2\text{O}_3$  shows high mechanical hardness, moderate thermal conductivity, High corrosion and wear resistance, Low density (3.75 to 3.95  $\text{g/cm}^3$ ) [11]. On the other hand it has the poor fracture toughness which restricts its use. The addition of graphene and magnesium oxide has the potential to enhance fracture toughness of  $\text{Al}_2\text{O}_3$ . In this research work attempt has been taken to prepare a novel composite of  $\text{Al}_2\text{O}_3$ -MgO-graphene composite by ball milling technique followed by sintering at 1550 °C. The microstructure, composition and hardness of composites were studied using various analytical techniques such as X-ray diffraction (XRD), Field emission, scanning electron microscopy (FESEM), Brunauer-Emmett-Teller analysis (BET) and nanoindentation.

### Experimental

Alumina, graphene and MgO are taken as the starting materials. The sample details are presented in table 1. The nano composites was prepared by both impact and shear forces developed in the planetary ball mill. The planetary ball mill works in such way that it overcomes the limitation of the gravitational field and provides strong acceleration field. The sample to ball charge ratio of 1:9 was maintained in the planetary ball mill. The ball milling of the samples was carried out for 8 hrs. After ball milled over, the samples were taken for sintering at 1550 °C for time period of 5 hrs. XRD patterns of the samples were taken by PANalytical X'Pert Pro diffractometer. The XRD patterns were taken in the  $2\theta$  range 5–95 at a scan speed of 0.019  $\text{min}^{-1}$ . The microstructures of samples were taken by FESEM (model: ZEISS SUPRA 55). Microhardness of composites was determined by Nanoindenter-UMIS system (Fisher-Cripps, Australia) with diamond Berkovich indenter (tip diameter: 400 nm) at a maximum applied load of 50 mN. Pore volume of composites were determined by BET method (Instrument used: ASAP2020, Micromeritics, USA) by  $\text{N}_2$  adsorption-desorption technique.

## RESULTS AND DISCUSSION

Crystalline nature and phase purity of  $\text{Al}_2\text{O}_3$ -MgO (2 wt%)-graphene (1 wt%) composites were studied by XRD analysis. The analysis result was done and presented in Fig.1. The crystalline behavior of composites is identified by comparing the determined  $d$ -values (experimentally determined) with the  $d$ -values of standard powder diffraction data file, C (graphite-2H): 00-041-1487,  $\text{Al}_2\text{O}_3$ : 01-075-1862 and  $\text{Al}_2\text{Mg}_0.4\text{O}_4$ : 01-087-0344 supplied in JCPDS-ICDD PDF-2 (2004). The XRD results were carried out in  $2\theta$  range of 5°-90°. XRD analysis report confirms the composite formation of nature of the sample. The XRD analysis of ball milled  $\text{Al}_2\text{O}_3$ -MgO (2 wt%)-graphene (1 wt%) composites shows the peaks of  $\text{Al}_2\text{O}_3$  with different planes of diffraction as (104), (113), (024), (116), (122) and (214). At around  $2\theta = 40.0^\circ$  and  $2\theta = 51.0^\circ$ ,  $\text{Al}_2\text{O}_3$  shows two intense major peaks. In the composite  $\text{Al}_2\text{Mg}_0.4\text{O}_4$  is observed. In the composite characteristic peak of C (002) is strongly appeared at  $2\theta = 26.5^\circ$  due to the presence of graphene in the composite. The position and FWHM of the peaks of the different phases with different planes were studied to their standard values which indicate the well-ordered and better crystalline nature of the composite.

FESEM analysis of the typical composites of  $\text{Al}_2\text{O}_3$ -MgO (2 wt%) -graphene (1 wt%) is presented in Fig. 2. The uniform distribution of  $\text{Al}_2\text{O}_3$  and MgO is very clearly observed. Uniform distribution of graphene within the  $\text{Al}_2\text{O}_3$  grains is very important to prepare superior quality composite for various industrial applications. The microstructure shows very high dense and packing nature between different phases or components. The composite is also found having no porosity and any kind of surface defects. No agglomeration on particle distribution is observed. Such improved microstructure with improved homogeneity is expected to enhance micro structural property of composite.





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Microhardness of Al<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>-graphene (1 wt%) and Al<sub>2</sub>O<sub>3</sub>-MgO (2 wt%)-graphene(1 wt%) composites determined by micro indentation technique method. Before graphene and MgO reinforced to Al<sub>2</sub>O<sub>3</sub> phase, it was thought that it may increase the mechanical property of the composites. This is interestingly matching to our initial predication that the microhardness value increases with the presence of MgO. Here only alumina shows hardness of 1410 ± 04 VHN. The work reports microhardness of Al<sub>2</sub>O<sub>3</sub>-MgO (2 wt%)-graphene(1 wt%) is 1712 ± 10 VHN. Composites with absence of porosity with optimized sintering (1550 °C) have significant distribution for the development of mechanical property. The above improved microhardness inspires to use the composite for advanced structural applications in industry.

## CONCLUSION

In this work, it has been possible to prepare two different compositions of Al<sub>2</sub>O<sub>3</sub>-graphene (1 wt%) and Al<sub>2</sub>O<sub>3</sub>-MgO (2 wt%)-graphene(1 wt%) composites by using a dry planetary ball milling technique for 8hrs followed by sintering at 1550 °C for 5 hrs. The peaks of Al<sub>2</sub>O<sub>3</sub>, C (graphene) and MgO were found by XRD study in the composites. Composites were found grown with free from micro free porosity and any kind of surface defects. The uniform distribution of graphene and MgO were found in the composite. It is evident that the microhardness of Al<sub>2</sub>O<sub>3</sub> were found to increase when MgO(2 wt%)-graphene(1 wt%) is added to the composite. Al<sub>2</sub>O<sub>3</sub> and Al<sub>2</sub>O<sub>3</sub>-MgO(2 wt%)-graphene(1 wt%) have microhardness of 1410 ± 04 VHN and 1712 ± 10 VHN respectively. Such values of micro hardness indicate improved microstructural and microhardness properties of the composites. The composite of Al<sub>2</sub>O<sub>3</sub>-MgO-graphene with improved mechanical property has great future scope to prepare advanced ceramic for structural applications.

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**Table 1: Samples details prepared by ball milling route**

Sample ID	weight percentage in gram
Al <sub>2</sub> O <sub>3</sub> -1	Al <sub>2</sub> O <sub>3</sub> -98wt%, MgO -2wt%,
Al <sub>2</sub> O <sub>3</sub> -2	Al <sub>2</sub> O <sub>3</sub> -99 wt%, graphene-1 wt%,
Al <sub>2</sub> O <sub>3</sub> -3	Al <sub>2</sub> O <sub>3</sub> -97wt%, MgO -2wt%, RGO -1wt%,





Table. 2: Microhardness measurement by nanoindentation method

Sample ID	Micro hardness in VHN	Total pore volume of pores (cm <sup>3</sup> /g)
Al <sub>2</sub> O <sub>3</sub>	1410 ± 04	0.003
Al <sub>2</sub> O <sub>3</sub> -graphene (1 wt%)	1620 ± 14	0.005
Al <sub>2</sub> O <sub>3</sub> -MgO(2 wt%)-graphene (1 wt%)	1712 ± 10	0.002

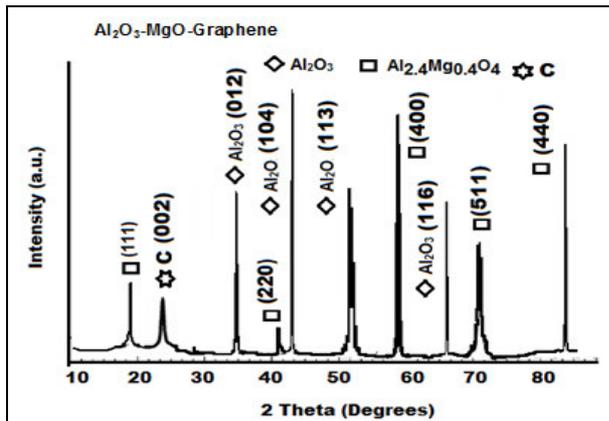


Fig.1 XRD pattern observed for typical Al<sub>2</sub>O<sub>3</sub>-MgO(2 wt%)-graphene(1 wt%) composite sample

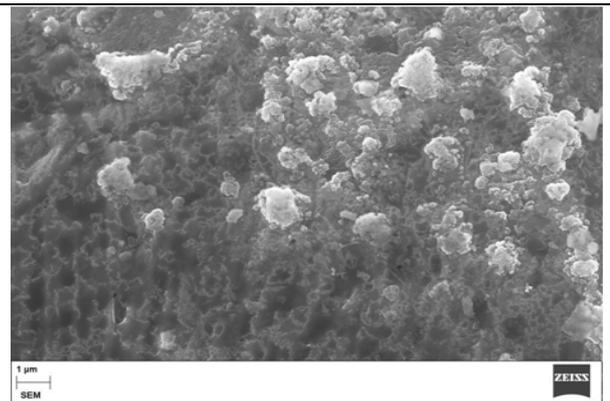


Fig. 2 FESEM micrograph of Al<sub>2</sub>O<sub>3</sub>-MgO (2 wt%)-graphene(1 wt%) composite sample





## Microstructural and Mechanical Studies of Thermal Arc Plasma Treated Tungsten Carbide

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### ABSTRACT

Thermal arc plasma melt-cast technique has employed to produce a high dense tungsten carbide product. This high temperature carbide was melted within 10-14 min of plasma reaction. Tungsten monocarbide (WC) after melt and cast was found to grow with additional phase of tungsten semicarbide phase (W<sub>2</sub>C). This WC-W<sub>2</sub>C product exhibits higher hardness value than only pure WC sample. It was observed that as melting time increases from 10 min. to 14 min., density of composite product increases. Composites consisting of WC, W<sub>2</sub>C and unbound C (graphite) were evaluated by X-ray diffraction, field emission microscopy, energy dispersive spectroscopy (of X-ray), BET analysis, fourier transform infra-red and mechanical properties. Melt-cast products exhibit three types of grains. In this work a very hard, tough and porous free melt-cast WC-W<sub>2</sub>C composite prepared by 14 min. melt-casting of WC sample is reported. WC sample prepared after 14 min. of plasma treatment was found to exhibit significantly high hardness (2606 VHN) and Young's modulus (640 GPa) values with almost zero porosity.

**Keywords:** Tungsten carbide composite, X-ray diffraction, Microscopy

### INTRODUCTION

Tungsten mono carbide (WC) is considered as a wonderful ceramic material due to combination of its very high melting point (~ 2700 °C) and high microhardness (~23 GPa) [1-6] properties. Tungsten carbide has two kinds of phases i.e. WC and W<sub>2</sub>C (tungsten semicarbide). In industries, composite of WC and W<sub>2</sub>C (called fused tungsten carbide) is prepared by melting followed by cooling technique. Tungsten carbide commonly used in making rock drill buttons, pressing dies, cutting tools for hard materials, and other abrasion-resistant components due to their



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combinations of considerable toughness, strength, and wear resistance properties [7-9]. W-C Phase diagram shown in fig. 1[10, 11] indicates at temperature below 2380°C in at% C range of 33.4-50, WC- W<sub>2</sub>C composite prepared. Chuvil'deev and co-workers [12] determined hardness of WC prepared by conventional sintering technique without binder is to be 2480 VHN. Similar type of value of hardness determined by Kim and his team for WC-20 at.% TiC composite 2032 VHN [13].

Tungsten carbide composites generally prepared by powder metallurgy process uses many steps of processing starting from binder mixing upto sintering of samples which involves high time and energy consumption. But tungsten carbide composites prepared by melt-cast technique involves lower porosity compared to sintered products. Because of high melting point of tungsten carbide, it is appropriate to adopt thermal arc plasma technique for treatment of this material instead of using conventional graphite or induction furnace. In thermal lab scale plasma, it is not difficult to produce temperature more than 3000 °C. Tungsten carbide samples were treated by arc plasma melt-cast technique within 12-14 of reaction. The surface morphology and microhardness properties determined by using X-ray diffraction (XRD), field effect scanning electron microscopy (FESEM), energy dispersive spectra (EDS) of X-ray, BET (Brunauer-Emmett-Teller) analysis, fourier transform infra-red, micro hardness and Young's modulus measurement. This study explores successful synthesis of WC-W<sub>2</sub>C composite by varying plasma treatment time between 10-14 min. Melt-cast WC products were prepared without any binder. The melt-cast composites exhibit outstanding mechanical properties with almost zero porosity.

### Materials and Characterizations Techniques Used

Tungsten monocarbide (WC) powder with grain size 7-10 µm powder was used in this research work. At first Pellets of tungsten monocarbide (WC) were prepared by using poly vinyl alcohol (PVA) binder and compressing at 7 T load for 40 sec. These pellets were air dried before doing plasma reaction of samples. 30 kW (dc) extended arc type plasma reactor was employed for melt-casting of WC samples. During plasma treatment following conditions was maintained: voltage 50–55 V (dc) and current 250–260 A. Argon (Ar) was used for generation of plasma. Plasma reaction was carried out for 10, 12 and 14 min. Melt-casting of samples was carried in graphite crucible placed at centrally of the reactor. After melting of samples was over, samples were allowed for cooling up to 4-5 hours to attain room temperature. Then after samples were taken out of the reactor for various characterizations.

PANalytical X'Pert Pro diffractometer system was employed for X-ray diffraction (XRD) analysis using CuKα, λ=0.15406nm radiation. Surface morphology of samples was taken by field effect scanning electron microscopy (FESEM)-ZEISS SUPRA 55. Energy dispersive spectrum (EDS) of X-ray was studied attached to TEM (transmission electron microscopy). BET method (ASAP 2020) was employed to determine the pore volume of melt-cast products. Density of melt-cast products was determined by using Archimedes' principle. Fourier transform infra-red (FTIR) spectra were studied in the range of 400–4000 cm<sup>-1</sup> (Spectrum GX, Perkin Elmer). Microhardness and Young's modulus was determined by UMIS system (Fisher-Cripps, Australia).

## RESULTS AND DISCUSSION

Different phases and planes grown in melt-cast WC samples (10 and 14 min. of plasma treatment) were carried out by XRD. Standard JCPDS data files (1999) as follows: WC: 73-0471, W<sub>2</sub>C: 79-0743, C (graphite-2H): 41-1487 were used to identify different phases grown in the composites. From the melt-cast WC samples, hexagonal crystal structure of WC, W<sub>2</sub>C and C(G) (graphite) was observed. So XRD shows two new phases (W<sub>2</sub>C and C(G) after melt-casting of WC sample. But C (G) was found as minor phase in the melt-cast products. All melt-cast products show WC and W<sub>2</sub>C composites as major components. Basically from XRD spectra, it is commonly marked that, intensity of W<sub>2</sub>C increases with increasing plasma melting duration from 10 to 14 min.. This is may be due to the sufficient time and energy developed in the hearth of plasma to decompose of WC into W<sub>2</sub>C and C. W<sub>2</sub>C phase formed at two theta of 37.9, 39.7 and 70.0 was found to increase with increasing plasma treatment time. WC peak at around two theta of





49.8 shows a peak intensity decreasing trend with increasing plasma treatment time. C is marked at around two theta of 26.8 was found to more intense with increasing duration of plasma reaction.

FESEM and EDS studies of melt-cast WC sample prepared by 14 min. of melting were carried out and shown in Fig.3. Samples show polycrystalline type of structure as observed by FESEM analysis. Typical three grain structures are found to be developed in the melt-cast samples. These three types of phases are contributed by WC, W<sub>2</sub>C and C(G) which confirm our XRD results. In the microstructure, volume % of white grains was found relatively more in amount than grey grains. If we compare with XRD result, it may be considered that white, grey and dark phases are due to WC, W<sub>2</sub>C and C(G) respectively. Dark grains basically found to grow at the grain boundary between white and grey. To know surface morphology and types of phases present FESEM analysis was done. FESEM (Fig. 3 (a)) shows three types of phases without any cracks and defects. In the microstructure there is a well defined linear boundary separating two regions. Dark grains were found to distribute uniformly in the right side of linear boundary. This is may be due to strong affinity of dark phases to that particular region. In overall analysis of microstructure, no surface defect or crack is marked in the composites. EDS analysis (Fig. 3 (b)) of typical of melt-cast WC sample shows elements of W, C and Cu. The appearance of Cu in the sample is due to Cu coated carbon grid used during EDS analysis. No impurity phase is detected in the melt-cast sample. FTIR spectrum of WC: 14 min. melt-cast sample shows peaks due to vibrational stretching of W-C in hexagonal crystal structure, C=C (aromatic) stretching and O-H stretching [14, 15]. FTIR result can be correlated to our XRD and EDS results for showing about the purity of sample.

The melt cast samples show density mostly more than 17.1 g/cm<sup>3</sup>. This is novelty of processing of materials by thermal plasma route. Pore volume of the melt-cast samples were analysed by BET method and it was measured that volumes of the pores were mostly in the range of 0.003-0.006 cm<sup>3</sup>/g. The results indicate about the optimized conditions adopted to prepare a porous free melt-cast WC sample by arc plasma melt-cast route. The melt-cast samples were then taken for study of mechanical property. It is interesting to note that WC melt cast samples showed high micro hardness and Young's modulus values in the range of 2204-2606 VHN and 540-670 GPa respectively. Such values of mechanical property are dedicated to optimized thermal plasma condition adopted in this work. The results were found to better than the samples prepared by sintering route [12-13].

## CONCLUSION

In this research work we have successfully prepared melt-cast WC samples by thermal arc plasma techniques by varying arc plasma treatment time duration between 10 and 14 min.. Three different phases of WC, W<sub>2</sub>C and unbound C(graphite) were observed in all melt-cast samples. In the melt cast products WC and W<sub>2</sub>C were found in major phases which were confirmed from XRD, EDS and FTIR studies. Microscopic analysis done by FESEM shows polycrystalline type of microstructures in the melt-cast samples. This work reports a very hard, tough and porous free melt-cast WC-W<sub>2</sub>C composite prepared only by 14 min. melt-casting of WC sample. This work reports a very hard, tough and porous free melt-cast WC-W<sub>2</sub>C composite prepared only by 14 min. melt-casting of WC sample. WC sample prepared after 14 min. of plasma treatment was found to exhibit significantly high hardness (2535 VHN) and Young's modulus (625 GPa) values with almost zero porosity.

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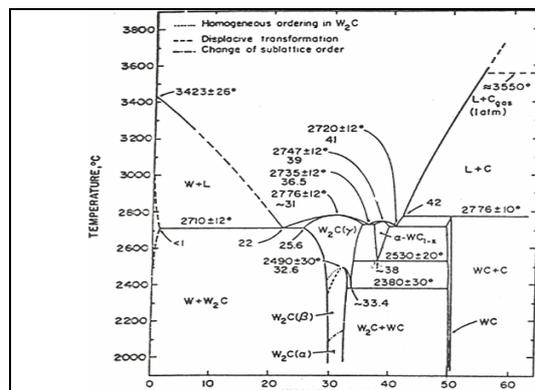




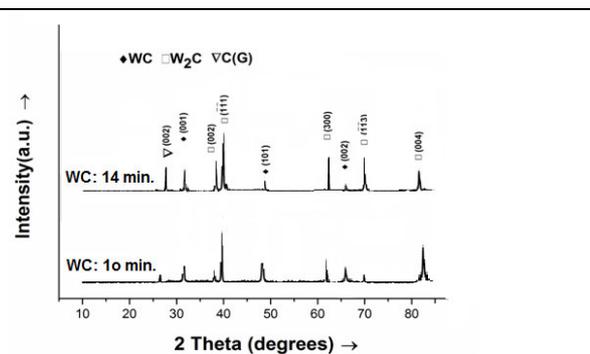
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**Table 1: Experimental procedure adopted for melt casting of WC samples and determination of pore volume, microhardness and Young’s Modulus values**

Sample ID	Electrical energy consumed (kWh / 0.1kg)	Ar gas flow rate (lt. per min.)	Arc length (cm)	Pore volume determined by BET method (cm <sup>3</sup> /g)	Microhardness (VHN)	Young’s Modulus (GPa)
WC: 10 min.	12.0	1	3	0.005	2204±19	540±18
WC: 14 min.	20.4	1	3	0.002	2606±16	640±07



**Fig. 1 Phase diagram of W-C system (Ref 10, 11)**



**Fig. 2 : XRD results of arc plasma melt-cast WC (10 and plasma treated) samples**



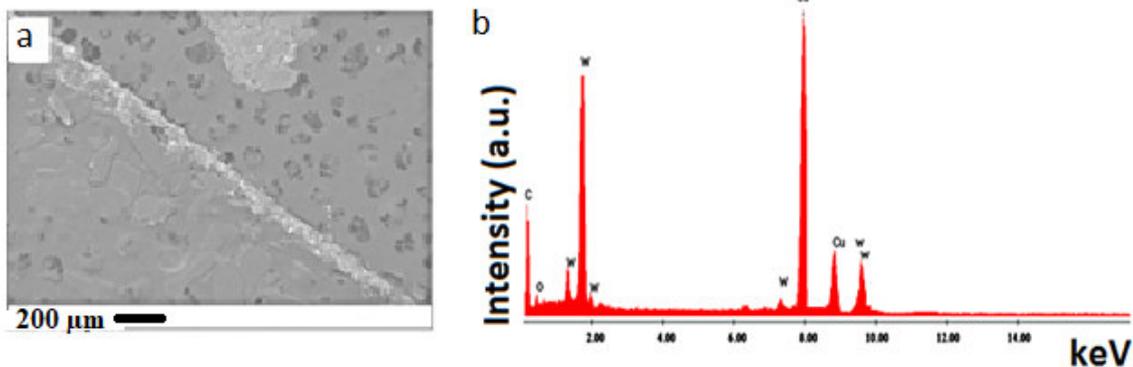


Fig.3 Optical micrograph, FESEM and EDS analysis of melt-cast WC (14 min. plasma treated) sample

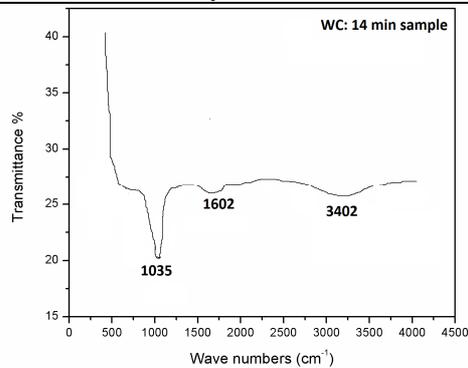


Fig.4 FTIR analysis of melt-cast WC (14 min. plasma treated) sample





## Indigenous Knowledge on Medicinal Plants used to Treat Haemorrhoids in Tribal-Rich Pockets of Odisha, India

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### ABSTRACT

The aim of present investigation mainly focussed on indigenous knowledge on medicinal plants used to treat haemorrhoids in some selected tribal-rich district of Odisha, India. The present communication provides information on 40 plant species belonging to 28 families used by many tribal communities in Odisha to treat haemorrhoids and associated problems. The data were obtained in the course of ethnobotanical exploration of various forest areas of Odisha during 1986-2010 through interviewing traditional healers locally known as 'Chera-muli doctor', 'Hakims', 'Baidyas', 'Mukhia' and 'Guru'. Information on botanical name, family, local name, habit, locality and mode of application is given. Most of the uses have not been reported so far. The practical knowledge of tribes as well as the rural communities on herbal medicines revealed that they are capable of curing haemorrhoids and other related ailments. The author emphasizes the need for incorporating some widely used herbal remedies in rural healthcare programmes.

**Keywords:** Indigenous knowledge, Medicinal plants, Haemorrhoids, Tribal-rich districts of Odisha

### INTRODUCTION

Ano-rectal diseases including haemorrhoids (Arsha), fistula-in-ano (Bhagandara) and fissure-in-ano ('Parikartika) were known to ancient Indian physicians since long ago. An elaborate description of its clinical features and its effective management has been discussed in various Ayurvedic texts. Sushruta (800 B.C.) for the first time elaborately described various ano-rectal disorders, among which haemorrhoids is a prominent one. Haemorrhoids or piles, fistula and fissure have gained notoriety for ages because of the accompanying pain, burning and bleeding



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from the rectum, which in turn causes great stress and anxiety. Haemorrhoids, also called piles, are swollen veins in the anus and lower rectum, similar to varicose veins. Haemorrhoids have a number of causes, although often the cause is unknown. They may result from straining during bowel movements or from the increased pressure on these veins during pregnancy. It can also be caused due to childbirth, persistent coughing, standing for long periods, overuse of laxatives or sitting on cold and hard surfaces for long periods of time. According to *Charaka Samhita* and *Chikitsa Sthana*, due to intake of 'guru' (heavy), 'madhura' (sweet), 'sita' (cold), 'abisandhikara' (channel-blocking), 'vidahi' (burning), 'virudda' (antagonistic), 'ajeerna' (uncooked), 'pramitasana' (too little), 'asatmya' (unsuitable), non-vegetarian and spicy foods, day sleep as well as abstaining from physical exercise, suppress 'agni' (digestive fire) causing 'mandagni', which subsequently causes excrements to get accumulated in excess ('mala samchaya'). This chronic constipatory ('mala samchaya') condition leads to various ano-rectal disorders especially haemorrhoids which may be located inside the rectum (internal haemorrhoids), or they may develop under the skin around the anus (external haemorrhoids). Haemorrhoids are very common. Nearly three out of four adults will have haemorrhoids from time to time. Sometimes they don't cause symptoms but at other times they cause itching, discomfort and bleeding. Occasionally, a clot may form in a haemorrhoid (thromboses haemorrhoid). These are not dangerous but can be extremely painful and sometimes need to be lanced and drained.

Haemorrhoids are usually not life threatening but they cause a lot of symptoms and social embarrassment through clinical features such as faecal incontinence. Some of the symptoms of this disease are: (i) painless bleeding of bright red blood along with the stools or afterwards, (ii) single or multiple swellings at the anal canal opening, which can be felt while washing after passing the stools, (iii) a sensation of a fleshy mass coming out during passing stool which goes back on its own after the completion of passing the stools, (iv) occasional pain, burning and discharge of mucous, (v) the tearing of border of anus and adjacent part very often leads to bleeding, inflammation and difficulty in passing of stool (Anal fissure), (vi) a tubular structure lined by granulation tissues which opens internally into anal canal or rectum and externally on the skin surface around the anus.

Fortunately, many effective options are available to treat haemorrhoids. Many people can get relief from symptoms with home treatments and lifestyle changes. Plants have been used for medicinal purposes long before prehistoric period. Evidence exist that Unani Hakims, Indian Vaidyas and European and Mediterranean cultures were using herbs for over 4000 years as medicine. Indigenous cultures such as Rome, Egypt, Iran, Africa and America used herbs in their healing rituals, while other developed traditional medical systems such as Unani, Ayurveda and Chinese medicine in which herbal therapies were used systematically. Traditional systems of medicine continue to be widely practised on many accounts. Population rise, inadequate supply of drugs, prohibitive cost of treatments, side effects of several synthetic drugs and development of resistance to currently used drugs for infectious diseases have led to increased emphasis on the use of plant materials as a source of medicines for a wide variety of human ailments. Among ancient civilisations, India has been known to be rich repository of medicinal plants.

The forest in India is the principal repository of large number of medicinal and aromatic plants, which are largely collected as raw materials for manufacture of drugs. About 8,000 herbal remedies have been codified in AYUSH systems in INDIA. Ayurveda, Unani, Siddha and Folk (tribal) medicines are the major systems of indigenous medicines. Among these systems, Ayurveda and Unani Medicine are most developed and widely practised in India. Recently, WHO (World Health Organization) estimated that 80 percent of people worldwide rely on herbal medicines for some aspect of their primary health care needs. According to WHO, around 21,000 plant species have the potential for being used as medicinal plants. In the present study an attempt has been made to collect medicinal knowledge and medicinal uses of plants to cure Haemorrhoids.

A number of plants have been used in ethno-medicine for curing various ailment in different tribal pockets of Odisha and reported by several researchers [1, 2, 3, 4, 5, 6, 7, 8, 9,10, 11, 12, 13, 14, 15, 16,17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72]. However, there is not a single published account on plants exclusively used in



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the treatment of 'ano-rectal diseases' especially haemorrhoids in the state of Odisha. The information mentioned in this article are the ones prescribed in the day-to-day life of tribes or rural folks inhabiting in inaccessible areas of tribal rich district of Odisha. The documentation embodied in the present communiqué will help the house-wives, barefoot-doctors, vaidyas, village medicine-men and medicine-women of rural India to manage the common 'ano-rectal' diseases especially haemorrhoids using locally available plants or plant materials.

**MATERIAL AND METHODS**

The materials for the present study form a collection of plants from various tribal-rich districts of Odisha (India) during 1986-2010. These plants were identified and confirmed with the authentic herbarium housed in Post Graduate Department of Botany, Utkal University, Bhubaneswar, Odisha and deposited in V.N. Autonomous College, Jajpur Road, Odisha, India. The plants are arranged in alphabetical order followed by synonym (if any), Accession No., the name of the family, local name and their mode of uses to treat piles.

The present chapter describes the study area, description of the study sites, methodology of survey, plant collection, herbarium preparation, plant identification and collection of data on medicinal use of plants. The field tours 10-15 days' duration were conducted in the unexplored tribal pockets of Odisha during 1986-2010. A general survey method with well planned questionnaire was followed for the collection of ethnomedicinal information. Several field trips were conducted to interview the local herbal healers and tribal medicine men and women to collect the information regarding the mode of uses of the plants to treat various diseases especially haemorrhoids. Screening of data was carried out based on available literature and the book entitled "Dictionary of Indian Folk Medicine and Ethnobotany" by S.K. Jain [73]. The voucher specimens were collected, identified and preserved in the form of herbarium specimens.

**Details of the Study Sites**

Odisha (formerly known as Orissa) is one of the 28 states in Indian republic. The state of Odisha is located between 21°17' N latitude and 85°5' E longitude in the eastern part of the Indian peninsula and the Bay of Bengal lies to its east while Chhattisgarh shares its border in the west and north-west. The state shares its geographic boundaries with West Bengal in the north-east, Jharkhand in the north and Andhra Pradesh in the south. The state is spread over an area of 155,707 km<sup>2</sup> and extends for 1030 km from north to south and 500 kilometres from east to west. Its coastline is 480 km long, which encompasses 30 districts further subdivided into 314 blocks. Physiographically, Odisha consists of coastal plains, central plateaus, central hilly regions, flood plains, and uplands. About a third of the state has a beautiful vegetation cover. Odisha topography consists of fertile coastal plains to the east bounded by Bay of Bengal. Mountainous highlands and plateau regions occupy the centre of the state. Western and north-western portions of the state consist of rolling uplands.

The western and northern portions of the state are part of the Chota Nagpur plateau. Out of 16 major forest type group in India, four major forest types that exist in Odisha are (i) Tropical dry deciduous forest (57.87%), (ii) Tropical moist deciduous forest (39.88%), (iii) Tropical semi-evergreen forest (0.68%), (iv) Littoral swamp forest (0.48%) and the total forest cover is about 31.41%. The highest mountain peak in the state is Deomali (1672 m), which is situated in Koraput district in southern Odisha. It is also one of the tallest peaks of the Eastern Ghats. The study sites covers Puri, Khurda, Cuttack, Dhenkanal, Angul, Sambalpur, Kendrapara, Jajpur, Bhadrak, Balasore, Keonjhar, Mayurbhanj, Sundergarh, Jharsuguda, Gajapati, Koraput, Kalahandi and Kandhamal districts of Odisha (Fig. 1). There are about 62 tribes are inhabiting in these area and the prominent tribal communities of the areas under study are Munda, Kharia, Kisan, Bhuyian, Santal, Saora, Kondha, Kolha, Juang, Bathudi and Kolha.



**Kunja Bihari Satapathy****Interview with informants:**

An extensive survey was carried out in some selected tribal-rich districts of Odisha during 1986-2010. The numbers of informants interviewed were 54 (34 Male, 20 Female). The information of this study was collected through questionnaire method from the villagers, elderly persons, traditional healers who are residing in the areas of the study to collect data on medicinal plants commonly used by them. The information includes different common human ailments including haemorrhoids, their occurrence, symptoms, regular mode of herbal treatments, plants and plant parts used for the treatment.

**Botanical identification of plants**

All the medicinal plants recorded during the field visits were botanically identified by referring 'The Botany of Bihar and Orissa' [74], The Supplements of Bihar and Orissa [75] and The Flora of Orissa [76].

**RESULTS AND DISCUSSION**

The ethnobotanical surveys revealed fascinating findings of great interest to the researchers and of immediate benefit to the communities concerned who safeguard the medical secrets. The present article provides information on 55 different plant species belonging to 35 families used by the tribes and rural communities in Odisha to treat haemorrhoids and associated problems. The details of collected plants are enumerated with their scientific name, family, local name, part(s) used, mode of uses to treat haemorrhoids presented in Table 1. Different parts of plants such as leaf, stem, root, rhizome, flower, fruit and seed are being used for treating haemorrhoids in the areas under study (Fig. 2). The herbal formulations prepared were either in crude form or are mixtures of various ingredients. From the survey, it was observed that maximum percentage of formulations were prepared from leaves followed by fruits for the treatment of haemorrhoids (Fig. 2).

Most of the plant species reported are herbs or trees and a few of them are shrubby species or climbers. The habit-wise groupings of the plant species shows 51 % are herbs, 11 % shrubs, 23 % trees and only 15% are climbers (Fig.3). Among the families, Asteraceae, Cucurbitaceae and Rutaceae with 4 species each are the dominant families followed by Caesalpiniaceae (with 3 species), Euphorbiaceae (with 3 species), Liliaceae (with 3 species) and Amaranthaceae, Asclepiadaceae, Combretaceae, Zingiberaceae with 2 species each respectively (Fig. 4). Some of the potential medicinal plants, widely used to treat haemorrhoids by the tribes are *Aegle marmelos*, *Aloe vera*, *Azadirachta indica*, *Carica papaya*, *Cassia auriculata*, *Cissus quadrangular*, *Gloriosa superba*, *Madhuca indica* and *Mesua ferrea*. The data collected during the investigation also revealed that the population of plant species such as *Alpinia calcarata*, *Gloriosa superba*, *Mesua ferrea*, *Cassia auriculata* and *Cissus quadrangula* were quite less as compared to other species in their natural habitat and were assessed to be under vulnerable category.

**Abbreviations**

Bath-Bathudi, Bh-Bhuyian, Bond-Bonda, G-Gond, J-Juang, K-Kisan, Kol- Kolha, Kondh-Kondha, M-Munda, O Oriya, Sao-Saora, S-Santal; KBS-Kunja Bihari Satapathy, the author.

**CONCLUSION**

The use of plant species as remedies is perhaps as old as the human civilization. The present article covers 55 different plant species, which are commonly used as household remedies against haemorrhoids. The prescriptions mentioned in Table-1 are the ones that are in practice in the tribal inhabiting remote areas of Puri, Khurda, Cuttack, Dhenkanal, Angul, Sambalpur, Kendrapara, Jajpur, Bhadrak, Balasore, Keonjhar, Mayurbhanj, Sundergarh, Jharsuguda, Gajapati, Koraput, Kalahandi and Kandhamal districts of Odisha. Tribal medicine-men, being herbal practitioners, have added these medications to their home-grown knowledge system through trial and error, spanning over hundreds of years. Based on these traditional practices, pharmaceutical industries may make some



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new preparations or improve the existing ones. The value of medicinal plants to Human livelihoods is essentially infinite and they evidently make fundamental contribution to human healthcare. Medicinal plants can be symbolically very important to people. During the course of investigation the author could observe that a number of potential medicinal plant species are threatened in their natural habitat due to their habitat loss, habitat degradation and over-harvesting. Hence, it is suggested that appropriate conservation strategies and new harvesting methodologies should be employed in the area to prevent these valuable threatened medicinal plants from wanton disappearance.

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Table 1: List of potential medicinal Plants used by different tribes of Odisha against Haemorrhoids.

Sl. No	Botanical name, Family name & Accession No.	Local name	Ethnomedicinal Uses
1.	<i>Abutilon indicum</i> (Linn.) Sweet ssp. <i>indicum</i> [MALVACEAE] KBS-477	Pedipedika(O) Kankati (S), Kakhi (Kh).	Its seeds are laxative, and very effective in curing piles, if administered in doses of 4 to 6 grams (once in a day for 5 days). Root paste is also effective against bleeding piles.
2.	<i>Acalypha indica</i> Linn. [EUPHORBIACEAE] KBS-407	Indramarisha (O), Basuni (S).	Decoction of whole plant (15 ml) along with honey (5 ml) is given twice a day for 15 days.
3.	<i>Achyranthes aspera</i> Linn. [AMARANTHACEAE] KBS-420	Apamaranga (O), Tabat-khanda (M).	A decoction of the powdered leaves, mixed with honey or sugar candy is useful in the early stages of piles. About 25 g root paste in 'water rice' is given with 250 ml goat's milk twice a day for 7 days.
4.	<i>Acorus calamus</i> Linn. [ARACEAE] KBS-434	Bacha(O),	One spoon root paste with one cup milk is given at bedtime for 3-4 months.
5.	<i>Aegle marmelos</i> (Linn.) Corr. [RUTACEAE] KBS-471	Bela(O), Sinjo(S), Lohagasi(K), Bael(Sao).	About 50 grams of the fruit along with 10 grams of old jaggery is prescribed once in a day for 15 days against bleeding piles. 2 g powdered fruit pulp mixed with 1 g of 'sunthi' powder is also given twice a day till the cure.
6.	<i>Allium cepa</i> Linn. [LILIACEAE] KBS-411	Piyaja (O)	Onion is very effective in bleeding piles. About 30 grams of onions should be finely ground on a slab with water and 60 grams of sugar added to it. This paste is given twice daily which brings relief within a few days.
7.	<i>Aloe vera</i> (Linn.) Burm.f. [LILIACEAE] KBS-454	Ghee-kuanri(O), Ghee-kumar(S).	About 5 ml of leaf juice mixed with 8-10 drops of 'tulsi juice' ( <i>Ocimum sanctum</i> ) is given twice a day for fifteen days in acute cases of piles or fistula.
8.	<i>Alpinia calcarata</i> Rosc. [ZINGIBERACEAE] KBS-429	Toroni (O).	The decoction of the leaves is taken against piles.
9.	<i>Amaranthus spinosus</i> Linn. [AMARANTHACEAE] KBS-452	Kanta khada (O), Janum arak (S), Jamun ara (M).	Extraction (10 ml) of whole plant mixed with 10 ml of ginger and 5 drops of honey is used to treat haemorrhoids.
10.	<i>Amorphophallus paenifolius</i> (Dennst.)Nicolson ( <i>A. campanulatus</i> Decne) [ARACEAE] KBS-409	Olua (O), OI (K).	Corm is encapsulated in mud, gently burnt and then pounded with a little common salt and mustard oil. This paste (two tea spoonful) given once a day for a week to cure piles.





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11.	<i>Anogeissus latifolia</i> (Roxb. ex DC.)Wall [COMBRETACEAE] KBS-473	Dhau (O), Hesel (K,S)	Decoction of bark (10 ml) is given once in a day for 15 days against piles.
12.	<i>Azadirachta indica</i> A. Juss. [MELIACEAE] KBS-415	Nimba (O), Ninba (Sao, Kondh &S).	The use of 5 grams of the inner bark of neem with 10 grams of jaggery every morning is very effective in piles. To check bleeding piles, 3 or 4 neem fruits can be administered with water.
13.	<i>Bauhinia variegata</i> Linn. [CAESALPINIACEAE] KBS-449	Kanchana (O), Buj(K), Kandol(Bh).	Floral buds fried and prescribed in the diet for 15 days to treat bleeding haemorrhoids.
14.	<i>Benincasa hispida</i> (Thunb.) Cong. (B. <i>cerifera</i> Sav.) [CUCURBITACEAE] KBS-460	Pani-kakharu(O), Raksha(K).	The fresh dilute fruit juice of ash gourd mixed with a teaspoon of 'aenla' ( <i>Phyllanthus emblica</i> ) or 'lime' ( <i>Citrus medica</i> ) juice is used as a specific medicine to stop profuse bleeding from affected part due to piles.
15.	<i>Blumea lacera</i> (Burm.f.) DC. [ASTERACEAE] KBS-437	Pokasungha (O), Kakranda (H), Kulala (G)	Leaf juice (10 ml) along with 5 gram of sugar is given once in a day against piles or fissures till the relief.
16.	<i>Boerhaavia diffusa</i> Linn. [NYCTAGINACEAE] KBS-456	Puruni (O), Khapra saga (Bh), Kenchua(K), Choic arak (Sao).	Root or whole plant is made in to a paste and given once in a day against piles. The patient is also advised to eat the leaves and tender branch tips as vegetables.
17.	<i>Brassica oleracea</i> Linn. var. <i>capitata</i> Linn. [BRASSICACEAE] KBS-466	Bandhakobi (O).	Leaves prescribed as a diet of patients suffering from fistula and liver troubles.
18.	<i>Calotropis gigantea</i> (Linn.) R.Br. ex Ait. [ASCLEPIADACEAE] KBS-418	Arakha (O), Akaona(S), Pak (Sao), Akond (Bh).	A paste prepared from leaf of 'lau' ( <i>Lagenaria vulgaris</i> ) and bark of 'karanja' ( <i>Pongamia pinnata</i> ) with the latex of this plant and that of 'siju' ( <i>Euphorbia ligularia</i> ) and applied on the affected part after mixing with cow's urine for 7 days or till the cure. External application of latex on affected part after cleaning is also advised.
19.	<i>Carica papaya</i> Linn. [CARICACEAE] KBS-440	Amruta-bhanda (O), Jhoda (K).	Leaf, fruit, seed or latex used in piles. Green fruits are boiled and made into a paste and given with a pinch of common salt and jeera ( <i>Cuminum cyminum</i> ) powder for six months.
20.	<i>Cassia auriculata</i> Linn. [CAESALPINIACEAE] KBS-468	Tarwa (Sao)	Leaf paste mixed with cow's ghee is applied to treat haemorrhoids.





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21.	<i>Cissus quadrangula</i> Linn. [VITACEAE] KBS-432	Hadabhanga(O), Hasjora (S)	Stem paste prepared with castor oil is applied externally to cure haemorrhoids.
22.	<i>Citrus limon</i> (Linn.) Burm.f. [RUTACEAE] KBS-457	Bada lembu (O)	Fruit juice mixed with ginger juice, mint and Honey is given once in a day for 15 days against internal haemorrhoids.
23.	<i>Coccinia grandis</i> (Linn.) Voigt. ( <i>Cephalandra indica</i> (Wt. & Arn.) Naud.) [CUCURBITACEAE] KBS-408	Kunduri (O), Bano kundri (K).	Juice of leaves (15 ml) with date palm jaggery (10 g) given once daily for a week for piles as well as blood dysentery. Decoction of the twig of plant along with that of flowers and young fruits are given once daily for seven days.
24.	<i>Cynodon dactylon</i> (Linn.) Pers. [POACEAE] KBS-458	Duba ghasa (O), Dhobi ghas (K&S).	10-15 ml of fresh juice of the whole plant is given 3 times a day for 15 days.
25.	<i>Cyperus rotundus</i> Linn. [CYPERACEAE] KBS-435	Mutha (O), Suraj (S), Batha-bijir(M).	Rhizome powder (10 g) mixed with 5 g of old jaggery is given once in a day after food to treat hemorrhoids.
26.	<i>Eclipta prostrata</i> (Linn.) Linn. [ASTERACEAE] KBS-410	Kesadura (O), Kamri (Kondh)	Leaf paste mixed with sugar candy is taken twice a day for 7 days.
27.	<i>Eryngium foetidum</i> Linn. [APIACEAE] KBS-422	Jangali Dhania (O)	Whole plant extract mixed with sugar or Honey is taken twice a day for 1 month against acute case.
28.	<i>Euphorbia hirta</i> Linn. [EUPHORBIACEAE] KBS-450	Chitakuti (O), Pusi toa (S,K)	Leaf extract mixed with the latex of 'arakh' ( <i>Calotropis procera</i> ) is applied externally on the affected part to cure haemorrhoids.
29.	<i>Euphorbia ligularia</i> Roxb. ( <i>E. nerifolia</i> auct. non Linn.) [EUPHORBIACEAE] KBS-413	Patra-siju, Mansa-siju (O).	Latex mixed with a pinch of 'turmeric powder' is applied on the affected part to cure external piles.
30	<i>Gloriosa superba</i> Linn. [LILIACEAE] KBS-469	Dasara phula (O), Lauri-kuli (Kondh), Jagara(M)	Tuber powder is given along with warm water to treat haemorrhoids.
31.	<i>Hygrophila auriculata</i> (Schum.) Heine [Asteracantha longifolia (Linn.)Nees]. [ACANTHACEAE] KBS-414	Koili-khia (O).	Leaf juice (5 ml) along with honey (5 drops) is given at evening for 15 days.





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32.	<i>Ichnocarpus frutescens</i> (Linn.) R.Br. [APOCYNACEAE] KBS-463	Suamlai(O), Dudhilata (S), Onol-sing (K), Saon-lar (Kharw)	Fresh root paste (10 g) is prepared with raw cow's milk and given twice a day for 7 days.
33.	<i>Limonia acidissima</i> Linn. ( <i>Feronia elephantum</i> Corr.) [RUTACEAE] KBS-419	Kaitha(O), Katbel(S), Bimul (Kondh), Belsain(Kharw)	The mashed seedless pulp of the unripe fruit, mixed with cardamom, honey and cumin seeds, is given against piles as well as indigestion.
34.	<i>Luffa acutangula</i> (Linn.) Roxb. [CUCURBITACEAE] KBS-433	Jahni(O), Jui(Ho), Paror jhanga(S).	Roots paste is applied on the affected part to cure bleeding piles. Seeds powder of this plant and equal amount of 'haladi' ( <i>Curcuma longa</i> ) powder mixed with mustard oil and is applied over the piles for the removal.
35.	<i>Madhuca indica</i> Gmel. ( <i>Bassia latifolia</i> Roxb.) [SAPOTACEAE] KBS-474	Mahula (O), Natikam(K) Aba(Sao), Mahua (Kondh).	2-3 drops of seed oil mixed with 50 ml warm cow's milk is given in early morning on empty stomach for 7 days.
36.	<i>Mesua ferrea</i> Linn. [CLUSIACEAE] KBS-431	Nageswara (O).	Flower buds made into a paste with butter and is administered (10 g) two times a day for 7 days to check bleeding due to piles.
37.	<i>Momordica charantia</i> Linn. [CUCURBITACEAE] KBS-416	Kalara(O), Kirla (K).	Decoction of the fruits is given to the patient in the morning in empty stomach at least for one month. The patient is also advised to include the fruit as vegetable in his daily diet. Fresh juice of seven leaves along with a pinch of rock salt is given once in the morning on empty stomach for seven days.
38.	<i>Murraya koenigii</i> (Linn.) Spreng. [RUTACEAE] KBS-461	Bhrusunga (O), Puspa (Bond), Mirsinga (Kondh).	One or two teaspoons of fresh juice of these leaves mixed with a teaspoon of 'lime' juice may be taken. The tender curry leaves, ground to a fine paste and mixed with honey or butter-milk, can be taken on an empty stomach with beneficial results in case of piles or stomach upsets.
39.	<i>Musa paradisiaca</i> Linn. [MUSACEAE] KBS-438	Kadali (O)	The inflorescence is cooked and given to the patients daily to treat hemorrhoids.
40.	<i>Nelumbo nucifera</i> Gaertn. [NYMPHAEACEAE] KBS-472	Padma (O).	About 5 g of central part of the flower made into a paste with butter and given once in a day for 7 days.





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41.	<i>Ocimum sanctum</i> Linn. [LAMIACEAE] KBS-466	Tulasi (O).	The mucilaginous jelly, formed by infusing 5 to 10 gram of the seeds in cold water for some time, can be administered with sugar to treat internal piles as well as constipation.
42.	<i>Pergularia daemia</i> (Forssk.) Chiov. [ <i>P. extensa</i> (Jacq.) N.E. Br. ; <i>Daemia extensa</i> (Jacq.) R.Br] [ASCLEPIADACEAE] KBS-507	Uturudi(O).	The herb is beneficial in the treatment of bleeding piles. About 24 grams of the leaves fried in ghee should be taken for a few days.
43.	<i>Plantago ovata</i> Forssk. [PLANTAGINACEAE] KBS-405	Isaphagul (O).	Two tablespoons of the seeds should be taken with milk or water once in a day against piles or fissure.
44.	<i>Plumbago zeylanica</i> Linn. [PLUMBAGINACEAE] KBS-511	Chitaparu (O), Sitaparu (Kondh). Chitur(M).	Root juice mixed with equal amount of honey and pinch of common salt is applied externally in haemorrhoids.
45.	<i>Pongamia pinnata</i> (Linn.) Pierre. ( <i>Pongamia glabra</i> Vent.) [FABACEAE] KBS-501	Karanja (O), Kamun (Sao), Karanjo (Kondh), Kuruin(S).	Seed powder (5 g) is given with cold water once in every morning for 15 days.
46.	<i>Sesamum orientale</i> Linn. [PEDALIACEAE] KBS-417	Tila, Khasa (O), Tilming (K), Pitilme (Kondh).	Seeds, especially the black ones (10 g) along with equal quantity of sugar candy is given twice a day for 15 days against fissure. Decorticated seed paste (10 g) along with buttermilk (20 ml) and sugar (10 g) is prescribed against bleeding piles.
47.	<i>Solanum nigrum</i> Linn. [SOLANACEAE] KBS-462	Lunulunia (O), Phut phutia (M)	Fresh unripe 7 fruits are given for 10 days to treat bleeding piles.
48.	<i>Sphaeranthus indicus</i> Linn. [ASTERACEAE] KBS-504	Bhuinkadamb a (O), Koirab (Bath), Belaunga(S)	Paste (15 g) of this plant is given with old jaggery (10 g) twice a day for 3 days to check bleeding piles.
49.	<i>Streblus asper</i> Lour. [MORACEAE] KBS-459	Sahada(O), Sukri-Saijang (M), Ripichum (Kol).	Fresh seed paste (10 g) is given once a day for 7 days against piles. Decoction of bark (10-15 ml) is given early in the morning on empty stomach till the complete cure of fissures. Root, bark or seed paste with 'fermented rice water' is used externally in fissures.

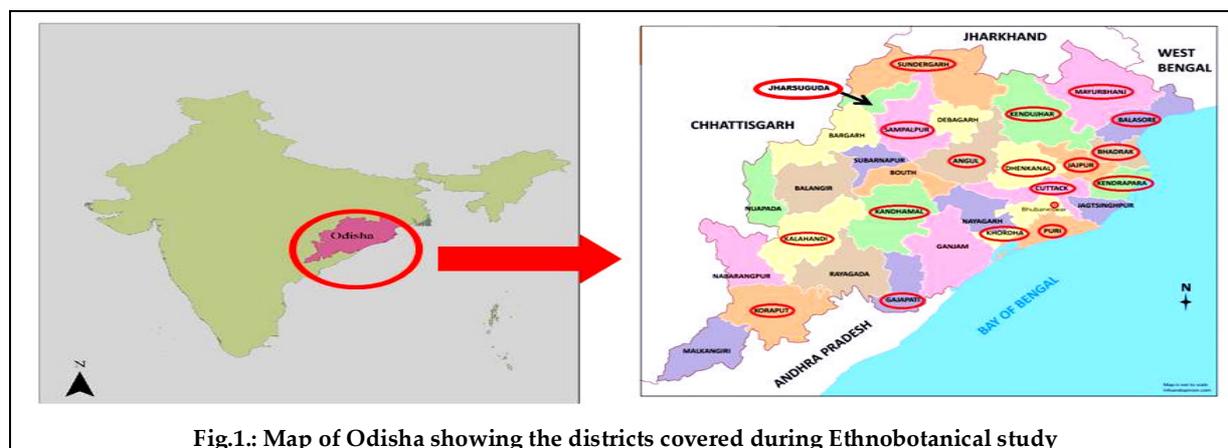




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50.	<i>Tagetes erecta</i> Linn. [ASTERACEAE] KBS-503	Gendu (O).	Leaf with 10 number of 'gola maricha' ( <i>Piper nigrum</i> ) made in to a paste (5 g) and is prescribed twice a day against chronic piles.
51.	<i>Tamarindus indica</i> Linn. [CAESALPINIACEAE] KBS-453	Tentuli (O), Jojo(K), Teten (Kondh)	Leaf juice is useful in bleeding piles.
52.	<i>Terminalia chebula</i> Retz. [COMBRETACEAE] KBS-412	Harida (O), Rola(K&S), Kakra (Sao).	The fresh fruits should be fried to a golden brown colour in castor oil, powdered and stored in an air-tight bottle. Half a teaspoon of this is dissolved on the tongue at bedtime brings about normal bowel movement in the morning and its astringent property is very effective in healing the pile masses.
53.	<i>Tribulus terrestris</i> Linn. [ZYGOPHYLLACEAE] KBS-506	Gokhara (O), Gokhru (Bath).	Infusion (15 ml) of matured fruits is prescribed early in the morning in empty stomach against piles.
54.	<i>Vitex negundo</i> Linn. [VERBENACEAE] KBS-509	Begunia(O), Huri (M), Sinoar (Kh).	Cake prepared from the roots of his plant and boiled rice is given against piles.
55.	<i>Zingiber officinale</i> Rosc. [ZINGIBERACEAE] KBS-508	Ada (O).	Half a teaspoon of fresh ginger juice, mixed with one teaspoon each of fresh lime and mint juices and a teaspoon of honey, constitutes an effective medicine for piles. This mixture should be taken thrice daily.

**Abbreviations:** Bath-Bathudi, Bh-Bhuyian, Bond-Bonda, G-Gond, J-Juang, K-Kisan, Kol- Kolha, Kondh-Kondha, M-Munda, O-Oriya, Sao-Saora, S-Santal; **KBS**-Kunja Bihari Satapathy, the author

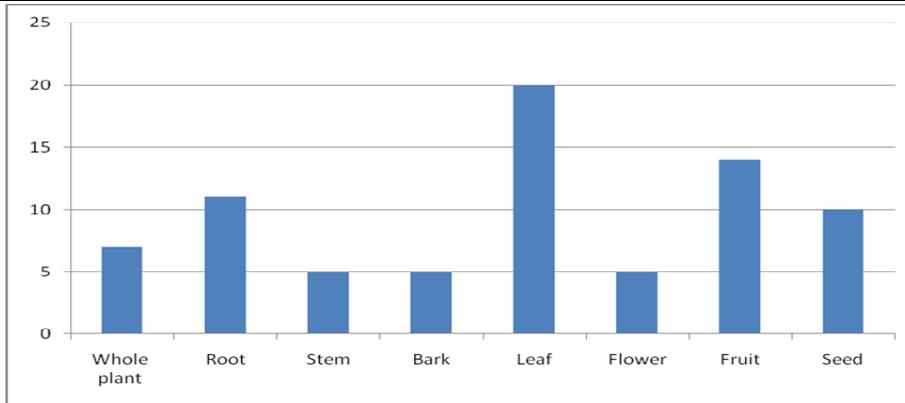


**Fig.1.:** Map of Odisha showing the districts covered during Ethnobotanical study

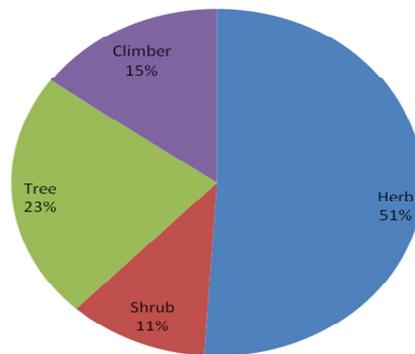




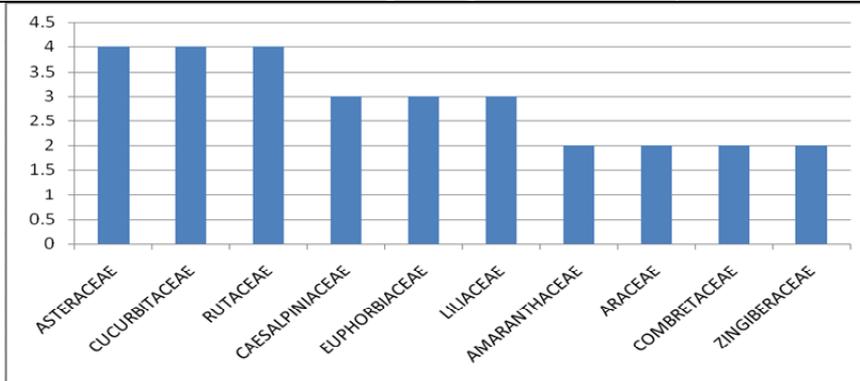
**Kunja Bihari Satapathy**



**Fig. 2: Frequency of plant part (s) used during preparation of herbal medicines**



**Fig. 3: Habit-wise distribution of medicinal plant species in the study area used in haemorrhoids**



**Fig. 4: Dominant angiospermic families comprising potential medicinal plants used by the tribes of Odisha against haemorrhoids**





## ***In silico* Cefixime Trihydrate in Novel Drug Delivery System: A Review**

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### **ABSTRACT**

The review article is focus on different novel formulations of cefixime trihydrate and the effect of its bioavailability by forming a drug delivery formulation for better therapeutic response. Cefixime is an orally active third generation cephalosporin with in vitro antibacterial activity against most important lower respiratory pathogens. Cefixime has a long elimination half-life (3 hours compared with 0.5 hours for cefaclor and 1.5 hours for cefalexin), which allows once daily administration. Because of its wide acceptability from paediatric to geriatric patients pharmaceutical scientist are in a race to formulate a novel dosage forms for better therapeutic response. Hence this review emphasizes different types of novel formulation using cefixime trihydrate.

**Keywords:** Cefixime Trihydrate, Novel Drug Delivery System

## **INTRODUCTION**

Cefixime Trihydrate is an oral 3rd generation cephalosporin antibiotic. It is extremely bitter in taste. It is active against most Grams positive and Gram negative organisms and it is useful in the treatment of uncomplicated urinary tract infections, otitis media, pharyngitis and tonsillitis, acute bronchitis and acute exacerbations of chronic bronchitis, uncomplicated gonorrhoea. CefiximeTrihydrate is an oral 3rd generation cephalosporin antibiotic.[3] It is extremely bitter in taste. It is active against most Grams positive and Gram negative organisms and it is useful in the treatment of uncomplicated urinary tract infections, otitis media, pharyngitis and tonsillitis, acute bronchitis and acute exacerbations of chronic bronchitis, uncomplicated gonorrhoea. Cefixime is an antibacterial agent of the cephalosporin class. [5]It is used in various infections like Otitis, Sinusitis and Pharyngitis. Like other cephalosporins, Cefixime exerts antibacterial activity by binding to and inhibiting the action of penicillin-binding proteins. Involved in the synthesis of bacterial cell walls. [1]This leads to bacterial cell lysis and cell death. Cefiximetrihydrate is a BCS class-IV drug. The half life of Cefiximetrihydrate is about 3-4 Hrs.[7]



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Oral cephalosporins have been available for over 25 years and have been used extensively in the therapy of outpatient infections in adults and in children. Many of these agents are variably subject to hydrolysis by some beta-lactamases.[2] Cefixime is a new orally absorbed cephalosporin and the first oral one of the third generation.[6] Cefixime is not hydrolyzed by the common plasmid-mediated enzymes and by chromosomal  $\beta$ -lactamases that inactivate the currently available oral penicillins and cephalosporins, and, for this reason, inhibits a wide variety of Gram-positive and Gram-negative aerobic bacteria, including *Haemophilus influenzae*, *Moraxella catarrhalis*, *Neisseria gonorrhoeae*, *Escherichia coli* and *Klebsiella* resistant to ampicillin, other oral cephalosporins and trimethoprim-sulfamethoxazole. Its broad spectrum activity permits its use in respiratory and urinary tract infections. [9] This paper is a review of chemical properties, antibacterial activity, pharmacokinetics, clinical pharmacology, indications and adverse effects of cefixime as compared to other orally absorbed cephalosporins and to amoxicillin or cotrimoxazole. [13] The chemical name of cefixime is (6R,7R)-7-[(Z)-2-(2-amino-4-thiazolyl)-2-(carboxymethoxyimino)-acet-amido]-8-oxo-3-vinyl-5-thia-1-azabicyclo-(4,2,0)-oct-2-ene-2-carboxylic acid. This semi-synthetic cephalosporin shares structural properties with parenteral third generation cephalosporins such as the 2-aminothiazolyl and the methoxyimino-groups, but differs from them in the position of the ethyl group and a carboxyl group added to the iminomethoxy of the 7-position acyl group. The international nonproprietary name is cefixime (cefiximetrihydrate).[15] Cefixime's physical appearance is that of a white to slightly yellowish crystal or crystalline powder, slightly soluble in ethanol and nearly insoluble in water. Since the pKa values of the two carboxylic acids of cefixime are 2.1 (at the 2-position) and 3.7 (at the 7-position) and that of the amino group at the thiazoyl moiety is 2.7, the increase in lipophilicity of cefixime with decreasing pH is in accordance with increase in the un-ionized forms of the carboxylic acid groups of cefixime. Therefore the bioavailability of Cefiximetrihydrate is very poor.[11] The absolute oral bioavailability of Cefixime is in the range of 22-54 %. Because of poor bioavailability there is a need to increase its bioavailability by forming a novel drug delivery formulation for better therapeutic response.[4]

## Clinical Pharmacology

The recommended dose of cefixime is 400 mg daily, for adults. This may be given as 400 mg once daily or as 200 mg every 12 h. For children, the recommended dose is 8 mg/kg per day. This may be administered as a single daily dose or may be given in two divided doses as 4 mg/kg every 12 h. Children weighing more than 50 kg or older than 12 years should be treated with the recommended adult dose.[13] Pharmacy There are several presentations for per oral use, depending on the countries: -- Tablets: white tablets, in boxes of 8 or 40, each tablet containing 200 mg of cefixime trihydrate with excipients which are dibasic calcium phosphate, magnesium stearate, glycerol, titanium dioxide, hydroxypropyl methylcellulose, microcrystalline cellulose, and pregelatinised starch. [13] Each tablet is convex, 10 mm in diameter, white to cream coloured and weighs 696 rag. -- Tablets containing 400 mg of cefiximetrihydrate in the USA. The comparative bioavailability studies of a single 400 mg dose of cefixime and two 200 mg tablets provide evidence that the two formulations are bioequivalent and that the pharmacokinetic profile achieved after a single 400 mg dose. It should support the clinical evaluation of the efficacy of a one daily dosage regimen for cefixime. -- Fine granule, the available form used for children in Japan, which can be absorbed alone or in a liquid solution. Other pediatric forms: powder for oral suspension (USA, UK) which when reconstituted produces 100 mg/5 ml, and lipidic suspension (Germany, Spain) which can be absorbed directly. The same studies have shown that the oral solution is bioequivalent to the other formulations.[13] There is no parenteral form of cefixime on the market and i.v. cefixime was only used for studies. Cefixime has to be stored at controlled room temperature of 15-30 °C.

## Therapeutic Use

Approved therapeutic indications Cefixime is indicated in the treatment of the following infections when caused by susceptible strains, although some variations can be noted from country to country: -- Uncomplicated or complicated



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acute, acute or chronic infections including cystitis, pyelitis, pyelonephritis and those infections associated with urologic surgery, neurogenic bladder or nephrolithiasis caused by Enterobacteriaceae. -- Acute otitis media caused by Haemophilus influenzae, Moraxella catarrhalis and Streptococcus pyogenes. -- Sinusitis. -- Acute bronchitis, exacerbations of chronic bronchitis and pneumonias. -- Urethritis due to penicillinase and non-penicillinase-producing N. gonorrhoea.[6]

### **Novel Formulation of Cefixime**

#### **As MICROSPHERES**

Cefiximetrihydrate is a 3rd generation broad spectrum  $\beta$ - lactam cephalosporin class of antibiotic administered orally in pediatric and adult patients and is extremely bitter in taste. Controlled release and bitter taste masking are the major challenges for better patient compliance particularly in an antibiotic treatment where dose and duration is important. Among the various techniques available for controlled release, microencapsulation is a useful technique as it has significant advantages over the other techniques. Also a polymer used provides protection to active moiety thereby increasing its stability. The oral route of administration is the most important route of administering drugs for systemic effects. [3]Reconstitutable suspensions necessitate water to prior for mixing. [3]Controlled release (CR) suspensions aimed at controlling the rate of release by maintaining desired drug levels in the blood for long duration of time. The most popular dosage forms being tablets and capsules, but one major drawback of the dosage forms however is the difficulty to swallow for children and the patients who have swallowing disorder.

#### **CefiximeTrihydrate as Mucoadhesive Tablets**

Mucoadhesive tablets of Cefiximetrihydrate were prepared using Carbopol 940P, HPMC K15M and Polyox WSR 303 as a mucoadhesive polymers and  $\beta$ -cyclodextrin as a solubility enhancer. Nine formulations were developed using 32 factorial designs. [4]Carbopol 940P is used as a primary polymer because of its excellent mucoadhesive property and secondary polymers like HPMC K15M & polyox were used. The formulations were tested for in-vitro drug release, mucoadhesive strength, swelling studies, residence time and surface pH.

#### **CefiximeTrihydrate as Bilayer Tablets**

The aim of present work was to develop a robust formulation of Bi-layer tablets of Cefiximetrihydrate and Dicloxacillin sodium using povidone k-30 as binder. [18]The basic aim of any Bi-layer tablet formulation is to separate physically or chemically incompatible ingredients and to produce repeat action or prolonged action tablet. Cefixime is a cephalosporin antibiotic used to treat infections caused by bacteria such as pneumonia, bronchitis, gonorrhoea, and ear, lung, throat, and urinary tract infections.[18] Dicloxacillin is a semi synthetic antibiotic which resists destruction by the enzyme penicillinase. It is used to treat different types of infections caused by bacteria such as bronchitis, pneumonia, etc.[18] A total number of nine formulations have been taken to optimize and develop a robust and stable formulation

#### **Cefiximetrihydrate as floating microsphere**

Floating microspheres of cefiximetrihydrate were prepared using polymers to prolong gastric residence time and increase drug bioavailability with decreased gastro intestinal side effects. [15]The floating micro carriers were prepared by ionotropic gelation method by dispersing cefiximetrihydrate with calcium carbonate and sodium bicarbonate separately into a mixture of anionic sodium alginate, as primary polymer with copolymers namely, HPMC K4M, HPMC K15M and ethyl cellulose into a solution of calcium chloride containing acetic acid. [15]The





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microspheres formulated with CaCO<sub>3</sub> show increased buoyancy and controlled drug release which makes it excellent in floating drug delivery systems

### Cefiximetrihydrate as transdermal patch

Cefiximetrihydrate is a third generation cephalosporin with a broad spectrum bactericidal activity. Due to its short biological half-life, it required for frequent dosing, so transdermal delivery system was chosen to deliver the drug directly to the systemic circulation thereby to reduce the dose as well as the frequency of dosing. [16] Transdermal matrix patches of cefiximetrihydrate were prepared by solvent casting method using chitosan and sodium alginate as polymers. Two types of chitosan with mol.wt. 190kDa and 419kDa were used. The patches found to be having good physicochemical properties. [17]

### CONCLUSION

Cefixime Trihydrate has been widely prescribed by physician as antibiotics from paediatrics to geriatrics. But due to its bitter taste and short half life it should be formulated properly as a novel drug to show its proper therapeutic activity with minimal toxicity as a novel drug delivery system.

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## COVID 19: An Updated Review

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### ABSTRACT

Corona virus causes respiratory infection including pneumonia, cold, sneezing and coughing while in animal it causes diarrhea and upper respiratory diseases. Corona virus transmitted human to human or human to animal via airborne droplets. Corona virus enters in human cell through membrane. WHO and ECDC advised to avoid public place and close contact to infected persons and pet animals. Firstly Corona virus (2019-nCoV) was isolated from Wuhan market China at 7 Jan. 2020. The proposed of this review article summarizes regarding major proposed on common types, Transmission, Symptoms, Epidemiology, Diagnosis, Prevention for COVID-19 and provides a summary of current ongoing clinical experience and treatment guidance for this novel epidemic coronavirus.

**Keywords:** Transmission, Epidemiology, Clinical Trials

### INTRODUCTION

The global pandemic of novel coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) began in Wuhan, China, at the end of 2019. As of April 5, 2020, there have been more than 1.2 million reported cases and 69,000 deaths in more than 200 countries. This novel Betacoronavirus is similar to severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV); based on its genetic proximity, it likely originated from bat-derived coronaviruses with spread via an unknown intermediate mammal host to humans. Currently, there is no evidence from randomized clinical trials (RCTs) that any potential therapy improves outcomes in patients with either suspected or confirmed COVID-19. There are no clinical trial data supporting any prophylactic therapy. More than 300 active clinical treatment trials are underway. This narrative review summarizes regarding Transmission, Symptoms, Epidemiology, Diagnosis, Prevention for COVID-19 and provides a summary of current ongoing clinical experience and treatment guidance for this novel epidemic coronavirus.





### Common Types

1. 229E (alpha coronavirus)
2. NL63 (alpha coronavirus)
3. OC43 (beta coronavirus)
4. HKU1 (beta coronavirus)

Rarer strains that cause more severe complications include MERS-CoV, which causes Middle East respiratory syndrome (MERS), and SARS-CoV, the virus responsible for severe acute respiratory syndrome (SARS). In 2019, a dangerous new strain called SARS-CoV-2 started circulating, causing the disease COVID-19.

### Transmission

Limited research is available on how HCoV spreads from one person to the next. However, researchers believe that the viruses transmit via fluids in the respiratory system, such as mucus. Coronaviruses can spread in the following ways: Coughing and sneezing without covering the mouth can disperse droplets into the air. Touching or shaking hands with a person who has the virus can pass the virus between individuals. Making contact with a surface or object that has the virus and then touching the nose, eyes, or mouth. Some animal coronaviruses, such as feline coronavirus (FCoV), may spread through contact with feces. However, it is unclear whether this also applies to human coronaviruses. The National Institutes of Health (NIH) suggest that several groups of people have the highest risk of developing complications due to COVID-19.

### These Groups Include

1. Young children
2. People aged 65 years or older
3. Women who are pregnant

Corona viruses can mutate effectively, which makes them so contagious. To prevent transmission, people should stay at home and rest while symptoms are active. They should also avoid close contact with other people. Covering the mouth and nose with a tissue or handkerchief while coughing or sneezing can also help prevent transmission. It is important to dispose of any tissues after use and maintain hygiene around the home. However, people with a more recent diagnosis had no connections with or exposure to the market, confirming that humans can pass the virus to each other. Few children get COVID-19, although they are still investigating the reasons for this. However, while some viruses are highly contagious, it is less clear how rapidly coronaviruses will spread. Symptoms vary from person-to-person with COVID-19. It may produce few or no symptoms. However, it can also lead to severe illness and may be fatal.

### Symptoms

1. Sneezing
2. Runny nose
3. Cough
4. Watery diarrhea
5. Fever in rare cases
6. Sore Throat
7. Exacerbated asthma





### Epidemiology

In December 2019, many pneumonia cases that were clustered in Wuhan city were reported and searches for the source have shown Huanan Seafood Market as the origin. The first case of the COVID-19 epidemic was discovered with unexplained pneumonia on December 12, 2019, and 27 viral pneumonia cases with seven being severe, were officially announced on December 31, 2019. Etiologic investigations have been performed in patients who applied to the hospital due to similar viral histories of these patients has strengthened the likelihood of an infection transmitted from animals to humans. On January 22, 2020, novel CoV has been declared to be originated from wild bats and belonged to Group 2 of beta-coronavirus that contains Severe Acute Respiratory Syndrome Associated Coronavirus (SARS-CoV).

Although COVID-19 and SARS-CoV belong to the same beta corona virus subgroup, similarity at genome level is only 70%, and the novel group has been found to show genetic differences from SARS-CoV. Similar to the SARS epidemic, this outbreak has occurred during the Spring Festival in China, which is the most famous traditional festival in China, during which nearly 3 billion people travel countrywide. These conditions caused favorable conditions for the transmission of this highly contagious disease and severe difficulties in prevention and control of the epidemic. The period of the Spring Festival of China was between January 17 and February 23 in 2003, when the SARS epidemic peaked, while the period of the festival was between January 10 and February 18 in 2020. Similarly, there was a rapid increase in COVID-19 cases between January 10-22. Wuhan, the center of the epidemic with 10 million populations, is also an important center in the spring festival transportation network. The estimated number of travelers during the 2020 spring festival has risen 1.7 folds when compared with the number traveled in 2003 and reached to 3.11 billion from 1.82 billion. This large-scale travel traffic has also created favorable conditions for the spread of this difficult-to-control disease.

### Diagnosis, Treatment, and Prevention

Diagnosis is also important in locations where a severe CoV outbreak is occurring, such as, at present, in the Middle East, where MERS-CoV continues to circulate. The identification of cases will guide the development of public health measures to control outbreaks. It is also important to diagnose cases of severe veterinary CoV-induced disease, such as PEDV and IBV, to control these pathogens and protect food supplies. RT-PCR has become the method of choice for diagnosis of human CoV, as multiplex real-time RT-PCR assays have been developed, are able to detect all four respiratory HCoVs and could be further adapted to novel CoVs. Serologic assays are important in cases where RNA may be difficult to isolate, is no longer present, and for epidemiological studies.

There is no anti-viral therapeutics that specifically target human coronaviruses, so treatments are only supportive. In vitro, interferons (IFNs) are only partially effective against coronaviruses. IFNs in combination with ribavirin may have increased activity in vitro when compared to IFNs alone against some coronaviruses; however, the effectiveness of this combination in vivo requires further evaluation [coronavirus]. The SARS and MERS outbreaks have stimulated research on these viruses and this research has identified a large number of suitable anti-viral targets, such as viral proteases, polymerases, and entry proteins. Significant work remains, however, to develop drugs that target these processes and are able to inhibit viral replication.

Only limited options are available to prevent coronavirus infections. Vaccines have only been approved for IBV, TGEV, and Canine CoV, but these vaccines are not always used because they are either not very effective, or in some cases have been reported to be involved in the selection of novel pathogenic CoVs via recombination of circulating strains. Vaccines for veterinary pathogens, such as PEDV, may be useful in such cases where spread of the virus to a new location could lead to severe losses of veterinary animals. In the case of SARS-CoV, several potential vaccines have been developed but none are yet approved for use.



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### Review of Selected Repurposed Drugs

Chloroquine and hydroxychloroquine have a long-standing history in the prevention and treatment of malaria and the treatment of chronic inflammatory diseases including systemic lupus erythematosus (SLE) and rheumatoid arthritis (RA).<sup>7</sup> Chloroquine and hydroxychloroquine appear to block viral entry into cells by inhibiting glycosylation of host receptors, proteolytic processing, and endosomal acidification. These agents also have immunomodulatory effects through attenuation of cytokine production and inhibition of autophagy and lysosomal activity in host cells. Chloroquine inhibits SARS-CoV-2 in vitro with a half-maximal effective concentration (EC<sub>50</sub>) in the low micromolar range.

Dosing of chloroquine to treat COVID-19 has consisted of 500 mg orally once or twice daily. However, a paucity of data exists regarding the optimal dose to ensure the safety and efficacy of chloroquine. Hydroxychloroquine dosing recommendations for SLE generally are 400 mg orally daily. However, a physiologically based pharmacokinetic modeling study recommended that the optimal dosing regimen for hydroxychloroquine in COVID-19 treatment is a loading dose of 400 mg twice daily for 1 day followed by 200 mg twice daily.<sup>15</sup> In contrast, alternative recommendations are made for 600 mg total daily dose based on safety and clinical experience for Whipple disease.<sup>11</sup> Further studies are needed to delineate the optimal dose for COVID-19.

#### Lopinavir/Ritonavir and Other Antiretrovirals

Early reports of lopinavir/ritonavir for the treatment of COVID-19 are mostly case reports and small retrospective, nonrandomized cohort studies, making it difficult to ascertain the direct treatment effect of lopinavir/ritonavir.<sup>45,46</sup> The most commonly used and studied lopinavir/ritonavir dosing regimen for COVID-19 treatment is 400 mg/100 mg twice daily for up to 14 days.<sup>12,23</sup> Given the significant drug-drug interactions and potential adverse drug reactions (summarized in Table 1), careful review of concomitant medications and monitoring are required if this drug is used. Adverse effects of lopinavir/ritonavir include gastrointestinal distress such as nausea and diarrhea (up to 28%) and hepatotoxicity (2%-10%).<sup>24</sup> In patients with COVID-19, these adverse effects may be exacerbated by combination therapy or viral infection because approximately 20% to 30% of patients have elevated transaminases at presentation with COVID-19.<sup>47</sup> A recent RCT showed approximately 50% of lopinavir/ritonavir patients experienced an adverse effect and 14% of patients discontinued therapy due to gastrointestinal adverse effects.<sup>23</sup>

### Ongoing Clinical Trials

The search terms COVID OR coronavirus OR SARS-COV-2 on ClinicalTrials.gov resulted in 351 active trials, with 291 trials specific to COVID-19 as of April 2, 2020. Of these 291 trials, approximately 109 trials (including those not yet recruiting, recruiting, active, or completed) included pharmacological therapy for the treatment of COVID-19 in adult patients. Of these 109 trials, 82 are interventional studies, with 29 placebo-controlled trials. Per description of the studies, there are 11 phase 4, 36 phase 3, 36 phase 2, and 4 phase 1 trials. Twenty-two trials were not categorized by phase or not applicable

### CONCLUSIONS

The COVID-19 pandemic represents the greatest global public health crisis of this generation and, potentially, since the pandemic influenza outbreak of 1918. The speed and volume of clinical trials launched to investigate potential therapies for COVID-19 highlight both the need and capability to produce high-quality evidence even in the middle of a pandemic. Future research on coronaviruses will continue to investigate many aspects of viral replication and pathogenesis. No therapies have been shown effective to date.





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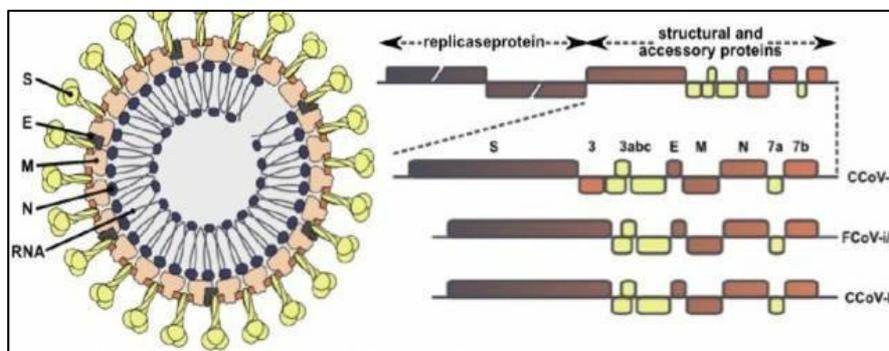


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**Table 1: The Director-General also noted that the risk of serious complications increases with age. According to the WHO.**

Stage of severity	Rough percentage of people with COVID-19
Mild disease from which a person can recover	More than 80%
Severe disease, causing breathlessness and pneumonia	Around 14%
Critical disease, including septic shock, respiratory failure, and the failure of more than one organ	About 5%
Fatal disease	2%



**Fig.1. Coronavirus structure and comparison of CCoV and FCoV genome**





## ***In vivo* Anti Microbial Study of Protein Hydrolysate of *C. moschata* and *L. siceraria* Seed**

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### **ABSTRACT**

*Cucurbita moschata* and *Lagenaria siceraria* seed proteins were extracted and hydrolysed with trypsin in order to recover antibacterial protein. The in vivo bactericidal activities of CMAH and LSAH were assayed using a mice model against *A. baumannii*. LSAH significantly ( $p < 0.05$ ) reduced the CFU count in the *A. baumannii* infected mice. Biochemical analysis showed that infectious mice showed significant elevation of neutrophil, WBC, count compared to CMAH, LSAH, standard treated mice and uninfected mice. Therefore, it was expected that the LSAH may used control infections caused by *A. baumannii*. This outcome is significant importance, as there are limited antibiotics available for treating Gram negative bacteria.

**Keywords:** *Cucurbita moschata*, *Lagenaria siceraria*, *A. baumannii*

### **INTRODUCTION**

Nowadays, multidrug-resistant (MDR) bacteria cause many remarkable threats to public health across the world (Antunes *et al.*, 2012). Though, there is a progress in knowledge and medical technology for the treatment of various complicated infectious diseases, still morbidity and mortality rate has become high among the people (Moellering *et al.*, 2007). Recently, a large number of novel antimicrobial drugs are being manufactured in the pharmaceutical industries and are available in the market, but they are found to be more resistant to the microorganisms (Nascimento *et al.*, 2000). The proper treatments of various infectious diseases caused by multidrug-resistant (MDR) bacteria are becoming more difficult due to production of extended spectrum lactamase in the Gram negative bacteria (Edward-Jones, 2013). Patients are infected by MDR bacterial isolates like *pseudomonas*, *Klebsiella*, and





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*Acinetobacter* during their long term hospitalization. It has also been reported that 51.5% of patients infected with these MDR bacteria at the time of admission to hospital (Dubey *et al.*, 2014). Among Gram negative bacteria, *Acinetobacter baumannii* is found to be more versatile pathogen developing a wide range of infections in the patients of hospital, particularly critical patients of intensive care units. Currently, the treatment of various infections caused by *A. baumannii* has become more challenging due to unavailability of novel molecules. The polymyxins and tetracycline are the only antibiotics, which are active against *A. baumannii* (Hornsey *et al.*, 2013). Recently, WHO emphasizes priority on research and development of new and effective antibiotics against Gram-negative bacteria, as most of them have become resistant (Tacconelli and Magrini, 2017). The establishment of new antibiotics has become more expensive in comparable to the rate of increase of multidrug resistance. Therefore, there is a need for the development of low cost drugs for multidrug-resistant bacteria. For last few decades, the antimicrobial agents from synthetic origin have been developing critical resistance against many of the pathogenic bacteria. Till date, resistance towards the antibiotics has been the major cause of public health problems, and that imparted in the discovery of novel antimicrobial agents from natural sources. The search of novel antimicrobial principles from natural sources has paid a remarkable attention in the field of research and formulation development, as they have fewer side effects, and offering a great challenge. The medicinal plants are thus being considered in scientific community and their isolated components are thought to fight fatal opportunistic infections (Aumeeruddy-Elalfi *et al.*, 2015).

Since last few decades, it has been observed that the storage proteins of some plants are used to treat as antimicrobial agent. Several classes of proteins from plant parts with antibacterial properties have now been identified as chitinases, ribosome-inactivating proteins, thionins, chitin-binding lectins and permatins (Cammue *et al.*, 1992). Antimicrobial proteins in plants have most commonly been found in seeds at higher concentration and function as storage proteins. These antimicrobial seed proteins are very similar in structure and function to those of human antimicrobial peptides produced as a part of their defence system (Bhat and Al-daihan 2014).

A cursory survey of literature has indicated that only few studies concerning potential application of proteins with antibacterial activity from plant sources have been reported. In our previous study it was reported that *Cucurbita moschata* and *Lagenaria siceraria* seed proteins hydrolysate showed good antibacterial effect against *A. baumannii* by *in vitro* assay (Dash & Ghosh, 2018). *In-vitro models are required to establish the initial dose response. The data obtained by in vitro model is very helpful to determine the utility of antimicrobial agents. Additionally, the in vitro studies don't depend upon the fluctuation of drug concentration within the body. Therefore, prior to clinical studies, the vital potency of tested drug is determined by in vivo model* (Davis, 2004). In most of the bacterial diseases, animal study is very essential for characterization of pathogens and their host response. Thus, *in vivo* model is required for evaluation of novel treatments, host immune response and bacterial virulence factors (McConnell *et al.*, 2013). Therefore in this study protein hydrolysates of *C. moschata* and *L. siceraria* are evaluated by *in vivo* method against *A. baumannii*.

### Extraction and Purification of Albumin from *C. moschata* and *L. siceraria* Seeds

Seeds of *Cucurbita moschata* and *Lagenaria siceraria* were purchased from local market of Bhubaneswar, Odisha. Seeds were dried at 50 °C, kernels were separated manually and ground in an electric grinder into a fine powder. The powdered sample of *C. moschata* and *L. siceraria* was then extracted with n-hexane to remove the fatty material. The residue, thus obtained was homogenized in magnetic stirrer for 40 min. with distilled water, and then centrifuged at 10,000g for 10 min at 4°C temperature to get albumin as supernatant. The sediment obtained was rinsed with 5 ml of distilled water, then homogenized, followed by centrifugation in the same condition. Albumin fraction of *C. moschata* and *L. siceraria* were purified using acetone and lyophilized and kept at -20 °C until use (Teugwa *et al.*, 2013).





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### Preparation of Albumin Hydrolysates

Albumin hydrolysate of *C. moschata* (CMAH) and *L. siceraria* (LSAH) were prepared according to the method of Dash & Ghosh (2018).

### Estimation of Protein Contents

The total protein content of seeds was determined using a Bio-Rad protein assay reagent and bovine serum albumin as described by Bradford (1976).

### *In vivo* Antimicrobial Study

**Bacterial Strain:** The test microorganisms used in this study includes three Gram-negative bacteria such as *Acinetobacter baumannii* (MTCC 1425) which were collected from the institute of microbial technology Chandigarh, India.

### Experimental Design

Mice (20-30gm) were obtained from the Department of Pharmacology, School of Pharmaceutical Sciences, S' O'A (Deemed to be University), Bhubaneswar, Odisha. Approval from the animal ethical committee of the institution was taken with letter number IAEC/SPS/SOA/09/2018. The animals had free access to standard pellet diet and water *ad libitum*. They were acclimatized in cages at an ambient temperature of  $25 \pm 2$  °C with 50–60% relative humidity for a period of one week with 12 hr day light and 12 hr dark cycle.

### *In vivo* Antimicrobial Activity of CMAH and LSAH against *A. baumannii i*

The antimicrobial efficacy of protein hydrolysates (CMAH/LSAH) was evaluated by mice model of *A. baumannii i*. In brief, five different groups of mice (4 animals in each) were taken, and each mice in each group was injected intraperitoneally with an inoculum of *A. baumannii i*, containing  $10^3$  CFU, followed by intraperitoneal administration of protein hydrolysate.

Group I: normal control (injected with saline solution)

Group II: negative control (injected with inoculums of *A. baumannii i* + saline solution)

Group III: injected with an inoculums of *A. baumannii i* + CMAH (500 mg/kg BW)

Group IV: injected with an inoculums of *A. baumannii i* + LSAH (500 mg/kg BW)

Group V: injected with an inoculums of *A. baumannii i* + gentamicin (10 mg/kg BW)

At the end of 7 days of experimental study, the mice were sacrificed by cervical dislocation. The peritoneal fluid, liver and spleen were removed aseptically from the infected mice. The blood samples were collected by heart puncture method and kept in different vials containing EDTA for prevention of clotting. A saline lavage of the peritoneal cavity was performed and lavage fluid (3 to 4 ml) was collected. Then, liver and spleen were excised, and portions of liver along with spleen and peritoneal fluid were subjected to a CFU count for viable cells on *A. baumannii i* agar medium (Maiti *et al.* 2014).

### Estimation of Quantitative Bacteriological Parameter

Liver and spleen tissues were cut into small pieces, homogenized and mixed with phosphate buffered saline (PBS). Aliquots of 10 fold serial dilutions of the homogenates in PBS were cultured on Mueller-Hinton agar plates to quantify the number of viable *A. baumannii i* organisms in the respective organs. Colonies were counted after 72 hours of incubation at 37 °C (KuoLee *et al.*, 2007). Results were expressed as number of CFU/g of organ.

### Estimation of Haematological Profile

At the end of experimental work, the 12 hours fasted rats were sacrificed by cervical decapitation. The blood samples were collected by heart puncture method and kept in different vials containing EDTA for prevention of clotting. Blood was analysed for haematological parameters such as total white blood cells (WBC), neutrophill and lymphocyte.





### Statistical Analysis

Results were expressed as mean values  $\pm$  standard deviation of three independent determinations. Statistical analysis was done using SPSS 11.0 (SPSS Inc., Chicago, IL, USA).

## RESULT AND DISCUSSION

### Estimation of Quantitative Bacteriological Parameter of Mice Treated with CMAH and LSAH against *A. baumannii* i

In order to determine the *in vivo* antibacterial activity, mice were infected with *A. baumannii* i. The *in vivo* bactericidal activities of CMAH and LSAH were assayed using a mice model as described in materials methods section. To assess the *in vivo* antimicrobial effect of CMAH and LSAH, a murine model was employed. Figure 1 showed the number of bacterial colonies of *A. baumannii* i in the spleen, liver and peritoneal fluid of mice. CMAH and LSAH treated mice significantly reduced blood and tissue bacterial burdens compared to those of infected saline-treated mice ( $P < 0.05$ ). As a result, we concluded that LSAH significantly ( $p < 0.05$ ) reduced the CFU count in the *A. baumannii* i infected mouse. Clinical signs, body weight, and survival of the mice were monitored. The body weights of the infected mice were slightly decreased due to acute infection. It is previously reported that *C. moschata* and *L. siceraria* is rich in cysteine, histidine, proline, tyrosine, glycine, arginine, lysine and serine (Yin *et al.*, 2010). Proteins rich in amino acids, such as cysteine, histidine, proline, tyrosine, glycine, arginine, lysine and serine were responsible for antimicrobial property. It was previously reported that these amino acids were frequently found in antimicrobial peptide fragments. Further, it was reported that hydrophobicity improves the hydrophobic reactions between lipid acyl chains in bacterial membrane, resulting in enhancement of membrane permeabilisation of bacteria (Song *et al.*, 2012). It is previously reported that hydrophobic amino acids content in LSAH (125.9 mg/g) was found to be more than CMAH (102.3 mg/g) (Dash & Ghosh, 2018). Lysine and arginine are the major structural units of peptides, which are help the major target molecules for interaction with bacterial membrane (Song *et al.*, 2012). The treatment of infections caused by Gram-negative pathogens was found to be much harder due to their high intrinsic drug resistance.

### Estimation of Haematological Profile of Mice Treated with CMAH and LSAH against *A. baumannii* i

Biochemical analysis showed that infectious mice showed significant elevation of neutrophil, WBC, count compared to CMAH, LSAH, standard treated mice and uninfected mice. At the end of the experiment, animals were examined for WBC and other immunological parameters. The results indicated that the WBC count of infected mice and mice treated with CMAH and LSAH was found to be  $7.3 \pm 0.6$  and  $7.9 \pm 0.2 \times 10^3$  cells/ $\mu$ L, respectively. The symptom of disease appeared in infected mice, showing increase in total WBCs count up to  $10.6 \times 10^3$  cells/ $\mu$ L in negative control mice as shown in Figure 2. The WBCs act as an immunological parameter and it determines the case of infection, while normal range of total WBCs count is  $4.2 \times 10^3$  cells/ $\mu$ L (Taha, 2013). Neutrophil content of infected mice (negative control) was  $11.8 \times 10^3$  cells/ $\mu$ L. The neutrophil content in gentamicin, CMAH and LSAH treated mice was found to be 3.25, 5.8 and  $4.25 \times 10^3$  cells/ $\mu$ L, respectively. It was found that neutrophil content of standard and LSAH was significantly not different ( $p < 0.05$ ). The neutrophil and macrophage engulf the pathogenic bacteria cells during phagocytosis. Therefore, the range of neutrophils is increased during bacterial infections (Taha, 2013). As neutrophils are hematopoietic immune cells, they are generated in the bone marrow and continued to be available in the circulations leading various types of infections. They protect the body from fungal and extra cellular bacterial infections by promoting bacterial clearance through phagocytosis, producing reactive oxygen and nitrogen species. To protect the body from infections, they also form neutrophil extracellular trap and inflammatory cytokines (Taha, 2013).

Nowadays, a multidrug-resistant (MDR) bacterium has become a global problem in public health. In this concern, *A. baumannii* i is found to be most potent antibiotic resistant Gram negative bacteria. As it is a versatile pathogen, it is





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involved in wide range of secondary hospital infections, especially in ICU patients and in widespread lineages for citywide and nationwide outbreaks. Therefore, a large number of novel antimicrobial agents must be identified to develop more extensive resistance in *A. baumannii* (Antunes *et al.*, 2012). The antibiotics like colistin untreatable with other commercially available antibiotics (Antunes *et al.*, 2012). Therefore, it was expected that the LSAH may used control infections caused by *A. baumannii*.

## CONCLUSION

Albumin hydrolysates of *C. moschata* and *L. siceraria* were active against *A. baumannii*. LSAH significantly ( $p < 0.05$ ) reduced the CFU count in the *A. baumannii* infected mice with compare to CMAH. Biochemical analysis showed that infectious mice showed significant elevation of neutrophil, WBC, count compared to CMAH, LSAH, standard treated mice and uninfected mice. This outcome is significant importance, as there are limited antibiotics available for treating Gram negative bacteria. Only limited data are presently available on the antimicrobial activity of plant extracts in food systems and this indicates continuation of our study and the need for further work.

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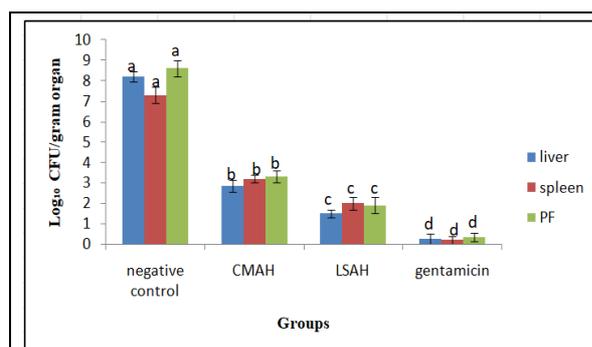
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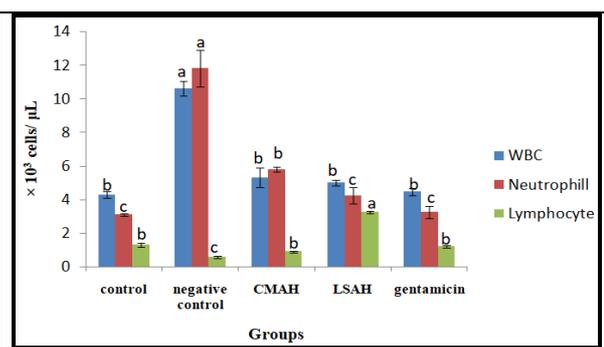


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**Figure 1** The bacterial burdens in liver, spleen and peritoneal fluid of CMAH, LSAH, and gentamicin treated mice. Results are expressed as mean ± standard deviation from 4 mice per group. Results were analyzed by analysis of variance (ANOVA) followed by Duncan's test ( $P < 0.05$ ).



**Figure 2** Haematological analyses of mice infected with *A. baumannii* and treated with CMAH and LSAH. Results are expressed as mean ± standard deviation from 4 mice per group. Results were analyzed by analysis of variance (ANOVA) followed by Duncan's test ( $P < 0.05$ ).





## Anti-Inflammatory Activity of Some Potential Bioactive Plants: A Review

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### ABSTRACT

From the prehistoric period, Ayurveda has been followed by Indian pupil for treatment of many ailments and it is the comprehensive summary of traditional medicines. Inflammation generally mediated through neutrophils produced from damaged or infected living tissues. Non steroidal anti-inflammatory drugs are the type of drug used for anti-inflammation by blocking cyclooxygenase pathway. Non steroidal anti-inflammatory drugs are act by different mechanisms with various side effects, so herbal drugs are preferred for relieve of pain, fever and inflammation. Africa continent enriched with several plants grown on different geographical regions with various climatic conditions and such plants contains potential active constituents having significant anti-inflammatory activity. Several studies of herbal anti-inflammatory drugs has been carried out by many researcher of Africa but further investigation is necessary to focus on unexplored bioactive plants. Consequence of this study aims in basic research encourage more ethnobotanical and ethnopharmacological survey in anti-inflammatory endowed biomedicines.

**Keywords:** Ayurveda, neutrophils, antioxidants, anti-inflammation

### INTRODUCTION

Traditional Indian medicine, Ayurveda, has a long history and one of the great traditions in the field of health issue. [1] Considerable research on pharmacognosy, chemistry, pharmacology, and clinical therapeutics has been carried out on Ayurvedic medicinal plants of India. [2,3] An enormous body of research supports the recommendations that antioxidant therapy is an attractive alternative approach for amelioration of diverse ailments such as cancer, cardiovascular diseases, inflammation, shock ischemia injury, diabetes, cataract, Alzheimer disease, and acute central nervous system injury. [4] antioxidants have been considered as one explanation for the beneficial effects of the healthy, Mediterranean-type diet. [5]



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Reports have shown that inflammation is usually triggered by damage to living tissues resulting from bacterial, viral, fungal infections; physical agents; and defective immune response. The fundamental aim of inflammatory response is to localize and eliminate the harmful agents; secondarily, to remove damaged tissue components to culminate in healing of the affected tissues, organs, or system. An inflammatory response involves macrophages, neutrophils known to secrete different mediators that are responsible for the initiation, progression, persistence, regulation, and eventual resolution of the acute state of inflammation. The resolution of inflammation is influenced by several anti-inflammatory mediators and the recruitment of monocytes for the removal of cell or tissue debris. [6,7] It is possible that the resolution may not occur in the acute phase, thereby turning into a chronic phase. Chronic inflammation plays a role in the burdens associated with pathological conditions in both developed and developing countries. For instance, chronic inflammation is known to play a role in the development of obesity-associated diabetes secondary to insulin resistance. [6]

Various nonsteroidal anti-inflammatory drugs can reduce pain and inflammation by blocking the metabolism of arachidonic acid by isoform of cyclooxygenase enzyme (COX-1 and/or COX-2), thereby reducing the production of prostaglandin. [8] Unfortunately, there are many side effects associated with the administration of nonsteroidal anti-inflammatory drugs. [8,9] However, there are medicinal plants with anti-inflammatory therapeutic effects with low or no side effects. The African continent is richly endowed with diverse medicinal plants with anti-inflammatory activities that have been shown to be effective in the treatment of inflammatory conditions in traditional medicine. Interestingly, scientists have examined some of these African medicinal plants and documented their biological and therapeutic activities. [10-13] Unfortunately, medicinal plants from different regions in Africa with anti-inflammatory properties have not been documented in a single review paper.[14] Therefore, it is important to document the ethnobotanical knowledge and applications of anti-inflammatory medicinal plants from selected countries representing different regions in the African continent.

For centuries, Africans have treated different disease conditions including inflammatory diseases using medicinal plants. Africa is a vast continent. From Egypt, Morocco, and Algeria in the north to Nigeria and Ghana in the west, Cameroon and Gabon in the center, Kenya and Tanzania in the east, and South Africa, Lesotho, Namibia, Swaziland, and Zimbabwe in the south, there are thousands of plants with therapeutic values.[15] For example, there are over 5000 plant species growing in Zimbabwe with over 10% of these plants having medicinal value while in South Africa over 30000 flowering plants are available and some of them are used in treatment and management of pain-related inflammatory disorders in both animal and human subjects[16].The truth is that African traditional medicine is usually the first contact in meeting the primary health care need in Africa and is related to its affordability, accessibility, cultural and spiritual acceptance, and knowledge of its preparations and use.[17] The potentials of plant-derived compounds from African medicinal plants have been reported and the interest to use medicinal plants in treatment and management of disease conditions is growing rapidly in Africa even among educated African urban dwellers.[18] Mechanisms of action of plants with anti-inflammatory potentials. Various mechanisms of actions have been proposed to explain the anti-inflammatory activity of medicinal plants. These include the following:

**Inhibition of 15-Lipoxygenases (LOX)**

The lipoxygenase group of enzymes (5, 8, 12, and 15 LOX) plays a role in various inflammatory disorders. The isomeric enzyme 15-LOX is a key enzyme involved in the synthesis of leukotrienes from arachidonic acids. Biologically active leukotrienes are mediators of many pro-inflammatory and allergic reactions, hence the inhibition of the synthesis of leukotrienes by 15-LOX is seen as one of the therapeutic strategies in the management of inflammatory condition. [19-21]



**Dharmendra Pradhan and Tapan Ku Sahu****Inhibition of NOS**

Inhibition of iNOS is not considered a general characteristic of plant flavonoids. However, plant flavonoids have been reported to inhibit nitric oxide (NO) production, thereby downregulating the expression of iNOS. Flavone and amino-substituted flavones have also been reported to inhibit NO production.[ 22-24]

**Inhibition of COX**

Flavonoids are a group of polyphenols with the ability to inhibit the biosynthesis of prostaglandins. There are two commonly known isomeric forms of COX (COX-1 and COX-2). The inhibition of COX-1 and COX-2 has been reported as the molecular target of several anti-inflammatory herbal extracts and herb-derived compounds. [8,25-28]

**Inhibition of Phospholipase A<sub>2</sub>**

Arachidonic acid is a precursor of eicosanoids and is released from membrane lipids by phospholipase A<sub>2</sub>, consequently synthesizing prostaglandins, thromboxanes, and leukotri-enes. The inhibition of phospholipase by any therapeutic agent blocks the COX and LOX pathways in the arachidonic cascade have been shown to be effective in the treatment and management of inflammatory conditions. The first flavonoid inhibitor of phospholipase A<sub>2</sub> to be identified is quercetin, which inhibited human neutrophils. Selected medicinal plants that have been shown to inhibit phospholipase A<sub>2</sub> include *Allium sativum*, *Curcuma longa*, *A. cepa*, *Xylopi frutescens*. [8,29]

Inhibition of pro-inflammatory cytokines

Different kinds of pro-inflammatory cytokines are known to regulate inflammatory reactions either directly or by their ability to induce the synthesis of cellular adhesion molecules or other cytokines in certain cell types.[30] Various investigators have reported on the inhibition of pro-inflammatory cytokines following the feeding of rats with plant extracts that are rich in flavonoids. [31-34]

**Modulation of Pro-Inflammatory Gene Expression**

The predominant points of cellular regulation affected by herbs and herb-based compounds are the various protein kinases involved in signal transduction including protein kinase C and mitogen-activated protein kinase. Through inhibition of these enzymes, DNA-binding capacity of transcription factors such as nuclear factor-kappa B or activator protein-1 is regulated, thereby controlling the expression rate of the target gene.[35-39]

**PLANTS WITH ANTI-INFLAMMATORY ACTIVITY**

A brief overview of the traditional therapeutic applications of the selected plants under study is described here so as to understand their medicinal importance.

**Acrous calamus:** The rhizome constitutes the drug “Calamus” of commerce. In the Ayurvedic system of medicine, the rhizomes are considered to possess anti spasmodic, carminative, and anthelmintic actions. It is also recommended for treatment of epilepsy, amelioration of mental ailments, chronic diarrhea, dysentery, bronchial catarrh, intermittent fevers, glandular/abdominal tumors, kidney/liver troubles, rheumatism, and eczema. [40].In the past couple of decades, despite the increasing interest of the public in phytomedicine, very few drugs from higher plants have attained any prominence in conventional medical practices. Some reasons for this may be due to lack of standardization and proper scientific validation of herbal drugs. [41]. Considering the high therapeutic amplitude of antioxidants, an urgent need of standardization of botanicals and the pleuropotent medicinal importance of selected plants prompted us to design the current studies on evaluation of an antioxidant and possible anti-inflammatory potential of selected medicinal plants that are usually prescribed in the Indian traditional system of medicine. [42]

**Aegle marmelos (Rutaceae):** The aqueous extract of the root bark of Bilwa was prepared and tested for anti-inflammatory activity in albino rats using Carrageenan induced paw edema model and cotton pellet induced



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granuloma and the standard drug was taken indomethacin and Bilwa. The result revealed that anti-inflammatory activity was expressed the inhibition.

***Bryophyllum pinnatum***(Crassulaceae): The anti-inflammatory potential of *Bryophyllum pinnatum* was investigated by ojewole et al. The study was undertaken to investigate anti-inflammatory and of the plant leaf aqueous extract in experimental animal models. In this experiment using fresh egg albumin-induced pedal (paw) oedema model and drug taken Diclofenac 100 mg/kg. The results revealed of this experimental animal study suggest that *Bryophyllum pinnatum* leaf aqueous extract possessed anti-inflammatory. The different flavonoids, polyphenols chemical constituents of the herb are speculated to account for the observed anti inflammatory of the plant. [43]

***Albizia lebbbeck***(Mimosaceae): The bark extract of *Albizia lebbbeck* Benth. obtained by cold extraction of mixture of equal proportions of petroleum ether, ethyl acetate and methanol was chosen for pharmacological screening. In rat paw edema model induced by carrageenan, the extract at the 200 and 400 mg/kg dose level showed 27.51% and 36.68% ( $P < 0.001$ ) inhibition of edema volume at the end of 4 h.

***Cassia fistula***(Caesalpinaceae): The bark extracts of *Cassia fistula* possess significant anti-inflammatory effect in the acute and chronic anti-inflammatory model of inflammation in rats. Reactive oxygen species (ROS) generated endogenously or exogenously are associated with the pathogenesis of various diseases such as atherosclerosis, diabetes, cancer, arthritis and aging process. ROS play an important role in pathogenesis of inflammatory diseases. The main constituents responsible for anti inflammatory activity of *Cassia fistula* are flavonoids and bio-flavonoids.

***Cassia occidentalis*** (Caesalpinaceae): Sreejith *et al.* was evaluated anti-inflammatory potential of whole plant of *Cassia occidentalis* using ethanolic extract. For investigation of anti-inflammatory potential dose taken 250 mg/kg and using carrageenan induced paw edema model. The result revealed that significant reduction in malondialdehyde levels of murine hepatic microsomes and significantly reduced carrageenan induced inflammation in mice at a dose of 250 mg/kg. [44]

***Berberis aristata***: The plant is an emmenagogue and is effective in the treatment of jaundice and enlargement of spleen. The fresh berries are laxative, antiscorbutic, and useful in piles, sores, and eye diseases. A decoction is used as a mouthwash for the treatment of gums and toothache. [45]

***Boerhavia diffusa***: Useful drug for treatment of inflammatory renal diseases and nephrotic syndrome. It is effective for edema and ascites resulting from early cirrhosis of the liver and chronic peritonitis. The plant is reported to be efficacious in abdominal tumors and cancer. It is also credited with antibacterial and cardiotoxic properties. [46]

***Calendula officinalis***: Flower extract possessed significant anti-inflammatory activity against carrageenan and dextran-induced acute paw edema. Oral administration of 250 and 500 mg/kg body weight *Calendula* extract produced significant inhibition (50.6 and 65.9% respectively) in paw edema of animals induced by carrageenan and 41.9 and 42.4% respectively with inflammation produced by dextran. In chronic anti-inflammatory model using formalin, administration of 250 and 500 mg/kg body weight *Calendula* extract produced an inhibition of 32.9 and 62.3% respectively compared to controls. TNF-alpha production by macrophage culture treated with lipopolysaccharide (LPS) was found to be significantly inhibited by *Calendula* extract. Moreover, increased levels of pro inflammatory cytokines IL-1beta, IL-6, TNF-alpha and IFN-gamma and acute phase protein, C-reactive protein (CRP) in mice produced by LPS injection were inhibited significantly by the extract. LPS induced cyclooxygenase-2 (Cox-2) levels in mice spleen were also found to be inhibited by extract treatment. The results showed that potent anti-inflammatory response of *C. officinalis* extract may be mediated by the inhibition of pro inflammatory cytokines and Cox-2 and subsequent prostaglandin synthesis. [47]



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***Cedrus deodar.*** Usually prescribed for fever, diarrhea and dysentery. Alcohol bark extract has considerable anti-inflammatory activity against acute and chronic inflammations. The wood possesses diaphoretic, diuretic, and carminative properties and is useful in pulmonary and urinary disorders. The wood powder is one of the ingredients of the well-known Ayurvedic preparations “mondooravataka,” “bhardradarvadi,” and “Taila,” prescribed for anorexia, edema, piles, diabetes, leprosy, and sciatica. [48]

***Cynodon dactylon*** (Poaceae): The anti-inflammatory activity of aqueous extract of *Cynodon dactylon* at different doses using carrageenan, serotonin, histamine and dextran induced rat paw edema and cotton pellet method. The study was carried out in three different doses levels of 200, 400 and 600 mg/kg orally. The Aqueous extract of *C. dactylon* was found to be safe at all doses used and there is no mortality up to the dose of 4000mg/kg of extract when administered orally. *C. dactylon* showed significant anti-inflammatory activities in all model. The extract was found to reduce significantly ( $P < 0.001$ ) the formation of edema induced by carrageenan, serotonin, histamine and dextran after 3 and 5 h.

***Emblica officinalis*** (Euphorbiaceae) *Emblica officinalis* is a tree growing in subtropical and tropical parts of China, India, Indonesia and Malay peninsula. It has been used for anti-inflammatory and antipyretic activities in these areas. In the recent studies, the anti-inflammatory activity was found in the water fraction of methanol extract of plant leaves. The effects of fraction were tested on the synthesis of mediators of inflammation such as leukotriene B<sub>4</sub>, platelet activating factor (PAF) and thromboxane. The water fraction of methanol extract inhibited migration of human PMNs in relatively low concentrations.

***Hibiscus rosa-sinensis*** (Malvaceae) The methanolic extract of *Hibiscus rosa-sinensis* leaves (250 and 500 mg/kg body weight orally) was used in carrageenin and dextran induced rat paw edema anti-inflammatory model. Indomethacin was used as standard drug which showed significant anti-inflammatory activity. The inhibition of edema by 17.12 and 16.46% with 250 mg/kg, 45.35%, and 44.51% with 500 mg/kg body weight after 3 h with carrageenin, dextran respectively. The plant extract at the dose level of 250 and 500-mg/kg body weight by oral route exhibited significant ( $P < 0.001$ ) anti-inflammatory activities against all the agents used.

***Moringa oliefera*** (Moringaceae) The aqueous and ethanolic extract of the stem bark of *Moringa oliefera* showed % inhibition after 5 h was maximum 27.27 and 30.30% significant reduction  $P < 0.01$  and  $P < 0.05$  in the edema volume at a dose of 300 mg/kg body weight, which is comparable to standard drug Diclofenac sodium. The standard drug showed % inhibition 44.44% (25 mg/kg) body weight and significant value  $P < 0.01$ . The percentage of paw edema was found to be better with the alcoholic extract than the aqueous extract.

***Sida cordifolia*** Linn. (Malvaceae) *Sida cordifolia* is a perennial shrub of the mallow family Malvaceae. *Sida cordifolia* is used in folk medicine for the treatment of inflammation of the oral mucosa, blepharitis, asthmatic bronchitis and nasal congestion. It has been investigated as an anti-inflammatory<sup>45</sup>, for preventing cell proliferation<sup>46</sup> and for encouraging liver growth. [49]

***Eleusine indica*** L. Leaves of the plant possessed anti-inflammatory and antioxidant properties. According to Sagnia *et al.*, 2014 EI shows anti-inflammatory activity. The activity was studied by in-vitro method. Inhibition of cytokines like tumor necrosis factor- $\alpha$  (TNF- $\alpha$ ) induced by lipopolysaccharide was measured in terms of anti-inflammatory activity. LPS induced cyclooxygenase-2 (Cox-2) levels found to be inhibited by extract treatment. [50]

***Melissa officinalis* L. (Lamiaceae)** had been reported in traditional Moroccan medicine to exhibit calming, antispasmodic, and strengthening heart effects. Therefore, this study is aimed at determining the anti-inflammatory activities of *M. officinalis* L. leaves. The effect of the essential oil of the leaves of this plant was investigated for anti-inflammatory properties by using carrageenan and experimental trauma-induced hind paw edema in rats. The



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essential oil extracted from leaves by hydrodistillation was characterized by means of gas chromatography-mass spectrometry (GC-MS). [51]

***Petrocarpus santalinus.*** The decoction of wood is effective as a tonic, astringent, and beneficial in fever, dysentery, and hemorrhage. Wood paste is externally applied in headache, inflammations, boils, piles, and in ophthalmia. [52]

***Pongamia glabra.*** Flowers are prescribed in diabetes. Seed powder is efficacious in whooping and irritating coughs in children. Oil is prescribed internally in stomachic and dyspepsia with sluggish fever; applied externally, either alone or in combination, for skin diseases, in sores, scabies, herpes, and eczema. Leaf juice is effective in cough, flatulence, and diarrhea. Leaf paste is applied internally to ulcers infested with worms. Bark paste has applications in bleeding piles, and decoction is given in beri-beri. Root extract is useful for external application to destroy maggots in foul ulcers and fistulous sores, clearing teeth, and strengthening gums. [53]

***Swertia chirayita.*** Whole plant, either powder, infusion, or as an extract, is used as an antidiarrheal, antimalarial, anthelmintic, and as a special remedy for bronchial asthma and liver disorders. It is given with sandalwood paste to stop internal hemorrhage in the stomach. [54]

***Tinospora cordifolia.*** Stem is a constituent of several Ayurvedic formulations used in general debility, dyspepsia, fevers, and urinary diseases. Dry twigs with intact bark are prescribed as anti-inflammatory, antispasmodic, and antipyretic. The roots are a powerful emetic and used for visceral obstruction. The watery extract is recommended for treatment of leprosy. Pulverized fruits are given as a tonic and also for amelioration of jaundice and rheumatism. [55]

***Withania somnifera.*** The leaves and fruits are prescribed as an antipyretic and anthelmintic. It is effective for amelioration of painful swelling, scabies, carbuncles, dropsy, cough, hiccup, leukorrhea, menstrual troubles, and rheumatism. It is found beneficial in restoring memory, used for nervous exhaustion, spermatorrhea, impotency, or seminal debility. The decoction of leaves and roots boiled with milk promotes nutrition. It is one of the important ingredients in various Ayurvedic formulations such as “ashwagandha ghrita,” “ashwagandha-arista,” and “narayana taila”. [56]

***Zingiber officinale*** (Zingiberaceae): Shimoda *et al.* 2010 was investigated the anti-inflammatory effect of *Zingiber officinale* and prepared 40% ethanolic extract from dried red ginger and evaluated its anti-inflammatory activity using acute and chronic inflammation models. The result possessed found a potent suppressive effect on acute and chronic inflammation, and inhibition of macrophage activation seems to be involved in this anti-inflammatory effect. [57]

## CONCLUSION

Plants are one of the most important sources of medicines. Since ancient time's medicinal plants have been used to treat different ailments due to their accessibility, availability, inherited practice, economic feasibility, and perceived efficacy. This review will help the recent and future researchers in more research work on these valuable medicinal plants. The aim of this review was to examine scientific studies on anti-inflammatory activities of selected medicinal plants in use in different regions of Africa. In this review, different plants from selected countries in the various geographical region (north, south, east, central, and west African countries) were identified. It can be seen that African countries are repository of medicinal plants that are readily available and used in the treatment and management of various disease conditions, including inflammatory conditions affecting the teeming population.



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Several drugs are available both in developed and developing countries (Africa inclusive) for treatment and management of inflammatory conditions; however, many of these drugs are associated with adverse effects. Africans who majorly depend on medicinal plants to meet their health needs believe that orthodox drugs are associated with severe side effects, hence many people in Africa, especially those living in poor-resource setting, use medicinal plants in the treatment of inflammation and pain. Many studies have been performed in different African countries to evaluate the anti-inflammatory activities of medicinal plants and to validate their use in traditional medicine. Plants have the capability to synthesize various forms of phytochemical compounds as secondary metabolites, many of which have been identified and continue to be relevant in the treatment of disease conditions in the African setting.

Inflammation remains a complex process that is important for the defense of the host. Excessive production of inflammatory mediators may lead to chronic disease. From this review, it is understood that plant extracts can demonstrate anti-inflammatory activities affecting different stages of the process involved in inflammation, inhibiting formation of cytokines and eicosanoids; prevention of inflammatory reaction cascade from commencing reduce flare, itching, and excessive exfoliation. Research on plants with inflammatory activities is one of the developing areas in modern bio-medicine. Further research on plants with anti-inflammatory activities is needed since a great percentage of traditional healers across Africa may have important information of plants that have not been researched.

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## Microsponge Drug Delivery System: An Updated Review

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### ABSTRACT

The drug delivery system has become rapidly evolving and highly competitive. Further developments in drug delivery technologies are being included to optimize the efficacy as well as cost-effectiveness of the therapy. Microsponge system is a rising tool for TDDS (topical drug delivery system). Microsponge contains, macroporous beads, characteristically 10 to 25 microns in diameter, loaded with an active agent. As applied on the skin, the microsponge liberates its active ingredient on a time mode and also in response to other stimuli (rubbing, temperature, pH, etc) that are used mostly for topical and recently for oral administration. Microsponge drug delivery method entraps different types of drugs with good efficiency and can be formulated into the creams, ointment, and gel. Microsponge can be prepared by methods such as Quasi Emulsion Solvent Diffusion and Liquid-liquid Suspension method. Drug released from microsponge is by a mechanism which is Solubility, Temperature change Pressure change, pH triggered systems. Evaluation is done by using the parameter such as morphology and surface topography of microsponges, particle size determination, determination of true density, determination of loading efficiency and production yield, compatibility studies, characterization of pore structure, resiliency (viscoelastic properties), polymer/monomer composition, dissolution studies, the kinetics of release.

**Keywords:** Microsponge Delivery system, Microsponge, Topical drug delivery system

### INTRODUCTION

Several conventional as well as reliable methods have been developed for systemic drugs under the route of the transdermal delivery system (TDS) via the skin as a portal of entry. It has enhanced the safety and efficacy of several drugs that may be better administered through the skin. But transdermal delivery system is not practical for the materials delivery whose ultimate target is the skin itself [1].



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A Microsponge Delivery System (MDS) is highly cross-linked, porous, patented, polymeric microspheres that can entrap a wide range of active drugs and then release them onto the skin over a time and in response to trigger. This method was working for the enhancement of the performance of topically applied drugs. It is a unique system for the controlled release of topical agents and consists of microporous beads, characteristically 10-25 microns in diameter, loaded with an active agent. When the MDS applied to the skin, drug release can be controlled through diffusion or other variety of triggers, including rubbing, friction, pH, moisture, or ambient skin temperature [2,3].

Moreover, the topical drugs application has several problems such as stickiness, greasiness, associated with the ointments, and so on, which frequently result in a lack of patient compliance. These vehicles need a active agents of high concentration for useful therapy because of their low efficiency of the delivery system, resulting in allergic reactions and irritation in significant users. Other disadvantages of topical formulations are unpleasant odour, uncontrolled evaporation of active ingredient. The fundamental demand of the Microsponge system stems from these problems practised with predictable formulations in releasing active ingredients over an complete period. Usual dermatological products characteristically give active ingredients in relatively high concentrations but with a short duration of action. This may guide to a cycle of short term over medication followed by long-term under medication. More severe side effects or rashes can arise when active ingredients penetrate the skin. In compare, Microsponge technology permits an even and sustained rate of release, falling irritation at the same time as maintaining efficacy [4,5]. MDS are spherical, uniform, porous polymeric microspheres having a countless of unified voids of particle size range 5-300 $\mu\text{m}$  (Figure 1).

## Advantages Over

### Conventional Formulations

Conventional formulations of relevant drugs are proposed to act on the outer layers of the skin. Such formulated products liberate their active ingredients upon application, making a extremely concentrated layer of active ingredient that is quickly absorbed. When contrasted to the Microsponge technology can avoid extreme accumulation of ingredients within the dermis and the epidermis. Potentially, the Microsponge technology can decrease considerably the irritation of useful drugs without decreasing their efficacy. For example, the active ingredient delivering slowly to the skin like Microsponge delivery system-Benzoyl peroxide formulations have better efficacy with negligible irritation.

### Microencapsulation and liposomes

The Microsponge delivery system has merits over other technologies such as liposomes and microencapsulation. Microcapsules cannot typically control the release rate of active drugs. Once the wall is ruptured the active drugs enclosed within microcapsules will be released. Liposomes suffer from difficult formulation, lower payload, microbial instability, and limited chemical stability. While Microsponge system in compare to the above systems is compatible with most ingredients and vehicles; stable over a range of pH 1 to 11, temperature up to 130 $^{\circ}\text{C}$ ; higher payload (50 to 60%), still free-flowing and can be cost-effective; self-sterilizing as average pore size is 0.25 $\mu\text{m}$  where bacteria cannot penetrate.

### Ointments

Ointments are frequently aesthetically unappealing, stickiness; greasiness etc. that regularly results in a lack of patient compliance. These vehicles need high concentrations of drug substances for useful therapy because of their low efficiency of the delivery system, resulting in allergic reactions and irritation in significant users. Other disadvantages of topical formulations are unpleasant odor, uncontrolled evaporation of active component, and possible incompatibility of drugs with the vehicles when microsponge technology maximize the amount of time that an active component is present either on the skin surface or within the epidermis while reducing its transdermal penetration into the body[6,7].





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## Characteristics

### Characteristics of Microsponges [8]

1. Microsponge formulations are stable over the range of pH 1 to 11;
2. Microsponge formulations are stable at the temperature up to 130°C;
3. Microsponge formulations are compatible with most vehicles and ingredients;
4. Microsponge formulations are self-sterilizing as their average pore size is 0.25µm where bacteria cannot penetrate;
5. Microsponge formulations have a higher payload (50 to 60%), still free-flowing, and can be cost-effective.

### Characteristics of Materials that is Entrapped in Microsponges [9]

1. Most liquid or soluble ingredients can be entrapped in the particles. Actives that can be entrapped in microsponges must meet the following requirements,
2. It should be either fully miscible in the monomer or capable of being made miscible by the addition of a small amount of a water-immiscible solvent.
3. It should be water-immiscible or at most only slightly soluble.
4. It should be inert to monomers.
5. The solubility of actives in the vehicle must be limited to avoid cosmetic problems; not more than
6. 10 to 12% w/w microsponges must be incorporated into the vehicle.
7. Otherwise, the vehicle will deplete the microsponges before the application.
8. The spherical structure of microsponges should not collapse.
9. Polymer design and payload of the microsponges for the action must be optimized for the required release rate for the given period.
10. It should be stable in contact with polymerization catalysts and conditions of polymerization.

### Method of Preparation of Microsponges [10-13]

Drug loading in microsponges can take place in two ways, one-step process or by two-step process; based on the Physico-chemical properties of the drug to be loaded.

### Liquid-Liquid Suspension Polymerization

Microsponges are conveniently prepared by the liquid-liquid suspension polymerization method. Polymerization of styrene or methyl methacrylate is carried out in a round bottom flask. In their preparation, the monomers are first dissolved along with non-polar active ingredients in a suitable solvent solution of monomer and then dispersed in the aqueous phase, which consists of additives such as a surfactant, suspending agents', etc. help in the formation of suspension. Once suspension with the discrete droplets of the desired size is established; polymerization is effected by activating the monomers either by catalysis or increased temperature or irradiation.

The various steps in the preparation of microsponges are summarized as:

- Selection of monomer or combination of monomers.
- Formation of chain monomers as polymerization begins.
- Formation of ladders as a result of cross-linking between chain monomers.
- Folding of monomer ladder to form spherical particles.
- Agglomeration of microspheres, which give rise to the formation of bunches of microspheres.
- Binding of bunches to form microsponges.





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The polymerization process leads to the formation of a reservoir type of system, which opens at the surface through pores. In some cases, an inert liquid immiscible with water but completely miscible with monomer is used during the polymerization to form the pore network. After the polymerization, the liquid is removed leaving the porous microspheres, i.e., microsponges. (Shown in figure 2)

### Quasi-Emulsion Solvent Diffusion

When the drug is sensitive to the polymerization conditions, the two-step process is used. Microsponges were prepared by a quasi-emulsion solvent diffusion method using the different polymer amounts. In that, an external phase containing 200 ml distilled water and 40 mg polyvinyl alcohol (PVA). The internal phase consisted of ketoprofen, ethyl alcohol, polymer, and triethyl citrate (TEC), which was added at an amount of 20%, of the polymer to facilitate the plasticity.

Then, the drug can be then added to the solution and dissolved under ultrasonication at 35 °C. At first, the internal phase was prepared at 60°C and added to the external phase at room temperature. After emulsification, the mixture was continuously stirred for 2 hours. Then the mixture was filtered to separate the microsponges. The product was washed and dried by vacuum oven at 40°C for 24 hours. <sup>[13]</sup> (Shown in figure 3)

### RELEASE MECHANISM [2,14]

Microsponges can be designed to release a given amount of active ingredients over time in response to one or more following external triggers.

**Pressure:** Rubbing/ pressure applied can release active ingredients from microsponges onto the skin.

**Solubility:** Microsponges loaded with water-soluble ingredients like antiperspirants and antiseptics will release the ingredient in the presence of water. The release can also be activated by diffusion taking into consideration the partition coefficient of the ingredient between the microsponges and the outside system.

**Temperature Change:** Some entrapped active ingredients can be too viscous at room temperature to flow spontaneously from microsponges onto the skin. Increased skin temperature can result in an increased flow rate and hence release. Drug release from the topical semisolid formulation can be studied by using Franz-type static diffusion cells.

**pH Triggered Systems:** Triggering the pH-based release of the action can be achieved by modifying the coating on the microsphere. This has many applications in drug delivery.

### EVALUATION PARAMETERS OF MICROSPONGES

Various factors are affecting the drug release from microsponges. So it can be evaluated by the following factors.

#### Particle Size Determination:

Particle size analysis of loaded and unload microsponges can be performed by laser light diffractometry or any other suitable method. The values ( $d_{50}$ ) can be expressed for all formulations as a mean size range. Cumulative percentage drug release from microsponges of different particle sizes will be plotted against time to study the effect of particle size on drug release. Particles larger than 30  $\mu\text{m}$  can impart gritty feeling and hence particles of sizes between 10 and 25  $\mu\text{m}$  are preferred to use in final topical formulation [15].





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### Morphology and Surface Topography of Microsponges:

For morphology and surface topography, prepared microsponges can be coated with gold-palladium under an argon atmosphere at room temperature, and then the surface morphology of the microsponges can be studied by scanning electron microscopy (SEM). SEM of a fractured microsphere particle can also be taken to illustrate its ultrastructure [16].

### Determination of Loading Efficiency and Production Yield:

The loading efficiency (%) of the microsponges can be calculated according to the following equation 1.

$$\text{Loading efficiency} = \frac{\text{Actual Drug Content in Microsponges}}{\text{Theoretical Drug Content}} \times 100 \text{ — Eqn no. (1)}$$

The production yield of the microsponges can be determined by calculating accurately the initial weight of the raw materials and the last weight of the microsphere obtained.

$$\text{Production Yield (PY)} = \frac{\text{Practical Mass of Microsponges}}{\text{Theoretical Mass (polymer + drug)}} \times 100 \text{ — Eqn no. (2)}$$

### Determination of True Density:

The true density of microsponges was measured using an ultra-pycnometer under helium gas and was calculated from a mean of repeated determinations [17,18].

### Characterization of Pore Structure:

Pore volume and diameter are vital in controlling the intensity as well as the duration of the effectiveness of the active ingredient. Pore diameter also affects the migration of active ingredients from microsponges into the vehicle in which the material is dispersed. Mercury intrusion porosimetry can be employed to study the effect of pore diameter and volume on the rate of drug release from microsponges. Porosity parameters of microsponges such as intrusion-extrusion isotherms pore size distribution, total pore surface area, average pore diameters, shape and morphology of the pores, bulk, and apparent density can be determined by using mercury intrusion porosimetry [19]. The pore diameter of microsponges can be calculated by using Washburn equation [19,20].

$$D = \frac{-4\gamma \cos\theta}{P} \text{ — — Eqn no. (3)}$$

Where D is the pore diameter ( $\mu\text{m}$ );  $\gamma$  the surface tension of mercury (485 dyne  $\text{cm}^{-1}$ );  $\theta$  the contact angle ( $130^\circ$ ), and P is the pressure (psia).

Total pore area ( $A_{\text{tot}}$ ) was calculated by using the equation,

$$A_{\text{tot}} = \frac{1}{\gamma \cos\theta} \int_0^{V_{\text{tot}}} P \cdot dV \text{ — — Eqn no. (4)}$$

Where P is the pressure (psia); V the intrusion volume ( $\text{mL g}^{-1}$ );  $V_{\text{tot}}$  is the total specific intrusion volume ( $\text{mL g}^{-1}$ ).

The average pore diameter ( $D_m$ ) was calculated by using the equation,

$$D_m = \frac{4V_{\text{tot}}}{A_{\text{tot}}} \text{ — — Eqn no. (5)}$$

Envelope (bulk) density ( $\rho_{\text{se}}$ ) of the microsponges was calculated by using the equation,





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$$\rho_{se} = \frac{W_s}{V_p - V_{Hg}} \quad \text{--- Eqn no. (6)}$$

Where  $W_s$  is the weight of the microsp sponge sample (g);  $V_p$  the empty penetrometer (mL);  $V_{Hg}$  is the volume of mercury (mL).

Absolute (skeletal) density ( $\rho_{sa}$ ) of microsponges was calculated by using the equation,

$$\rho_{sa} = \frac{W_s}{V_{se} - V_{tot}} \quad \text{--- Eqn no. (7)}$$

Where  $V_{se}$  = the volume of the penetrometer -the volume of the mercury (mL).

Finally, the percent porosity of the sample was found from the equation,

$$\text{Porosity (\%)} = \left( 1 - \frac{\rho_{se}}{\rho_{sa}} \right) \times 100 \quad \text{--- Eqn no. (8)}$$

Pore morphology can be characterized by the intrusion–extrusion profiles of mercury in the microsponges [21].

### Compatibility studies [22,23]

Compatibility of drugs with reaction adjuncts can be studied by thin-layer chromatography (TLC) and Fourier Transform Infra-red spectroscopy (FT-IR). The effect of polymerization on the crystallinity of the drug can be studied by powder X-ray diffraction (XRD) and Differential Scanning Colorimetry (DSC). For DSC approximately 5mg samples can be accurately weighed into aluminum pans and sealed and can be run at a heating rate of 15oC/min over a temperature range 25–430°C in an atmosphere of nitrogen.

### Polymer/monomer composition [24]

Factors such as microsphere size, drug loading, and polymer composition govern the drug release from microspheres. The polymer composition of the MDS can affect the partition coefficient of the entrapped drug between the vehicle and the microsp sponge system and hence have a direct influence on the release rate of the entrapped drug. The release of drug from microsp sponge systems of different polymer compositions can be studied by plotting cumulative % drug release against time.

### Resiliency (viscoelastic properties) [25]

Resiliency (viscoelastic properties) of microsponges can be modified to produce bead lets that are softer or firmer according to the needs of the final formulation. Increased cross-linking tends to slow down the rate of release.

### Dissolution studies

The dissolution profile of microsponges can be studied by the use of dissolution apparatus USP XXIII with a modified basket consisted of 5µm stainless steel mesh. The speed of the rotation is 150 rpm. The dissolution medium is selected while considering the solubility of actives to ensure sink conditions. Samples from the dissolution medium can be analyzed by a suitable analytical method at various intervals.

### Kinetics of release

To determine the drug release mechanism and to compare the release profile differences among microsponges, the drug released amount versus time was used. The release data were analyzed with the following mathematical models:

$$Q = k_1 t \text{ or } \log Q = \log k_1 + n \log t \dots (9)$$





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Where  $Q$  is the amount of the released at the time ( $h$ ),  $n$  is a diffusion exponent which indicates the release mechanism, and  $k_1$  is a constant characteristic of the drug-polymer interaction.

From the slope and intercept of the plot of  $\log Q$  versus  $\log t$ , kinetic parameters  $n$  and  $k_1$  were calculated.

For comparison purposes, the data was also subjected to Eq. (10), which may be considered a simple, Higuchi type equation.

$$Q = k_2 t^{0.5} + C \dots\dots (10)$$

Eq. (10), for release data dependent on the square root of time, would give a straight line release profile, with  $k_2$  presented as a root time dissolution rate constant and  $C$  as a constant.

### SAFETY CONSIDERATIONS [26, 27]

1. Skin and eye irritation studies in rabbits
2. Oral toxicity studies in rats
3. Mutagenicity in bacteria
4. Allergenicity in guinea pigs

### APPLICATIONS OF MICROSPONGE SYSTEMS

Microsponge delivery systems are used to enhance the safety, effectiveness, and aesthetic quality of topical prescription, over-the-counter, and personal care products. Products under development or in the market place utilize the Topical Microsponge systems in three primary ways:

1. As reservoirs releasing active ingredients over an extended period,
2. As receptacles for absorbing undesirable substances, such as excess skin oils, or
3. As closed containers holding ingredients away from the skin for superficial action.

Releasing of active ingredients from conventional topical formulations over an extended period is quite difficult. Cosmetics and skincare preparations are intended to work only on the outer layers of the skin. The typical active ingredient in conventional products is present in a relatively high concentration and, when applied to the skin, maybe rapidly absorbed. The common result is overmedication, followed by a period of under medication until the next application. Rashes and more serious side effects can occur when the active ingredients rapidly penetrate below the skin's surface. Microsponge technology is designed to allow a prolonged rate of release of the active ingredients, thereby offering a potential reduction in the side effects while maintaining the therapeutic efficacy. Microsponges are porous, polymeric microspheres that are used mostly for topical and recently for oral administration. Microsponges are designed to deliver a pharmaceutically active ingredient efficiently at the minimum dose and also to enhance stability, reduce side effects, and modify drug release.

#### (i) Topical drug delivery using microsponge technology

Benzoyl peroxide (BPO) is commonly used in topical formulations for the treatment of acne and athletes' foot. Skin irritation is a common side effect, and it has been shown that the controlled release of BPO from a delivery system to the skin could reduce the side effect while reducing percutaneous absorption. Benzoyl peroxide microparticles were prepared using an emulsion solvent diffusion method by adding an organic internal phase containing benzoyl peroxide, ethylcellulose, and dichloromethane into a stirred aqueous phase containing polyvinyl alcohol [28].

Disorders of hyperpigmentation such as melasma and postinflammatory hyperpigmentation (PIH) are common, particularly among people with darker skin types. Hydroquinone (HQ) bleaching creams are considered the gold standard for treating hyperpigmentation. Recently, a new formulation of HQ 4% with retinol 0.15% entrapped in microsponge reservoirs was developed for the treatment of melasma and PIH. Microsponges were used to release HQ gradually to prolong exposure to treatment and to minimize skin irritation<sup>36</sup>. Microsponges containing mupirocin were prepared by an emulsion solvent diffusion method. The optimized microsponges were incorporated into an emulgel base. Drug release through cellulose dialysis membrane showed diffusion-controlled release pattern





and drug deposition studies using rat abdominal skin exhibited significant retention of active in the skin from microsp sponge based formulations by 24 h. The optimized formulations were stable and nonirritant to skin as demonstrated by Draize patch test. Microsponges-based emulgel formulations showed prolonged efficacy in the mouse surgical wound model infected with *S. aureus*. Mupirocin was stable in topical emulgel formulations and showed enhanced retention in the skin indicating the better potential of the delivery system for treatment of primary and secondary skin infections, such as impetigo, eczema, and atopic dermatitis [29]. An MDS system for retinoic acid was developed and tested for drug release and anti-acne efficacy. Statistically significant greater reductions in inflammatory and non-inflammatory lesions were obtained with entrapped tretinoin in the MDS40.

### (ii) Oral drug delivery using microsp sponge technology

In oral drug delivery, the microsp sponge system increases the rate of solubilization of poorly water-soluble drugs by entrapping them in the microsp sponge system's pores. As these pores are very small the drug is in effect reduced to microscopic particles and the significant increase in the surface area thus greatly increases the rate of solubilization. Controlled oral delivery of ibuprofen microsponges is achieved with an acrylic polymer, eudragit RS, by changing their intraparticle density[9].The release of ketoprofen incorporated into modified-release ketoprofen microsp sponge 200 mg tablets and Profenid Retard 200 mg was studied in vitro and in vivo. The formulation containing ketoprofen microsponges yielded well modified-release tablets. An in vivo study was designed to evaluate the pharmacokinetic parameters and to compare them with the commercially available ketoprofen retard tablets containing the same amount of the active drug. Commercial ketoprofen retard tablets showed a more rapid absorption rate than modified-release tablets and peak levels were reached within almost 3.6 h after administration. However, the new modified-release tablets showed a slower absorption rate, and peak levels were reached 8 h after administration [29].

### (iii) Bone tissue engineering using microsp sponge technology

3D biodegradable porous scaffold plays a very important role in articular cartilage tissue engineering. The hybrid structure of 3D scaffolds was developed that combined the advantages of natural type I collagen and synthetic PLGA knitted mesh. The mechanically strong PLGA mesh served as a skeleton while the collagen microsponges facilitated cell seeding and tissue formation.

The scaffolds were divided into 3 groups:

THIN: collagen microsp sponge formed in interstices of PLGA mesh;

SEMI: collagen microsp sponge formed on one side of PLGA mesh;

SANDWICH: collagen sponge formed on both sides of the PLGA mesh.

Bovine chondrocytes were cultured in these scaffolds and transplanted subcutaneously into nude mice for 2, 4, and 8 weeks. All three groups of transplants showed homogeneous cell distribution, natural chondrocyte morphology, and abundant cartilaginous ECM deposition. Production of GAGs per DNA and the expression of type II collagen and aggrecan mRNA was much higher in the SEMI and SANDWICH groups than in the THIN group.

### (iv) Cardiovascular engineering using microsp sponge technology

Biodegradable materials with autologous cell seeding require a complicated and invasive procedure that carries the risk of infection. To avoid these problems, a biodegradable graft material containing collagen microsp sponge that would permit the regeneration of autologous vessel tissue has developed. The ability of this material to accelerate in situ cellularizations with autologous endothelial and smooth muscle cells was tested with and without precellularization. Poly (lactic-co-glycolic acid) as a biodegradable scaffold was compounded with a collagen microsp sponge to form a vascular patch material. This poly (lactic co- Glycolic acid)-collagen patches with (n = 10) or without (n = 10) autologous vessel cellularization were used to patch the canine pulmonary artery trunk. Histologic and biochemical assessments were performed 2 and 6 months after the implantation. There was no thrombus formation in either group, and the poly (lactic-co-glycolic acid) scaffold was almost completely absorbed in both groups. Histologic results showed the formation of an endothelial cell monolayer, a parallel alignment of smooth muscle cells, and a reconstructed vessel wall with elastin and collagen fibers. The cellular and extracellular





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components in the patch had increased to levels similar to those in native tissue at 6 months. This patch shows promise as a bioengineered material for promoting in situ cellularizations and the regeneration of autologous tissue in cardiovascular surgery [10].

#### (v) Reconstruction of the vascular wall using microsponge technology

The tissue-engineered patch was fabricated by compounding a collagen-microsponge with a biodegradable polymeric scaffold composed of polyglycolic acid knitted mesh, reinforced on the outside with woven polylactic acid. Tissue-engineered patches without precellularization were grafted into the porcine descending aorta (n = 5), the porcine pulmonary arterial trunk (n = 8), or the canine right ventricular outflow tract (as the large graft model; n = 4). Histologic and biochemical assessments were performed 1, 2, and 6 months after the implantation. There was no thrombus formation in any animal. Two months after grafting, all the grafts showed well in situ cellularizations by hematoxylin/eosin and immunostaining. The quantification of the cell population by polymerase chain reaction showed a large number of endothelial and smooth muscle cells 2 months after implantation. In the large graft model, the architecture of the patch was similar to that of native tissue 6 months after implantation and this patch can be used as a novel surgical material for the repair of the cardiovascular system[30].

#### Marketed Formulations of Microsponge

Marketed formulation using the MDS includes Dermatological products that can absorb large amounts of the excess of the skin oil while retaining an elegant feel on the skin's surface. Among these products (given in table 1) are skin cleansers, conditioners, oil control lotions, moisturizers, deodorants, razors, lipstick, makeup, powders, and eye shadows; which offers several advantages, including improved physical and chemical stability, greater available concentrations, controlled release of the active ingredients, reduced skin irritation and sensitization, and unique tactile qualities.

#### CONCLUSION

A Microsponge drug delivery system is widely applicable to the transdermal drug delivery system. Microsponge Delivery System consists of microporous beads, has entrapped a wide range of active ingredients, and then controlled release of actives onto the skin over time and in response to other triggers such as pressure, ambient skin temperature and moisture. MDS is originally developed for topical delivery. MDS is originally developed for topical delivery of drugs like anti-acne, anti-inflammatory, anti-fungal, anti-dandruff, antipruritics, rubefacients, etc. Nowadays it can also be used for tissue engineering and controlled oral delivery of drugs using bio erodible polymers, especially for colon-specific delivery. MDS holds a promising future in various pharmaceutical applications in the coming years by their unique properties like small size, efficient carrier characteristics enhanced product performance and elegance, extended-release, reduced irritation, improved thermal, physical, and chemical stability so flexible to develop novel product forms. Thus MDS is a very emerging field which is needed to be explored.

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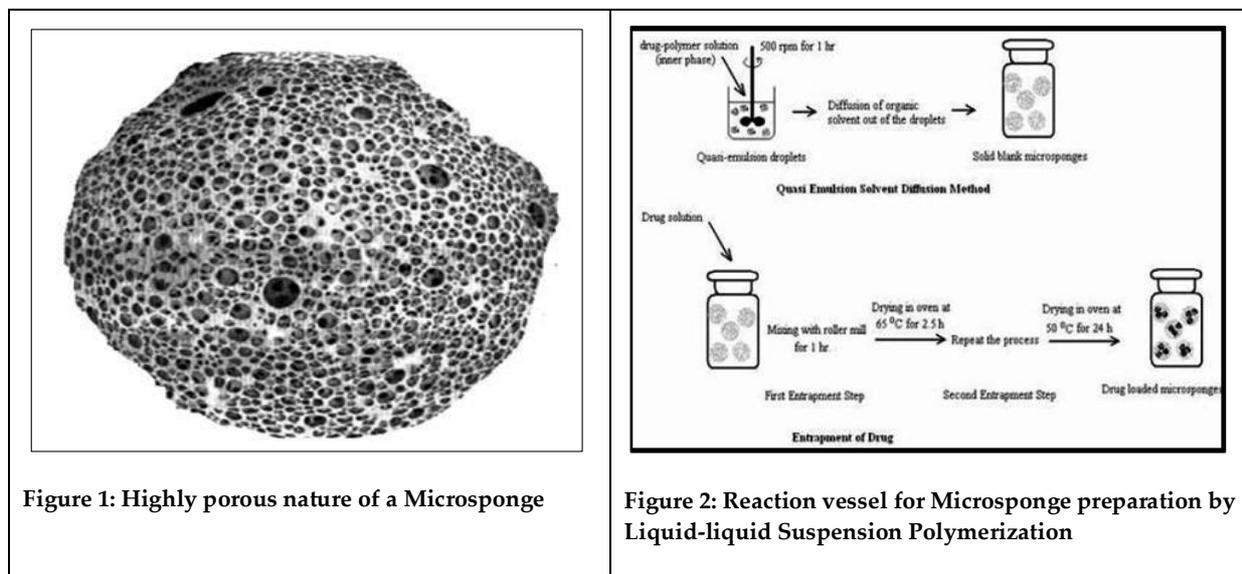


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**Table 1: Marketed Formulations of Microsponges**

Product Name	Company
Retin-A-Micro	Ortho-McNeil Pharmaceutical, Inc.
Carac cream, 0.5%	Dermik Laboratories, Inc. Berwyn, PA19312 USA
Line eliminator dual retinol facial treatment	Avon
Retinol cream	Biomedic
Retinol 15-night cream	Biomedic, sothys
EpiQuin micro	Skin Medica Inc
Sports cream RS and XS	Embil Pharmaceutical.
Salicylic peel 20 and 30	Biophora
Micro peel plus	Biomedic
Oil-free matte block spf-20	Dermalogica
Oil control lotion	Fountain Cosmetics
Lactrex™ 12% moisturizing cream	SDRPharmaceuticals, Inc., Andover, NJ, S.A. 07821
Dermalogica oil control lotion	John and Ginger Dermalogica skincare products
Aramis fragrances	Aramis Inc
Ultra guard	Scott Paper





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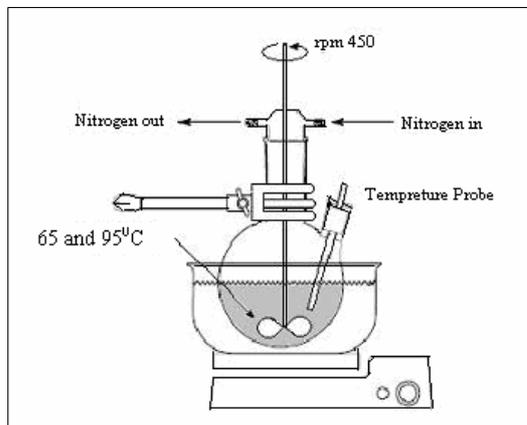


Figure 3: Preparation of Microsponges by Quasi Emulsion Solvent Diffusion Method<sup>[14]</sup>





## Biodegradable Natural Gelatin Nanoparticles are Excellent Vehicle for Controlled Release Anti-Viral Therapy

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### ABSTRACT

Gelatin nanoparticles cross-linking based valacyclovir have been efficiently prepared by two-step desolvation method using acetone as disolvating and glutaraldehyde as cross-linking agent along with a number of variables. FESEM images of optimized formulation elucidate the homogenous, smooth and spherical particles of mean size  $110 \pm 71.5$  nm diameter. FTIR study confirmed the absence of drug-excipients interaction and DSC spectra identified the presence and stability of valacyclovir in gelatin matrix. XRD thermogram confirmed the amorphous configuration of valacyclovir in gelatin nanoparticles. The optimized formulation have highest entrapment efficacy of 89 %. The  $T_{max}$  value of optimised formulation and commercially available "Valcivir" tablet were found 5 h and 2 h respectively in rabbit plasma with HPLC method using photodiode array (PDA) detector and reverse phase C18 analytical column. The mean  $AUC_{0-24}$  of optimised formulation was found 50% higher than that of valcivir. The study revealed that gelatin nanoparticles cross-linking based valacyclovir is not only simple and cost efficient delivery but also offers a promising controlled release with anti-viral therapy through oral administration.

**Keywords:** Gelatin nanoparticles, Valacyclovir, Two-step desolvation, Controlled release, Chromatogram, Pharmacokinetics.

### INTRODUCTION

Nanotechnology is a new generation of theranostic approaches in the field of novel drug delivery due to large surface to volume ratio, increased surface reactivity as compared to bulk material and their porous or core shell structure [1]. Gelatin is a naturally occurring protein having both cationic (lysine and arginine) and anionic (glutamic and aspartic acid) along with hydrophobic groups (leucine, isoleucine, methionine and valine) present in its



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macromolecule. The high stability of gelatin is due to its unique triple helix structure consisting of three polypeptide  $\alpha$ -chains [2]. The chemical structure of gelatin is given below:

Gelatin is obtained either by partial acid or alkaline hydrolysis or by thermal or enzymatic degradation of structural animal protein collagen. Collagen represents 30% of all vertebrate body protein. More than 90% of the extracellular protein in the tendon & bone and more than 50% protein in the skin consist of collagen [3]. Over the last three decades, gelatin nanoparticles (GNPs) have been considered as real drug delivery vehicles due to their unique characteristics like nontoxic, biodegradability, biocompatibility, non-antigenicity, cost-effective, high nutritional value, abundant renewable sources, extraordinary binding capacity of various drugs, controlled and site-specific drug delivery as well as less opsonization by the reticuloendothelial system (RES) through an aqueous steric barrier in addition to greater stability during storage and *in vivo* [4].

Valacyclovir, a guanine derivative nucleoside analogue has strong antiviral activity against Herpes Simplex Virus types-1&2 and Varicella Zoster Virus [1]. After oral administration, approximately 54% valacyclovir is absorbed from the gastrointestinal tract and peak plasma concentration reaches within 2-3 h. The absorbed valacyclovir, more than 99% is rapidly hydrolyzed to acyclovir and L-valine, an essential amino acid by first-pass metabolism with the help of valacyclovir hydrolase to give high plasma acyclovir concentration [5]. Herpes virus encoded thymidine kinase is approximately 200 times greater active in virus infected cells than normal human thymidine kinase [6]. The acyclovir is selectively monophosphorylated only within virus-infected cells by virus encoded thymidine kinase, then to diphosphate by the action of host cellular guanylate kinase, and finally by cellular enzymes to form acyclovir triphosphate which terminates the production of viral DNA by inhibiting viral DNA polymerase. As acyclovir triphosphate lacks the 3'-hydroxyl group as in Figure 2, the DNA replication is competitively inhibited, resulting successful modalities for treatment and suppression of Herpes Simplex Virus (HSV) epidemics as well as cytomegalovirus suppression in immune-compromised patients. Daily effective oral dose of valacyclovir for the treatment of herpes simplex is 1 g twice a day, for herpes-zoster is 1 gm thrice a day and for cytomegalovirus is 2 g 4 times a day [7]. To reduce high expense, dosing frequency, adverse effects and to increase the bioavailability, the development of controlled release formulation is required to maintain the relatively constant drug concentration in blood level for longer duration.

Now-a-days gelatin polymer are the major focus for researchers due to high content of amino acids like glycine, proline and alanine which occur in repeating sequences and confer its triple helical structure [8, 9]. It has intrinsic protein structure with large number of different accessible functional groups, multiple modification opportunities for coupling with cross-linkers and targeting ligands which may be especially useful for developing targeted drug delivery vehicles [10]. Gelatin based nanoparticles commonly employed as a pharmaceutical adjuvant and an encapsulating drug material due to its biocompatibility, biodegradability, low antigenicity and cross-linking to make a promising carrier system for drug delivery [11, 12]. Compared to other colloidal carriers, gelatin nanoparticles are better stable in biological fluids to provide the desired controlled and sustained release of entrapped drug molecules. Only a few HPLC methods were reported in the literature for the quantitative determination of valacyclovir tablets in human serum and human biological fluids [13-14].

We developed an assay method for the estimation of valacyclovir in rabbit plasma using high-performance liquid chromatographic (HPLC) method with photodiode array (PDA) detector and the assay was validated according to Food Drug Administration (FDA) guidelines to reduce dosing frequency and physico-chemical instability as well as achieved controlled release with increased bioavailability.



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## MATERIALS AND METHODS

### Materials

Valacyclovir was provided as a gift sample from Ranbaxy Laboratories Ltd., Utrakhnad, India. Gelatin type-A (180 Bloom) and Sodium metabisulphite were obtained from Sigma-Aldrich, Co (St. Louis, MO, USA). Market sample of Valcivir-1000 and Acivir-200 DT (Cipla Ltd., Sikkim, India) were procured from the retail pharmacy. Glutaraldehyde 25% v/v aqueous solution from Merck (Darmstadt, Germany), Potassium di-hydrogen phosphate ( $\text{KH}_2\text{PO}_4$ ), Disodium hydrogen phosphate ( $\text{Na}_2\text{HPO}_4$ ), Acetone, Sodium hydroxide (NaOH), Sodium chloride (NaCl) and Potassium chloride (KCl) of analytical-reagent grade were purchased from S.D. Fine Chem. Ltd. (Mumbai, India). All other chemicals and solvents used were analytical grade.

### Method

Gelatin nanoparticles (GNPs) were prepared by two-step desolvation method previously reported by Coester *et al.* [15] with slight modification of different components as shown in Table 1 and schematically represented as in Figure 3. For preparing different batches, various concentration ranges from 0.5 to 3.5 % w/v of gelatin type A were dissolved in 25 ml of *Milli-Q* water at 37 °C under magnetic stirring (600 rpm) until a clear solution was obtained. Then 25 ml acetone (desolvating agent) was added to the gelatin solution in order to precipitate the high molecular weight (HMW) gelatin. Then the supernatant consisted of some desolvated gelatin as well as gelatin in solution was discarded and the HMW gelatin was re-dissolved by adding 25 ml of *Milli-Q* water containing different amounts of valacyclovir (drug: gelatin from 1:1 to 1:50) at 37 °C under magnetic stirring (600 rpm) with adjusted at pH 2.5. GNPs with narrow range of size were formed *in situ* during a second desolvation step by drop wise addition of about 75 ml of acetone with continuous stirring. After 10 minutes, variable amounts of 25% v/v aqueous glutaraldehyde solution (100 to 400  $\mu\text{l}$ ) were added to crosslink the nanoparticles and after half an hour the cross-linking process was stopped by addition of 5 ml of 12% w/v aqueous sodium meta-bisulphite solution under magnetic stirring (600 rpm) for 12 hrs. Then the GNPs dispersion was centrifuged at 25,000 g for 30 min and the particles were purified by three fold centrifugation with acetone: water (30: 70). Then it was lyophilized at 2 mbar and -40 °C for 24 h. The prepared freeze-dried GNPs powder was stored under vacuum desiccators (2 mm Hg) at 25 °C for further use.

## CHARACTERIZATION OF VALACYCLOVIR LOADED GELATIN NANOPARTICLES

### Field Emission Scanning Electron Microscopy (FESEM)

Surface morphology of pure valacyclovir (VC), blank and optimized formulations ( $F_4$ ) was determined by field emission scanning electron microscope (JSM-6500F, JEOL UK) at an accelerating voltage of 20 kV. A small amount of sample was placed onto a FESEM holder with double sided adhesive tape and coated with a layer of gold of 150 Å for 2 min working in a vacuum ( $3 \times 10^{-1}$  atm.) of argon gas. Each experiment was carried out in triplicate.

### Size and Distribution Analysis

Particle size and distribution analysis was measured by Zetasizer NanoZS90 (Malvern Instruments, Malvern, UK) using dynamic laser light scattering (DLS) technique at a 90 degree scattering angle at 25 °C. VC loaded GNPs powder sample was mixed with 10 ml PBS (pH 7.4) and vortexed for 3 min in a glass tube. Then the prepared dispersion was filtered using syringe filter (0.45  $\mu\text{m}$ ). The mean particle size, polydispersity index and standard deviation ( $\pm$ S.D.) were obtained from the instrument. The polydispersity index (PI) value was determined as a measurement of the width of the size distribution. The PI values lower than 0.3 indicated a homogenous and mono-disperse phase while greater than 0.3 indicated high heterogeneity [16, 17]. Each experiment was carried out in triplicate.





### Drug Entrapment Efficiency

Drug encapsulation efficiency of VC loaded GNPs was determined by using ultra-centrifugation technique for separating the non-entrapped drug [18]. According to this method, 1 ml aliquot of VC-GNPs dispersion was ultra-centrifuged (Remi CPR-24) at 40,000 rpm for 2h. The supernatant solution was separated. Then the nanoparticles residue was suspended in PBS at pH 7.4 and then centrifuged again. This washing procedure was repeated two times to ensure that the untrapped drug was no longer present in the void volume between the nanoparticles. The supernatant was separated each time and drug content was determined by UV±VIS spectrometry (JASCO V-560) at 252 nm using 1-cm quartz cells against phosphate buffer (pH 7.4) as a blank. Amount of entrapped drug was obtained by subtracting amount of untrapped drug from the total drug incorporated. Each experiment was carried out in triplicate. The drug entrapment efficiency (%) was calculated by using the following formula [19].

$$\text{Drug entrapment efficacy (\%)} = \frac{\text{Amount of drug entrapped}}{\text{Total amount of drug used}} \times 100 \quad (1)$$

### Fourier Transforms Infra-Red (FT-IR) Spectroscopy

FT-IR spectroscopy was employed to record the spectrum of pure VC, blank and F<sub>4</sub> formulation using Jasco FTIR spectrophotometer (Model FTIR-4100, Jasco, USA). Samples were prepared in a KBr pellet disk with a constant resolution of 0.9 cm<sup>-1</sup> in the scanning range of 4000-400 cm<sup>-1</sup> at ambient temperature to examine the interaction between drug and excipients.

### Differential Scanning Calorimetry (DSC)

DSC measurements of pure valacyclovir, blank and F<sub>4</sub> formulations was performed by using a Perkin-Elmer differential scanning calorimeter (Model Pyre's Diamond, DSC, USA) to check the physical state of VC-GNPs whether crystalline or amorphous powder. Samples were placed in flat bottomed aluminium pans and heated from 35 °C to 350 °C using platinum crucible and alpha alumina powder as reference material. The furnace was heated at a linear heating rate of 12 °C / min with nitrogen stream at 20 ml/min.

### X-Ray Diffractometry (XRD)

XRD study was conducted to record the crystalline structure of pure VC, blank and F<sub>4</sub> formulation using an Ultima IV Multipurpose X-ray diffractometer (Rigaku, Japan). The samples were measured with nickel filtered, Cu targeted, graphite diffracted beam monochromator with voltage of 40 kV and current of 30 mA. Scanning rate employed as 1°/min over a diffraction angle of 2θ in a range from 3° to 45°.

### Kinetic Modeling

The kinetic behaviour and release mechanism of valacyclovir from glutaraldehyde modified gelatin nanoparticles were evaluated using different kinetic equations [20]. The obtained release data was fitted into different mathematical equations like zero order kinetics, first order kinetics, Higuchi kinetics and Korsmeyer-Peppas model [Eqs. (2) – (5)].

For Zero order model,

$$Q_t = Q_0 + k_0 t \quad (2)$$

For First order model,

$$Q_t = e^{-k_1 t} \quad (3)$$

For Higuchi model,

$$Q_t = Q_0 + k_H t^{1/2} \quad (4)$$

Korsmeyer-Peppas model,





$$\frac{Q_t}{Q_\infty} = k_p t^n \quad (5)$$

Where  $Q_t$  = the amount of drug released in time  $t$ ,  $Q_0$  = the initial amount of drug within nanoparticles,  $k_0$  = the zero order released rate constant,  $k_1$  = the first order released rate constant,  $k_H$  = the Higuchi rate constant,  $Q_t/Q_\infty$  = the fraction of drug released at time  $t$ ,  $k_p$  = the Korsmeyer-Peppas released rate constant and  $n$  = the released exponent that characterize the mechanism of drug released.

### Stability Studies

As per ICH (International Conference of Harmonisation) guidelines, VC-GNPs powder formulations were packed and sealed in amber glass vials and subjected to stability studies at refrigerator (2-8 °C) and room temperature (25±2 °C) for a period of 3 months [21]. At a predetermined time intervals of 1, 2 and 3 months, samples were withdrawn and hydrated with PBS and determined by monitoring any drug precipitation from the formulations under optical microscope. The mean particle size and entrapment efficiency of each sample was determined and also compared to the freshly prepared VC-GNPs formulation. Each experiment was carried out in triplicate. Further the samples were also evaluated for retention of VC (%) obtained as

$$\text{Retention of valacyclovir (\%)} = \frac{\text{Entrapped valacyclovir after storage}}{\text{Entrapped valacyclovir before storage}} \times 100 \quad (6)$$

### HPLC Analysis

Standardization of HPLC method for the quantification of valacyclovir in rabbit plasma was done by precipitation technique.

### Instrumentation

The HPLC (Shimadzu, Kyoto, Japan) consisted of a Shimadzu LC-20AD prominence solvent delivery module with manually operated 20 µl volume injector and a SPD-M20A Prominence Diode array (PDA) detector. The degasser DGU 20A3R and low pressure gradient valve FCV10AL (Shimadzu, Japan) were used to degas and control the mobile phase components respectively. Analysis was performed by using software class LC10 (version 1.6, Shimadzu, Japan). Chromatogram was carried out on a reverse phase C18 analytical column (particle size 5 µm; 250 mm × 4.6 mm i.d.; Phenomenex, Torrance, USA) at an ambient temperature.

### Standard and Working Solutions

A stock solution of valacyclovir was prepared by at a concentration of 1 mg/ml in HPLC grade water. The working solution made by diluting the stock solution with HPLC water to yield a concentration of 100 µg/ml. The stock IS solution of 0.1 mg/ml was prepared by dissolving 10 mg equivalent of acyclovir tablet powder in 100 ml of 0.1N NaOH solution. A working solution of IS (5000 ng/ml) was prepared by diluting the stock solution with HPLC water. Standard calibration curve was prepared by spiking different concentration of VC (100, 500, 1000, 2000, 5000, 10000, 20000, ng/ml) into blank rabbit plasma with addition of equal volume (100 µl) of IS working solution to each concentration. Quality control standards of valacyclovir were prepared at four different concentrations of 100, 1000, 5000 and 20,000 ng/ml and stored at -20 °C until further analysis.

### Sample Preparation

200 µl of rabbit plasma was spiked with 100 µl of VC in 2 ml micro-centrifuge tube (Ependroff, USA). To this, 100 µl of IS working solution (5000 ng/ml) was added to precipitate the plasma proteins for complete extraction of drug and IS. The mixture was centrifuged at 10,000 × g for 10 min at 4 °C. Clear supernatant was transferred into a glass centrifuge tube and evaporated to dryness under a stream of nitrogen. The residue was reconstituted with 200 µl of mobile phase and the samples were filtered through a syringe filter (0.2 µm). A 20 µl aliquot of the solution was injected into the HPLC system for analysis.





### Optimization of Chromatographic Conditions

Generally, the chromatographic separation was significantly affected by the mobile phase conditions, such as the type and composition of the organic modifiers [22]. Therefore, before optimization of the mobile phase, a number of preliminary trials were carried out with different combinations of various organic solvents and buffers at different pH, compositions, and flow rate to check the retention time, shape, resolution, and other chromatographic parameters of VC and IS. From these experiments, the mobile phase combination of buffer (0.1% acetic acid in water) and methanol with ratio 80: 20 at a flow rate 0.5 ml/min and the UV detection wavelength at 252 nm was found the most suitable.

### Method of Validation

The analytical method HPLC was validated in accordance with USFDA guide lines for industry and bio-analytical method for sensitivity, selectivity, linearity, precision, accuracy and stability. Rabbit's plasma was used for validation of this assay method.

### Selectivity and Specificity

The selectivity test was carried out to quantify accurately and specifically of VC in presence of other components in the sample. The VC peak was not superimposed by the endogenous plasma peak. The specificity was determined by comparing the chromatograms obtained from the samples containing VC and IS with those obtained from blank plasma.

### Sensitivity

According to ICH (International Conference of Harmonization) guide lines LOD (limit of detection) is the lowest amount of analyte in a sample which can be detected but not necessarily quantitated under the stated experimental conditions and LLOQ (lower limit of quantification) is the lowest amount of analyte in a sample which can be quantitatively determined with suitable precision and accuracy [23]. The LOD and LLOQ were determined according to following equation:

$$LOD \text{ or } LLOQ = \frac{kSB}{S} \quad (7)$$

Where k is a constant (3 for LOD and 10 for LLOQ), SB is the standard deviation of the analytical signal and S is the slope of the concentration/response graph.

### Linearity

Linearity was determined by plotting standard calibration curves by using seven non-zero standard points covering the range of 100–20,000 ng/ml with addition of blank plasma and fixed concentration of IS. The calibration curve was developed by plotting peak area-ratios of valacyclovir to the internal standard (IS) against the plasma concentration.

### Precision and Accuracy

Precision is the measure of how close the data values are to each other for a number of measurements under the same analytical conditions and accuracy is the measure of how close the experimental value is to the true value. Precision and accuracy were determined by the quality control of solutions containing lowest, intermediate, and highest concentrations of the calibration curve (i.e. 100, 1000, 5000, and 20,000 ng/ml) of valacyclovir. Six injections of these concentrations were injected within the same day (intra-day) for repeatability, and over a period of 6 days (inter-day) for reproducibility.

### Stability

Stability studies were performed to evaluate the assay values of blank plasma spiked with known concentration of VC (i.e. 100, 1000, 5000, and 20,000 ng/ml) within the acceptable limits of accuracy and precision under different



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conditions. The samples were subjected to three times for freeze–thaw cycles at  $-20\text{ }^{\circ}\text{C}$ , short term stability at room temperature for 24 h and long term stability at room temperature for 1 month.

### Animal Study

*In vivo* study was carried out accordance with Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), Ministry of Social Justice and Empowerment, Central Government of India and Institutional Animal Ethics Committee, Jadavpur University. Ten New Zealand albino adult male rabbits weighing 1.4–2.0 kg were used. The rabbits were kept in individual cages and supplied with diet and water *ad libitum*. The animal house was well ventilated with maintained at ambient temperature. Ten rabbits were divided into two groups of five each and kept overnight fasting before the start of experiment. Oral solution of VC was administered to Group I at a dose of 140 mg/kg body weight and Group II also fed with 140 mg/kg of optimized nanoparticles formulation ( $F_4$ ) to compare the pharmacokinetic parameters [24].

### Pharmacokinetic Analysis

Blood samples (0.5 ml) of rabbits were collected carefully from marginal ear vein at 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 8.0, 12.0 and 24.0 h after giving the dose into heparinised centrifuge tubes (2 ml). The total blood collected from a rabbit should not exceed safe bleed limit, i.e., 6.5–7.5 ml/kg body weight [25]. The plasma was immediately separated by centrifugation at 3000 g for 10 min at  $25\text{ }^{\circ}\text{C}$ . The supernatant plasma layer was collected and stored at  $-20\text{ }^{\circ}\text{C}$  until analyzed. Non-compartmental pharmacokinetic analysis was performed by the PK Solver (Version 2.0), an add-in program for pharmacokinetic data analysis in Microsoft Excel [26].

## RESULT AND DISCUSSION

### FESEM Image and Particle Size Distribution Analysis

The surface morphology of pure VC, blank and  $F_4$  formulation was found by using FESEM study as shown in Figure 4 (A), (B) and (C) respectively. The images of  $F_4$  formulation were smooth, distinct and spherical shape as compared to crystalline structures with variable sizes of pure valacyclovir. It was interesting to see that the nanoparticles maintain their spherical integrity even on encapsulation of drug. But the size of valacyclovir loaded nanoparticles increased corresponding to blank nanoparticles. No aggregate was observed. The size and diameter of valacyclovir loaded gelatin nanoparticles observed by FESEM were found well correlated with corresponding values obtained from DLS measurements at  $25.0\pm 0.1\text{ }^{\circ}\text{C}$ .

### Entrapment Efficiency

One of the most desired qualities of successful nanoparticles was their high drug loading capacity. Entrapment efficiencies of valacyclovir loaded GNPs formulations were found between 74–89 % as shown in **Table 1**. The mechanisms involved for drug loading into GNPs were physical entrapments, electrostatic attraction or chemical bonding [27]. It also depended on the molecular weight and the nature of the substance incorporated. Valacyclovir was successfully loaded into GNPs in aqueous gelatin solution by physical entrapment. The  $F_4$  formulation showed higher entrapment efficacy (89 %) than other formulations ( $p < 0.05$ ) due to their smaller particles which had larger surface area for uniform absorption and ionic interaction between the drug and matrices of gelatin nanoparticles to increase the drug loading [28].

### FTIR Spectra

FTIR spectra were recorded to analyze any interaction or incompatibility between drug and excipients during encapsulation process. The positions and the relative intensities of the absorption bands of pure VC, blank and  $F_4$  formulation were analyzed using FTIR spectrophotometer as shown in **Figure 5 (A)**. FTIR spectra of pure valacyclovir HCl showed an intense peak at  $3442.31\text{ cm}^{-1}$  which was narrated to -NH stretching. Another distinct peaks were observed at  $3325.64\text{ cm}^{-1}$  (OH stretching),  $2929.34\text{ cm}^{-1}$  (CH stretching),  $1745.26\text{ cm}^{-1}$  (C=O stretching),

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1683.55  $\text{cm}^{-1}$  (NH bending), 862.025  $\text{cm}^{-1}$  (CH bending), 675.75  $\text{cm}^{-1}$  (C=C-N bending), 624.53  $\text{cm}^{-1}$  (C=C-C bending) 1082.93  $\text{cm}^{-1}$  (C=N vibration), 1031.71  $\text{cm}^{-1}$  (C-O vibration). These peaks were existed without any tangible shifting but in slightly amend in F<sub>4</sub> formulation which suggested the absence of chemical interaction between valacyclovir and excipients in the gelatin nanoparticles formulation.

**DSC Study**

DSC study was carried out to confirm the physical state of VC in nanoparticles matrix. In **Figure 5 (C)**, the DSC thermogram of pure VC showed a sharp peak at 205.66 °C which close to its melting point but other two peaks at 70 °C and 85 °C were attributed to loss of water due to evaporation of absorbed water. However, VC-GNPs exhibited a very broad peak at 89.92 °C indicating the loading of valacyclovir in molecularly dispersed state in GNPs. So, DSC characteristics indicated the absence of interactions between the drug and the carriers during preparation of the formulation. This may lead to an increase in the dissolution profile of valacyclovir because amorphous drug not required energy to break up the crystalline lattice.

**XRD Study**

XRD study was elucidated the crystalline structure of valacyclovir in tailored nanoformulation as shown in **Figure 5 (B)**. The XRD pattern of valacyclovir showed that the peaks were intense and sharp, suggesting it was in crystalline state whereas blank and F<sub>4</sub> formulation exhibited few sharp peaks of low intensities indicating the amorphous state. These results confirmed the amorphous configuration of valacyclovir in GNPs.

**Stability Study (in vitro)**

**Figure 6 (A)** and **(B)** depicted the entrapment efficacy and particle size stability of F<sub>4</sub> formulation stored at refrigerated condition (2-8 °C) and room temperature (25-27 °C) during three months respectively. The change of entrapment efficacy was small but more change of particle size during in refrigerated and room temperature during three month. In **Figure 6 (C)**, it was found that the percentage of retention of valacyclovir in F<sub>4</sub> formulation was not remarkably difference at refrigerated and room temperature during 3 months. The obtained results indicated that F<sub>4</sub> formulation was more stable and remained relatively unaltered under refrigerated conditions than at room temperature, illustrating the stability of encapsulated VC in gelatin nanoparticles.

**Optimization of Chromatographic System**

In order to develop suitable HPLC method for valacyclovir (VC), several combinations of buffer and organic solvent have been tested. Buffer consisted of 0.1 % acetic acid in water produced optimal condition for separation of VC over other interfering components of plasma. Optimal isocratic separation was obtained by maintaining a reverse phase C18 column at room temperature and delivered a mobile phase (buffer and methanol in the ratio of 80:20) at a flow rate of 0.5 ml/min. This method was selected on the basis of resolution, absence of interferences and economical cost to produce good peak for valacyclovir which was well separated from IS.

**VALIDATION OF THE PROPOSED METHOD****Selectivity and Specificity**

No interfering endogenous compound peaks with analyte or internal standard was detected in **Figure 7**. Under chromatographic conditions, the retention time of valacyclovir and IS were 6.79 and 8.88 min. respectively.

**Linearity and Sensitivity**

The linear regression of the peak area ratios verses concentrations was fitted over the concentration range of 100-20,000 ng/ml in rabbit plasma. The inter- and intra-day calibration curves showed consistent linearity, as seen in consistency of intercept, slope and coefficient of correlation. The linear regression equation was calculated by the least squares method using Microsoft Excel® program. The correlation coefficient ( $R^2=0.9998$ ), indicated a strong





linear relationship between the variables. The current assay had a lower limit of quantification of 100 ng/ml, which was sufficient for monitoring valacyclovir plasma levels over a period of 24 h after a single oral administration.

### Precision and Accuracy

In this assay, the inter- and intra-day precisions ranged from 0.04 to 0.84% and from 0.03 to 0.87% for each QC level, respectively as in **Table 2**. Mean accuracy ranged from 98.49 to 99.93%. The results, calculated using one-way analysis of variance (ANOVA), indicated that the values were within the acceptable range and the method was accurate and precise. Intra- and inter-day precision in this study was expressed as percent of coefficient of variation (CV).

### Stability (*in vivo*)

Stability assessment indicated that valacyclovir was stable in plasma at the end of three consecutive freeze–thaw cycles and on the bench at room temperature for 24 h and 1 month. Additionally, valacyclovir did not show any significant degradation as in **Table 3**. When stored in plasma at  $-20\text{ }^{\circ}\text{C}$ , the peaks of valacyclovir did not have any interference with the matrix components and also not with placebo blend during storage.

### Bioavailability Study

The developed method was applied to determine the valacyclovir concentration in plasma followed by a single oral administration (140 mg/kg) with 10 rabbits. Utilizing a single step extraction and short run time, the assay demonstrated suitable accuracy and precision for application in bioavailability assessment. The method was found to be most sensitive in terms of limit of detection and more economical due to shorter retention time ( $<9\text{ min}$ ). The validation results demonstrated that precision and accuracy values were within an acceptable range and the method was suitable for application in animal or human bioavailability studies. The mean plasma concentration–time profiles of valacyclovir after oral administration of Valcivir (marketed drug) and  $F_4$  nanoparticles formulation was shown in Figure 8. Non-compartmental pharmacokinetic parameters were calculated using PK Solver and were shown in Table 4. Results indicated that  $C_{\max}$  values of Valcivir and  $F_4$  nanoparticles were  $10.90 \pm 2.57$  and  $5.10 \pm 0.88$ , respectively.  $T_{\max}$  values of Valcivir and  $F_4$  formulation were 2 h and 5 h, respectively. Again, the mean  $AUC_{0-24}$  of formulation  $F_4$  was 50% higher than that of marketed drug (Valcivir).

## CONCLUSION

Gelatin based valacyclovir nanoparticles were successfully fabricated by two-step desolvation method. GNPs with suitable concentration of glutaraldehyde and drug: polymer ratios produced smallest size, homogeneous, spherical and smooth nanoparticles with 89% entrapment efficacy. We have developed and validated a reliable, economical and sensitive reverse phase C18 analytical column of HPLC method to determine the valacyclovir in rabbit plasma using PDA detector with reasonable accuracy and precision. A good resolution was obtained between VC, Plasma and IS with retention time 6.79, 8.33 and 8.88 min, respectively. There was no interference peaks observed within them. The method was found linear ( $R^2=0.9998$ ) within the analytical range of 100–20,000 ng/ml. Furthermore, the plasma concentration–time graph of VC nanoparticles ( $F_4$ ) was significantly higher than those of marketed drug in rabbits. The  $T_{\max}$  and  $C_{\max}$  values showed a significant difference between the Valcivir tablet and valacyclovir loaded GNPs ( $F_4$ ). The study revealed that the rate and extent of oral absorption of valacyclovir from the nanoparticles formulation was comparatively higher than that of marketed product (Valcivir). Thus, the gelatin nanocarrier based valacyclovir nanoparticles formulation is a propitious controlled release anti-viral remedy through oral administration.





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**Table 1: Composition, % entrapment efficiency and particle size analysis of various nanoparticles formulations of valacyclovir. GLT: Gluteraldehyde; PI: Polydispersity index. Data are expressed as means±SD, n=3.**

Formulation Code	% (w/v) Gelatin solution	GLT solution (µL)	Drug : gelatin ratio	% Entrapment efficiency	Mean particle size (nm)	PI
F <sub>1</sub>	0.5	100	1:1	84.52±1.26	187±65.3	0.030
F <sub>2</sub>	1.0	150	1:5	83.06±1.48	214±52.3	0.043
F <sub>3</sub>	1.5	200	1:10	81.56±1.43	288±52.0	0.045
F <sub>4</sub>	2.0	250	1:20	89.30±1.18	110±71.5	0.046
F <sub>5</sub>	2.5	300	1:30	81.03±1.36	292±127.3	0.061
F <sub>6</sub>	3.0	350	1:40	77.54±1.25	358±127.9	0.051
F <sub>7</sub>	3.5	400	1:50	74.32±1.27	399±125.4	0.067

**Table 2: Precision and accuracy of valacyclovir in rabbit plasma by HPLC method**

Nominal concentration (ng/ml)	Mean concentration observed (ng/ml)	SD	CV (%)	Mean accuracy (%)
Inter-day (n = 3)				
100	98.49	0.83	0.84	98.49
1000	987.15	5.82	0.59	98.71
5000	4936.25	7.89	0.16	98.73
20000	19782.35	8.31	0.04	98.91
Intra-day (n = 6)				
100	99.42	0.87	0.87	99.42
1000	988.12	3.42	0.35	98.81
5000	4961.24	4.23	0.08	99.23
20000	19986.65	5.99	0.03	99.93





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**Table 3: Stability of valacyclovir in rabbit plasma under various conditions (n=3 per test and each concentration) sdsd**

Storage condition	Nominal Conc. (ng/ml)	Mean conc. (ng/ml)	SD	CV (%)	Mean accuracy (%)
Short term stability at room temperature for 24 h	100	98.42	0.67	0.68	98.42
	1000	986.26	4.43	0.45	98.63
	20000	19812.63	7.13	0.04	99.06
Three freeze–thaw cycles at -20 °C	100	99.68	0.37	0.38	99.68
	1000	1001.28	1.70	0.17	100.13
	20000	19992.65	5.59	0.03	99.96
Long term stability at room temperature for 1 month	100	98.12	0.85	0.87	98.12
	1000	983.38	2.75	0.28	98.4
	20000	19763.78	5.73	0.03	98.82

**Table 4: Pharmacokinetic parameters of single dose administration of 140 mg/kg Valcivir and F<sub>4</sub> formulation (n = 3).**

Parameters	Valcivir	F <sub>4</sub> formulation
Lambda <sub>z</sub> (1/h)	0.24±0.02	0.08±0.02
C <sub>max</sub> (µg/ml)	10.90 ± 2.57	5.10 ± 0.88
T <sub>max</sub> (h)	2	5
t <sub>1/2</sub> (h)	2.82±0.53	8.18±0.79
AUC <sub>0-24</sub> (µg/ml)*h	43.88 ± 4.02	65.90± 7.82
AUC <sub>24-∞</sub> (g/ml)*h	0.99±0.06	0.86±0.08
AUC <sub>0-∞</sub> (µg/ml)*h	43.93± 4.33	76.52± 8.76
AUMC <sub>0-∞</sub> (µg/ml)*h <sup>2</sup>	146.31±11.64	933.31.68±41.37
MRT <sub>0-∞</sub> (h)	3.33±0.13	12.19±0.61
V/F (L)	76.45±0.18	127.29±0.27
Cl/F (L/h)	18.78±0.36	10.78±0.79

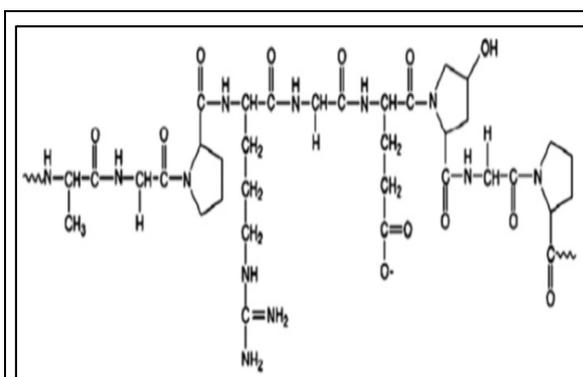


Figure 1: Chemical structure of gelatin

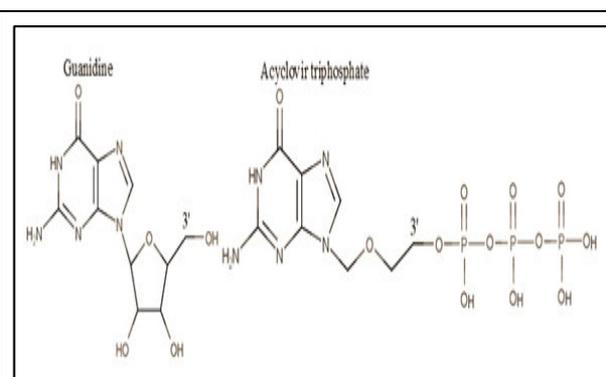


Figure 2: Structure of Guanine and Acyclovir triphosphate



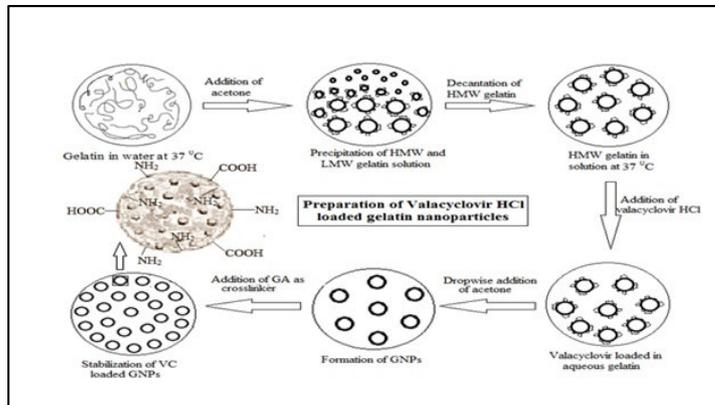


Figure 3: Schematic representation of valacyclovir loaded GNP preparation by two-step desolvation method.

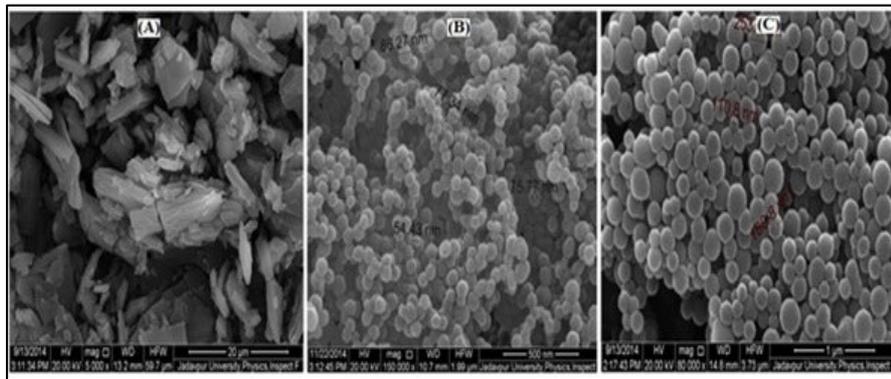


Figure 4: FESEM images of (A) Pure valacyclovir (B) Blank and (C) F<sub>4</sub> formulation

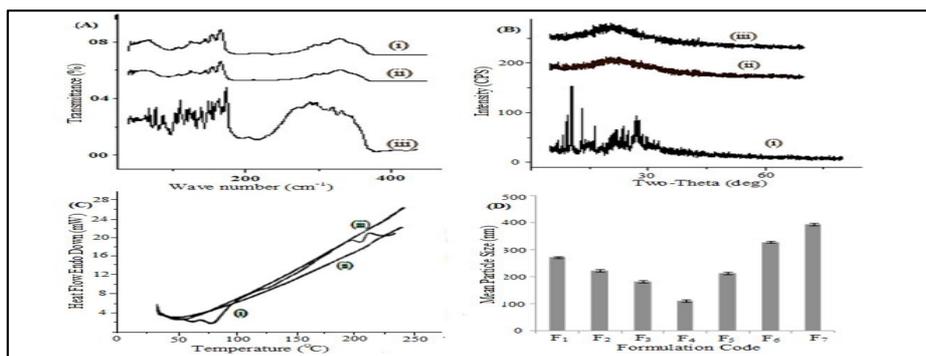


Figure 5: (A) FTIR spectra of (i) Pure valacyclovir, (ii) Blank, (iii) F<sub>4</sub> formulation. (B) XRD of (i) Pure valacyclovir, (ii) Blank, (iii) F<sub>4</sub> formulation. (C) DSC thermograms of (i) Pure valacyclovir, (ii) Blank, (iii) F<sub>4</sub> formulation. (D) Size distribution intensity of prepared nanoparticles formulation (F<sub>1</sub>–F<sub>7</sub>) (Mean ± SD, n = 3).



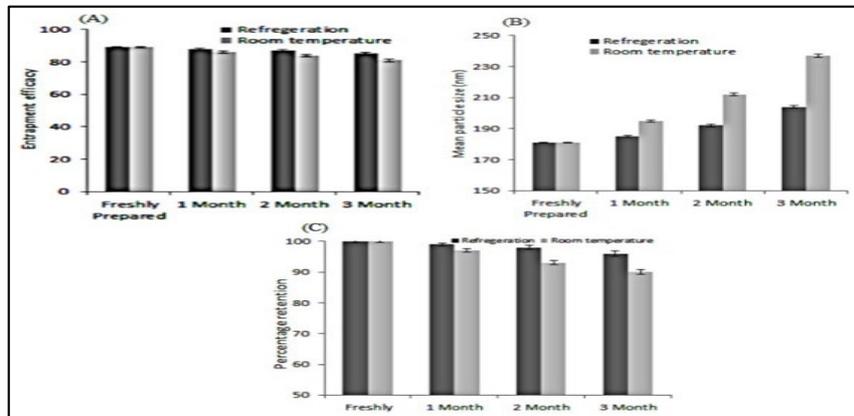


Figure 6: (A) Change of drug entrapment efficiency (%) (B) Change of nanoparticles size (nm) (C) Change of retention (%) of valacyclovir in F<sub>4</sub> formulation upon storage in refrigeration and room temperature during 3 months (Mean ± SD, n = 3).

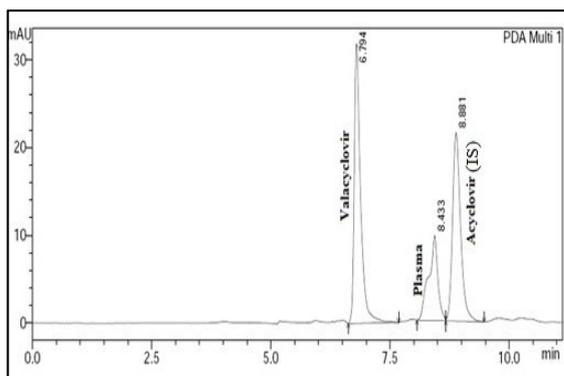


Figure 7: Chromatogram Valacyclovir, Plasma and Acyclovir (IS).

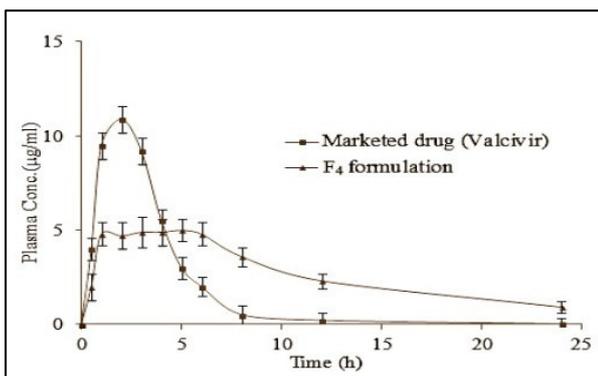


Figure 8: Comparative study of mean plasma concentration–time graph of Valcivir and F<sub>4</sub> formulation after oral administration (140 mg/kg, mean ± SD, n = 3).





## Tailor Made Polymeric Nanoparticle: Smart Approaches for Effective Drug Delivery to Tumor Cells

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### ABSTRACT

Cancer is a disease which causes due to abnormal and uncontrolled cell division coupled with proliferation of tissues caused by mutations of genes. The location, grade and stage of the tumor as well as the general state of the patient determine the choice of appropriate therapy. Compared to free drugs, nanocarrier encapsulated drugs preferentially accumulate in the tumor sites thereby improving therapeutic outcomes and reducing side-effects. And due to the enormous flexibility in customization and optimization of polymers, targeting using polymeric nanocarriers can further improve the efficiency and specificity of drug delivery. Incorporation of active targeting ligands such as, antibodies, carbohydrates, peptides, folates, aptamers on the surface of polymeric nanoparticles using techniques such as functionalization, adsorption and conjugation continues to play a crucial role in the delivery of therapeutic agents towards tumor cells. Hence, polymeric nanoparticles are being carrier of choice to deliver drugs towards different tumor cells such as breast tumor, colon tumor, lung tumor prostate tumor, liver and spleen tumors.

**Keywords:** Polymeric Nanoparticle, Drug delivery, Cancer, ligand, Antibodies





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## INTRODUCTION

### Background

Cancer is a large group of diseases having the basic characteristics property of abnormal cell growth. Normal growth of cells is a regulated process, whereas cancer growth is highly uncontrolled process. Cancer progress is a multistep process involving progressive or rapid acquirement of genetic changes, caused by epigenetic mechanisms such as gene amplification or inactivation, leading to inception of malignancy, the crucial in understanding the molecular origins of cancer. Cancer research has exposed that cancer is a disease involving vibrant alterations in the genome [1]. Proto-oncogenes are normal genes which, is altered by mutation, becomes an oncogene that can throw in to cancer. Proto-oncogenes may have many dissimilar functions in the cell. Some proto-oncogenes supply signals that guide to cell division. Other proto-oncogenes direct programmed cell death (apoptosis). The defective versions of proto-oncogenes, known as oncogenes, can cause a cell to divide in an unregulated manner. This growth can arise in the absence of normal growth signals such as those provided by growth factors. A key feature of oncogene movement is that a single altered copy leads to unregulated growth. There is basic morphological (size, shape and vasculature) and physiological dissimilarity between ordinary tissue and tumor tissue [2].

Tumors are highly heterogeneous, showing elevated proliferation along with necrosis or hemorrhages in the core and are characterized by independence in growth signals, inconsiderateness to anti-growth signals, avoiding apoptosis, wild replication, uninterrupted angiogenesis, tissue invasion and metastasis and blood vessels developed due to tumors are highly permeable due to the presence of open gaps (inter endothelial junctions & trans-endothelial channels), vesicular vascular organelles and fenestrations. Hence, this feature of the vasculature enhances macromolecular transport [3]. There are many types of tumor staging systems, but the most ordinary and helpful staging system for most types of tumors is the TNM system where T is for tumor only increasing in the most superficial layer of tissue, without growing into deeper tissues and also called in situ cancer or pre-cancer. and N is for a tumor that has spread into nearby lymph nodes and M is for a tumor which is metastasized to distant locations. Treatment for an early-stage cancer is surgery or radiation, while a more advanced-stage cancer needs to be treated with chemotherapy [4].

So far different cancer treatment modalities have been used and generally grouped in to four categories: surgery, radiation, chemotherapy and immunotherapy. The location, grade and stage of the tumor as well as the general state of the patient determines the choice of appropriate therapy. Apart from various treatment modalities chemotherapy is one of the best approaches to combat cancer but its drawbacks are becoming bothersome and its success depends on the selection of optimum delivery system [5]. Most cancer chemotherapeutics that are in common use currently (doxorubicin, topotecan, cyclophosphamide, vincristine, docetaxel or cisplatin and paclitaxel) owe insignificant selectivity for cancer cells to their higher proliferation rates, thereby increasing systemic toxicity and less therapeutic efficacy [6].

Few decades back, significant achievements has been made in understanding the molecular principles of oncologic diseases. Based on the extensive knowledge developed regarding the features of cancers, many different strategies have been devised and evaluated for cancer treatment and drug targeting to tumor cells. Some of these systems exploit the over expression of cancer related surface markers on diseased cells or the development of a dense but leaky vascular system within a tumor, forming the basis for a tumor targeting strategy [7]. Targeting of drugs to tumor cells is based on the administration of drug nanocarriers that are surface functionalized with a ligand which is capable of selectively recognizing for malignant tumor cells. ligand or receptor-mediated drug delivery to tumor cells is obtained via chemical conjugation of tumor specific molecules such as aptamers, folates, peptides, antibodies and transferrins onto the nanoparticle surface, which can be selectively bind to overexpressed receptors that are unique to cancer cells or minimally expressed on healthy cells [8].



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Nowadays, Nanotechnology system focused on the development of target specific and slow but controlled drug release system. And this paved the way for the designing of molecules with the property of delivering of various formulations using organic/inorganic materials, easy modification of targeting molecules, drugs or other molecules on them, effective delivery to target sites, high therapeutic efficacy of drugs, controlling drug release by external/internal stimuli, minimize unwanted side effects [6]. The most common types of nanocarriers for targeted drug deliveries include: polymeric nanoparticles, liposomes, dendrimers, nanoshells, carbon nanotubes, and super paramagnetic nanoparticles. Hence, due to the unique advantage of delivering a higher concentration of pharmaceutical agent to a desired location and Increasing the stability of any volatile pharmaceutical agents, the ability to modify drug release and their very convenient feature for the manufacture of countless and varied molecular designs that can be integrated into unique nanoparticle constructs, the engineered carriers the so called polymeric nanoparticles (PNP's) are becoming the ideal candidates of drug delivery system [9].

Polymer based nanoparticles are the promising vehicles for drug delivery to target tumor cells. These carriers can be helpful to deliver higher concentration of pharmaceutical agent to the desired specific target and Increase the stability of any volatile pharmaceutical agents; such an advantage improves the drug safety. PNP's carry drugs, proteins, and DNA to target cells and organs effectively. Their nanometer-size promotes effective permeation through cell membranes and stability in the blood stream [10].

### **Drug Delivery Using Polymeric Nanoparticles**

Nanoparticle technologies have the potential to transform the era of drug development process and change the scene of pharmaceutical industry. Due to their unique physicochemical properties, PNP's have shown greater significance in delivering a range of molecules to desired sites in the body while improving the therapeutic index of drugs by enhancing their efficacy, improving the bioavailability of drugs, carrying large payloads, protecting the therapeutic agents from physiological barriers, as well as enabling to tackle the adverse effects of different drugs [11]. Polymeric type of NP's show promise as drug delivery systems as a result of their controlled and sustained release properties, sub cellular size, biocompatibility with tissue and cells. And most of these carriers owe an important advantage of preferentially targeting tumor cells by the enhanced permeability and retention (EPR) phenomenon exhibited by solid tumors compared with normal tissues. Moreover, PNP's as therapeutic carriers have other unique properties of higher therapeutic efficacy, biocompatibility, biodegradability, lower toxicity and the ability to encapsulate and deliver poorly soluble drugs [12]. For targeted drug delivery one of the following mechanisms with polymeric systems generally can be done: drug and targeting moiety are conjugated to the polymer and physically entrapping of the drug with in a polymer carrier that has been modified with a targeting moiety [13].

### **Preparation of Polymeric Nanoparticles (PNP's)**

Polymeric nanoparticles can be prepared from natural and/or synthetic polymers. Cellulose, starch, chitosan, carrageenan, alginates, xanthan gum, gellan gum, pectins are some of the biocompatible, biodegradable, less toxic and easily available types of natural polymers. And polymers such as poly lactic acid (PLA), poly(D,L lactide-co-glycolide) acid (PLGA), and polycaprolactone (PCL), poly cyanoacrylates, Poly amides, poly ortho esters, poly ethylene glycol(PEG), Poly vinyl alcohol (PVA) and Poly ethylene oxide (PEO) are the most commonly used FDA approved biocompatible synthetic polymeric materials useful for the preparation of polymeric nanoparticles [13].

Preformed polymers or direct polymerization of monomers using classical polymerization or poly reactions are the methods by which PNP's can be prepared [14] (Figure 1). The nature of the drug to be incorporated within the PNP's determines the selection of a particular method. For instance, to encapsulate hydrophilic drugs, double emulsion is preferred. And for hydrophobic drugs, nano precipitation, single emulsion, and salting-out methods can be used [15].





### Solvent Evaporation Technique

This is a technique related with dissolving both the drug and the carrier in a common solvent and then evaporating the solvent under vacuum to produce a solid solution. This technique helps to produce a solid solution of the drug and the carrier [16] (Figure 2).

### Micro-Emulsion Polymerization Technique

Micro-emulsion polymerization is a new and effective approach for preparing nanosized polymer particles and has attracted significant attention. This produces an optically clear pre-concentrate containing a mixture of oil, hydrophilic surfactant and hydrophilic solvent which dissolves a water soluble drug. Upon contact with water, the formulations spontaneously disperse (self-emulsifies) to form a very clear emulsion of exceedingly small and uniform oil droplets containing the solubilized drug [17].

### Supercritical Fluid (SCF) Technology

This is a technique of preparing PNP's by dissolving drugs and polymers in supercritical fluids (whose temperature and pressure are greater than its critical temperature and critical pressure), allowing it to assume the properties of both a liquid and a gas (Figure.3). At near critical temperatures, SCFs, are highly compressible allowing moderate changes in pressure to greatly alter the density and mass transport characteristics of the fluid that largely determine its solvent power. Once the drug particles and polymers are solubilised within the SCF (usually CO<sub>2</sub>), they may be recrystallised at greatly reduced particle size using the technique of rapid expansion of supercritical solution (RESS) [16,17].

### Salting-Out Technique

It is a technique of preparing PNP's based on the separation of a water miscible solvent from aqueous solution via a salting out effect. Polymer and drug are initially dissolved in a solvent such as acetone, which is subsequently emulsified into an aqueous gel containing the salting-out agent such as magnesium chloride, calcium chloride, and magnesium acetate, or non-electrolytes such as sucrose and a colloidal stabilizer such as polyvinyl pyrrolidone or hydroxyl ethyl cellulose. The oil/water emulsion is diluted with a sufficient volume of water or aqueous solution to enhance the diffusion of acetone into the aqueous phase, thus inducing the formation of nanospheres. Finally, both the solvent and the salting out agent are eliminated by cross-flow filtration [18].

A smart drug delivery system needs synergistic consideration of several factors. But due to other influencing factors it is difficult to get all considerations for an effective drug delivery system. High quality, reliability, efficiency and reproducibility are the most significant issues while designing an effective drug delivery system. Also the drug delivery systems have to induce the drug release and stop the release by their own manner [14]. It would be highly benefited, if the system recognizes the disease affected part, estimated the disease affected ratio, and then act to release the exact quantity of active drugs. Hence, in order to design effective drug delivery system using nanoparticles various factors should be taken in to account [18].

## Designing of Targeted Polymeric Nanoparticles Towards Specific Tumor Cells

### Passive Targeting

Nanoscale drug carriers can target tumor cells via two mechanisms namely passive or active targeting. Passive targeting is based on the transport and accumulation of PNP's through leaky tumor capillary fenestrations into the tumor interstitium by the help of enhanced permeability and retention (EPR) effect and passive diffusion to tumor tissues (Figure 4)[6]. Moreover, this targeting mechanism is devoid of any targeting molecules or ligands attached to the carrier system and this targeting mechanism do not undergo an interaction with specific receptors on tumor cells but simply enter into the tumor site through diffusion [19].





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### Ligand-Based Targeting of PNP's (Active Targeting)

The mechanism of active targeting is through recognition of the ligand by its target substrate. To the specific receptor site Ligands may bind, after that they then can be internalized into the cell mainly through the mechanism of endocytosis. Thus, ligands stand for a diverse class of molecules that can be exploited for targeted drug delivery because the ligand-receptor complex is the result of a specific molecular interaction that requires structural complementarity [5]. Design of actively-targeted PNP drug carriers is a complex process because the ligand conjugation chemistry, the NP architecture, the types of ligands available, route of administration and protein binding nature of the PNP's all contribute to the success of the process and should be taken into account during designing [14]. To formulate a targeting drug delivery system that can develop the specific ligand-receptor interaction and subsequent receptor-mediated endocytosis, a unique process essential to the disease state must be recognized, from which key receptors, antigens, and/or binding domains associated with the disease can be used as homing devices (Figure 5)[20].

**Antibody and Antibody Fragments:** The use of tumor-associated antigens for the targeting of antibodies has been the most widely exploited form of anticancer targeting drug delivery. The source for this is that certain antigens frequently are expressed in lesser degree in normal tissues than in tumor tissues. such antigens are: the carcinoembryonic antigen, prevalent in gastrointestinal (GI), lung, and breast tumors, was the first to be identified, and it has been used extensively as a target. Hence, antibodies and their fragments have been used as homing devices for specific drug delivery [21].

**Selectins:** selectins are types of cell-cell adhesion mediator molecules that are responsible for carbohydrate binding. They mediate cell adhesion by recognizing specific carbohydrate ligands arranged on the surfaces of cells. In addition, it has been suggested that cell-cell adhesion may not be a result of only a single selectin-carbohydrate binding but rather the cumulative effect of multiple interactions of many sugar moieties (E.g Tetrasaccharide glycolipids of sialyl-Lewis X (sLex) and sialyl-Lewis A (sLea). When presented in a cluster they significantly increase their affinity and selectivity than their respective monomers. Therefore, carbohydrates can be used as a ligand to target these selectine molecules on the surface of tumor cells [22].

**Integrins:** Integrins are the heterodimeric glycoproteins consist of different subunits, which combine to form the various types of integrins. Integrin family has been identified as excellent candidates for the development of target specific cancer therapies. Adhesion between cell-cell and cell-extracellular matrix occur when integrin recognizes and specifically interacts with minimal peptide core sequence (RGD, LDV and YIGSR) in the extracellular matrix. The binding to minimal core sequences establish in the extracellular matrix depends on the degree of integrin expression on the cell surface. Integrin expression is up regulated in cancer cells compared with normal cells. Integrin function could be disrupted by using monoclonal antibodies, peptide antagonists, and small molecules as specific ligands [23].

**Vitamins:** Vitamins are essential for normal cellular function and growth. In pathological conditions, these vitamins also play crucial roles. As such, cell surface receptors for vitamins have been considered as drug targets because vitamins generally are internalized into the cell by receptor-mediated endocytosis. Such vitamins as folic acid, riboflavin, biotin and vitamin B6 all have been evaluated as potential ligands for targeted delivery of therapeutic agents to specific cells [12]. Folate receptors typically are not present in normal cells, but in a variety of human tumors they are greatly overexpressed. In addition, folate receptors mediate internalization by endocytosis. For these reasons folic acid has been examined as a homing device [7].

**Transferrin:** transferrin is a glycoprotein responsible for transporting iron into cells. Iron binds to transferrin and enters the cell through a highly specific receptor-mediated endocytosis via the transferrin receptor. Rapid recycling of the transferrin receptor allows for approximately 200 molecules of transferrin to be internalized into each cell per



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minute. The transferrin receptor is expressed on the surfaces of cells in both proliferating and nonproliferating normal tissue, but it is highly upregulated in tumor cells, as evident by reduced transferrin levels in patients with cancer. Hence, the use of transferrin to target the transferrin receptor has been investigated for targeted drug delivery [24].

**Hormones:** The presence of hormone receptors in hormone-sensitive cancers presents potential applications of hormone-targeted drug delivery of drugs. In fact, studies have demonstrated that when doxorubicin is conjugated to an analogue of the luteinizing hormone–releasing hormone (LH-RH), cancer cell death was observed at sub-nanomolar concentrations. Therefore, this approach is potentially applicable to ovarian, endometrial, and breast cancers because the onset of tumor growth in each of these tissues is accompanied by an increase in hormone receptors [5].

**Low-Density Lipoprotein (LDL):** Lipoproteins are naturally occurring spherical macromolecular particles that transport lipids such as cholesterol and triacylglycerols through the blood–cell membrane barrier of various cells. The function of these LDL particles is mainly related with solubilizing hydrophobic lipids and transporting lipids to specific cells and tissues throughout the body. As such, they promise to be very good candidates for the targeted drug delivery of anticancer drugs to various tissues (Figure.6). In particular, various tumor cells aggressively overexpress the LDL receptors that recognize lipoproteins such as apo lipoprotein E (apoE) and apolipoprotein B-100. Since they are of natural origin, these molecules are biodegradable and biocompatible, non-immunogenic, and free from being recycled by the reticulo-endothelial system (RES) [25].

The target molecules are receptors that are mainly over expressed on diseased organs or on the surface of tumor cells. Target molecules can be proteins, sugars or lipids such as; Folate receptor (mainly expressed on breast, colon and lung tumor cells), transferrin receptor (over expressed on malignant tumors), Human Epidermal growth factor Receptor, EGFR (HER1,HER2,HER3 and HER4) mainly overexpressed on breast, ovary, prostate, bladder, lung, head and neck tumor cells. Furthermore, there are also target receptors such as vascular endothelial growth factor receptor (VEGFR) and integrin that are mainly over expressed on the vasculature of tumor cells. The types of commercially available ligands and their targets are summarized in table-1 [26].

### Mechanisms of ligand-PNP coupling

Specific ligands such as carbohydrates, folate, antibodies and nucleic acids are conjugated with the preformed PNP's using a technique called surface functionalization (Figure.7). Based on their application the nano-carriers have been commonly functionalized with various chemical functional groups such as thiols, disulfides, amines, nitriles, carboxylic acids, phosphines and bio-macromolecules. And this surface functionalization technique can be made by various modifications on the preformed PNP's through adsorption, functional surfactants, emulsification, polymerization, covalently bounded functional molecules and various forms of bio-conjugation [7,27]. The preparation of targeted PNP's involves either chemical conjugation or physical adsorption/interaction of targeting ligands with the outer surface of the PNP's (Figure.8). Chemically binding targeting ligands to nanocarriers is more desirable because it provides more precise control in terms of the density and orientation of the attached ligands and forms a stable linkage under in vivo conditions [23]. Furthermore, chemical modification can be carried out either before or after nanocarrier formation and drug incorporation. Targeting ligands are usually coupled to the terminal groups of the "stealth" PEG corona (or the corona of other hydrophilic polymers) which are easily accessible by targeting ligands for conjugation [6].

### Characterization of Polymeric Nanoparticles (PNP's)

Evaluation of PNP based drug delivery involves size distribution, porosity, solubility, surface chemistry, stability, particle size, purity, aggregation or agglomeration state, all determine the in vivo distribution, drug loading ability and release pattern, safety, stability, toxicity, efficacy of the nanoparticle and provide a basis for understanding the





structure and activity relationship (Figure 9) [1]. Simple molecules can be characterized by their molecular weight and spectral properties to determine purity and functionality. However for nanoparticles which are multipart and multifunctional, through assessment of individual parts, chemical stability, physicochemical properties along with in vitro and in vivo evaluation needs to be performed [28].

### Size Distribution, Particle Size and Surface Properties

The release of drug can be affected by Particle size, as lesser particles have big surface area[1]. Surface properties influence the adsorption of proteins, fugacity from phagocytes and fate of bioavailability [28]. These parameters are determined using the following techniques such as scanning electron microscopy (SEM), Atomic force microscopy (AFM) and Photon-correlation spectroscopy (PCS) also known as dynamic light scattering (DLS) [29].

### Hydrophobicity

Surface charge determines the electrostatic interaction of polymeric nanoparticles with bioactive compounds. This is evaluated through Zeta potential of the PNP's, which provides information about surface hydrophobicity, storage stability, and nature of the material encapsulated. Surface hydrophobicity can also be determined by contact angle measurements, bi-phasic partitioning, hydrophobic interaction chromatography, while specific chemical groups attached to the surface can be identified by X-ray photon correlation spectroscopy [1,23].

### Purity and Functional Characterization

The structure, purity and functionality of PNP's can be characterized using NMR spectroscopy, UVvisible detectors and fluorescence detectors. And their composition can also be determined by Atomic absorption (AA) and Atomic emission (AE) [11].

### Stability

Stability of the PNP's under physiological and non-physiological conditions deems essential for their biological activity, storage, light and thermal exposure, lyophilisation, ultra filtration, pH variation. Molecular weight can be determined by Matrix-assisted laser desorption ionization time-of-flight (MALDI-TOF) mass spectroscopy, along with presence of impurities. Quantification of nanoparticles can be performed by Enzyme-linked immunosorbent assay (ELISA) or bicinchoninic acid (BCA), UVspectroscopy or High performance liquid chromatography [24-27].

### Drug Loading

Drug loading and subsequent release are the two major factors which determine the amount of drug reaching the tumor site. As the drug reached the targeted site, its release is governed by drug solubility, desorption of the surface adsorbed drug, PNP's matrix degradation, drug diffusion through carrier matrix and combination of erosion/diffusion processes. Dialysis bag diffusion method, agitation followed by ultracentrifugation, centrifugal ultracentrifugation methods, analyse the time period for the release of drugs And and an important parameter in the development of successful formulations is the efficient release of the PNP encapsulated drug. Different techniques are such as UV spectroscopy, gel filtration and NMR spectroscopy are used to analyse the mechanisms of drug loading [1,5,16-29].

### In-vitro and In-vivo Characterization

In-vitro characterization of PNP's performed frequently with in-vivo studies that assesses the pharmacokinetics, efficacy, physiological and biochemical mechanisms, providing information about the biodistribution and toxicity profiles of nanoparticles [1]. In-vitro characterization includes cell-binding and pharmacology, cellular uptake and distribution, contact with blood, sterility and pyrogenicity. Moreover, In-vitro characterization establishes the strategy of investigations required for in-vivo trials [30].





### Applications of Targeted PNP's for the Treatment of Different Cancers

Actively targeted PNP's have paramount applications in the management of many neoplastic diseases such as brain tumor, prostate tumor, cervical tumor, ovarian cancer, endometrial tumor and other tumor types [1]. And some important applications of PNP's for the treatment of some selected tumor types are discussed below.

#### Breast Cancer

Breast tumor is the most common tumor that affect females and one of the main causes of mortality in women. Most of the invasive type of breast tumors overexpress the receptor called VEGFR human epidermal receptor (HER-1,2,3&4). And this receptor has been the target of many ligands of monoclonal antibodies (such as trastuzumab and pertuzumab) that are conjugated with the PNP's incorporated with drug like paclitaxel (PTX) or Doxorubicin (Dox) has shown to enhance tumor progression free survival of patients. Due to the enhanced folate requirements for DNA synthesis the majority of tumor cells overexpress folate receptors onto their surfaces. Hence, doxorubicin - loaded PNP's surface engineered with PEG and folic acid were shown to have greater accumulation in the tumor cells and have greater antitumor activity by reducing the mean tumor volume [21].

#### Liver and Spleen Cancers

Peptides that contain RGD domains can preferentially bind cells in tumor microvasculature that express the  $\alpha v \beta 3$  integrin. Integrin receptors are also expressed on the cell membrane of macrophages and it is shown that RGD bioconjugates aggregate in spleen and liver tissues due to macrophage clearance. Using an RGD-targeted stealth system, NPs carrying Dox were found to accumulate faster and in higher concentrations in the liver and the spleen [31].

#### Lung Cancer

Lung cancer (LC) involves signaling pathways that influence angiogenesis, tumorigenesis and tumor growth, and different targeted agents have been used towards vascular endothelial growth factor receptor (VEGFR), platelet-derived growth factor receptor (PDGFR), EGFR and insulin-like growth factor 1 receptor (IGF-1R). Of these receptors IGF-1R is a key signaling pathway that leads to the growth and survival of tumor cells and is commonly overexpressed in lung cancer cells. Figitumumab is a fully human monoclonal antibody that is a specific and potent inhibitor of IGF-1R. In combination with PNP's containing carboplatin/PTX, figitumumab has shown to be a promising antitumor agent as first line treatment of LC [1, 20].

#### Colon Cancer

In the case of colon cancer, it was investigated that the introduction of peptides containing the RGD sequence such as PR-b (a peptide sequence that mimics the cell adhesion domain of fibronectin) onto the surface of 5 - fluorouracil loaded PNP's was found to be capable of targeting colon cancer cells that express the integrin  $\alpha 5 \beta 1$ , leading to a greater cytotoxicity compared to the non -targeted nanoplatfrom [32].

### SUMMARY

Cancer is a group of diseases which causes an abnormal and uncontrolled cell division coupled with proliferation of tissues caused by mutations of genes with malignant behavior such as invasion and metastasis. The location, grade and stage of the tumor as well as the general state of the patient determine the choice of appropriate therapy. Tumor cells have different development stages. And tumor in the early-stage can be treated with surgery or radiation, while a more advanced-stage cancer needs to be treated with chemotherapy. Compared to free drugs, nanocarriers (polymer)-encapsulated drugs preferentially accumulate in the tumor sites through the EPR effects so called passive targeting, thereby improving therapeutic outcomes and reducing side-effects. Targeting of polymeric nanocarriers can further improve the efficiency and specificity of drug delivery. Polymer systems offer enormous flexibility in customization and optimization of nanocarriers particularly polymeric nanoparticles to efficiently deliver therapeutics to their specific targets. Incorporation of active targeting agents such as, antibodies, peptides, folates,



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aptamers on the surface of polymeric nanoparticles using techniques such as functionalization, adsorption and conjugation will continue to play a crucial role in the delivery of therapeutic agents towards different target molecules over expressed on the tumor cells the so-called active targeting.

### Future Research Directions

So far, though considerable amount of researches have been done in the field of drug delivery using polymeric nanoparticles, most of the researches have been focused on designing of polymeric nanoparticles for a specific applications. Therefore, based on the upshot of this thesis some research directions are highlighted for further investigation by future researcher's. Designing of polymeric nanoparticles with high drug encapsulation capacity. Polymeric nanoparticles with multiple drug and ligands. Preparation and characterization of polymeric nanoparticles for other pathologies.

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**Table 1: Commercially available ligands and their targets for different types of target molecule expressing tumor cells**

Ligand type	Target molecule or receptor	Site of target
Antibody fragments Antigen binding fragments (fab) Single chain variable fragments(scFv)	Human epidermal receptor (HER-1,HER-2,HER-3 and HER-4)	Breast, ovarian, bladder, prostate, head and neck tumors .
Monoclonal antibodies - Bevacizumab - Panitumumab - Cetuximab - Trastuzumab	-Vascular endothelial growth factor receptor (VEGFR) -Epidermal growth factor receptor ( EGFR)	Colorectal tumor, breast tumor, prostate tumor and lung tumor [5].
- Transferrin(Tf) -Lowdensity lipoproteins(LDL) -Cell	Transferring receptor 1 and 2 LDL- receptors	-Brain tumor, breast tumor, prostate tumor and squamous cell carcinomas and other tumors [14].
A10 aptamer	Prostate specific membrane antigen (PSMA)	Prostate tumor
Vitamines (Folic acid, riboflavin and biotin)	Vitamin receptors (e.g folic acid receptor)	Colon, lung, Uterus, prostate, and brain tumors
Arginine-Glycine-Aspartic acid(RGD) or LDV	$\alpha$ v $\beta$ 3, $\alpha$ v $\beta$ 5 integrin receptors	tumor-associated vascular endothelial cells [21].





Table 2: Summary of types of reactions and functional groups used for PNP-ligand coupling

Types of Reactions	Functional Groups at Nanocarrier Surface	Functional Groups at Targeting Ligands
Electrophilic addition of Thiol to alkene	Maleimide Carboxylic acid Pyridyldithiopropionate(PDP) Vinylsulfone	Thiol Thiol Maleimide Thiol
Nucleophilic acyl substitution Reaction	Carboxylic acid Amine P-nitrophenyl carbonyl	Amine Amine Amine
Hydrazide coupling Disulfide exchange Biotin-streptavidin Diel's-Alder Click-chemistry	Hydrazide PDP Biotin Furan Azide	Aldehyde Thiol Streptavidin Maleimide Alkyne

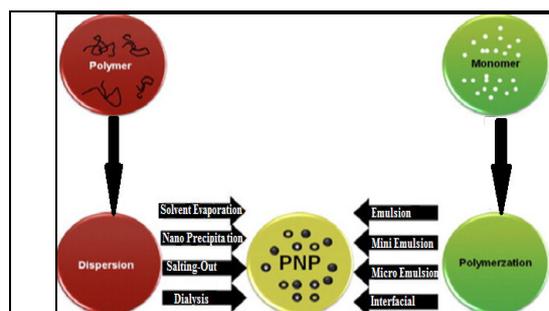


Figure 1: Various techniques used for the preparation of polymeric nanoparticle

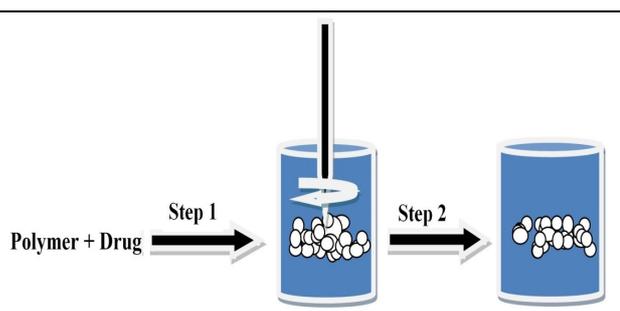


Figure 2: Schematic representation of PNP preparation using solvent evaporation technique.

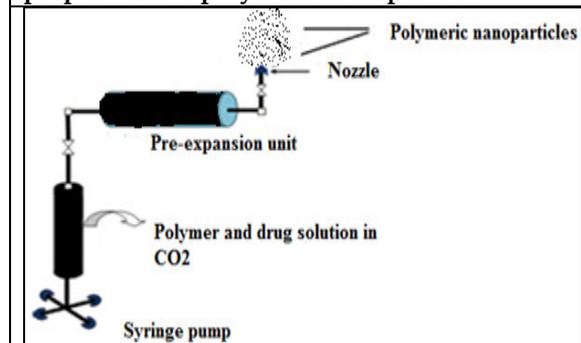


Figure 3: Diagram showing the preparation of PNP's using supercritical fluid technology

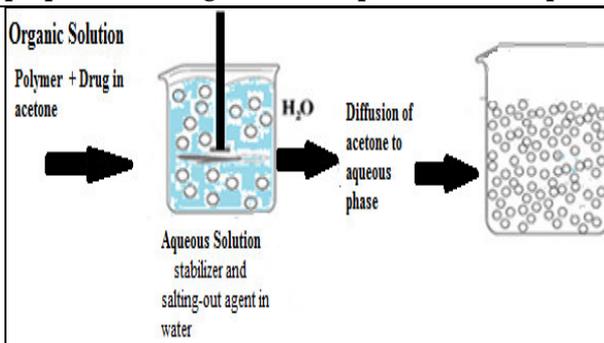


Figure 4: Schematic representation of preparing PNP's using salting out technique.



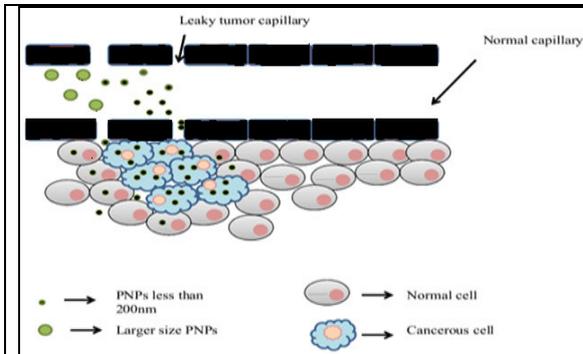


Figure-5: passive tumor targeting of non- engineered pnp by EPR effect

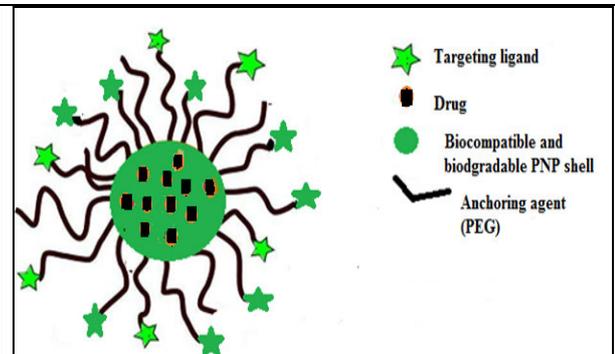


Figure 6: Schematic representation of polymeric nanoparticle coupled with targeting ligands

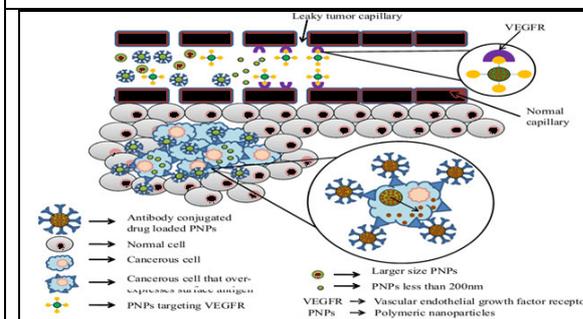


Figure 7: Diagram of active tumor targeting of engineered PNP

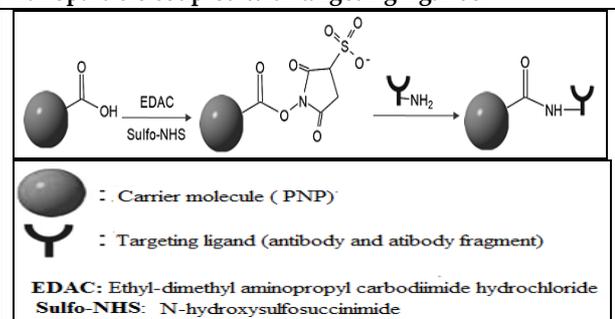


Figure 8: Schematic representation for the reaction of nanocarriers with primary amine-containing targeting ligands

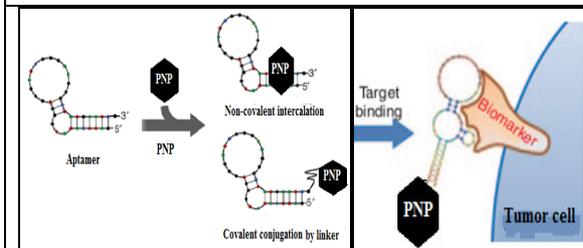


Figure 9: Schematic diagram of non-covalent or covalent ligand-drug conjugation and ligand- target interaction

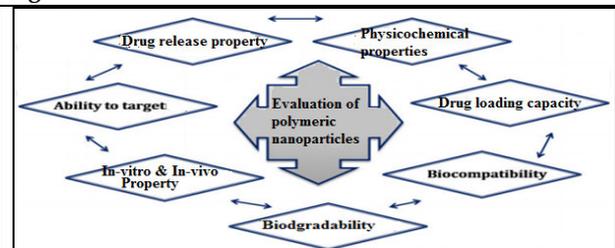


Figure 10: Schematic representation for the characterization of polymeric nanoparticles.





## Simultaneous Estimation of Lamivudine, Zidovudine and Nevirapine by HPTLC in Pure and Pharmaceutical Dosage Form

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### ABSTRACT

A simple, accurate precise and reproducible High Performance Thin layer Chromatographic (HPTLC) method has been developed for the simultaneous estimation of Lamivudine, Zidovudine and Nevirapine in pharmaceutical dosage forms. It was performed on TLC plate precoated with silica gel 60F254 as stationary phase using mobile phase comprising of Chloroform: Methanol (90:10 v/v). The detection was carried out by UV detection at 265 nm showing R<sub>f</sub> value 1.66 for Lamivudine, 8.66 for Zidovudine and 11.60 for Nevirapine. The percentage estimation of labeled claims of Lamivudine, Zidovudine and Nevirapine from marketed tablet was found to be 99.68, 99.36 and 99.81 respectively. The method was validated in terms of accuracy, precision, specificity and ruggedness. Linearity was observed between 900-2100 µg/ml for Lamivudine, 1800-4200 µg/ml for Zidovudine and 1200-2800 µg/ml. The recovery studies were carried out by adding known quantity of standard drugs in the pre-analysed test solution and percentage recovery calculated in each case. The percentage recovery studies for Lamivudine, Zidovudine and Nevirapine were found within the range of 99.41- 99.58 %. The proposed method was found to be accurate, precise, simple and rapid could be used for routine analysis.

**Keywords:** HPTLC, Lamivudine, Zidovudine and Nevirapine and Tablets



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## INTRODUCTION

**Zidovudine (ZDV)** [1-6] is an orally administered thymidine derivative with effects for the management of HIV infection. It is from the class of nucleoside reverse transcriptase inhibitor. Chemically, 3'-azido-2',3'-di deoxythymidine. Its empirical formula is C<sub>10</sub>H<sub>13</sub>N<sub>5</sub>O<sub>4</sub> and molecular weight 267.242. The mode of action is by terminating the growth of the DNA chain and inhibiting the reverse transcriptase of HIV.

**Lamivudine (LMV)** [1-6] is an orally administered. It also belongs to the class of nucleoside reverse transcriptase inhibitor. Chemically, lamivudine is L-2',3'-dideoxy-3'-thiacytidine. Its empirical formula is C<sub>8</sub>H<sub>11</sub>N<sub>3</sub>O<sub>3</sub>S and molecular weight is 229.26. It acts by competes with deoxycytidine tri- phosphate for binding to reverse transcriptase and incorporation into DNA results in chain termination.

**Nevirapine (NVR)** [1-6] is an orally administered antiretroviral drugs. It belongs to the class of non-nucleoside reverse transcriptase inhibitor (NNRTI). Chemically, nevirapine is 1-cyclopropyl-5,11-dihydro-4-methyl- 6H-dipyrido[3,2-b: 2', 3'-e][1,4]diazepin-6-one. Its empirical formula is C<sub>15</sub>H<sub>14</sub>N<sub>4</sub>O and molecular weight is 266.298. It acts by binding to reverse transcriptase adjacent to the catalytic site and terminate the DNA chain. The earlier literature survey [7-18] reveals the analytical methods like UV, HPLC and HPTLC are available for determination of these drugs individually and other combinations in pharmaceuticals and biological preparations. There is no method has been reported for the estimation of LMV, ZDV and NVR simultaneously. In the present investigation an attempt was made to develop a simple and economical HPTLC with greater precision, accuracy and sensitivity for the simultaneous estimation of LMV, ZDV and NVR in pure and tablet dosage forms.

## EXPERIMENTAL

All chemicals and reagents used were of AR/HPLC grade silica gel precoated aluminium plates with thickness of 200 µm, E-Merck, Germany were used as a stationary phase with the instrument CAMAG-HPTLC system comprising of CAMAG LINOMAT IV sample applicator, CAMAG TLC scanner III with CATS software and CAMAG twin trough chamber with stainless steel lids. Pure samples of LMV (3 TC), ZDV and NVR (NEV) were obtained as a gift samples from AEON Pharmaceuticals, Puduchery.

### Preparation of Standard Solution

An accurately weighed quantity of 150 mg Lamivudine (working standard) and 300 mg Zidovudine (working standard) and 200 mg Nevirapine was dissolved in mobile phase (Chloroform and Methanol (90:10)) make up to 10 ml to obtain a stock solution of 15000 µg/ ml of Lamivudine, 30000 µg/ ml of Zidovudine and 20000 µg/ ml of Nevirapine.

### Chromatographic Conditions

Various solvent systems were evaluated to arrive at an optimum resolution of the two drugs. The solvent system consisting of Chloroform: Methanol (90:10 v/v) gave dense, compact and well separated spots of the drugs from the mixture. The chamber was saturated for 10 min. sample was applied at a constant rate of 0.16/µl/sec having scan speed of 10 mm/sec with 16 mm band width the samples were separated by ascending technique. The chamber was maintained at 20± 0.50 C temperature and 50-60% relative humidity. The scanning of the plate was scanned at 265 nm.





### Calibration Curve

LMV, ZDV and NVR solutions ranging from 900-2100 µg/ml, 1800-4200 µg/ml and 1200-2800 µg/ml were applied on TLC plate by automatic sample applicator. The plates were developed, dried and densitometrically scanned at 265 nm. Peak height and area were recorded for each concentration and curves (Peak area Vs concentration) were constructed.

### Sample Preparation

To determine the content of Lamivudine, Zidovudine, and Nevirapine simultaneously in conventional tablets (Label claim: 300 mg of Lamivudine, 200 mg of Zidovudine and 200 mg of Nevirapine per tablet). Twenty tablets were weighed, their mean weight determined and they were finely powdered and powder equivalent to 150 mg of Lamivudine, 300 mg of Zidovudine and 200 mg of Nevirapine was weighed. Then equivalent weight of the powder was transferred into a 100 ml volumetric flask. The contents were dissolved in chloroform: methanol (90:10) and volume made up to the mark. The contents were mixed well using Ultrasonicator and filtered through Whatman filter paper No.42. The filtered solution was then used for the estimation.

### ESTIMATION METHOD

The sample solution was spotted on the chromatoplate with the help of Linomat IV spotting system. The chromatoplate was developed in a twin trough chamber containing the mobile phase. The chromatograms were recorded and R<sub>f</sub> values were determined for Lamivudine, Zidovudine and Nevirapine. The amount of drug present was calculated by comparing the peak area values of standard with that of sample as follows.

$$\text{Amount of drug in each tablet} = \frac{\text{Peak area of test}}{\text{Peak area of Standard}} \times \frac{\text{Standard dilution factor}}{\text{sample dilution factor}} \times \text{Ave. weight of tablet}$$

### RESULTS AND DISCUSSIONS

Various solvent systems were evaluated to arrive at an optimum resolution of the two drugs. The solvent system consisting of Chloroform: Methanol (90:10 v/v) gave dense, compact and well separated spots of the drugs from the mixture. The R<sub>f</sub> values were found to 01.66, 08.66 and 11.60 for Lamivudine, Zidovudine and Nevirapine, respectively. All the peaks were symmetrical in nature and low value of tailing was observed when plates were scanned at 265 nm. The plot of peak areas versus concentration of Lamivudine, Zidovudine, and Nevirapine were found to be linear in the concentration range 900-2100 µg/ml, 1800-4200 µg/ml and 1200-2800 µg/ml, respectively. The corresponding correlation values are given in Table-1.

The proposed method was successfully applied to the analysis of Lamivudine, Zidovudine, and Nevirapine in tablet (labeled to contain Lamivudine 150mg, Zidovudine 300mg and Nevirapine 200 mg as active substances). The results and statistical parameters are shown in Table-2. The low values of %RSD indicated high precision of the method. The precision of the method was demonstrated by repeatability studies. The precision of the proposed method was determined by assaying the standard solutions on the same day and on three different days over a period of two weeks and expressed as %RSD. The intra-day and inter-day precision has been depicted in Table-3. To confirm the accuracy of the proposed method, recovery experiments were carried out by standard addition technique by adding a known amount of standard at three different levels to the pre-analyzed sample. Each level was repeated three times and the amount of drug found by the assay method, results and statistical parameters are reported in Table-4. The results show that the method is precise and accurate.





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Table-1 Linearity Studies

Drug	Linearity range( $\mu\text{g}$ )	Coefficient of correlation	Slope	Y-Intercept
Lamivudine	900-2100	0.9996	4.9607	13.18
Zidovudine	1800-4200	0.9998	6.387	40.60
Nevirapine	1200-2800	0.9999	6.3247	34.23

Table -2 Estimation of Lamivudine , Zidovudine and Nevirapine

Drug	Label Claim (mg/tab)	Amount estimated*	%Amount estimated*	% RSD	S E
Lamivudine	150	149.53 + 0.303	99.68 + 0.202	0.20	0.13
Zidovudine	300	298.10 + 0.78	99.36 + 0.26	0.26	0.35
Nevirapine	200	197.62 + 0.15	98.81 + 0.075	0.07	0.067

\*Mean and +standard deviation for five determinations RSD: Relative Standard Deviation, SE: Standard Error

Table -3 Recovery of Lamivudine , Zidovudine and Nevirapine.

Label claim (mg/tablet)	Amount added ( $\mu\text{g}$ )	Amount Recovered* ( $\mu\text{g}$ )	% Recovery*	Average Recovery (%)	% RSD
Lamivudine -150 mg	300	297.57 $\pm$ 0.04	99.19	99.41	0.197
	600	596.1 $\pm$ 0.06	99.35		
	900	897.21 $\pm$ 0.09	99.69		
Zidovudine - 300 mg	600	596.76 $\pm$ 0.23	99.46	99.58	0.265
	1200	1193.88 $\pm$ 0.25	99.49		
	1800	1796.22 $\pm$ 0.30	99.79		
Nevirapine -200 mg	400	397.96 $\pm$ 0.04	99.49	99.52	0.06
	800	796.24 $\pm$ 0.06	99.53		
	1200	1194 $\pm$ 0.08	99.54		

\*Mean and standard deviation for three determinations

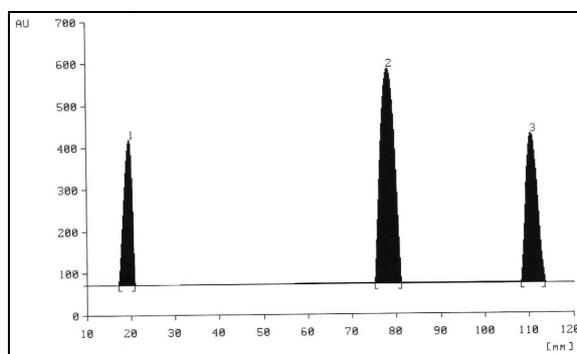


Figure-1 Densitogram of the recovery studies of Lamivudine, Zidovudine and Nevirapine at 265 nm by developed method





## Ion-Pair Spectrophotometric Estimation of Sertaconazole Nitrate

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### ABSTRACT

Two simple, accurate, sensitive and reproducible Ion –pair Spectrophotometric methods (1& 2) have been developed for the determination of Sertaconazole Nitrate (STZ) in bulk drugs and also in tablets and spiked human urine. The proposed methods are based on complexation of the drug with Alizarin Red S (Method 1) and Patent blue vf (Method 2), extracted with chloroform, showing absorbance maxima at 416 nm and 633 nm respectively. Beers law obeyed over a concentration range of 20-80µg/ml and 05-40µg/ml for Method 1 and Method 2 respectively. Results of analysis for the two methods established were validated statistically and also by ICH guidelines. All the variables were studied to optimize the reaction conditions. No interference was observed in the presence of common pharmaceutical excipients. The validity of the methods was tested by analyzing the drug in its pharmaceutical formulation. Good recoveries were obtained.

**Keywords:** ion –pair color complex, STZ, Alizarin red S, Patent blue vf and molar absorptivity.

### INTRODUCTION

Sertaconazole nitrate is a chemically 1-[2-[(7-chloro-1-benzothiophen-3-yl) methoxy]-2-(2,4-dichlorophenyl) ethyl]imidazole; nitric acid. It is a nitrate salt form of Sertaconazole, a synthetic imidazole derivative with antifungal property [1].It has also antipruritic activity [2].A survey of the literature revealed that several analytical methods have been reported for the determination of the studied drugs in the pure drug form, pharmaceutical dosage forms and biological samples using liquid chromatography, either in single or combined form[3–5], capillary zone electrophoresis methods [6] electrochemical methods [7] , non-aqueous titration [8] spectrofluorimetric methods and

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spectrophotometric methods [9-13]. Visible spectrophotometry has remained competitive in the area of chromatographic techniques for pharmaceutical analysis due to its simplicity and cost effectiveness, sensitivity and selectivity, fair accuracy, precision and available in most quality control laboratories. In addition, this method does not require the costly instrumentation that is required for the published HPLC methods. Extractive spectrophotometric procedures are popular due to their sensitivity in the assay of drugs, and therefore, ion-pair spectrophotometry has received considerable attention for the quantitative determination of many pharmaceutical compounds [14-18].

## MATERIALS AND METHODS

**Instrumentation Used:** A Shimadzu UV-Vis double beam Spectrophotometer (pharmaspec-1700) with 1cm matched quartz cells was used for all spectral measurements. Microprocessor based colorimeter (Elico CL 220), UV-visible spectrophotometer double beam (Elico SL 220), Metzer colorimeter, Metzer pH meter and single electronic pan balance (Contech) were used in the assay procedure, acetate buffer (pH 3.0), Patent blue vf (0.02%), Alizarin Red S (0.1%), double distilled water.

### METHOD-1(ARS)

**Standard Stock Solution:** Standard stock solution of STZ (100 $\mu$ g/ml) was prepared in acetate buffer (pH 3.0) and used for the analysis.

**Working Standard Stock Solution:** 2, 3, 4, 5, 6, 7 and 8ml of standard stock solutions were taken in 07(seven) different 10ml volumetric flasks and diluted up to mark with acetate buffer (pH 3.0) in order to get 20, 30, 40, 50, 60, 70 and 80 $\mu$ g/mL drug concentration respectively.

**Selection of  $\lambda$  Max:** 30  $\mu$ g/mL of drug solution was scanned between 350 to 700 nm to find out  $\lambda$  max (i.e. the wavelength at which amplitude is maximum) 416nm.

**Stability of Color Complex:** It has been observed that the yellow color complex was stable for more than 2 hours. The absorbance was measured at an every 20mins for 2 hours and found that S.D. is 0.22.

**Construction of Calibration Curve:** Entire content of working standard stock solution were transferred to seven (7) different 125ml separating funnels. 2ml of alizarin red s (0.1%) was transferred into each separating funnel and shaken well for 5mins and kept aside for 5mins. 10ml of chloroform was added into each separating funnel and shaken well for 3mins and the drug was extracted into the chloroform layer and it was separated into seven (7) different 25ml volumetric flasks. The organic layer was then passed over anhydrous sodium sulphate and the maximum absorbance was measured at 416nm against the reagent blank. The blank solution was prepared by utilizing all the above reagents excluding the drug solution. The calibration curve was plotted using concentration Vs. absorbance. The linear regression equation was found to be  $Y = 0.0307x - 0.5856$  and the Correlation coefficient ( $r^2$ ) = 0.9924. The linearity data of drug is given in the Table 1. The linearity curve is shown in the Figure 1. The overlay visible absorbance spectrum is shown in the Figure 2.

**Assay of Tablet:** Twenty tablets are weighed accurately and ground into a fine powder. An amount of powder equivalent to 10mg of Sertaconazole nitrate was weighed into a 100ml volumetric flask, about 40ml of freshly prepared buffer pH 3.0 was added and sonicated thoroughly for about 5mins, then the volume was made up to the mark with the buffer, well and filtered using Whatman filter paper No 42 and the first few milliliters of the filtrate were discarded. 3ml of filtered tablet sample solutions were transferred into four different 10 ml volumetric flasks



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and the volume was made up to the mark with the double distilled water. The contents of the volumetric flasks were transferred into four (4) different 125ml separating funnels and 1ml of alizarin red s solution (0.1%) was added into each separating funnel. 10ml of chloroform was added into each separating funnel and shaken for 5mins and kept aside for 3mins. The chloroform layers were collected in volumetric flasks and measured the absorbance at **416nm**. The concentration of the drug was calculated by employing the linear regression equation. The results of tablet analysis are shown in the Table 2.

**Accuracy:** It was found out by recovery study using standard addition method. Known amounts of standard solution was added to pre-analyzed samples at a level of 80%, 100% and 120% and then subjected to the proposed colorimetric method. Results of recovery studies are shown in Table 3.

**Urine Sample :** Drug- free human urine was obtained from a healthy male aged about 28 years.

#### **Procedure for Assay in Spiked Urine (Pure Drug)**

10 mL of urine, 5 mL of acetonitrile, and 10 mL of 30 µg/mL Sertaconazole nitrate solutions [in buffer (pH 3.0)] were added into a 25 mL volumetric flask. The resulting solution was filtered through a Whatman No. 42 filter paper and then transferred into a 125 mL separating funnel. Then, 1mL of Alizarin Red S (01%) was transferred into a separating funnel and it was shaken for 3 minutes. 15 mL of chloroform was added into the separating funnel and shaken well for 5 min and kept aside for 5 min. The drug was extracted into the chloroform layer and it was separated into 25 mL volumetric flasks. The organic layer was then passed over anhydrous sodium sulfate, and the maximum absorbance was measured at 416 nm against the reagent blank. The blank solution was prepared by utilizing all the above reagents excluding the drug solution. The concentration of STZ in urine was found by using the linear regression equation. The results are given in the Table 4.

#### **Procedure for Assay in Spiked Urine (Formulation, I.E. Tablet)**

In a 25 mL volumetric flask, 10 mL of urine, 5 mL of acetonitrile, and 10 mL of 10 µg/mL tablet sample solution [in acetate buffer (pH 3.0)] were added. The resulting solution was filtered through a Whatman No. 42 filter paper, and then transferred into a 125 mL separating funnel. Then, 1 mL of patent blue vf solution (0.1%) was transferred into a separating funnel and 15 mL of chloroform were added into the separating funnel and shaken well for 5 min and kept aside for 5min. The drug was extracted into the chloroform layer, and it was separated into 25 mL volumetric flasks. The organic layer was then passed over anhydrous sodium sulfate, and the maximum absorbance was measured at 633 nm against the reagent blank. The blank solution was prepared by utilizing all the above reagents excluding the drug solution. The concentration of STZ tablet in urine was found by using the linear regression equation. The results are given in the Table 5.

#### **Robustness and Ruggedness**

The robustness of the method was evaluated by making small incremental changes in volume of dye and contact time, and the effect of these changes on the absorbance of the colored systems was studied. The changes had negligible influence on the results as revealed by small intermediate precision values expressed as %RSD ( $\leq 2\%$ ). Method ruggedness was demonstrated by having the analysis done by a single analyst performing analysis on four different instruments in the same laboratory. Intermediate precision values (%RSD) of this study were in the range 2.16 – 3.99% indicating acceptable ruggedness.

#### **Method 2**

**Standard Stock Solution:** Standard stock solution of STZ (100µg/ml) was prepared in acetate buffer (pH 3.0) and used for the analysis.





**Working Standard Stock Solution :** 0.5, 1, 1.5, 2, 2.5, 3, 3.5 and 4ml of standard stock solution was transferred into eight different 10ml volumetric flask and diluted up to the mark with acetate buffer (pH 3) to get 05,10,15,20,25,30,35 and 40 µg/ml drug concentration respectively.

**Selection of  $\lambda$  Max:** 10 µg/mL drug solution was scanned between 300 to 800 nm to find out  $\lambda$  max (i.e. the wavelength at which amplitude is maximum). The  $\lambda$  max was found to be having green color chromogen **633nm**.

**Stability of the Color Complex:** the absorbance was measured at an every 20mins for 3 hrs and found that S.D.is 0.21.It has been observed that the green color complex was stable for more than 3 hrs.

**Construction of Calibration Curve:** Entire content of working standard stock solution were transferred to eight different 150ml of separating funnel. 2ml of 0.02% Patent blue vf was added into each separating funnel. Then the separating funnel was shaken for 2 to 3 minutes. 10ml of chloroform was added into each separating funnel and again shaken for 2 to 3minutes. Then separate the chloroform layer into eight different 10ml volumetric flask. The organic layer was then passed over anhydrous sodium sulphate and the maximum absorbance was measured at **633nm** against the reagent blank. The blank solution was prepared by utilizing all the above reagents excluding the drug solution. The calibration curve was plotted using concentration Vs. absorbance. The linear regression equation was found to be  **$Y = 0.0179x - 0.0480$**  and **Co-relation coefficient ( $r^2 = 0.988$ )**. The linearity data is shown in the Table 6. The linearity curve of the drug is shown in the Figure 8.

**Assay of Tablets:** Twenty tablets are weighed accurately and ground into a fine powder. An amount of powder equivalent to 10mg of Sertaconazole was weighed into a 100ml volumetric flask, about 40ml of freshly prepared Acetate buffer pH 3.0 was added and sonicated thoroughly for about 5mins, then the volume was made up to the mark with the Acetate buffer pH 3 mixed well and filtered using Whatman filter paper No. 42 and the first few milliliters of the filtrate were discarded. 1ml of filtered tablet sample solutions were transferred into five different 10 ml volumetric flasks and the volume was made up to the mark with the buffer. The contents of the volumetric flasks were transferred into different 125ml separating funnels and 2ml of patent blue vf solution was added into each funnel. 10ml of chloroform was added into each separating funnel and shaken for 5mins and kept aside for 3mins. The chloroform layers were collected in volumetric flasks and measured the absorbance at 633nm. The concentration of the drug was calculated by employing the linear regression equation. The results of tablet analysis are shown in the Table 7.

**Accuracy:** It was found out by recovery study using standard addition method. Known amounts of standard solution was added to pre-analyzed samples at a level of 80%, 100% and 120% and then subjected to the proposed colorimetric method. Results of recovery studies are shown in Table 8.

## RESULTS AND DISCUSSION

The results of analysis of average recoveries obtained in each instance were compared with 100percent theoretical value of Students't' test. As the calculated't' values are less than theoretical't' values. It is concluded that the results of recoveries obtained are in accordance with 100 percent for each analyze. So the percent recovery experiments revealed good accuracy of the data. Less than 02 S.D. was observed in both the methods. So the method is precise. The molar ratio of the drug : dye was determined by Job's method and found to be 1:1. The recovery results of the proposed method were well agreed with the reported RP-HPLC method for the drug. So both the proposed methods are simple, economy, accurate, precise and reproducible and highly sensitive methods and can be used for quality control laboratory.



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**Table 1: The linearity data of Sertaconazole nitrate (Method 1)**

SL. No.	Concentration (µg/ml).	Absorbance (416 nm)
1	20	0.115
2	30	0.319
3	40	0.548
4	50	0.931
5	60	1.224
6	70	1.602
7	80	1.897

**Table 2: Results of Tablet analysis (Onabet V1 ®, Glenmark)**

Formulation(µg/ml)	Label claim of tablet (mg/tab)	Amount found (mg/tab)	C.I.	SD	SE	T
30	500	506.78	100.732±1.237	0.777	0.388	1.883
	500	503.19				
	500	502.56				
	500	499.19				

**Table 3: Recovery data of Sertaconazole**

% Level of recovery	Formulation (µg/ml)	Amount of standard drug added (µg/ml)	Amount Of Pure drug Found (µg/ml)	C.I.	SD	SE	T
80	10	8	18.29	100.27±2.87	1.805	1.80	0.307
	10	8	18.16				
	10	8	17.57				
	10	8	18.18				
100	10	10	19.78	99.625±2.74	1.726	1.73	0.39
	10	10	19.55				
	10	10	20.35				
	10	10	20.05				
120	10	12	22.36	101.80±2.73	1.715	1.68	2.1
	10	12	22.77				





	10	12	21.89			
	10	12	22.57			

SD: Standard deviation, SE: Standard error, C.I.: Confidence Interval within which true value may be found at 95% confidence level =  $R \pm ts/\sqrt{n}$ , R: Mean percent result of analysis of Recovery study (n = 4). Theoretical 't' values at 95% confidence level for n-1 degrees of freedom  $t(0.05, 3) = 3.182$ .

Table 4: The results of pure drug in spiked urine

Pure drug ( $\mu\text{g/mL}$ )	Amount found ( $\mu\text{g/mL}$ )	C.I.	SD	SE	T
30	30.11	100.220 $\pm$ 3.23	2.03	1.01	0.21

Table-5 concentration of STZ tablet in urine by using linear regression equation

Formulation ( $\mu\text{g/mL}$ )	Label claim of tablet (mg/tab)	Amount found (mg/tab)	C.I.	SD	SE	t
30	500	500.50	101.01 $\pm$ 2.0	1.29	0.64	1.56

Table 6: The linearity data of Method 2

Sl. No.	Conc.	Absorbance
0	0	0
1	5	0.048
2	10	0.092
3	15	0.195
4	20	0.290
5	25	0.399
6	30	0.483
7	35	0.59
8	40	0.688

Table 7: Results of Tablet analysis (Onabet V1®, Glenmark)

Formulation ( $\mu\text{g/ml}$ )	Label claim of tablet (mg/tab)	Amount found (mg/tab)	C.I.	SD	SE	T
10	500	506.78	100.732 $\pm$ 1.237	0.777	0.388	1.883
	500	503.19				
	500	502.56				
	500	499.19				





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**Table 8: Recovery data of Sertaconazole**

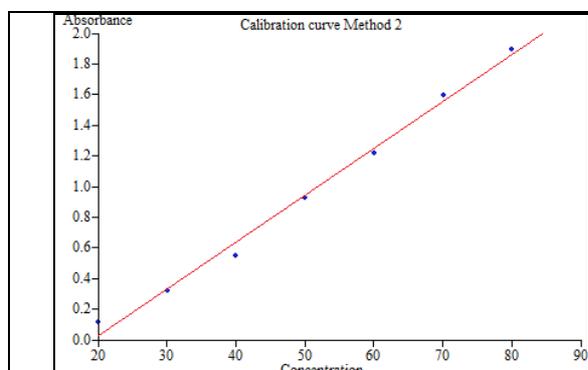
% Level of recovery	Formulation (µg/ml)	Amount of standard drug added (µg/ml)	Amount Of Pure drug Found (µg/ml)	C.I.	SD	SE	t
80	10	8	17.89	99.30±2.67	1.68	1.691	0.82
	10	8	17.56				
	10	8	17.77				
	10	8	18.28				
100	10	10	19.78	100.82±2.59	1.5	1.487	1.09
	10	10	20.08				
	10	10	20.35				
	10	10	20.45				
120	10	12	22.26	101.69±2.71	1.7	1.671	1.9
	10	12	22.67				
	10	12	21.89				
	10	12	22.67				

**Table 9: the results of pure drug in spiked urine**

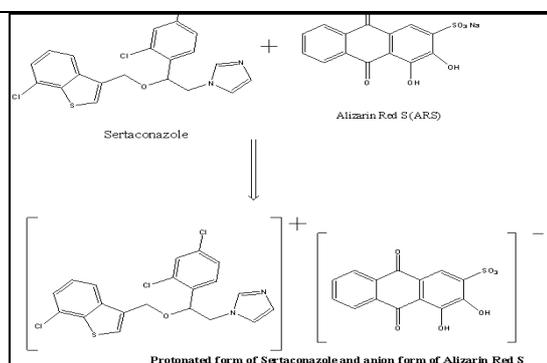
Pure Drug (µg/ml)	Found Concentration.* (µg/ml)	C.I.	SD	SE	t
10	10.8025	101±2.59	1.62	0.81	2.08

**Table 10: the result of assay in spiked urine (formulation, i.e. tablet)**

Formulation (µg/ml)	Label claim (500mg/tab)	Found Concentration.* (mg/tab)	C.I.	SD	SE	t
10	500	500.44	100.88±3.0	1.91	0.95	0.91



**Figure 1: The linearity curve of method 1**



**Figure 2: proposed reaction mechanism of Sertaconazole and Alizarin Red S.**



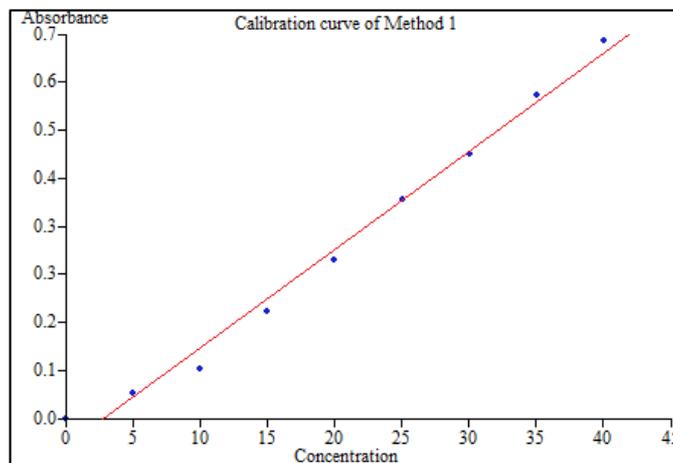


Figure 3. Linearity curve of Sertaconazole





## Impact of Covid-19 on Education Systems Including Pharmacy

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### ABSTRACT

COVID-19 pandemic has seriously affected educational systems nationwide, leading to the closures of schools, colleges and universities. Most governments around the world and in India have temporarily closed educational institutions in an attempt to check the spread of corona virus infection. According to UNICEF monitoring, 134 countries are currently implementing nationwide closures and 38 are implementing local closures, impacting about 98.5 percent of the world's student population. More than 1500 pharmacy institutions with annual intake of 1,00,000 students in India are immensely affected by COVID-19 due to suspension of face-to-face activities. As a result, pedagogical methods of education has changed dramatically, with the distinctive rise of e-learning, whereby teaching is undertaken remotely and on digital platforms. With this sudden shift away from the classroom in many parts of the globe, some are wondering whether the adoption of online learning will continue to persist post-pandemic, and how such a shift would impact the worldwide education market and job opportunity. The unplanned and rapid move to online learning – with no training, insufficient bandwidth, and little preparation – will result in a poor user experience, unsuccessful education activities and detrimental to sustained growth. A new hybrid model of education based on integration of information technology will be accelerated and the online education system will eventually become an integral component of education including pharmacy in future. The objective of writing this article is to explain the impact of COVID 19 on education systems in India including pharmacy education. How pharmacy students, teachers, institutions as well as economy and society are going to change and respond to this pandemic crisis? The evolution of traditional education systems in India and its transition to online mode are explained. The major challenge in the education systems is now integration of classroom learning with e-learning modes to build a unified learning system. The comparison of face-to-face teaching with online education and the problems associated with virtual classes are described.

**Keywords:** COVID 19, Education systems, Pharmacy education, face-to-face teaching, Online classes





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## INTRODUCTION

The COVID-19 causes great concern to the education systems in India and many other countries. Pharmacy education and institutions are seriously affected due to nationwide lockdown, closure of colleges and universities, and suspension of face-to-face activities. Its fear is giving sleepless nights to students who were to appear in their regular classes, annual/semester exams as well as competitive exams, interviews, GD, PI for campus selection etc. With COVID-19, spreading to large parts of India in March 2020, the central and state governments closed down schools, colleges, educational institutions as a precautionary measure against the disease. Coronavirus/COVID-19 has been declared as Pandemic by World Health Organization (WHO) and there is a sense of fear and panic all around the globe. Some 1.3-1.5 billion students and youth across the planet are affected by school, college and university closures. These nationwide closures are impacting over 98 % of the world's student population.

On June 12, 2020 during Lockdown 5.0/Unlock 1.0, India has registered the total number of corona cases in the country is 2,97,534, according to Union Ministry data, of this, 1,41,842 are active cases, as many as 8,498 deaths and while 1,47,194 people have been cured/discharged. Since the first case of COVID-19 has emerged in India, state governments are taking all the possible precautionary steps to curb the spread of the disease and that include shutting down educational institutes, vacating hostels, postponing entrance examinations, convocation ceremonies, and more [1]. Beside these, the COVID-19 pandemic has made a rapidly changing world with more and more online activities, propelled into newer and newer orbits by not just science and technology, but by newer political realities, socioeconomic changes and the emergence of newer opportunities, newer aspirations, newer lifestyles etc.

## Suspension of Face-To-Face Activities & Rescheduling of Academic Calendar

As the pandemic spreads, which seems inevitable, all most all countries followed mandatory measures to suspend face-to-face activities for all educational institutions like classroom teaching, examination, practical classes etc where close gatherings are required. No one knows for sure how long these closures are likely to last. Initial measures taken by many governments have ranged from 15 to 30 days, but one can easily anticipate that they will be extended until the pandemic subsides. It is not unreasonable to imagine scenarios where this situation can last two months or more, or as in the case of Spain and Italy where the decision was announced not to resume face-to-face classes for the rest of the academic course which normally ends in June[2]. In India, examination authorities rescheduled their examinations and academic calendar due to lockdown for COVID-19. Few such decisions are mentioned below [3]:  
May 8, 2020: All India Council for Technical Education (AICTE) launched 'CovidGyan' recently to help people deal with the challenge of information overload on the novel coronavirus. May 6, 2020: MHRD revealed that grading in college and University exams could be a composite of 50% marks in case the COVID-19 situation does not appear to be normal. For the pending CBSE 10<sup>th</sup> and CBSE 12<sup>th</sup> exams, the HRD Minister announced that the CBSE is working on to reduce the syllabus for the new academic session.

Government think-tank NITI Aayog has announced that it has suspended its internship programme for the next three months, starting from May, in wake of the ongoing coronavirus outbreak in the country. The All India Council for Technical Education (AICTE) has released a revised academic calendar for technical institutions. The engineering counseling for admission for allotment of seats to be completed on or before August 15, 2020 May 4, 2020: All India Council for Technical Education (AICTE) released a detailed set of guidelines and a revamped academic calendar for the Indian Technical Education Institutes to follow. Ministry of Human Resource and Development announced the alternative academic calendar for classes 9 and 10 released by the NCERT. The Ministry of Human Resource Development (MHRD) shifted the dates for the JEE Main 2020 April Exam to July 18-23 and National Eligibility and Entrance Test ( NEET 2020 exams) to July 26.



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All India Council for Technical Education (AICTE) launched 49 e-learning courses for free. Amid closed academic institutions, postponed exams and delayed results, AICTE e-learning courses will not only prevent academic loss of students but will also help students utilize the COVID-19 lockdown period effectively by upgrading their skills. Pharmacy schools are no exception, as many institutions have been closed, causing teachers and students to seek out innovative ways to complete their coursework for the semester.

## **Impact of COVID-19 and Effect of Lockdown/Shutdown**

The decision to temporarily close educational institutions was prompted by the principle that large gatherings of students, teachers and non-teaching persons constitute a serious risk to safeguarding public health during the pandemic. Pharmacy institutions and indeed all educational institutions tend to close their doors in situations where some form of confinement or quarantine has been legislated. For the students the most immediate impact has naturally been that the temporary cessation of face-to-face teaching at colleges has left them in a completely new situation without a clear idea of how long it will last, immediate impacts on daily life, costs incurred and financial burdens and, of course, learning continuity, national and international mobility for education.

Students have had to rearrange their daily lives to adjust to a situation of confinement. Most of the students, who were displaced far from their families, but within the same country, have returned home. However, in the case of students abroad, the situation remains highly variable, with tens of thousands stranded in destination places waiting for on-site activities to resume or because they are unable to return to their home due to closure of airports and borders. Inevitably, the loss of social contact and socialization routines that are part of the daily experience of a higher education, student will take its toll. The isolation associated with confinement will have effects on socio-emotional balance. A survey in the United States shows, that 75% students have experienced anxiety and depression as a result of the crisis. Another question if the cessation of face-to-face activities is prolonged to the equivalent of one academic term or even longer, then there is the problem for promotion to higher class and who are aspiring to enter higher education. If so, the implications in terms of financial burdens for those students who have loans or credits will affect them and their families. Even they have to bear extra costs associated with their higher education.

Teachers are also affected significantly at the workplace and professionally. First, the fact that not all pharmacy colleges have strategies for the teaching continuity activity which must be taken into account, and in this instance, temporary contracts may be terminated. The most evident impact on teachers is that they continue to teach using the virtual modality, which they are not trained and habituated. In theory, at least, virtual education is present in most large institutions but it is difficult to find one that does not have a virtual campus and a virtual classroom for each subject. Non-teaching staff constitute the most vulnerable sector in terms of the possible reduction in the number of jobs that private colleges & universities, for example, would have to effect in the face of possible financial curtailment due to the cancellation of fees or reduction in student enrollment.

Pharmacy institutions will face huge disruption of their functioning due to temporary cessation of the physical activities. The impact of this disruption is highly variable and depends on their ability to remain active in their academic activities and on their financial sustainability. This implies that many institutions would face serious financial difficulties. Fees collection may not be enough, creating cash flow problems and perhaps even financial survival, particularly in the case of private colleges & universities. This can be especially critical for small or medium-sized private institutions that cannot guarantee continuity of training in virtual mode. In these cases, if the situation continues, it is very likely that, failing to offer teaching, they will have to temporarily suspend the collection of fees. In such a context, it is also possible that larger private colleges attempt to capture these orphaned students. In this scenario, many institutions may need to close.





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## The Substitute for Face-To-Face Classes

In the wake of this emergency situation of COVID-19, educational institutes around the globe are shifting their teaching related operations to online mode. Top educational institutions of India have temporarily suspended their offline operations and have shifted to their teaching-learning procedure online. The choice for online activities requires strong internet connectivity in common households. The percentage of households with an internet connection and mobile lines per 100 inhabitants is comparatively low in India, about 50% whereas Europe 86.5 % and America provide 71.8 %; individuals using the internet in Asia 48.4 %, Europe 82.5 %, America 77.2 % [4].

The physical facilities required for online classes are a functioning computer, a good internet connection, videoconferencing software, a microphone and a webcam. A desktop or a laptop any computer, even a smart phone will do the job of online classes but it should be in good conditions. A strong internet connection can make smooth conversation with teacher, making the exchanges easier and so the learning process. For this reason, it is necessary to have a minimum data rate of 5MB. A videoconference software should contain all the necessary gear to take lessons on the internet like video, chat, text editor, excel sheet, digital board, share screen option, different views etc, anything needed for a quality class. Top free Video Conferencing Softwares used currently are Zoom, UberConference, Google Hangouts Meet, Cisco Webex Meetings, RingCentral Meetings, Skype, GoToMeeting, Pexip, ezTalks Meetings, etc.

The change of medium and long-term teaching and learning modality may have impact for students. If the traditional dynamics are reproduced through technological means, then effects should not be very significant because the return to the classroom will be experienced as a return to normality, especially when formulas for continuous evaluation of online learning have been planned. Another effect on students studying abroad that many students will resign to continue their studies and academic stays interrupted by psychological affectations, epidemiological restrictions, visas conditions, as well as for economic reasons since the support funds have also been decreased or canceled.

Of course, this uncomfortable turn of events has created some good learning opportunities for students—how to adopt the new procedure of online systems, how to communicate, how to be flexible and creative and innovative in the face of adversity. The pandemic is forcing educators to seek out innovative solutions to support students as they are needed to quickly provide help on the frontlines in the battle with COVID-19[5, 6]. Traditional education system to online classes, e-learning, m-learning (mobile), online exams etc. Evolution of education systems in India in the past and present, and predicted for future is mentioned below: Early system, in which gurukul, home schooling and primary methods of teaching were followed, where books, blackboards etc are less used by the teacher as a teaching aid and teachers mainly play the key role with face-to-face oral instructions.

Traditional systems include classroom teaching, college or university systems providing education on mass scale with the teacher as the knowledge provider and the student as the passive recipient, which is physical or face-to-face teaching, Modern classroom education, where the classrooms are equipped with whiteboards, projectors or audio-visual display equipment, digital boards etc. It is now the transition phases i.e. chalk and talk to computer based multimedia supported teaching with use of computers and internet which helped in increasing access and equity. Future system will include online education or smart method of teaching and e-learning using high-speed internet, m-learning (using smart mobile technology), social media platforms(e.g. WhatsApp, e-mail, Facebook, messenger), and videoconference facilitating personalized learning anytime anywhere and redefining the role of teachers as sensitizer, facilitators or mentors.

Online education, where the information technologies and communications are used to help in the development and acquisition of knowledge from the different remote locations. It uses the internet and video/audio and text





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communication and software to create the learning environment. Currently in the COVID-19 era, we are in a state of massive transformation from modern classroom system to future online education systems where the focus is on student's learning outcomes with less role of teacher. Online classes, video conference, Email, WhatsApp etc are the major methods of teaching and learning. The primary focus areas of delivery are employability, marketing, student engagement in latest knowledge in pharmacy practice area and experience in disease management, availability of quality medicines, research excellence and society including industry responsibility.

In a situation where the students are not allowed to go to school, the alternative is to move from traditional to online education. In this case the essential parts are the internet coverage, availability of computers or smart phones in the population. The number of the computers owned by families, especially in the rural areas of the country are lower than a 50%, that can have a negative influence on the whole online education, but in some cases, the modern smart phones can be used as a substitute, if the platform of education is mobile friendly or have the mobile application available. Different countries worldwide have introduced various solutions during the pandemic to continue the education process. Online libraries, TV broadcasts, guidelines, resources, video lectures, online channels were introduced in at least 96 countries. To increase the coverage of the syllabus to the student population, the live transmission of lessons is broadcasted through the TV channel in different subjects.

The COVID-19 has resulted in the distinctive rise of e-learning, whereby teaching is undertaken remotely and on digital platforms. With this sudden shift away from the classroom in many parts of the globe, some are wondering whether the adoption of online learning will continue to persist post-pandemic, and how such a shift would impact the worldwide education market. Even before COVID-19, there was already high growth and adoption in education technology, with global edtech investments reaching US\$18.66 billion in 2019 and the overall market for online education projected to reach \$350 Billion by 2025. Whether it is language apps, virtual tutoring, video conferencing tools, or online learning software, there has been a significant surge in usage since COVID-19[7]. The pandemic has significantly disrupted the higher education sector which is a critical determinant of a country's economic future. The bigger concern on everybody's mind is the effect of the Pandemic on the employment rate. Recent graduates in India are fearing withdrawal of job offers from corporates because of the current situation. The Centre for Monitoring Indian Economy's estimates on unemployment shot up from 8.4% in mid-March to 23% in early April and the urban unemployment rate to 30.9% [8]. Further, it is also important to establish quality assurance mechanisms and quality benchmark for online learning systems and its providers as well as e-learning platforms which is growing rapidly.

## CONCLUSION

The pandemic has transformed the centuries-old, traditional chalk-talk class room teaching model to virtual classes in the online mode which is driven by IT technology. In this post COVID era a well-rounded and effective educational practice is needed which will develop skills that will ensure effective teaching and learning, the employability, productivity, health, and well-being in the decades to come, and make the overall progress of India.

Lots have been changed and will be changed in the field of education and learning in the months and years to come. Same things will be occurred in our society. But one thing is for sure that we can't go back to the 'pre-crisis' era that is now behind us. We will have to accept the change in the education, teaching and learning patterns; we will also have to accept the change in the society, economy reformation with online activities. Rather we have to think how quickly we can overcome the loss and damage caused by COVID-19, and improve in the near future. Tomorrow will be a new dawn. What we make of it is entirely in our own hands. Change is desirable; change is inevitable. Change in fact has been forced upon us. Whether we use the opportunity to advantage or let it pass us by will decide whether the future will shock us or we will create shock-absorbers that will in fact use the impact to cushion us in our journey to a better tomorrow.







## ESL Students' Speaking Skill: An Exploratory Study

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### ABSTRACT

Most of the students in India learn English as Second Language (ESL) as they speak different Indian languages as their first language or mother tongue. In India, the ESL learners come from various linguistic backgrounds and their proficiency in English language also varies. But in the midst of globalization, all college students must meet the global standard in English language proficiency. This research intends to find out if and how well the entry level ESL college students of Odisha possess the prerequisite skills in English language to meet the global challenge. The present study is aimed at determining the ESL students' proficiency level in speaking skill. A standardized language proficiency test with reference to speaking skill has been administered to assess ESL learners' proficiency level in English. It is found that the ESL students of Odisha at degree level do not possess adequate proficiency in speaking skill. Moreover, the learners have been interviewed and they have been recommended for the enhancement of their speaking skill.

**Keywords:** ESL students, proficiency, enhancement, speaking skill

### INTRODUCTION

Learners of English from non-western former British colonies are termed as second language (ESL) users irrespective of the fact that it is possible that the learner may not speak the first language usually associated with the mother tongue or ethnic identity. In spite of linguistic diversity in Odisha, English has been chosen as the medium of instruction for college students at degree level continuing their studies under all the Government as well as private universities except Sanskrit University present in the state. But, in real classroom practice, it has been observed that Hindi and Odia are being used in the classroom along with English. The teachers themselves, as Tickoo (2004) pointed out, are not well-equipped to teach neither correct English pronunciation nor speaking or reading skills to students. Except reading and writing skills, no other skills are being practised. It may be because the teachers might have been brought up in a similar educational system, with little expertise in ELT and phonetics as there is no provision in the state universities to teach phonetics or spoken English in the undergraduate courses. Moreover,

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there are scopes (like on-line courses) for the teachers engaged for undergraduate courses to master the language skills but there are various reasons why teachers do not subscribe to these courses inducting lack of motivation. The complete teaching-learning system, Tickoo (2004) pointed out, could be at fault due to lack of English proficiency in our students, as they have been taught by teachers those who are not highly proficient in its use. Gokak (1964) points out that “The foundational years for the teaching of English in schools are in the hands of teachers who neither know enough English nor are familiar with the latest and far- reaching developments in the pedagogy of English” (p.65). Observing the rapid change in the place of English in India Scrase (1989) remarked:

“English is recognised as an important global or international language, essential for professional employment and Significantly, a key component of the cultural capital of middle class Indians.”

Lax English language proficiency restricts the ESL students in Odisha for their academic and professional growth. It cannot be denied that better English language proficiency has been considered to be an important parameter in the selection process for getting well- paid jobs or better institutions for higher studies. It has been treated as the most significant language in India. So, in order to compete with the students of other states and countries, the students of Odisha at degree level have to be proficient in English language skills. In this regard, assessment of their language competence becomes essential. It will help them not only in acquiring English language but also all other subjects that they go through. In order to make them well equipped to face the academic and professional career in life the assessment of English language skills and finally, the recommendation for improvement is to be made.

**Importance of Speaking**

Lado (1961) comments on speaking skill that it is the ability to express oneself in a live situation. The systematic arrangement of lexical items to express oneself in different situations may be termed as the speaking activity. When the ability to speak in a fluent manner using flawless language, both grammatically and lexically, becomes possible with somebody, we realize that that the speaking skill is acquired. In order to establish one’s mastery over a particular language one needs to acquire speaking skill. Aural comprehension skills are closely interrelated with oral production tasks. But in the testing process the data received in both the skills are different from each other. However, the effectiveness of listening skill can be closely observed through this test. Speaking skill being a productive skill can be empirically observed with accuracy of data. Depending upon the types of speaking tasks it can be divided into four different categories:

- a. **Imitative:** In this case it is expected from the test-taker simply to imitate a text- a word or phrase or sometimes even sentence(s). The pronunciation and the ability of the test- taker to comprehend the text or interest to take part in an interactive conversation are being observed through such types of speaking texts.
- b. **Intensive:** In intensive category of speaking the competence level at lexical, phonological and grammatical are being tested. The speaker is expected to be aware of the semantic properties of the text for responding to the test administrator at best.
- c. **Responsive:** In case of responsive texts the stimulus is an oral text with a limited number of follow-up questions. These tasks include short conversation type, simple comments or requests, greetings and the like.
- d. **Interactive:** Interactions in the forms of transactional and interpersonal exchanges differentiate themselves in the form of their lengths and complexities. Interpersonal communications display a pragmatically complex meaning with the use of even colloquial languages.





### Proficiency Tests

As per Oxford Advanced Learners' Dictionary (2015) A skill is "an ability to do something better". The general ambience or in other words, the environmental stimuli stand responsible for the easy and quick acquisition of any language. Proficiency tests have been designed to assess learner's language proficiency. These tests are highly required for academic and other reasons like travel and short stay in native English-speaking countries. There are many standardized proficiency tests and among them tests like TOEFL, IELTS, SAT are very popular among test-takers. In these tests related to speaking skill the test takers are being evaluated on their ability to synthesize and convey information for the integrated questions. The spontaneity, clarity and coherence in the speaking abilities of the test takers are tested.

### METHODOLOGY

The mixed-method approach has been followed for the current study. Both qualitative data and quantitative data have been taken through participant observation, literature review, semi-structured interview, questionnaire and a standardized language proficiency test. Random sampling technique has been adopted to achieve accuracy in result. The samples for the present study have been carefully chosen among the ESL college students of Odisha using random sampling techniques. For this purpose, students from five different technical and non-technical degree colleges have been taken into account. In total 300 numbers of students, equally from each college, form the sample size for the current study.

### Instruments Used

A semi-structured questionnaire, standardized language proficiency test with reference to speaking skill and an interview protocol were the instruments used as to carry out the present research work. A statistical tool like SPSS 21.0 has been used for data interpretation. Before administering the questionnaire and the test for speaking skill a pilot study was conducted in order to check the level of difficulty of the test questions designed for the study. It helped to adopt and standardize the test questions. The participants were well informed about the purpose of the test and ethical practices as prescribed by American Psychological Association (1982) was followed which deals with human samples.

### RESULTS AND DISCUSSION

The diagram (Diagram No.-1) highlights learners' perception about their proficiency in speaking skill. There is a set of seven relevant questions for the ESL students in order to check their perception about speaking skill. A three-point Likert scale (i.e. always, sometimes and never) is used to find learners' perception about speaking skill with specific reference to ESL. Out of 300 respondents, in the study, 270 students are 'always' able to introduce themselves in English. 30 students opined 'sometimes' they can introduce themselves in English. Nobody is there to respond 'never' to the first question regarding self-introduction. The second question, as shown in the diagram (Diagram No.-1), needs information from the respondents about their ability to describe an object in English. 108 students responded to this question as 'always' they describe objects in English whereas, 136 responses are in favour of 'sometimes' and the rest 6 students said 'never'. During peer-group interaction 144 students are 'always' able to interact in English. 108 out of 300 samples 'sometimes' use English in peer group interaction and 64 students 'never' interact in English with peers. Question 4 asks about interaction in English outside the classroom. Out of all the responses 138, as shown in diagram, 'always' communicate in English outside the classroom. 144 students 'sometimes' speak English outside the classroom and 18 students 'never' speak English outside the classroom. The fifth question, as mentioned, asks about the students' interaction with the officials. It is found that 156 students 'always' speak English while talking to officials; 138 'sometimes' speak English and only 6 students 'never' speak English while talking to officials. Question-6 asks about presentation in English. A good response i.e. 180 students





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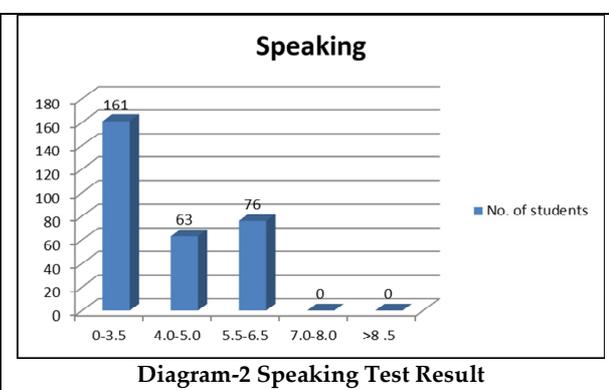
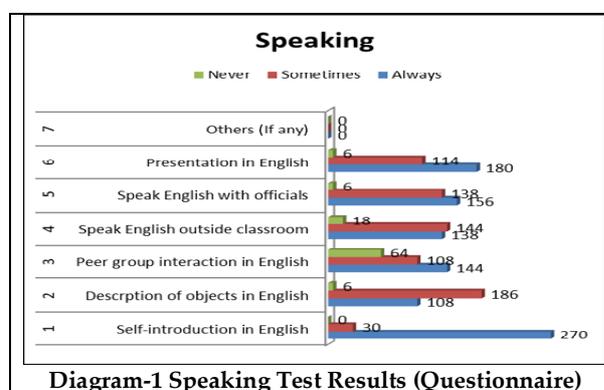
'always' use English during presentation. 114 students 'sometimes' and only 6 students 'never' use English during presentation. There is nil response for the last question i.e. others category indicating if any special situation to be mentioned. The diagram (Diagram-2) shows the results of the achievement test related to speaking skill of 300 samples adopted for the test. The result shows 76 out of 300 students are comfortable in speaking English scoring within the range of 5.5-6.5 or B2 level (CEFR rating). 63 students are in the range of 4-5 which is B1 level as per CEFR rating scale. However, 161 students are within 0-3.5 range which is below the average standard.

**CONCLUSION**

After the reality check by administering the standardized language proficiency test focusing on speaking skill and the interview protocol it has been observed that the average standard of the language proficiency level of ESL college students is far below than the global standard. Hence, it may be suggested that proper infrastructure may be provided in different institutions to enable a healthy environment to enhance language proficiency and to boost up academic growth of the students. Moreover, not only the language teachers but also the teachers of all other subjects and peer-group interaction must contribute towards the creation of the general ambience to enhance ESL students' language proficiency.

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## An Experimental Study on the Competence Level of ESL Students' Writing Skills

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### ABSTRACT

Practising all the basic language skills like listening skill, speaking skill, reading skill and writing skills in the acquired language makes one proficient in that language. However, among all these skills writing skill is considered the most difficult one as it involves the language components like vocabulary, grammar etc. Graddol (2006) found that although, India produces 2.5 million university graduates each year only a quarter are suitable for employment in multilingual companies. He found that weak language skills among graduate of non-elite schools and colleges and uneven quality of English language curricula and faculty reduces the chances of employability of our graduates. The present study intends to determine the ESL students' proficiency in writing skills. A language proficiency test with reference to writing skill has been implemented to assess learners' proficiency in English. It has been observed from the current study that the ESL students of Odisha at Degree level do not possess adequate proficiency in writing skills. Furthermore, students have been interviewed and recommendations have been made to enhance students writing skill.

**Keywords:** Writing skill, Proficiency Tests, Language Components

### INTRODUCTION

As we know, language has been accepted as one of the most powerful tools to express ourselves. . Language takes its origin from its users over a long period of time. In order to acquire a language, one has to go through four different language skills: Listening skill, speaking skill, Reading skill and Writing skill. A skill may be termed as the ability to accomplish a task in a more efficient manner within a specific time limit using all the potentiality one has/possesses. It requires certain environmental stimuli for acquiring a skill. Like all other skills learning a language, in order to use, is categorized under a skill. In order to be proficient in a specific language one must have the ability to comprehend,



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interpret, express and to create a discourse in various social, educational and official contexts primarily to communicate.

**The Importance of Writing**

“Writing a foreign language”, Lado (1961) states, “shows the ability of the writer to use the language and its graphic representation productivity even in very common written situations.” Writing skill is one of the productive language skills that demands more practice in order to attain perfection. One’s ability to use the lexical items in a congruent manner for the creation of a context following the syntactic arrangement of meaningful items is represented through writing skill. In fact, this is the most difficult skill if we analyze all four basic language skills. Different techniques are being used to test different types of writing pieces in a certain language. It includes all aspects of any language like: - starting from vocabulary, grammar use, use of punctuation marks and coherency between sentences and above all, achieving the overall goal of the specific task assigned. A second language writer is required to produce more than 50 genres of writing which include writing tasks within the curriculum and also beyond that. These include academic writing, professional writing, and personal writing and so on. The written performance is further sub-categorized into four different forms which differentiates writing skill from the other three skills with its uniqueness.

- a. **Imitative** : To create a piece of writing the learner is expected to be aware of the basic tasks of writing like letters, words, use of punctuation marks, creation of small coherent sentences. Form, at this stage, is the primary focus though not the exclusive focus. Creation of context and finding meaning out of it are of less importance.
- b. **Intensive**: These types of writings demand more appropriate context specific vocabulary, use of idioms and phrases, correct grammatical features with more focus on meaning and context creation.
- c. **Responsive**: At this stage the learner is expected to compose logically connected sentences and also paragraphs to create a context specific passage. Usually, brief narratives, reports, summaries, interpretation of charts, pictures etc come under this category of writings.
- d. **Extensive**: Extensive writing implies matured writings that fulfil all the purposes where the writer focuses on meeting the target with suitable sentences in a well-connected manner for the creation of a complete text in all aspects.

**Language Components**

Language components include vocabulary and grammar. Learners need language components to use language accurately. The following sections discuss language components in detail.

**Vocabulary**

The most essential part to comprehend a passage is one’s vocabulary knowledge. So, one can opine that vocabulary knowledge energizes one’s reading and comprehending ability. Studies at different times have shown the close association of size and depth of vocabulary with each other. (Qian, 1999, 2002; Schmitt & Meara, 1997; Vermeer, 2001). On the other hand, Vermeer (2001) did not find any conceptual difference between breadth and depth of vocabulary knowledge. ESL readers, Carlo et al. (2004) determined that learners’ vocabulary size and depth are significantly correlated. Both dimensions of vocabulary knowledge also correlated significantly with learners’ reading comprehension.



**Pradeep Kumar Sahoo****Grammar**

While comprehending a text grammatical knowledge is essential in order to find out the coherency in the passage (Givon, 1995). Grammar is also essential for establishing propositional meaning to word integration. (Fender, 2001; Kintsch, 1998; Perfetti & Britt, 1995) Lax grammatical knowledge results in poor comprehending a passage. (Bowey, 1986). Lexical information without grammatical cues in a text shows the importance of grammar while comprehending a passage. In the second language reading research, Alderson (2000) points to "the importance of a knowledge of particular syntactic structures, or the ability to process them, to some aspects of second-language reading" and suggests that "the ability to parse sentences into their correct syntactic structure appears to be an important element in understanding text" (p. 37). Berman (1984) after a careful study found the grammatical effect on reading comprehension.

**Proficiency Tests**

'Just as no medical intervention would be prescribed before a thorough diagnosis of what ails the patient, so no language teaching programme should be designed without thorough analysis.' (Long,2005 P. 1) .A test measures an individual's ability to learn, knowledge on the topic, or performance in the specific subject. So, in case of a language test, the test measures performance, but the results imply the test-takers ability, or, to use a concept common in the field of linguistic competence. 'A language test', as Douglas (2000) says, "aims to elicit a person's language behaviour and to provide for a means of describing and judging that behaviour."

**METHODOLOGY**

As the present study intends to find out learners' performance in a writing test along with the reasons of the specific levels they achieve, there is a need to adopt mixed-methods approach which can trace out reasons from various perspectives. The mixed-methods approach has helped in the process of 'triangulation' and 'development' of the research data. The samples for the present study have been carefully chosen among the ESL college students of Odisha using random sampling techniques. For this purpose, students from five different technical and non-technical degree colleges have been taken into account. In total 300 numbers of students, equally from each college, form the sample size for the current study.

**Instruments Used**

The questions for writing test have been extracted from a standardised language proficiency test. Along with the questions for the written test a semi-structured interview has been arranged in order to determine the gap between the perception level and achievement level of the students' language proficiency and their overall views on English language.

**RESULTS AND DISCUSSION**

The above mentioned diagram (Diagram No.-1) depicts learners' perception on their proficiency in writing skill. There are seven relevant questions for the under-graduate ESL students in order to check their perception about writing skill. The same yardstick, as used for the other basic language skills, i.e. a three-point Likert scale (i.e. always, sometimes and never) is used to find out learners' perception about writing skill. The diagram (Diagram No.-1) shows out of 300 respondents 270 students are 'always' able to prepare answers in English for the class assignments. On the other hand, only thirty student can 'sometimes' write down the answers for the class assignments in English. There is nil response to the 'never' category. The second question makes an enquiry about whether the students are able to write examinations in English. It is found that all the respondents i.e. 300 out of 300 students are 'always' able



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to write examinations using English. Question no. 3 asks the abilities of the students about writing down stories in English. 186 respondents are 'always' able to write down stories in English. Out of the rest, 108 students can 'sometimes' write down stories in English and 6 students only opined that they can 'never' write down stories in English. Similarly, in question no.4 108 respondents, as shown in the diagram (Diagram No.-4) are 'always' able to create blogs and write down in English. However, 60 students expressed that they can 'never' create and write blogs in English. On the other hand, 132 students can 'sometimes' create and write down blogs in English. 264 samples expressed that they are 'always' able to write down laboratory records in English. On the other hand, 36 students responded that they can 'sometimes' write down laboratory records in English. There is nil response for 'never' category. Out of 300 respondents 234 students are 'always' able to answer letters or e-mails in English. The rest 66 can 'sometimes' answer the letters or e-mails in English. However, there is nil response for the 'never' category. Similarly, the last question has not been responded by any sample.

The diagram (Diagram -2) shows the achievement test, related to speaking skill, results of 300 samples taken for the study. It contains 3 different questions in three different parts i.e. Part-1, Part2 and Part-3. Six students have excellent performance to put themselves in 7-8 brackets which is C1 category as per CEFR rating. Similarly, 94 students have a very good flair for writing as they have scored 5.5-6.5. 93 respondents out of 300 are within 4-5 range. Similarly, the rest 107 participants have underscored. The above diagram (Diagram-3) shows the score of 300 respondents for question no. 2. 9 respondents out of 300 have scored 7-8 to keep themselves in C1 category as CEFR rating scale. However, there is no student who has scored more than 8 in this piece of writing. Similarly, in the 5.5-6.5 category there are 92 students and in 4-5 category, 87 students. 112 students have underscored which is below 3.5. The diagram (Diagram-4) displays the score of all the respondents about their performance in question no. 3 of the achievement test related to writing skill. As shown in the diagram, (Diagram-4) nobody has scored more than 8 for this question. However, 6 students have excellent performance and scored 7-8. Out of the rest 83 students have performed well in this answer and scored 5.5-6.5. Similarly, 78 students are in the 4-5 range and 133 students have underscored i.e. below 3.5.

**CONCLUSION**

Data reveals the prominent gap between the perception level and achievement level of the English language proficiency among ESL college students in Odisha. Improper infrastructure, academic background of the students, inappropriate syllabus (not paying attention to communicative competence) may be treated as the prime factors responsible for the inadequate competency level among the ESL students in Odisha. Language teachers need to ensure that learners get ample opportunities to practice writing both inside and outside classroom situation. Similarly, the syllabus designers and materials producers should provide scope to the learners to practice writing by incorporating interesting and motivating writing tasks which should be from guided writing to free writing.

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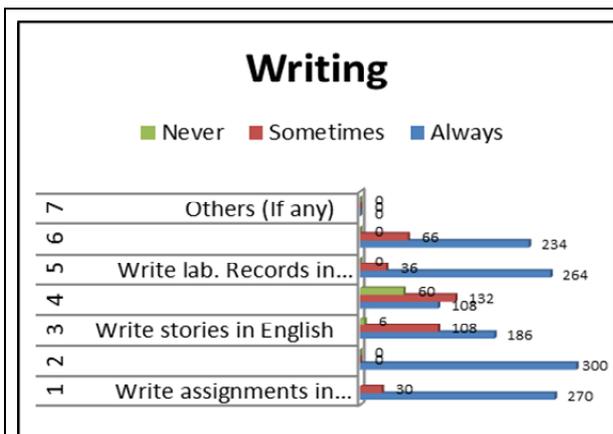


Diagram-1 Writing Test Results (Questionnaire)

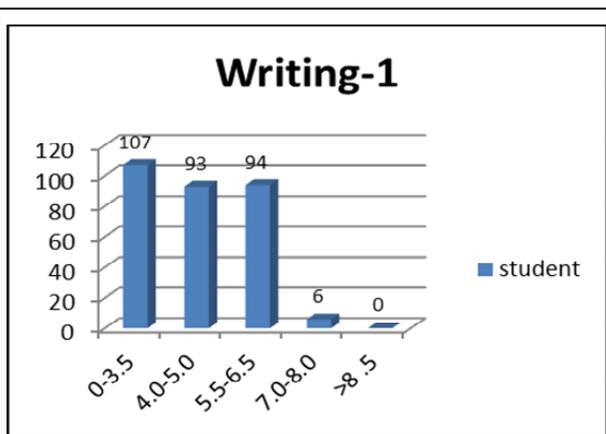


Diagram-2 Writing Test Result (Part-1)

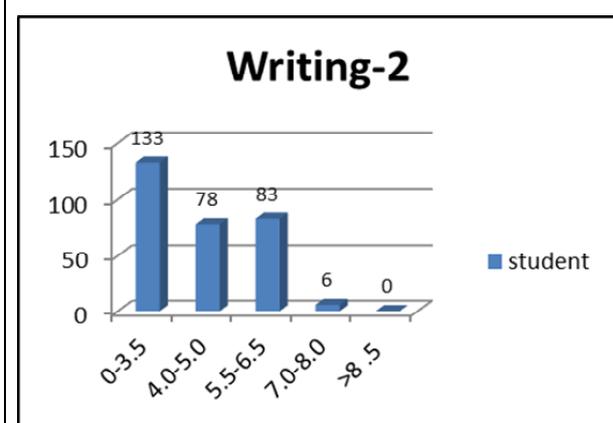


Diagram-3 Writing Test Result (Part-2)

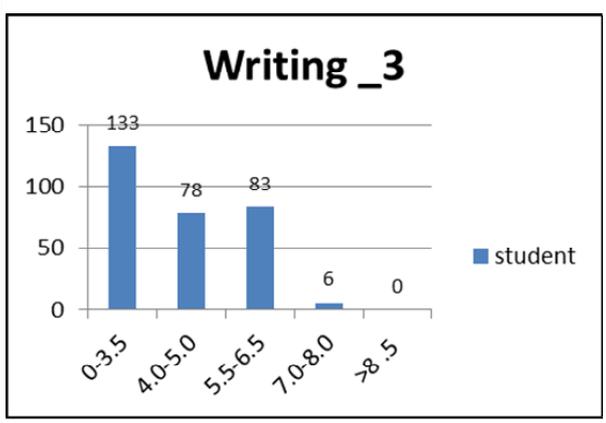


Diagram-4 Writing Test Result (Part-3)





## Influence of Working Condition and Sanitation Facility on Employees Commitment of Work: A Case Study of Apsrtc, Srikakulam Depot

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### ABSTRACT

Transportation is one of the major industries in the state of Andhra Pradesh and has displayed tremendous service base creation of wide range of area coverage in the development of efficient human resource. Transportation has rolled out potential improvements in the method for living and the manner by which social orders are composed and in this way have an extraordinary impact in the advancement of civilization. This chapter conveys an understanding of the importance of study on APSRTC in the modern society by presenting selected characteristics of existing transportation systems in HRM practices and relationships to other human activities. Transport in the Republic of India is an important part of the nation's economy. This research paper is an attempt to investigate is it always possible the welfare facilities provided by the organisations sufficient to provide job satisfaction to its employees. This research investigates whether the welfare facilities like Improved Working Condition and Sanitation facility can help to provide job satisfaction in to APSRTC employees in Srikakulam Depot (AP). To investigate this primary data were collected then with the use of chi-square method the hypotheses were tested that highlights welfare facilities always do not provide job satisfaction.

**Keywords:** Working Condition, Sanitation facilities, Commitment, Employee Welfare etc.





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## INTRODUCTION

Transportation systems form important area for a modern society. Efficient and safe movement of people and goods guarantees a thriving economy and provides for an improved quality of life. Because transportation systems are interrelated with many other activities, the challenges of creating and managing transportation systems must be addressed in an interdisciplinary approach. The greatest strength of India is its abundant human resources. The prosperity of a nation or an organization depends on the proper development and utilization of its human resources, as all other resources can be generated by a well motivated human resource. Organizational growth, change and success ultimately depend on the actions of human resources.

The Transportation is one of the major industries in the state of Andhra Pradesh and has displayed tremendous service base creation of wide range of area coverage in the development of efficient human resource. Transportation has rolled out potential improvements in the method for living and the manner by which social orders are composed and in this way have an extraordinary impact in the advancement of civilization. This chapter conveys an understanding of the importance of study on APSRTC in the modern society by presenting selected characteristics of existing transportation systems in HRM practices and relationships to other human activities. Transport in the Republic of India is an important part of the nation's economy.

In the present global industrial scenario, every industry is trying its best to regain top position to attract and retain its customer base. It is essential to inculcate effective provisions of welfare measures to employees, consciousness of welfare activities both inside and outside environment of an organization. Many companies identified this as a major thrust area from the beginning and continuously putting efforts for improvement in the welfare systems in a positive & effective manner in the organization. These efforts have been appreciated and recognized by several Government bodies and APSRTC is also one amongst them.

## LITERATURE REVIEW

The labour welfare measures determine its influence on job satisfaction that affect the attitudes of employees towards work. Particularly the labour welfare facilities improve the employee morale and confidence to improve their working life, family life and overall welfare. Research explored the connectedness between welfare and job satisfaction, but limited research done in the field transport companies where most of the employees work more than eight hours per day. It seems to be very ineffective for providing proper working condition and slowly reducing the interest of the employees.

Goyal (1995) investigated the impact of labour welfare measures on job satisfaction in the textile industries in Punjab and observed the relationship in between job satisfaction and labour welfare. The study investigated that the rate of job satisfaction is depending on the welfare facilities provided by the organization. More the facilities can leads to the performance of the workers a lot. Hence awareness of welfare facilities will improve the efficacy among the employees. Further the study critically assessed the problems and suggested ways to improve the implementation of labour welfare measures. In her research a comparative study was made between six cotton textile industries in Punjab belonging to the private, public, and co-operative sectors. Based on random sampling, 350 textile workers in these sectors in Punjab formed the sample of the study. The results of the study revealed that majority of textile workers were satisfied with their job. The findings of the study also revealed the percentage of workers in the textile industries studied, who were satisfied with their jobs due to the provision of various statutory labour welfare facilities. Majority of the workers were satisfied with their jobs with respect to retirement benefits like gratuity and provident fund. The number of such satisfied workers was the highest in the private sectors and the minimum in the public sectors. But only a few workers were found to be highly satisfied and highly dissatisfied with their jobs in this regard.





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A small percentage of workers were dissatisfied with their jobs with respect to recreational facilities. The percentage of satisfied workers was the highest in the private sectors and minimum in the public sectors. A fairly large percentage of workers were satisfied with their jobs with respect to medical benefits and housing facilities. The private sectors had the maximum number of satisfied workers while in the public sectors minimum number of the workers was satisfied in this regard. In her study, Goyal (1995) determined the extent of job satisfaction experienced by textile workers due to primarily the statutory labour welfare services provided by private, public and co-operative textile sectors in Punjab, the awareness and implementation of these labour welfare services and their correlation with job satisfaction, including relationship between job satisfaction and labour welfare. However researcher did not investigate the influence of personal factors (such as gender, age and experience) and hierarchy on the level of job satisfaction of the textile workers studied, compared to the level of job satisfaction experienced by these workers in the different sectors of the textile industry, that influence of the non-statutory measures. The difference of statutory and non-statutory measures of welfare facilities can influence the employee in various sectors towards their job satisfaction.

Assessment of welfare provisions can be measured by 1) Trend analysis and 2) Opinion survey (Aswathappa, 2007). The former is indirect method, which measures trends of efficiency, turnover and social evil as an impact of welfare activities, observed at pre and post implementation of welfare provisions. The later is most effective and real time method based on measurement of employee's satisfaction and perception relating to 58 welfare provision. Hence, the second method is adopted for assessment of implementation of welfare measures in private and public sector companies. The term labour welfare is only applicable to labour. During industrialization process, the stress on labour productivity increased; and brought about changes in the thinking on labour welfare. An early study under the UN observed as follows "in our opinion most underdeveloped countries are in the situation that investment in people is likely to prove as productive, in the purely material sense, as any investment in material resources and in many cases, investment in people would lead to a greater increase of the flow of goods and services than would follow upon any comparable investment in material capital" (UN, 1951). The theory states that welfare expenditure, especially expenditure on health and education, is productive investment has led to the view that workers could work more productively if they were given a fair deal both at the work place and in the community.

Lawrence A. Leger (1993) explained that both labour groups and national press frequently justify demands for protection against industrial adjustment on the justification that it leads to the destruction of communities and traditional ways of life, with a devastating effect on welfare. To justify this claim in the context of a Ricardian open-economy model requires quite strong restrictions on worker preferences, but a plausible case can be made. It presents a model based on the attachment of workers to their socio-cultural environment, and suggests some policy options for redressing trade-induced inequities. Steven J. Haider, et. al (2003) explored nationally, the welfare caseload declined by more than 50% between 1994 and 2000. Considerable research has been devoted to understanding what caused this decline. Much of the literature examining these changes has modeled the total caseload (the stock) directly. Klerman and Haider (forthcoming) model shows the underlying flows and show analytically and empirically that previous methods are likely to be biased because they ignore important dynamics. However, due to their focus on the bias of the stock models, they present only limited results concerning the robustness of their findings and utilize only a single measure of economic conditions, the unemployment rate.

Van De Stadt et al., (1985) and Winkelmann and Winkelmann (1998) the two closest antecedents were studied panel data on subjective welfare. The first researcher worked in panel data by utilizing the model called money metric of subjective welfare in the Netherlands. The entire study has constructive to the difference in the dependent variable, where they do not allow for latent individual effects. However, they do allow for changes, by including the lagged subjective welfare measure as a regressor (though they cannot reject the null that its coefficient is unity). The researchers admitted on the narrow concept in the expectation that will offer sharper results on the welfare effects of economic variables and also use a better income measure.



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On the other hand Winkelmann and Winkelmann, (1998) explained, anyone can also expect that the income measurement error can be correlated with other variables. For example, it can be assume that a wealthy person tend to understate their incomes when asked by a stranger in an interview for some survey. (In the mid 1990s this is not improbable in Russia). They are just like unemployed. Then there will be negative correlation exist between unemployment and subjective welfare which also could possible as a measurement errors. Unemployment will appear to lower subjective wellbeing even it has no real welfare effect beyond the loss of income. Similarly, when the time period is short to measure the incomes it considered as self-assessments of welfare. The authors can expect unemployment and possibly other characteristics to be correlated with the difference between the two income measures i.e. employment and unemployment. Unemployment might have a significant negative effect on subjective welfare at given current income because respondents naturally worry about future income also. That does not mean that leisure is objectionable, or that there are no adverse incentive effects of unemployment compensation. Otherwise remarkably high estimate of the level of unemployment benefits needed to create unemployment implied by the results in the research where income effect is underestimated while the unemployment coefficient is overestimated.

In addition of income to subjective welfare this could be claimed as relative income for some reference group but not considered as absolute income that matters to wellbeing. Stadt et al., (1985) and Clark and Oswald (1996) worked on subjective welfare indicator on both own income and group income named as mean income of people with similar characteristics. The group income is found to have a significant negative coefficient with own income. Both research concluded that it is relative income that matters to welfare. However, the significant effect on predicted income could also reflect a misspecification. For example, earnings are influenced by latent personality traits in subjective welfare via the effects on higher job satisfaction of labour turnover and clash (discussed by Frank, 1985 and Clark & Oswald, 1996). Then the significance between predicted income and own income could correlate on determinants of subjective welfare. Hence income endogeneity can generate spurious comparison group effects.

The wage inequality is deeply explained in the trade theoretic models such as wage predictions in the higher-dimensional Heckscher-Ohlin (H-O) framework, Feenstra and Hanson (1995) and Marjit, Broll and Sengupta (2000). All the studies revealed about the wage inequalities among the income groups. They explained empirically, but lot of ambiguity found where no specific ideas explained on structural characteristics of wage turn over or capital mobility. No studies done in the less developed countries where labour welfare is a measure concern.

### Research Gap

1. Particularly no research revealed about sanitation facilities provided by the organization like a transportation company which is a major part of statutory welfare facilities. In the present research paper we tried to find the gap to test the impact of Sanitation facilities provided by APSRTC on employee job satisfaction.
2. No research properly examined the working conditions in Transportation Company where large population expects adequate working condition. In this paper we examined the research gap to test the impact of working condition provided by APSRTC on employee job satisfaction.

### OBJECTIVES

1. To assume employee welfare services and the performance of employee.
2. To test the impact of sanitation facilities provided on APSRTC's employees' commitment those who are working in APSRTC.
3. To test the impact of working condition of APSRTC's employees' those who are committed APSRTC.





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## HYPOTHESES

1. **Null Hypothesis (H<sub>0</sub>):** There is no significant influence of sanitation facilities on APSRTC's employees' commitment those who are working in APSRTC.  
**Alternate Hypothesis (H<sub>1</sub>):** There is significant influence of Sanitation facilities on APSRTC's employees' commitment those who are working in APSRTC.
2. **Null Hypothesis (H<sub>0</sub>):** There is no significant influence of working condition on APSRTC's employees' commitment those who are working in APSRTC.  
**Alternate Hypothesis (H<sub>1</sub>):** There is significant influence of working condition on APSRTC's employees' commitment those who are working in APSRTC.

## RESEARCH METHODOLOGY

### Sampling Frame Work

Sampling frame is defined as the set of selected source materials. Sample design in the present survey is very important to frame the sample. Further the definition encompasses the purpose of sampling frames, which provides a means for choosing the particular members of the target population that are to be interviewed in the survey. The sampling frame has significant influence on the outlay for conducting the survey and the quality of any survey; here the survey is directed to be conducted on the employees of APSRTC working in Srikakulam Depot. In such kind of sample surveys imperfect sampling frames are a common source of non-sampling error, particularly under-coverage of important population sub-groups. Therefore it is absolute to elaborate the perfect practice in sample frame construction and use various techniques of sampling.

Particularly, the nature of research is to obtain the statistical information from the opinion of the employees. The area selected for the research is APSRTC Srikakulam Depot as a whole. Thus completely, the data were collected from the APSRTC, Srikakulam Depot. The sample will be selected from the total population of the respondents. Under this section it is important to frame the sample in such a manner that the information received will be maintained in proper and authentic way to justify the result. The following respondents are classified as:

### Sampling Technique or Method

The present study Influence of working condition and sanitation facility on employees commitment of work: A case study of APSRTC, Srikakulam Depot is a study based on the survey method among the employees working in APSRTC Srikakulam Depot (Andhra Pradesh). A sample of 431 employees has been taken at Srikakulam Depot on the basis stratified random sampling grouped into 10 categories. The sample covered all the segments of employees in the organization. To collect first-hand information an administered questionnaire was circulated to selected manpower.

### Sample Size

To determining the sample size in a given population an efficient method is used. The sample is selected on the basis of the research work of Krejcie & Morgan (1970), Glenn (1992) which is adequate enough to represent the whole population. The present study thus covers approximately 431 respondents who are the employees of APSRTC located in Srikakulam Depot (Andhra Pradesh) and they constituted the total population for the survey. As per the sample size selection procedure out of total 431 sample population size only 186 samples were considered for survey.

$$S = \frac{X^2 NP (1-P)}{d^2 (N-1) + X^2 P (1-P)}$$

s = requisite sample size.

X<sup>2</sup> = chi-square table value for 1 degree of freedom at the desired confidence level is (3.841).

Here the value 3.841 is derived by 1.96 X 1.96 = 3.841

N = the size of population.





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P = the population proportion (assumed to be .50 as the maximum sample size).

d = the degree of accuracy articulated as a proportion (.05).

**Sampling Unit**

Sampling unit consist of a single section selected to research and gather statistics of the whole. Here in this case when there is the requirement to study the group of employees working in APSRTC located in Srikakulam Depot, a single employe of APSRTC will be considered as a sampling unit.

**Data Source**

This refers from where the data are to be collected so that the research can be conducted in a proper manner. The source of data in this research thesis is APSRTC, Srikakulam Depot. The data are collected from the employees work in different department and fragment in Srikakulam Depot (Andhra Pradesh).

**Data Preparation**

For data preparations following things were taken into consideration:

**i) Target Population**

The target population was all staff working for APSRTC and all of them were deployed at Srikakulam Depot (Andhra Pradesh) approx. 431. The target population consist all the organization's department. From the target population the sample selection has been done.

**ii) Data Collection Instrument**

At the time of constructing theoretical framework, secondary data collection procedure was used. The secondary data sources are internet, books, reports and journals, newspaper etc. Whereas, the primary source of data collection were used for the purpose of collecting data to examine data for bringing the findings. Here the primary source of data is structured as questionnaires for interview. Structure questionnaire contain multiple choice questions that is based on the four point LIKERT scale. It includes 4 for very satisfied, 3 for satisfied, 2 for least satisfied and 1 meant for not satisfied. In this way the research has used both primary and secondary data which helps in determination of accurate findings.

**iii) Validity and Reliability of instruments**

Reliability of measurement instruments contributes to validity of research findings. If an instrument will be measuring what is not designated to measure, then the instrument fails to be valid and would yield unreliable result. Therefore in this research the data validation methodology was applied as well as the other trusted qualitative research methodology was used.

**Instruments Reliability**

It is a way to ensure that whenever the researcher uses any instrument to measure, the experimental variable will give the same result every time.

**Validity of the Instruments**

To ascertain research validity of the research instrument, the researchers intensively consulted his supervisor on items analysis and accuracy of the questionnaire and the observation guide items in relation to the variables of the study. The researcher also widely made consultations with colleagues on questionnaire development. This led the development of a scale which logically reflected what it purported to measure, enabling the researcher to obtain sufficient information on the factors affecting performance of employees with provided welfare facilities.

In order to insure validity and reliability of data following things were carried on:

- i. Use of past data



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- ii. Discussion with expert
- iii. Cross checking of the filled questionnaire open ended questions.
- iv. Explore the new facts rather than being prejudiced on past researches.

**Analysis**

This analysis section is divided into two sections, the section-A deals with the demographic condition of the employees of APSRTC and the section-B deals with the statistical analysis.

**SECTION-A**

In this section, the researcher has taken all the steps to test the employee welfare and its impact on the job satisfaction in APSRTC and its role in delivering the sustainable growth. For this reason, the researcher decided to use the Likert type scale and used the primary information received from the employees of APSRTC placed at Srikakulam Depot located in Andhra Pradesh region who are involved in providing different services to the people of Andhra Pradesh. The researcher here under-explains the demographic distribution of the respondents who are primarily the employees of APSRTC, Srikakulam Depot (AP).

**Demographic Conditions of Respondents**

According to the objectives the data have arranged systematically and collected through 4-point Likert scale to find the suitable result. Table.2 reveals that total 215 numbers of questionnaires were actually distributed among the various age group of both male and female respondents. Table.2 represents the response status of respondents, which highlights out of total distributed 215 questionnaires only 14 questionnaires were not returned which accounts 6.51%. While rest 201 questionnaires came up with the mix of correct and incorrect information in which 15 were incomplete responses, which count merely 6.97%. This reflected another side of the response sheet. 186 respondents come up with their responses without any error. Hence we considered 186 samples as final inputs of this survey.

The following Table.3 pointed out the gender of the employees working in APSRTC Srikakulam Depot. It is observed that out of 186 respondents 168 are males and rest 18 belong to women category. Thus it is to conclude that 9.68% of women are employed in APSRTC at Srikakulam Depot while 90.32% of male are employed in the same organisation. The following Table.4 exhibited the information regarding years of employment of the employees working in APSRTC Srikakulam Depot. The above Table.4 reveals that total 186 numbers of respondents only were taken into consideration to find their experience with APSRTC. It is observed that largest of among 58 respondents were have 15 to 20 years of work experience with APSRTC and their percentage is highest amongst all with 31.18%. The respondents those were covered in the research having more than 10 years of work experience were of 31 in numbers that count to 16.67%. 24.73% of respondents were of 5 to 10 years experience in APSRTC followed by less than 5 years experience in APSRTC which constitute 18.82% of the total. The data collected from the respondents brought out an interesting fact that less than 10% respondents were having experience for more than 20 years.

The following Table.5 exhibited information regarding the marital status of the employees who are working in APSRTC Srikakulam Depot. The above Table.5 provides the information about the marital status of the employees working in APSRTC at Srikakulam Depot. This section is divided into three (3) categories i.e. Married, Single and Widowed. The responses received from the participants of research survey that the married personnel are of higher side that accounts 119 in numbers out of 186 that makes 63.98%. Whereas; the percentage of single account to 31.72%, i.e. 59 in number, But this section does not include widowed. It is clear from the above table that out of 186 total number of sample respondents widowed accounts to 8 and their percentage is 4.30%. When the employee respondents were asked about the awareness of welfare facility, the responses received in the form of yes and no. From the following Table.6 it is observed that the 75.81% of respondents agreed that these 141 number of employees





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are very much aware about the welfare facility provided by APSRTC Srikakulam Depot. But in contrary 24.19% of employees are not satisfied with the welfare services provided by APSRTC Srikakulam Depot. When the employees were asked about the level of satisfaction of welfare facility received in APSRTC, the responses received in the form of Excellent, Good, Fair and Bad. From the following Table.7, it is observed that the 87.62% of respondents agreed that they are getting satisfaction because of the welfare facility they are receiving. But they rate it in different forms some said excellent and some said fair. Out of 186 respondents 74 respondent that counts highest amongst all these responses the level of welfare facility received by them is excellent i.e. 39.78%. At the same time 53 out of 186 respondents viewed good about the level of welfare facility they received i.e. 28.49%. it is observed from the following table that 19.35% of the employees are of fair opinion about the level of welfare facility that counts to 36. The following section-B will discuss in detail on various aspects relating to impact of welfare activities carried out by the APSRTC, Srikakulam Depot.

## SECTION-B

### Testing of Hypothesis

**Null Hypothesis (H<sub>0-1</sub>):** There is no significant influence of sanitation facilities on APSRTC's employees' commitment those who are working in APSRTC.

**Alternate Hypothesis (H<sub>1-1</sub>):** There is significant influence of Sanitation facilities on APSRTC's employees' commitment those who are working in APSRTC.

In this present study the researchers have to test the hypothesis on "There is no significant influence of sanitation facilities on APSRTC's employees' commitment those who are working in APSRTC". To test the hypothesis the researchers took the response from 186 employees distributed under four categories i.e. drivers, conductors, workshop employees and clerical and administrative staff and for obtaining the response through Four point Likert's type scale. The researchers asked eight questions that lead to the level of satisfaction derived due to the sanitation facility provided to them. The detailed of responses were recorded in the table and the chi-square test was used to test the hypothesis on satisfaction of employees on sanitation facility provided by APSRTC.

From this given table it is can be observed that the tabulated value of 40.1 is higher than the calculated value calculated value of 8.09 (i.e.  $8.09 < 40.1$ ) at 27 degree of freedom at 5% level of significance. Hence the hypothesis is accepted.

### Testing of Hypothesis

**Null Hypothesis (H<sub>0-2</sub>):** There is no significant influence of working condition on APSRTC's employees' commitment those who are working in APSRTC.

**Alternate Hypothesis (H<sub>1-2</sub>):** There is significant influence of working condition on APSRTC's employees' commitment those who are working in APSRTC.

To test the above hypothesis the researchers took the responses from 186 employees distributed under four categories i.e. drivers, conductors, workshop employees and clerical and administrative staff. They used Four point Likert's scale and asked ten questions that lead to the level of satisfaction derived due to the working conditions on employees' commitment level. The details of responses were examined through the chi-square to validate the hypothesis. From the above table it is observed that the tabulated value at 27 degree of freedom at 5% level of significance is 40.1 which is higher than the calculated value, i.e. the calculated value is less than the tabulated value ( $9.34 < 40.1$ ).



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## SUGGESTIONS AND CONCLUSION

The present study is an investigation of working condition and sanitation facility on employee's commitment of work in APSRTC, Srikakulam Depot. This research is an approach to find the extent of awareness and implementation of labour welfare measures like providing the sanitation facilities as well as providing better working condition to the employees and the extent to which these measures have been successful to improve the employees' job satisfaction. Further the study critically assessed the problems and suggested ways to improve the implementation of labour welfare measures in providing the sanitation facilities and better working condition. The research has found that the welfare facilities like sanitation facilities and improved working condition facilities do not significantly put impact on the employees' job satisfaction of APSRTC in Srikakulam Depot, Andhra Pradesh. It is observed that the majority of the APSRTC employees are not aware about non-statutory welfare measures and only very few of them are aware about statutory welfare measures. It gives a clear conclusion that employees are unable to identify the measures that are part of statutory and non-statutory welfare measures. Hence, there is a need for awareness programs through conducting workshops, keeping boards specifying the statutory and non-statutory welfare measures at work places. It is also felt that there is an immediate need for conducting sessions or workshops for creating awareness to the existing as well as newly joined employees from the categories including Drivers, Conductors, Workshop Employees and Clerical & Administrative staff.

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**Table. 1 Respondents classification**

Sl. No.	Type of Respondents	No. of Respondents
1	D.M	1
2	P.D	6
3	A.D	3
4	Traffic	22
5	Drivers	147
6	Conductors	192
7	Security	5
8	Garage (Maintenance / Technical)	47
9	S.S	1
10	ITI	7
<b>Total Responses</b>		<b>431</b>

**Table.2: Rate of Responses of Respondents**

1	2	3	4
Very Satisfied	Satisfied	Least Satisfied	Not Satisfied

Sample Data	Responses Received	Percentage of Responses Received
Actual distributed	215	100%
Returned	201	93.48%
Never Returned	14	6.51%
Response Received	186	86.51%
Incomplete	15	6.97%
Response %	86.51%	86.51%
Total Non Response %	13.48%	13.48%

Source: Field Survey

**Table.3: Employees Gender classifications**

Gender	Number of Respondents	Percentage of Responses
Female Respondents	18	9.68
Male Respondents	168	90.32
Total Respondents	186	100

Source: Field Survey

**Table.4: Years of employment in APSRTC at Srikakulam Depot**

Years of employment	Number	percentage
Less than 5 years	35	18.82
5 years to10 years	46	24.73
10 years to15 years	31	16.67
15 years to 20 years	58	31.18
Above 20 years	16	8.60
	186	100

Source: Field Survey





Table.5: Classification on Marital Status

Marital Status	Number	Percentage
Married	119	63.98
Single	59	31.72
Widowed	8	4.30
<b>Total</b>	<b>186</b>	<b>100</b>

Source: Field Survey

Table.6: Awareness on Welfare Facility

Opinion of Respondents	Number	percentage
Yes	141	75.81
No	45	24.19
<b>Total</b>	<b>186</b>	<b>100.00</b>

Source: Field Survey

Table.7: Level of Welfare Facility of the Employees

Opinion	Number	Percentage
Excellent	74	39.78
Good	53	28.49
Fair	36	19.35
Bad	23	12.37
	<b>186</b>	<b>100</b>

Source: Field Survey

Table.8: Opinion of APSRTC's employees towards the impact of Sanitation facilities on the employee commitment level Observed Frequency

Sanitation Facility	Not Satisfied	Least Satisfied	Satisfied	Very Satisfied	Total
My depot has good sanitation for employees.	5	3	4	3	15
My depot has good latrines for employees.	5	5	4	4	18
My depot has separate latrines for female and male employees.	5	3	7	4	19
This depot has a staff room.	5	3	5	4	17
The staff room has working tables for employees.	4	8	5	5	22
The depot have enough sitting facilities for all employees	4	6	7	4	21
This depot has good drainage that keeps off running water from entering classes	5	4	5	3	17
The depot environment is secure from intruders.	5	6	5	5	21
This depot is well fenced.	3	6	5	5	19
All depot floors are well cemented.	6	4	3	4	17
<b>Total</b>	<b>47</b>	<b>48</b>	<b>50</b>	<b>41</b>	<b>186</b>





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Table.9: Expected Frequency

Sanitation Facility	Not satisfied	Least satisfied	Satisfied	Very satisfied	Total
My depot has good sanitation for employees.	3.79	3.87	4.03	3.31	15
My depot has good latrines for employees.	4.55	4.65	4.84	3.97	18
My depot has separate latrines for female and male employees.	4.80	4.90	5.11	4.19	19
This depot has a staff room.	4.30	4.39	4.57	3.75	17
The staff room has working tables for employees.	5.56	5.68	5.91	4.85	22
The depot have enough sitting facilities for all employees	5.31	5.42	5.65	4.63	21
This depot has good drainage that keeps off running water from entering classes	4.30	4.39	4.57	3.75	17
The depot environment is secure from intruders.	5.31	5.42	5.65	4.63	21
This depot is well fenced.	4.80	4.90	5.11	4.19	19
All depot floors are well cemented.	4.30	4.39	4.57	3.75	17
<b>Total</b>	<b>47</b>	<b>48</b>	<b>50</b>	<b>41</b>	<b>186</b>

Table.10: Chi-square Test

Test	Calculated Value	df	Tabulated Value	Decision
Chi-Square ( $\chi^2$ )	8.09	27	40.1	ACCEPT

Table.11: Opinion of APSRTC's employees towards the influence of Working Condition on the employee commitment level-Observed Frequency

Working Condition	Not Satisfied	Least Satisfied	Satisfied	Very Satisfied	Total
Employees prepare daily work Fig	6	8	7	4	25
Always employees use work Fig in the office.	5	6	3	6	20
Employees are always present at depot supervising all depot activities.	7	3	6	4	20
There is efficient employee management system at depot.	5	5	4	5	19
There is regular attendance by all employees at depot.	5	4	5	3	17
There is regular assessment of employees through feedback and self assessment	6	5	3	3	17
The turn up of employees in staff meetings is high.	3	4	3	5	15
The supervisor is always at depot supervising depot activities.	4	4	6	4	18
There is effective employee participation in staff meetings.	3	3	4	3	13
Employees always maintain a record of work covered.	6	5	6	5	22
<b>Total</b>	<b>50</b>	<b>47</b>	<b>47</b>	<b>42</b>	<b>186</b>



**Table.12: Expected Frequency**

Working Condition	Not Satisfied	Least Satisfied	Satisfied	Very Satisfied	Total
Employees prepare daily work Fig	5.91	6.59	6.32	6.18	25
Always employees use work Fig in the office.	4.73	5.27	5.05	4.95	20
Employees are always present at depot supervising all depot activities.	4.73	5.27	5.05	4.95	20
There is efficient employee management system at depot.	4.49	5.01	4.80	4.70	19
There is regular attendance by all employees at depot.	4.02	4.48	4.30	4.20	17
There is regular assessment of employees through feedback and self assessment	4.02	4.48	4.30	4.20	17
The turn up of employees in staff meetings is high.	3.55	3.95	3.79	3.71	15
The supervisor is always at depot supervising depot activities.	4.26	4.74	4.55	4.45	18
There is effective employee participation in staff meetings.	3.08	3.42	3.28	3.22	13
Employees always maintain a record of work covered.	5.20	5.80	5.56	5.44	22
<b>Total</b>	44	49	47	46	186

**Table.13: Chi-square Test**

Test	Calculated Value	df	Tabulated Value	Decision
Chi-Square ( $\chi^2$ )	9.34	27	40.1	ACCEPT





## Mathematical Model to Develop Rule for Pulmonary Tuberculosis

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### ABSTRACT

A In the recent years many research works have been conducted and developed many therapies to diagnose pulmonary tuberculosis .There are thousands of common symptoms for several diseases which makes it very difficult to find which symptoms are responsible for pulmonary tuberculosis. In this paper we did a comparative study by using local covering techniques and strength of rough set to find the reduct which leads to give correct information regarding symptoms of pulmonary tuberculosis.

**Keywords:** Physician data, Rough Set theory, Descriptive and Predictive Data mining

### INTRODUCTION

The field of medical science has witnessed many research works and produced different results regarding several unconventional diseases which always bring challenge for the doctors to handle these diseases with conventional therapy. Large physician database has always been a challenge for scientists and doctors to correctly derive knowledge [1]. Database on human biology have gathered huge volumes of medical information. Analysis of the gathered information provided with new medical information often ended with insufficient information [2]. Often data analysis based upon assumptions of knowledge about the reliance, theory of probability and various experiments, not useful tool to derive the conclusions correctly neither from non-detail information nor to manage the data consistency. The very basic techniques used in physician data processing are NN [3], BC [4], GA [5], DT [6], FT [7]. The basic concept of RST develops by Polish Mathematician Z.Pawalk in early 80's. Rough set theory loosely based on conventional set theory which is useful to derive rules from non- detail information. It is very useful to





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find the relationship between the information set to evaluate the usefulness of the entities and to find the nature of the entities. To get a conclusion, decrease all repeated entities and its properties and seek the least subset to get a satisfactory result. Further, rough set reduction algorithms are very handy in developing new ideas and to guess the conclusion, they forms a class using general pattern algorithm [9]. Rough set theory is nicely handled by scientists around the globe and it is now one of the most useful tool in developing Data Analysis Tool with brain, different from other research methodology such as FST. RST does not require any additional variables for decision making it extract the hidden information from the given data set [10]. In our investigation we give major importance to derive a pattern by using the available samples of the pulmonary tuberculosis cases. We divided this entire paper in four different Sections as follows: Section 1 is introductory in nature; Section 2 contains the basic concept of RST and some basic statistics. Section 3 Analyze the information which we collected from different hospitals and develop a general purpose algorithm to classify pulmonary tuberculosis. Section 4 deals on statistical validation of the rule that is generated from the algorithm and conclusion.

## ELEMENTARY CONCEPTS

**Rough Set Theory:** RST was develop by Z. Pawlak [8] derive from crisp set theory which is helpful in decision making.

**Conjecture Space.**  $(U, R)$  is called as Conjecture space where  $U$  is the universe and  $R$  is the set of equivalence classes define on  $U$ .

**General Report System.**  $(I, A)$  is called as GRS where  $I$  is general information system and  $A$  is the set of attributes define on it.

**Rule Derivation Table.** A RDT is a special case of GRS systems  $K = (I, L = P \cup \{d\})$ ,  $P$  and  $d$  are called as conditional attributes and decision attributes respectively. Where  $d$  not present in  $P$ .

### Attributes Dependencies

$R$  is depending upon  $P$  with degree  $s$  if for  $(0 \leq s \leq 1)$  denoted by  $R \rightarrow^s P$  if  $R = V(s, P) = \frac{POSITIVE_C}{|CARDINALITY|}$  where

$POSITIVE_C(P) = \text{Universal Set}$  and  $R \subset P$

### Reduct and Core

Let  $K = (\text{Universal}, A = \text{Con} \cup \text{Dece})$  is a table. Subset of  $A$  is called as Reduct if it is minimal sub set of a any further reduction does not helpful in decision making.

### Chi Squared Distribution

$\chi^2$  Test is a useful tool for statistically validate the claim for moderate sample size. It is Just to verify the result between the observed and expected frequencies difference.

### Error in Statistics

- 1) class-1 not accepting the concept when true
- 2) class-2 accepting the concept when not true





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### Key Ideas

The key ideas for the proposed work are developed from basic Health care system. We collect 1000 samples of Pulmonary tuberculosis cases and then choose three conditional attributes (Fever, Chest pain, Cough) for these conditional attributes we choose two decision attributes positive and negative.

### Reduction of Collected Data

As the complexities of medical science increases which is directly related with different types of unconventional disease which are not known previously. Volume of medical related data grows with time it is next to impossible to decide the symptoms for a particular disease. In this paper we have given more thrust on predictive and descriptive data mining that give emphasize on symptoms rather than expensive medical test. To describe this we are using RST concept on 20 different groups of specimen which we get by using statistics applied on 1000 specimen of pulmonary tuberculosis cases. In this paper the three conditional attributes Fever, Chest pain, Cough and the decision attributes as positive and negative which described in the table given below. For better understanding and clarity ( $R_1, R_2, R_3, R_4, R_5, R_6, R_7$ ) are define as entity sets and  $k_1$  as Fever,  $k_2$  as Chest Pain and  $k_3$  Cough and decision attribute Pulmonary Tuberculosis as I

### Boundary Region

In Rough set theory there are two basic ideas which make it different from conventional set theory that is lower approximation, upper approximation and boundary region. Lower approximation is object of interest is definitely within the region, upper approximation is probably inside the region boundary region is the difference between the upper approximation and lower approximation

### Analysis and Classification Result Extraction

To derive rule we used lower covering algorithm before using the algorithm. First find the characteristic sets the characteristics set is as follows. For incomplete information table the definition of tag of an attributes pair of values is updated.

- For an attribute  $k$  if  $\exists$  an instance  $y$  such that  $k(y) = ?$ , implies the respective result is not found, then instance  $y$  is not included in any tag  $[(k, t)]$  in  $k \forall t$
- For an attribute  $k \exists$  an instance  $y$  such that  $k(y) = *$ , then  $y$  included in  $\text{tag}[(k, t)] \forall t$
- For an attribute  $\exists k$  case  $y$  implies the related result is an feature result, i.e.,  $k(y) = -$ , again implies related result  $y$  should be included in  $\text{tag}[(k, y)] \forall$  specified values  $y \in V(y, k)$  of attribute  $k$ , where  $V(y, k) = \{k(y) \mid k(x) \text{ is specified, } y \in U, d(y) = d(x)\}$ .  $d$  is for the rule and  $L$  is the position of entities in the decision table given above

$[(T, 36.9)] = \{L_6\}$ ,  $[(\text{Temperature}, 38.7)] = \{7\}$ , where  $T$  is for Temperature  
 $[(T, 39.7)] = \{L_1, L_5\}$ ,  $[(\text{Temperature}, 41.8)] = \{3\}$ , Where  $T$  is for Temperature  
 $[(\text{CP}, \text{Significant})] = \{L_1, L_2, L_3, L_6\}$ ,  $[(\text{CP}, \text{Insignificant})] = \{L_4, L_5, L_7\}$ , where  $\text{CP}$ :Chest Pain  
 $[(\text{Cough}, \text{Significant})] = \{L_1, L_2, L_7\}$ .  
 $[(\text{Cough}, \text{Insignificant})] = \{L_4, L_5, L_6\}$ .

If  $y \in U, K_B(y)$  is defined as  $\bigcap$  of  $K(y, a), \forall a \in B$ , If  $a(y)$  is identified, then  $K(y, a)$  is the  $\text{tag}[(a, a(y))]$  and its value  $a(y)$ , derive in the following way

- for  $a(y) = ? \bigcup a(y) = * \rightarrow K(y, a) = \text{Universal Set}$ ,
- If  $a(y) = -$ , then the corresponding set  $K(y, a)$  is equal to the union of all tag of attribute-value pairs  $(a, v)$ , where  $v \in V(y, a)$  if  $V(y, a)$  is nonempty. If  $V(y, a)$  is empty,  $K(y, a) = U$ .





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$E=M$  Where M is all attributes presents in the table-1

$$P_K(1) = \{1, 5\} \cap \{1, 2, 3, 6\} \cap \{1, 2, 7\} = \{1\},$$

$$P_K(2) = \text{Universal Set} \cap \{1, 2, 3, 6\} \cap \{1, 2, 7\} = \{1, 2\},$$

$$P_K(3) = \{3\} \cap \{1, 2, 3, 6\} \cap U = \{3\},$$

$$P_K(4) = \text{Universal Set} \cap \{4, 5, 7\} \cap \{4, 5, 6\} = \{4, 5\},$$

$$P_K(5) = \{1, 5\} \cap \{4, 5, 7\} \cap \{4, 5, 6\} = \{5\},$$

$$P_K(6) = \{6\} \cap \{1, 2, 3, 6\} \cap \{4, 5, 6\} = \{6\}, \text{ and}$$

$$P_K(7) = \{7\} \cap \{4, 5, 7\} \cap \{1, 2, 7\} = \{7\}.$$

$P_K(y)$  may be explained as the minimum characteristics set of cases which are indistinguishable using all attributes from K, which can be explained for missing attribute values.

The relation  $T(B)$  is defined for the Universal set U.  $T(B)$  relation signifies for the set  $K(y) \forall y \in \text{Universal set}$

According to our case study  $(K1) = \{(1, 1), (2, 1), (2, 2), (3, 3), (4, 4), (4, 5), (5, 5), (6, 6), (7, 7)\}$

As there are two concepts that is two decision values that is yes and no  $(x, y) \in P(K)$  iff  $y \in P_B(x)$ .

Decision table presented below let us consider  $B = A$ . A-lower and A-upper approximations:  $\{1, 2, 3, 4\}$  and  $\{5, 6, 7\}$  are given below

$$\underline{K1}[1, 2, 3, 4] = [1, 2, 3],$$

$$\underline{K1}[5, 6, 7] = [5, 6, 7],$$

$$K1[1, 2, 3, 4] = [1, 2, 3, 4],$$

$$K1[5, 6, 7] = [4, 5, 6, 7].$$

#### Single Lower Local Covering Algorithm I/P :Input ,O/P:Output (SLLCA)

I/P: a set  $P \subset R$

O/P: a unique LC, S of P Set, (LC- Local covering)

Start

$R := P;$

$N := \emptyset;$

$J := \emptyset;$

while  $R \neq \emptyset$

begin

$S := \emptyset;$

$S_s := \emptyset;$

$S_n := \emptyset;$

$S(R) := \{t \mid [t] \cap R \neq \emptyset\};$

while  $(S = \emptyset \text{ or } [S] \not\subset P)$  and  $S(R) \neq \emptyset$

begin

Select a pair  $z = (at, vt)$  in such a manner that it belongs to  $S(R)$  and  $|[t] \cap R|$  is maximal.

If there is tie situation then, select a pair  $t \in S(R)$  with minimal cardinality of  $[t]$ ;

if tie is repeat for the 2<sup>nd</sup> time then select first pair;

$S := S \cup \{k\};$

$R := [k] \cap R;$

$S(R) := \{k \mid [k] \cap R \neq \emptyset\};$

if at is symbolic {let Vat be the domain of at} then

$S_s := S_s \cup \{(at, v) \mid v \in \text{Vat}\}$

else

$S_n := S_n \cup \{(kt, x..y) \mid \text{completely without any common in } x \text{ to } y \text{ and } u \text{ to } v\}$

Or  $\{(kt, x..y) \dots x, y \supseteq u, v\};$





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```

S(K) :=S(K) – (Sp ∪ Sn1);
end {while};
if [S] ⊆ P then
begin
  For each attributes that take any values within a given interval at with (at, k..l) ∈ S
  do
  While (S contains minimum two distinct Pairs (at, k..l) and (at, m..n) with Equal attribute that take any values
  within a given interval at)
  Substitute these with another fresh pair
  (at, frequent part of k..l and m..n);
  for every b in S
  do
  if [S – {b}] ⊆ P
  then S:= S – {b};
  N := N ∪ {S};
  end {then}
  else M := M ∪ {S};
  R:=P-[S][ J]S where S_f S [J]
end while;
for each S_J
do
if union of all equivalence class in J-S equals to all equivalence
class in J
then J:=J-S
end {procedure}
    
```

The set S (R) gives us all important pair R = {1, 2, 3, 4} is {(T, 39.1..40.8), (T, 36.8..40.3), (T, 40.3..40.8), (CP, significant), (CP ,insignificant), (Cough, significant), (Cough, insignificant)}.

[t] ∩ R is define as for t = (CP, significant) → {1, 2, 3} is the result, so (CP significant). The attribute CP is representative. As [(Headache, significant)] 6 ⊆ {1, 2, 3, 4}, so we go for the second iteration of the inner loop. In the inner Loop R = {1, 2, 3}, and the set S (R), after dropping S<sub>s</sub> ∪ S<sub>n</sub>, is {(T, 39.1-40.8), (T, 36.8-40.3) so (T,40.3 to 40.8) and (Cough is significant)}. The using two attribute pair values we have the following result) then [t] ∩ R gives us larger value. Length of [t] are equal for values of attribute pairs, so so we use the initial one(T, 39.1 to 40.8) → S = {(CP significant), (T, 39.1.40.8)}, [S ] = {1, 3} ⊆ {1, 2, 3, 4}, S is identified as basic candidates .Next a for loop which check whether T is minimal → first minimal complex and S = {S }.

New findings R = P- [S] = {1, 2, 3, 4} – {1, 3} = {2, 4}. The set S(R) of all applicable value of attribute pairs connected with fresh R is {(CP significant), (CP, insignificant), (Cough, significant), (Cough, insignificant)}. The initial principle, related to |[t] ∩ R|, is not selected any attribute. The next measure, the length of [t], completed with the following attributes: (CP, insignificant), (Cough, significant), (Cough, insignificant), we next choose value- attribute pair between next three: t = (CP, insignificant). [t] = {4, 5, 7} and R = {4} since [T]={ CP ,no} ⊄ {1,2,3,4} so enter to next process . The least significant attributes pair of values is (cough, no), → S={(chest pain, no), (cough, no)} Equivalence class S is {4,5} ⊄ {1,2,3,4}, S={4}, but S(R)= ∅ .

{1,2,3,4} - {(1,3) ∪ (4,5)}={2} is the next significant attribute. The only significant attribute-values pairs ,members of S(R), are (CP, yes) and (Cough ,yes)={1,2} ⊂ {1,2,3,4}.This is not changed in the initial iteration → the least set of attributes so the lower local cover is S {(CP, significant),(T ,39.1to40.8)},{(Cough, significant), (CP, significant)}. CP,





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T are defined in the above.

**So the rule generate as follows**

1. {(Chest pain, significant)}, (Temperature 39.1..40.8),} → (pulmonary tuberculosis ,positive)
2. {(Cough, significant) and (Chest pain, significant)} → (pulmonary tuberculosis, posit
3. (Temperature, 36.8,39..1) → (pulmonary tuberculosis, negative)
4. (Temperature,39.1,40..8) and (Chest pain, insignificant) → (pulmonary tuberculosis, negative)

**RESULT VERIFICATION USING STRENGTH OF ROUGH SET THEORY**

The information table used above is now implemented by using RST, to develop this we consider 20 samples by using correlation techniques out of 1000 samples , 5 conditional attributes allow of leaf note ,fever, chest pain, cough and body ache and values of these attributes are significant , insignificant and attributes for decision are yes and no to use these attributes for good understanding we gives new name to these 5 conditional attributes allow of leaf note ,fever, chest pain , cough body ache as 1 ,2,3,4,5 respectively and values significant as a and insignificant as b decision attributes as r,t respectively. Proposed algorithm Initial table is given below Algorithm to find reduct using strength of rough set.

Proposed Algorithm

```

1. start
2. set S = ϕ ;S is the reduct set
3. do
while
{
E (count of attribute sets ) E and S ≠ ϕ
Count = ϕ
If
Strength=(no of denomination decision attribute values)/ (no of denomination conditional attributes values)
If
{
Strength >50%
Count=Count++
else
go to step-3
end[while]
end[do]

```

The decision table (Table -2), takes the initial values before finding the reduct. Looking at the data table, it is found that entities L<sub>15</sub>,L<sub>16</sub> provide ambiguity at the decision level although both having same conditional values but different decision values are represented in this form. So both the attributes are dropped from further classifications

Using quick reduct algorithm we have got following set of vectors as our reduct (1,2,3,4), (2,3,4,5), (1,2,3,5) then Core of the following reduct is (2,3) by using the formula  $\bigcap$  (reduct) so (2,3) cannot be further classified . To get more accuracy we calculated the equivalence classes using strength [11] and get the following result ,L<sub>Significant</sub>={L<sub>3</sub>,L<sub>4</sub>, L<sub>7</sub>,L<sub>9</sub>, L<sub>11</sub>,L<sub>12</sub>, L<sub>14</sub>,L<sub>20</sub>} L<sub>insignificant</sub>={L<sub>1</sub>,L<sub>2</sub>, L<sub>5</sub>,L<sub>6</sub>, L<sub>8</sub>,L<sub>10</sub>, L<sub>13</sub>,L<sub>18</sub>,L<sub>19</sub>}





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$L(1)_{a_1}(\text{significant})=6/8$  about 70%  $E(1)_{b_1}(\text{insignificant})=4/9$  about 34%,  $E(a_2)_{b_1}(\text{yes})=7/8$  about 88% similarly we have strength(11) of  $E(a_2)_{b_2}(\text{false})=8/9$  about 90%  $E(a_3)_{b_1}(\text{yes})=6/8$  about 75%  $E(a_3)_{b_2}(\text{false})=7/8$  about 88%  $E(a_4)_{b_1}(\text{True})=66\%$   $E(a_4)_{b_1}(\text{True})=66\%$   $E(a_5)_{b_1}(\text{True})=32\%$   $E(a_5)_{b_2}(\text{false})=31\%$  From the we have conclude attribute  $a_1$  and  $a_5$  not necessary so we can drop these table from the decision table safely now the reduct table derived from Table-3 is new table that is the Table-4. Reduct  $a_1$  provide true cases almost 70% but the false case is also about 34% so it is not in the higher side

$(E_2, E_{11}), (E_3, E_4), (E_5, E_6), (E_{17}, E_{18}), (E_1, E_{12}), (E_7, E_{13}), (E_8, E_9), (E_{17}, E_{18})$  are ambiguous in nature so we can drop these Records from the table for further classification and  $(E_{14}, E_{20})$  are providing the same result so we merge both and keep one Records for classification. So we have the final reduct table (Table -5).

We can easily derive rules for pulmonary tuberculosis [12], just analyzing the above table, i.e Table-4. As predicting a result and from large domain of medical data set we depends more or less predictive data mining. We apply Rough set concept for this purpose. Hence, rule for the above data is presented below:

1. Fever and Cough (Yes)  $\rightarrow$  (pulmonary tuberculosis, yes)
2. Chest pain (Yes)  $\rightarrow$  (pulmonary tuberculosis, yes)
3. Fever, Chest Pain, Cough (Yes)  $\rightarrow$  (pulmonary tuberculosis, yes)

From the above rule we concluded that  $a_2, a_3, a_4$  are significant attributes for the classification Hence, fever, chest pain and cough are prime symptoms for pulmonary tuberculosis . We get a conclusion that both local covering algorithm and finding reduct using strength provide the same result, but major attributes in this case will be Fever, Cough, Chest Pain and combination of these attributes produces pulmonary tuberculosis .The result has been obtained from local lower covering algorithm.

## EXPERIMENTAL SECTION

### Statistical Validation

We depended upon chi-square test to validate our findings. We are taking data of positive cases of pulmonary tuberculosis from various NGOs and private hospitals then applied  $\chi^2$ -test for justification of our result. The observed samples are 25, 28, 37, 35, 68, 25 totaling 200 samples. The expected numbers of samples per each day are 20, 30, 40, 30, 70, 20. Then we used chi-square distribution to verify our result. Using chi-square test, we claim that the results obtained are correct.

## FUTURE WORK

This theory can be extended to the field of entertainment, Small scale business sector.

## CONCLUSION

Many People around the world died of Pulmonary Tuberculosis, because of ignorance as most of it's symptoms match with several common diseases. For this reason we use two different concept to finding reduct to classify pulmonary tuberculosis and rule generation.

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**Table 1. Initial data Table**

R	k <sub>1</sub>	k <sub>2</sub>	k <sub>3</sub>	I
R <sub>1</sub>	39.8	significant	significant	positive
R <sub>2</sub>	?	significant	significant	positive
R <sub>3</sub>	40.8	significant	?	positive
R <sub>4</sub>	?	insignificant	insignificant	positive
R <sub>5</sub>	39.8	insignificant	insignificant	negative
R <sub>6</sub>	36.8	significant	insignificant	negative
R <sub>7</sub>	38.4	insignificant	insignificant	negative

**Table 2. Initial information after correlation**

E	1	2	3	4	5	D
L <sub>1</sub>	b	b	a	a	b <sub>1</sub>	t
L <sub>2</sub>	b	a	a	a	b <sub>2</sub>	t
L <sub>3</sub>	a	a	b	b	b <sub>1</sub>	r
L <sub>4</sub>	a	a	b	b	b <sub>1</sub>	r
L <sub>5</sub>	a	a	b	b	a	t
L <sub>6</sub>	a	a	b	b	b	t
E <sub>7</sub>	b	b	b	b	b	r
L <sub>8</sub>	a	a	a	a	a	t
L <sub>9</sub>	b	a	a	a	b	r
L <sub>10</sub>	a	b	b	b	b	t
L <sub>11</sub>	b	a	a	a	b	r
L <sub>12</sub>	a	b	a	a	b	r





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L13	a	b	b	b	a	t
L14	b	b	a	b	a	r
L15	b	a	a	a	b	r
L16	b	a	a	a	b	t
L17	a	b	b	b	a	r
L18	a	b	b	b	b	t
L19	a	a	a	a	b	r
L20	a	b	a	b	a	r

**Table 3. Initial information after dropping ambiguous records**

E	1	2	3	4	5	D
L1	b	b	a	a	a	t
L2	b	a	a	a	b	t
L3	a	a	b	b	a	r
L4	a	a	b	b	a	r
L5	a	a	b	b	a	t
L6	a	a	b	b	b	t
L7	b	b	b	b	b	r
L8	a	a	a	a	a	t
L9	b	a	a	a	b	r
L10	a	a	b	a	b	r
L11	b	a	a	a	b	r
L12	a	b	a	a	b	r
L13	a	b	b	b	a	t
L14	b	b	a	b	a	r
L17	a	b	b	b	a	r
L18	a	b	a	b	b	t
L19	a	a	a	a	b	r
L20	a	b	a	b	a	r

**Table 4. Reduction table after reduction of Table 3**

E	2	3	4	D
L1	b	a	a	t
L2	a	a	a	t
L3	a	b	b	r
L4	a	b	b	r
L5	a	b	b	t
L6	a	b	b	t
L7	b	b	b	r
L8	a	a	a	t
L9	a	a	a	r
L10	a	b	a	r





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L <sub>11</sub>	a	a	a	r
L <sub>12</sub>	b	a	a	r
L <sub>13</sub>	b	b	b	t
L <sub>14</sub>	b	a	b	r
L <sub>17</sub>	b	b	b	r
L <sub>18</sub>	b	b	b	t
L <sub>19</sub>	a	a	a	r
L <sub>20</sub>	b	a	b	r

**Table 5. Reduce table after reduction of Table 4**

E	2	3	4	D
L <sub>10</sub>	a	b	a	r
L <sub>14</sub>	b	a	b	r
L <sub>19</sub>	a	a	a	r





## Application of DTM to Solve Ordinary Differential Equations

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### ABSTRACT

A Concept of differential transform was first introduced by Zhou in 1986. This method is a semi-analytical method for solving differential equations. Indeed, the differential transform method is based on Taylor series expansion, in a different manner in which the differential equation is converted into a recurrence relation to get a series solution in terms of polynomials. This paper is mainly concerned with DTM for ODEs. Firstly, we use the one dimensional transform method to solve initial value problems as well as boundary value problems for ordinary differential equations.

**Keywords:** Non-linear ODE; DTM

### INTRODUCTION

Most of nonlinear equations do not have a precise analytic solution; so numerical methods have largely been used to handle these equations. There are also some analytic techniques for nonlinear equations. Some of the classic analytic methods are Lyapunov's artificial small parameter method [1], perturbation techniques [2–11], and  $\delta$ -expansion method [12]. In the recent years, many authors mainly had paid attention to study solutions of nonlinear partial differential equations by using various methods. Among these are the Adomian decomposition method (ADM) [13, 14], tanh method, homotopy perturbation method (HPM), sinh-cosh method, HAM, the DTM, and variational iteration method (VIM) [15, 16].





## Numerical Examples

### Example: 1

Solve the following initial value problem (IVP),

$$2y' + 3xy = 4x, y(0) = 1 \quad (1)$$

### Solution:

The exact solution of eqn. (1) is:

$$y = \frac{4}{3} - \frac{1}{3} e^{-\frac{3x^2}{4}} \quad (2)$$

Applying DTM to the eq. (1), we get

$$Y(k+1) = \frac{1}{2(k+1)} \left( 4\delta(k-1) - 3 \sum_{r=0}^k \delta(r-1) Y(k-r) \right), k = 0, 1, 2, \dots \quad (3)$$

Solving the recurrence relation (3) we have,

$$Y(2) = \frac{1}{4}(4 - 3Y[0]), Y(4) = -\frac{3}{32}(4 - 3Y[0]), Y(6) = \frac{3}{128}(4 - 3Y[0]),$$

$$Y(8) = -\frac{9}{2048}(4 - 3Y[0]), Y(10) = \frac{27}{40960}(4 - 3Y[0]),$$

and,  $Y(k) = 0$  for  $k$ , odd.

Putting the initial condition  $Y(0) = 1$  we get,

$$Y(2) = \frac{1}{4}, Y(4) = -\frac{3}{32}, Y(6) = \frac{3}{128}, Y(8) = -\frac{9}{2048}, Y(10) = \frac{27}{40960},$$

$Y(k) = 0$ , for  $k$ , odd.

Hence the DTM solution will be,

$$y(x) = 1 + \frac{1}{4}x^2 - \frac{3}{32}x^4 + \frac{3}{128}x^6 - \frac{9}{2048}x^8 + \frac{27}{40960}x^{10}. \quad (4)$$

We have compared both the solutions (2) & (4) of (1) in Table: 1 and drawn the behaviour in Fig. 1. Graphical representation of the error depicted in Table: 1 is shown in Fig. 2.

## EXACT AND DTM SOLUTION

### Example: 2

Solve the following IVP by using DTM





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$$y' = -\frac{2x + y + 3}{x + 3y + 1}, y(0) = 1 \tag{5}$$

**Solution.**

The exact solution of eqn. (5) is,

$$y = \frac{1}{3} \left( \sqrt{16 - 16x - 5x^2} - x - 1 \right). \tag{6}$$

Applying DTM to eqn. (5), we get for  $k = 0, 1, \dots$

$$Y(k+1) = -\frac{\sum_{r=0}^k (k-r+1)\delta(r-1)Y(k-r+1)}{(k+1)(3Y(0)+1)} - \frac{3\sum_{r=0}^{k-1} (r+1)Y(r+1)Y(k-r) + (2\delta(k-1) + Y(k) + 3\delta(k))}{(k+1)(3Y(0)+1)} \tag{7}$$

Solving the recurrence relation (7) with  $Y(0) = 1$  we get,

$$Y(1) = -\frac{1}{2}, Y(2) = -\frac{7}{64}, Y(3) = -\frac{7}{1024}, Y(4) = -\frac{175}{65536}, Y(5) = -\frac{469}{1048576},$$

$$Y(6) = -\frac{4907}{33554432}, Y(7) = -\frac{18431}{536870912}, Y(8) = -\frac{730303}{68719476736},$$

$$Y(9) = -\frac{3183145}{1099511627776}, Y(10) = -\frac{31271177}{35184372088832}.$$

Hence the DTM solution is,

$$y(x) = 1 - \frac{1}{2}x - \frac{7}{64}x^2 - \frac{7}{1024}x^3 - \frac{175}{65536}x^4 - \frac{469}{1048576}x^5 - \frac{4907}{33554432}x^6 - \frac{18431}{536870912}x^7 - \frac{730303}{68719476736}x^8 - \frac{3183145}{1099511627776}x^9 - \frac{31271177}{35184372088832}x^{10}. \tag{8}$$

We have compared both the solutions (6) & (8) of (5) graphically in Fig. 3 and numerically in Table: 2.





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**Example: 3.** Solve the following problem by DTM

$$2y' = (2x + y)^2, y(0) = 1 \tag{9}$$

**Solution:**

The exact solution is

$$y(x) = 2 \tan \left( x + a \tan \left( \frac{1}{2} \right) \right) - 2x \tag{10}$$

Now, applying DTM to eq. (9), we obtain the following recursion formula

$$Y(k+1) = \frac{1}{2(k+1)} \left( \sum_{r=0}^k (Y(r) + 4\delta(r-1))Y(k-r) + 4\delta(k-2) \right) \tag{11}$$

with  $Y(0) = 1, k = 0, 1, 2, \dots$

Hence the DTM solution is

$$\begin{aligned} y(x) = & 1 + \frac{5}{2}x + \frac{9}{4}x^2 + \frac{67}{24}x^3 + \frac{125}{48}x^4 + \frac{271}{96}x^5 + \frac{1691}{576}x^6 + \frac{25055}{8064}x^7 \\ & + \frac{52553}{16128}x^8 + \frac{47467}{13824}x^9 + \frac{1165013}{322560}x^{10} + \frac{80957963}{21288960}x^{11} + \frac{73041257}{18247680}x^{12} \\ & + \frac{13996507309}{3321077760}x^{13} + \frac{206313110021}{46495088640}x^{14} + \frac{6517440802661}{1394852659200}x^{15}. \end{aligned} \tag{12}$$

We have compared both the solutions (10) & (12) of (9) graphically in Fig. 4 and numerically in Table: 3.

**Example: 4** Solve the following initial value problem by DTM

$$3y' = \cos(2x)y^2, y(0) = 1 \tag{13}$$

**Solution.**

The exact solution is

$$y(x) = \frac{-6}{\sin 2x - 6} \tag{14}$$

Now applying DTM to eq. (13), we get

$$Y(k+1) = \frac{1}{3(k+1)} \left( \sum_{k_2=0}^k \sum_{k_1=0}^{k_2} \frac{2^{k_1}}{k_1!} \cos \left( \frac{k_1\pi}{2} \right) Y(k_2 - k_1)Y(k - k_2) \right), \tag{15}$$

Solving the recurrence relation (15) with the initial condition  $Y(0) = 1, k = 0, 1, 2, \dots$ , we get the DTM solution as,





$$y(x) = 1 + \frac{1}{3}x + \frac{1}{9}x^2 - \frac{5}{27}x^3 - \frac{11}{81}x^4 - \frac{31}{1215}x^5 + \frac{173}{3645}x^6 + \frac{715}{15309}x^7 + \frac{2663}{229635}x^8 - \frac{8923}{688905}x^9. \quad (16)$$

We have drawn the graphical behaviour of both the solutions (14) & (16) and the error in Fig. 5.

**Example: 4.7:** Assume the following system of ordinary differential equations

$$y''' + y'' - y' - y = e^{-x} \quad (17)$$

With initial conditions:  $y(0) = 1, y'(0) = 2, y''(0) = 0$ .

**Solution:**

The exact solution is,

$$y(x) = \frac{1}{8}e^{-x}(-3 + 11e^{2x} + 2x - 2x^2). \quad (18)$$

Applying DTM to equation (17), we get

$$Y(k+3) = \frac{k!}{(k+3)!} \left[ \left( \frac{(-1)^k}{k!} + 1 \right) Y(k) + (k+1)(Y(k+1) - (k+2)Y(k+2)) \right] \quad (19)$$

Solving the coupled recurrence relation (19) with corresponding initial conditions  $Y(0) = 1, Y(1) = 2, Y(2) = 0$  we get the desired DTM solution as,

$$y_1(x) = 1 + 2x + \frac{2}{3}x^3 - \frac{1}{8}x^4 + \frac{1}{15}x^5 - \frac{1}{90}x^6 + \frac{1}{360}x^7 - \frac{1}{2688}x^8 + \frac{11}{181440}x^9 - \frac{1}{151200}x^{10} + \frac{1}{1247400}x^{11} - \frac{1}{13685760}x^{12} \quad (20)$$

The graphical behaviour of solutions (18) & (20) depicted in Fig 4.8 & Fig. 4.9 with different orders of DTM solution. Errors due to the different order of DTM solutions with compared to exact solution are numerically tabulated in Table 4. Figs. 6 & 7 and Table 4 are in good agreement with each other. From the above studies, it is confirm that higher order of DTM gives solution closer to exact solution. Graphical and tabular representation are given below.

**CONCLUSION**

- The graphical behaviour of solutions depicted in figures with different orders of DTM solution.
- Errors due to the different order of DTM solutions with compared to exact solution is numerically are in good agreement with each other.





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- From the above studies, it is confirm that higher order of DTM gives solution closer to exact solution.

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**Table: 1 Comparision Of Solution**

x	EXACT	DTM	ERROR
0.0	1.000000	1.000000	0.000000
0.1	1.002491	1.002491	0.000000
0.2	1.009851	1.009851	0.000000
0.3	1.021757	1.021757	0.000000
0.4	1.037693	1.037693	0.000000





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0.5	1.056990	1.056990	0.000000
0.6	1.078874	1.078874	0.000000
0.7	1.102512	1.102513	0.000001
0.8	1.127072	1.127077	0.000005
0.9	1.151763	1.151784	0.000021
1.0	1.175878	1.175952	0.000074

**Table: 2 Comparison Of Solution**

x	EXACT	DTM	ERROR
0.0	1.000000	1.000000	0.000000
0.1	0.896046	0.902380	0.006333
0.2	0.783216	0.808952	0.025736
0.3	0.659573	0.718608	0.059035
0.4	0.522160	0.629725	0.107565
0.5	0.366025	0.539785	0.173759
0.6	0.181587	0.444583	0.262996
0.7	-0.055676	0.336381	0.392057
0.8	-0.600000	0.199291	0.799291
0.9	-0.633333	-0.002644	0.818530
1.0	-0.666667	-0.356076	0.807479

**Table: 3 Comparison of Solution**

x	EXACT	DTM	ERROR
0.00	1.000000	1.000000	0.000000
0.05	1.028315	1.130991	0.102676
0.10	1.064085	1.275584	0.211498
0.15	1.108724	1.436619	0.327895
0.20	1.163932	1.617642	0.453709
0.25	1.231782	1.823148	0.591366
0.30	1.314837	2.058961	0.744124
0.35	1.416315	2.332780	0.916466
0.40	1.540323	2.655042	1.114719
0.45	1.692197	3.040269	1.348072
0.50	1.879010	3.509304	1.630294

**Table: 4 Error Comparison with Dtm.**

x	ORDER-5	ORDER-8	ORDER-10	ORDER-12
0.0	0.000000	0.000000	0.000000	0.000000
0.1	0.000000	0.000000	0.000000	0.000000
0.2	0.000001	0.000000	0.000000	0.000000
0.3	0.000008	0.000000	0.000000	0.000000
0.4	0.000041	0.000000	0.000000	0.000000
0.5	0.000153	0.000000	0.000000	0.000000
0.6	0.000446	0.000001	0.000000	0.000000
0.7	0.001098	0.000002	0.000000	0.000000
0.8	0.002385	0.000007	0.000000	0.000000
0.9	0.004715	0.000021	0.000000	0.000000
1.0	0.008651	0.000055	0.000001	0.000000





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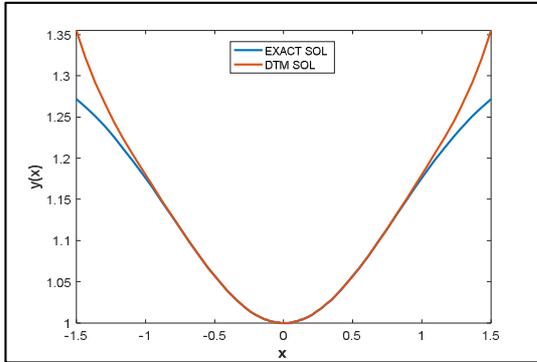


Fig. 1 Variation of EXACT and DTM solution

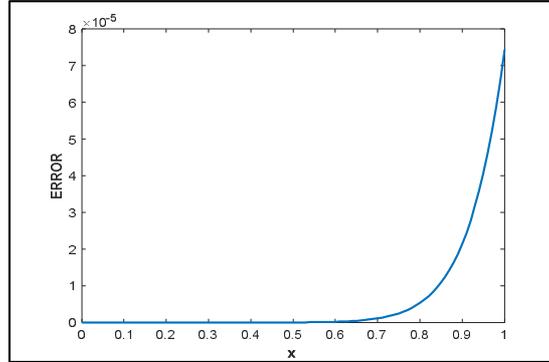


Fig. 2 Error graph between

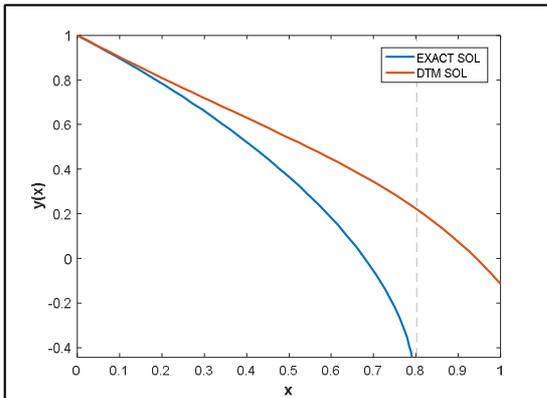


Fig. 3 Variation of EXACT and DTM solution

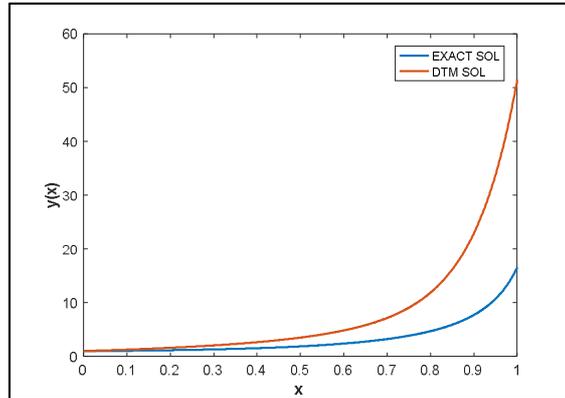


Fig. 4 Variation of EXACT and DTM solution

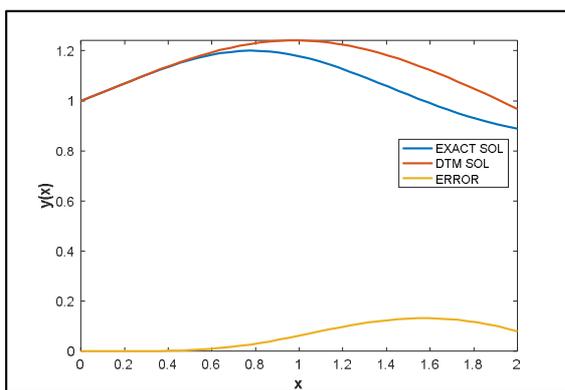


Fig. 5 Variation of EXACT and DTM solution with ERROR

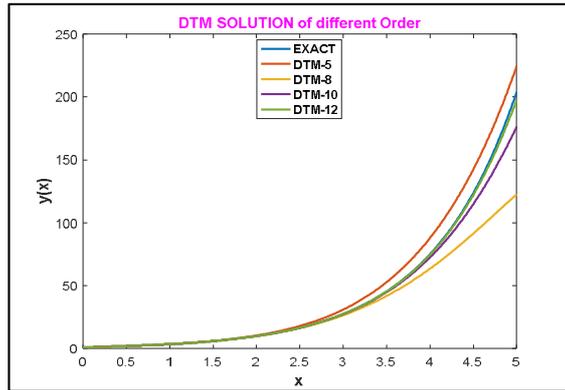


Fig. 6 Variation of EXACT and DTM solution





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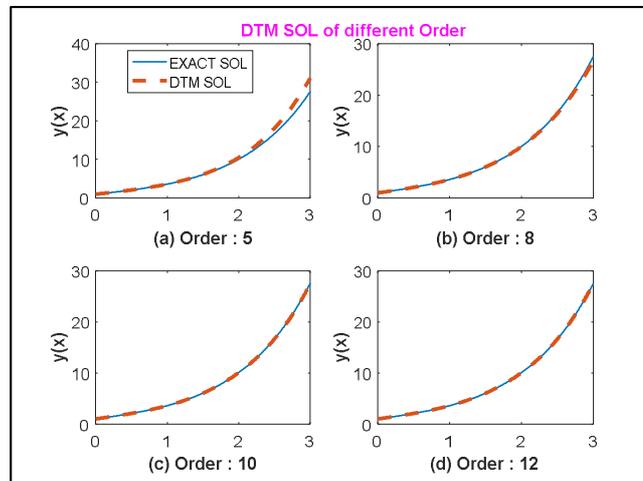


Fig. 7 Variation of EXACT and DTM solution with (a) Order 5 (b) Order 8 (c) Order 10 (d) Order 12





## Slip and Radiation Effects on Dual Solution of Stagnation Point Flow of Heat and Mass Transfer

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### ABSTRACT

The present problem studies a steady two-dimensional dual solution of stagnation-point flow with heat and mass transfer through shrinking sheet where effects of velocity slip and thermal radiation is investigated. The present model incorporates the influences of various parameter such as Prandtl number, Schmidt number, the velocity ratio parameter radiation parameter and slip parameter. The non-linear partial differential governing equations with respective boundary conditions are converted first by imposing suitable similarity transformation and then 4<sup>th</sup> order Runge-Kutta (RK) method along with shooting technique has been deployed to carry out the process. The influence of above parameters on all the profiles used in the work are shown graphically by using MATLAB software. Some results are also compared for validation check as special case

**Keywords:** Dual solution, Stability analysis, heat and mass transfer, Runge-Kutta method.

### INTRODUCTION

Many engineers control the processes of two dimensional steady flow. However, unsteadyness effects the ideal flow environment. Tie-Gang et al. [1] have studied an unsteady flow on account of shrinking sheet hence procured the explained form of the Navier Stokes equations. The unparalleled solution has been carried out by Merkin et al. and Khuzaimah et al. [2, 3] on the unsteady boundary layer flow over a shrinking sheet under the influence of magnetic field and ohmic heating respectively. We specify that there are number of papers that the authors have executed the stability analysis to specify a reliable and stable solution. Mahapatra et al. [4, 5] in his studies analysed the stability of fluid flow over a nonlinear stretching sheet and dual solutions for stagnation-point flow respectively. In [6],





Awaludin et al. extended the above work and studied about stability analysis of stagnation point flow by introducing shrinking sheet.

<b>Nomenclature</b>			
$a$	straining rate	$c$	shrinking/stretching rate
$C$	concentration	$D_B$	Brownian diffusion
$C_f$	skin friction coefficient	$c_p$	specific heat
$Pr$	Prandtl number	$q_r$	radiative heat flux
$k$	thermal conductivity	$k^*$	mean absorption coefficient
$Nu_x$	local Nusselt number	$R$	radiation parameter
$q_w$	wall heat flux	$Re_x$	local Reynolds number
$q_m$	wall mass flux	$Sc$	Schmidt number
$Sh_x$	local Sherwood number	$T$	fluid temperature
$U$	stretching velocity	$u, v$	velocity components
<b>Greek symbols</b>			
$\eta$	Similarity variable	$\rho$	density of fluid
$\alpha$	thermal diffusivity	$\nu$	kinematic viscosity
$\lambda$	velocity ratio parameter	$\delta$	velocity slip parameter
$\psi$	stream function	$\tau_w$	shear stress
$\gamma$	eigen value	$\mu$	dynamic viscosity
$\sigma^*$	Stefan Boltzmann constant		

Najib et al. [7] discussed about exponentially shrinking cylinder the stability of dual solutions. Bhattacharyya [8] has discussed the dual solutions on a stretching/shrinking sheet with first order chemical reaction in boundary layer stagnation point flow and mass transfer. Again, Bhattacharyya et al. [9] presented slip condition effects due to a shrinking sheet on stagnation point flow.

Due to many more industrial applications MHD flow study now a days takes an important aspect of research. Various properties on MHD near the stagnation point was discussed by Salem et al. [10]. A study by Fang et al. [11] was carried out analytically to find the effects of closed-form solution of MHD viscous fluid over shrinking sheet. Mishra et al. [12] examined the mass and heat transfer analysis over a stretching surface in presence of transverse magnetic field over an electrically conducting viscoelastic (Walters B') fluid. In [13], Jena et al. considered MHD flow over a stretching sheet where chemical reaction effect through porous media with heat generation/absorption discussed. Pattnaik et al. [14-17] have analyzed different fluid behavior and effects such as thermophoretic effect, thermal radiation effect, effects of thermal stratification on nano fluid over stretching/shrinking sheets and examined different pertinent parameters behavior for different papers.

Recently Jena et al. [18-20] have shown their interest for different fluids like Jeffery fluid, viscoelastic fluid to investigate different characters of different used parameters for which they have elaborately drawn fantastic conclusions in research works. Similarly a study regarding Casson fluid over an exponentially penetrable shrinking sheet has been carried out by Nadeem et al. [21]. Mehmood et al [22], Mukhopadhyay et al. [23], Narayanaand





Sibanda [24] have putted their attention on MHD boundary layer flow of different fluid models by taking different pertinent parameters with suitable convective boundary conditions.

## MATHEMATICAL ANALYSIS

Let consider a 2-D steady laminar boundary layer stagnation point flow for an incompressible fluid flow under effects of radiation and slip which is driven by shrinking sheet. The corresponding governing equations are as follows:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad (1)$$

$$u \frac{\partial u}{\partial x} + v \frac{\partial v}{\partial y} = U \frac{dU}{dx} - \nu \frac{\partial^2 u}{\partial y^2} \quad (2)$$

$$u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \alpha \frac{\partial^2 T}{\partial y^2} - \frac{1}{\rho C_p} \frac{\partial q_r}{\partial y} \quad (3)$$

$$u \frac{\partial C}{\partial x} + v \frac{\partial C}{\partial y} = D_B \frac{\partial^2 C}{\partial y^2} \quad (4)$$

The appropriate boundary conditions are

$$\left. \begin{aligned} u = cx + L \left( \frac{\partial u}{\partial y} \right), v = 0, T = T_w, C = C_w \quad \text{at } y = 0, \\ u \rightarrow U(x) = ax, T = T_\infty, C = C_\infty \quad \text{as } y \rightarrow \infty \end{aligned} \right\} \quad (5)$$

where  $L$ , slip length.  $c > 0$  and  $c < 0$ , stretching and shrinking rate respectively with  $a > 0$  (straining rate parameter). Using the Rosseland approximation,  $q_r = -(4\sigma^*/3k^*) \partial T^4 / \partial y$ . Using Taylor's series expansion for  $T^4$  about  $T_\infty$  we get,  $T^4 = 4T_\infty^3 T - 3T_\infty^4$  where higher-order terms are neglected.

So now equation (3),

$$u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} = \alpha + \alpha \frac{16\sigma^* T_\infty^3}{3kk^*} \frac{\partial^2 T}{\partial y^2} \quad (6)$$

Eqns. (2, 4 - 6) with the following similarity transformations:

$$\eta = \sqrt{\frac{a}{\nu}} y, u = axf'(\eta), v = -\sqrt{av} f(\eta), \psi(x, y) = \sqrt{av} xf(\eta), \theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty}, \phi(\eta) = \frac{C - C_\infty}{C_w - C_\infty} \quad (7)$$

can be reduced as:





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$$\left. \begin{aligned} f''' + ff'' - f'^2 + 1 &= 0 \\ \frac{1}{Pr}(1 + R)\theta'' + f\theta' &= 0 \\ \frac{1}{Sc}\phi'' + f\phi' &= 0 \end{aligned} \right\} \tag{8}$$

and

$$\left. \begin{aligned} f(\eta) = 0, f'(\eta) = \lambda + \delta f''(0), \theta(\eta) = 1, \phi(\eta) = 1 \quad \text{at } \eta = 0 \\ f'(\eta) \rightarrow 0, \quad \theta(\eta) \rightarrow 0, \quad \phi(\eta) \rightarrow 0 \quad \text{as } \eta \rightarrow \infty \end{aligned} \right\} \tag{9}$$

where

$$Pr = \frac{\nu}{\alpha}, Sc = \frac{\nu}{D_B}, R = \frac{16\sigma^* T_\infty^3}{3kk^*}, \lambda = \frac{c}{a}, \delta = L \left( \frac{a}{\nu} \right)^{1/2}$$

### THE PHYSICAL QUANTITIES OF INTEREST

Skin friction coefficient, Local Nusselt number, Local Sherwood number of the problem are respectively defined as:

$$C_f = \frac{\tau_w}{\rho U_w^2}, Nu_x = \frac{xq_w}{k(T_w - T_\infty)}, Sh_x = \frac{xq_m}{D_B(C_w - C_\infty)}$$

where  $\tau_w = \mu \left( \frac{\partial u}{\partial y} \right)_{y=0}$ ,  $q_w = \left( -k \frac{\partial T}{\partial y} + q_r \right)_{y=0}$ ,  $q_m = -D_B \left( \frac{\partial C}{\partial y} \right)_{y=0}$ ,  $Re_x = \frac{U_w x}{\nu}$

A simple calculation gives,

$$\sqrt{Re_x} C_f = f''(0), Nu_x / \sqrt{Re_x} = - \left( 1 + \frac{4}{3} R \right) \theta'(0), Sh_x / \sqrt{Re_x} = -\phi'(0)$$

### RESULTS AND DISCUSSION

Fig.1 shows the validation check for velocity, temperature and concentration profiles and from the figure it is clear that the problem well agrees the boundary condition which gives an approval for our results. Figs. 2 & 3 presents the effect of ( $\delta$ ) on velocity and temperature profiles. Due to active slip parameter, velocity gets enhanced in 1<sup>st</sup> solution but in the range  $0 \leq \eta \leq 1.5$  and  $4.2 \leq \eta < \eta_{max}$ , the profile is increasing and for  $1.5 \leq \eta \leq 4.2$  it decreases. This behaviour of velocity profile is witnessed in Fig. 2. Temperature is a decreasing function of velocity slip parameter ( $\delta$ ) for both the solutions which can be confirmed from Fig. 3. Influence of Prandtl number on both velocity and temperature profiles is depicted in Figs. 4 & 5. Both the profiles are showing opposite behaviour, as expected, for increasing values of Pr. Velocity profile gets decelerated for increasing values of Prandtl number in





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both the solutions but 2<sup>nd</sup> solution shows opposite behaviour away from boundary i.e, for  $\eta \geq 3$ . Temperature, on the otherhand, shows the opposite trend for both the solutions. Fig. 6 & 7 are the evidences of decreasing profile of solutal boundary layer thickness for increasing values of velocity parameter and Schmidt number ( $S_c$ ). Fig.8 presents the graphical behaviour of  $C_f$  for both ( $\lambda$ ) and ( $\delta$ ). We have taken the '-ve' range for ( $\lambda$ ) and '+ve' range for ( $\delta$ ). When  $\delta$  is increased,  $C_f$  increases but  $\lambda$  is to decelerate it. Figs. 9 & 10 present the increasing values of both  $\delta$  and  $P_r$  along with '-ve' range of  $\lambda$  increases the Nusselt number coefficient. But it decreases with increasing values of radiation parameter ( $R$ ). Figs. 12 & 13 confirms the accelerated behaviour of Sherwood number with increasing values of both  $\delta$  and  $P_r$  along with '-ve' range of  $\lambda$ .

### Concluding Remarks

The existence of dual solutions is clearly shown in the figures. The stability analysis is checked through our in-house program using MATLAB software for stability of both the solutions and it is found that the 1<sup>st</sup> solution (solid line) is stable and valid physically, while the 2<sup>nd</sup> solution (dotted line) is unstable.

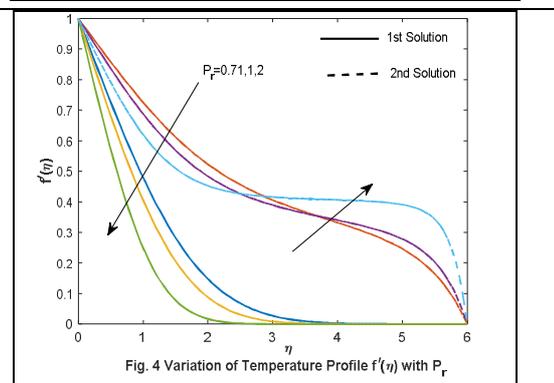
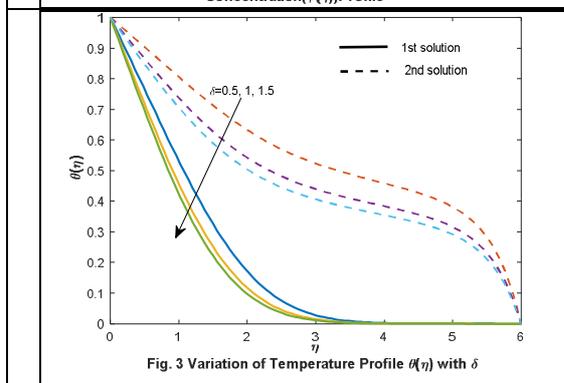
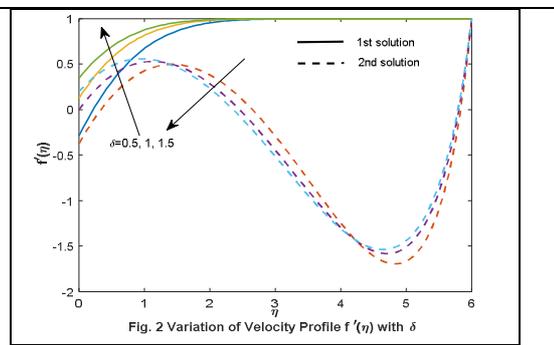
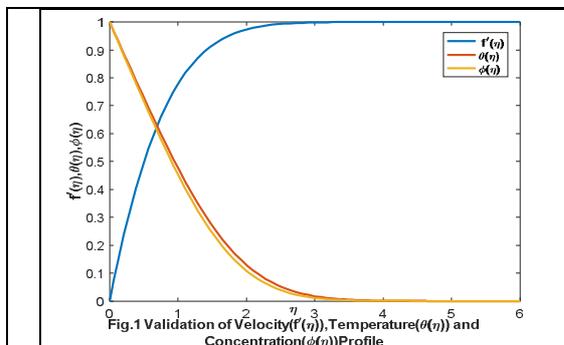
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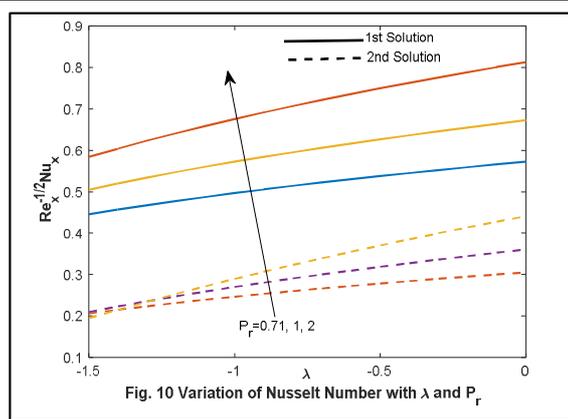
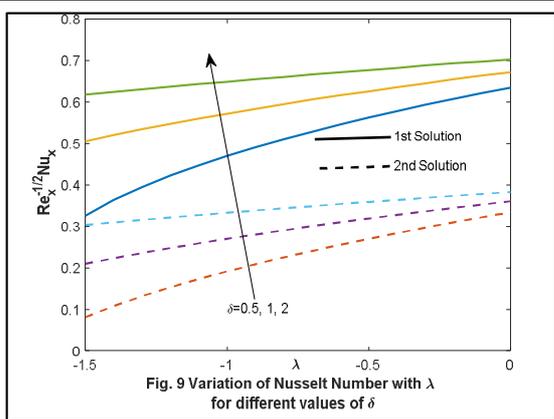
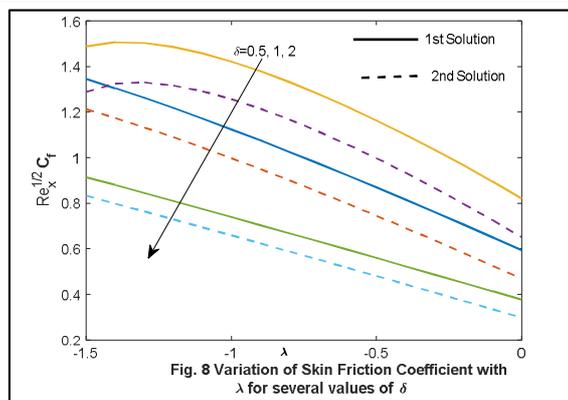
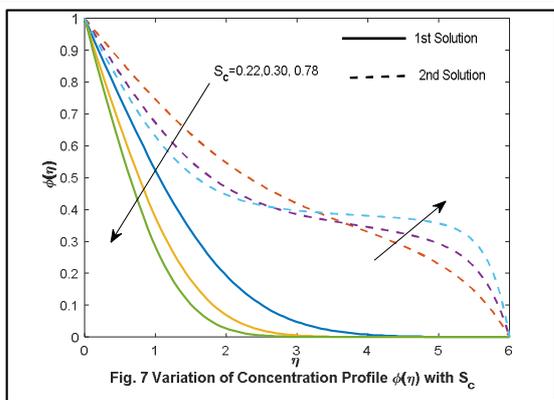
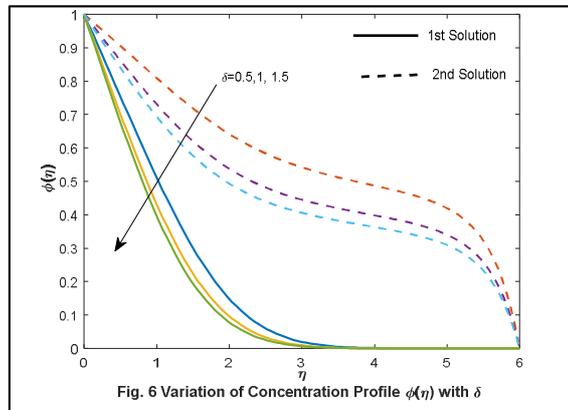
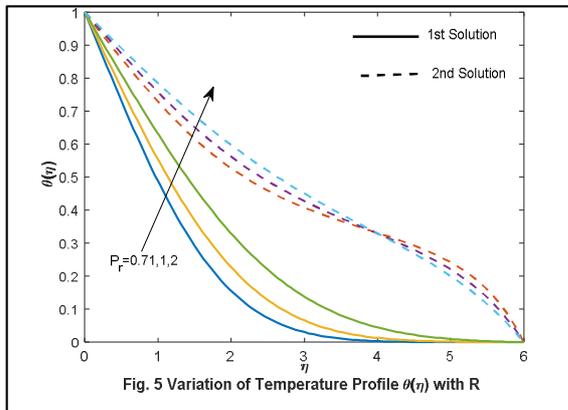
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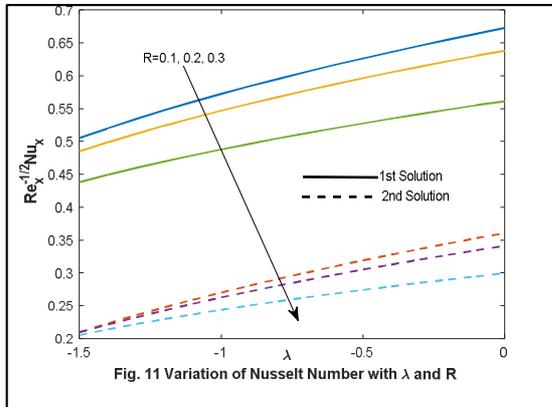


Fig. 11 Variation of Nusselt Number with  $\lambda$  and R

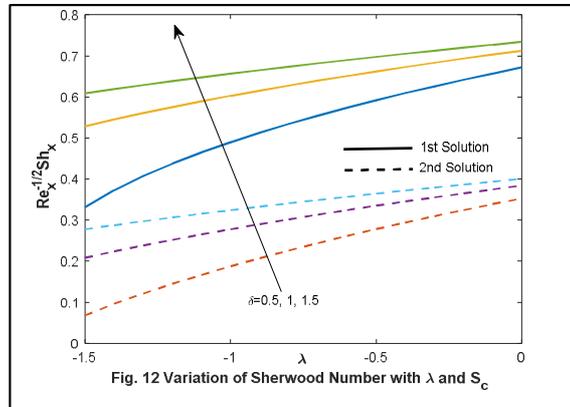


Fig. 12 Variation of Sherwood Number with  $\lambda$  and  $S_c$

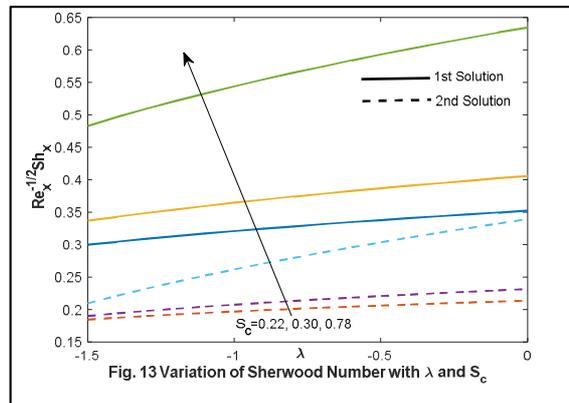


Fig. 13 Variation of Sherwood Number with  $\lambda$  and  $S_c$





## Solutions of Partial Differential Equations by Differential Transform Method

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### ABSTRACT

A Two dimensional differential transform method (DTM) have been applied with its fundamental theorems. Moreover, applying DTM, exact close form solutions of linear and non-linear PDEs have been derived. The results of the examples are presented analytically as well as graphically. This Research confirms the use of DTM to linear as well as nonlinear PDEs and can be easily applied. This work ensures the reduction capacity of the computational procedure. Conclusion drawn towards this method that exact analytical close form solutions can be obtained with no need of lumbering work and it can be a valuable tool with analytical solutions.

**Keywords:** PDEs; DTM; Mathematica; Matlab.

### INTRODUCTION

Present work analyses the behaviour of solution of systems of linear and PDEs. Such systems can be applied in different arena of mathematics, engineering especially in electrical and mechanical engineering problems and in physical sciences also. Application of these types of equations include wave propagation and shallow water waves [1–3] where different models of population growth are initiated by a system of PDEs. Most common methods include a semi-analytical method, Adomian decomposition method (ADM) which were used effectively to handle systems of PDEs by [4]. The concept of differential transform applied to electric circuit problems effectively solved the problem was first confirmed by Zhou [5]. The work consist of some linear and non-linear initial value problems. This method computes the coefficients of the Taylor series and gives a series solution using. But, the present method avoids to do

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more computational procedures for large orders, can be seen in [6, 7]. In the present work, a demonstration to the feasibility of the theory of DTM is shown by considering two examples of coupled PDEs and solved analytically and graphically by using two well equipped softwares MATHEMATICA and MATLAB.

**Two Dimensional Differential Transform Method (DTM)**

The definition two dimensional transform method is defined as:

$$H(l, m) = \frac{1}{l!m!} \left[ \frac{\partial^{l+m} h(x, y)}{\partial x^l \partial y^m} \right]_{(0,0)} \tag{1}$$

where  $h(x, y)$ , original function,  $H(l, m)$ , transformed function.

Throughout our work, we have considered lower and upper case letters to present the original and it's transformed functions respectively.

The differential inverse transform of  $H(l, m)$  is defined as,

$$h(x, y) = \sum_{l=0}^{\infty} \sum_{m=0}^{\infty} H(l, m) x^l y^m. \tag{2}$$

So,

$$h(x, y) = \sum_{l=0}^{\infty} \sum_{m=0}^{\infty} \frac{1}{l!m!} \left[ \frac{\partial^{l+m} h(x, y)}{\partial x^l \partial y^m} \right]_{(0,0)} x^l y^m \tag{3}$$

In the next section, we have stated the fundamental theorems of the two dimensional transform without proof.

**FUNDAMENTAL THEOREMS**

**Theorem 1**

Differential transform of  $h(x, y) = f(x, y) \pm g(x, y)$  is given by,  $H(l, m) = F(l, m) \pm G(l, m)$ . (4)

**Theorem 2**

Differential transform of  $h(x, y) = cf(x, y)$ ,  $c$ , constant, is given by,  $H(l, m) = cF(l, m)$ . (5)

**Theorem 3**

Differential transform of  $h(x, y) = \frac{\partial f(x, y)}{\partial x}$  is given by,  $H(l, m) = (k + 1)F(k + 1, h)$ . (6)

**Theorem 4**

Differential transform of  $h(x, y) = \frac{\partial f(x, y)}{\partial y}$  is given by,





$$H(l, m) = (l + 1)F(k, h + 1). \tag{7}$$

**Theorem 5**

Differential transform of  $h(x, y) = \frac{\partial^{p+q} f(x, y)}{\partial x^r \partial y^s}$  is given by,

$$H(l, m) = (l + 1)(l + 2) \dots (l + p)(m + 1)(m + 2) \dots (m + q)F(l + p, m + q). \tag{8}$$

**Theorem 6**

Differential transform of  $h(x, y) = f(x, y)g(x, y)$  is given by,

$$H(l, m) = \sum_{p=0}^l \sum_{q=0}^m F(p, m - q)G(l - p, q). \tag{9}$$

**Theorem 7**

Differential transform of  $h(x, y) = x^p y^q$  is given by,

$$H(l, m) = \delta(l - p, m - q) = \begin{cases} 1, & l = p \text{ and } m = q \\ 0, & \text{otherwise} \end{cases} \tag{10}$$

**Theorem 8**

Differential transform of  $h(x, y) = \frac{\partial f(x, y)}{\partial x} \frac{\partial g(x, y)}{\partial x}$  is given by,

$$H(l, m) = \sum_{p=0}^l \sum_{q=0}^m (p + 1)(l - p + 1)F(p + 1, l - q)G(l - p + 1, q). \tag{11}$$

**Theorem 9**

Differential transform of  $h(x, y) = \frac{\partial f(x, y)}{\partial y} \frac{\partial g(x, y)}{\partial y}$  is given by,

$$H(l, m) = \sum_{p=0}^l \sum_{q=0}^m (m - q + 1)(q + 1)F(p, m - q + 1)G(l - p, q + 1). \tag{12}$$

**Theorem 10**

Differential transform of  $h(x, y) = \frac{\partial f(x, y)}{\partial x} \frac{\partial g(x, y)}{\partial y}$  is given by,

$$H(l, m) = \sum_{p=0}^l \sum_{q=0}^m (l - p + 1)(m - q + 1)F(l - p + 1, q)H(p, m - q + 1). \tag{13}$$

**Theorem 11**

The 2D differential transform of  $h(x, y) = f(x, y)g(x, y)h(x, y)$  is given by,





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$$H(l, m) = \sum_{n=0}^l \sum_{t=0}^{l-n} \sum_{q=0}^m \sum_{p=0}^{m-q} F(n, m - q - p) G(t, q) \Omega(l - n - t, p). \tag{14}$$

**Theorem 12**

Differential transform of  $h(x, y) = f(x, y) \frac{\partial g(x, y)}{\partial x} \frac{\partial \omega(x, y)}{\partial x}$  is given by,

$$H(l, m) = \sum_{n=0}^l \sum_{t=0}^{l-n} \sum_{q=0}^m \sum_{p=0}^{m-q} (t+1)(l-n-t+1) F(n, m - q - p) G(t+1, q) \Omega(l - n - t + 1, p). \tag{15}$$

**Theorem 13**

Differential transform of  $h(x, y) = f(x, y) g(x, y) \frac{\partial^2 \omega(x, y)}{\partial x^2}$  is given by,

$$H(l, m) = \sum_{n=0}^l \sum_{t=0}^{l-n} \sum_{q=0}^m \sum_{p=0}^{m-q} (l-n-t+2)(l-n-t+1)(n, m - q - p) G(t, q) \Omega(l - n - t + 2, p). \tag{16}$$

**Numerical Examples**

**Example 1.** Let's consider a linear system of PDEs:

$$\frac{\partial f}{\partial t} + \frac{\partial g}{\partial x} = 0 \tag{17}$$

$$\frac{\partial g}{\partial t} + \frac{\partial f}{\partial x} = 0 \tag{18}$$

with initial conditions:

$$f(x, 0) = e^x \tag{19}$$

$$g(x, 0) = e^{-x} \tag{20}$$

**Solution**

Applying 2-dimensional DTM to Eqs. (17) - (20) we get,

$$F(l, m + 1) = -\frac{(l+1)}{(m+1)} G(l+1, m) \tag{21}$$

$$F(l+1, m) = -\frac{(m+1)}{(l+1)} G(l, m+1) \tag{22}$$

$$F(l, 0) = \frac{1}{l!} \tag{23}$$





$$G(l, 0) = \frac{(-1)^l}{l!} \tag{24}$$

Using Eqs. (23) and (24) in Eqs. (21) and (22) recursively, we get,

$$F(0, 1) = \frac{1}{0!1!}, F(1, 1) = -\frac{1}{1!1!}, F(2, 1) = \frac{1}{2!1!},$$

$$F(0, 2) = \frac{1}{0!2!}, F(2, 2) = \frac{1}{2!2!}, \dots$$

$$G(0, 1) = \frac{1}{0!1!}, G(1, 1) = -\frac{1}{1!1!}, G(2, 1) = -\frac{1}{2!1!},$$

$$G(0, 2) = \frac{1}{0!2!}, G(2, 2) = \frac{1}{2!2!}, \dots$$

Generalizing for  $l = 0, 1, 2, \dots$  we get,

$$F(l, m) = \begin{cases} \frac{1}{l!m!}, & m \text{ is even} \\ \frac{(-1)^l}{l!m!}, & m \text{ is odd} \end{cases} \tag{25}$$

$$G(l, m) = \begin{cases} \frac{(-1)^l}{l!m!}, & m \text{ is even} \\ -\frac{1}{l!m!}, & m \text{ is odd} \end{cases} \tag{26}$$

Tabular representation of  $F(l, m)$  and  $G(l, m)$  for  $l, m = 0 \rightarrow 4$  are given below:

Applying the procedure of Eqn. (3), the required solution in truncated form can be obtained by using MATHEMATICA as follows:

$$f(x, t) = 1 + t + \frac{t^2}{2} + \frac{t^3}{6} + \frac{t^4}{24} + \frac{t^5}{120} + \frac{t^6}{720} + \frac{t^7}{5040} + x - tx - \frac{t^2x}{2} - \frac{t^3x}{6} + \frac{t^4x}{24} - \frac{t^5x}{120} + \frac{t^6x}{720} - \frac{5040}{tx^3} + \frac{2}{t^2x^3} + \frac{2}{t^3x^3} + \frac{4}{t^4x^3} + \frac{12}{t^5x^3} + \frac{48}{t^6x^3} + \frac{240}{t^7x^3} + \frac{1440}{x^4} + \frac{10080}{tx^4} + \frac{6}{t^2x^4} - \frac{6}{t^3x^4} + \frac{12}{t^4x^4} - \frac{36}{t^5x^4} + \frac{144}{t^6x^4} - \frac{720}{t^7x^4} + \frac{4320}{x^5} - \frac{30240}{tx^5} + \frac{24}{t^2x^5} + \frac{48}{t^3x^5} + \frac{144}{t^4x^5} - \frac{576}{t^5x^5} + \frac{2880}{t^6x^5} + \frac{17280}{t^7x^5} + \frac{120960}{x^6} - \frac{120}{tx^6} - \frac{120}{t^2x^6} + \frac{240}{t^3x^6} - \frac{720}{t^4x^6} + \frac{2880}{t^5x^6} - \frac{14400}{t^6x^6} + \frac{86400}{t^7x^6} - \frac{604800}{x^7} + \frac{720}{tx^7} + \frac{1440}{t^2x^7} + \frac{4320}{t^3x^7} + \frac{17280}{t^4x^7} + \frac{86400}{t^5x^7} + \frac{518400}{t^6x^7} + \frac{3628800}{t^7x^7} + \frac{5040}{x^7} - \frac{5040}{tx^7} + \frac{10080}{t^2x^7} - \frac{30240}{t^3x^7} + \frac{120960}{t^4x^7} - \frac{604800}{t^5x^7} + \frac{3628800}{t^6x^7} - \frac{25401600}{t^7x^7}$$





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$$\begin{aligned}
 g(x,t) = 1 - t + & \frac{t^2}{2} + \frac{t^3}{6} + \frac{t^4}{24} - \frac{t^5}{120} + \frac{t^6}{720} - \frac{t^7}{5040} - x - tx - \frac{t^2x}{2} - \frac{t^3x}{6} - \frac{t^4x}{24} - \frac{t^5x}{120} \\
 & \frac{720}{x^3} - \frac{5040}{tx^3} + \frac{2}{t^2x^3} - \frac{2}{t^3x^3} + \frac{4}{t^4x^3} - \frac{12}{t^5x^3} + \frac{48}{t^6x^3} - \frac{240}{t^7x^3} - \frac{1440}{x^4} - \frac{10080}{tx^4} - \frac{120}{t^2x^4} \\
 & - \frac{6}{t^3x^4} - \frac{6}{t^4x^4} + \frac{12}{t^5x^4} - \frac{36}{t^6x^4} + \frac{144}{t^7x^4} - \frac{720}{x^5} - \frac{4320}{tx^5} - \frac{30240}{t^2x^5} + \frac{24}{t^3x^5} - \frac{24}{t^4x^5} + \frac{48}{t^5x^5} \\
 & - \frac{144}{t^6x^5} + \frac{576}{t^7x^5} - \frac{2880}{t^8x^5} + \frac{17280}{t^9x^5} - \frac{120960}{x^6} - \frac{120}{tx^6} - \frac{120}{t^2x^6} - \frac{210}{t^3x^6} - \frac{720}{t^4x^6} \\
 & - \frac{2880}{t^5x^6} - \frac{14400}{t^6x^6} - \frac{36400}{t^7x^6} - \frac{60480}{t^8x^6} + \frac{720}{x^7} - \frac{720}{tx^7} + \frac{1440}{t^2x^7} - \frac{4320}{t^3x^7} + \frac{17280}{t^4x^7} \\
 & - \frac{36400}{t^5x^7} + \frac{518400}{t^6x^7} - \frac{3628800}{t^7x^7} - \frac{5040}{x^8} - \frac{5040}{tx^8} - \frac{10080}{t^2x^8} - \frac{30240}{t^3x^8} - \frac{120960}{t^4x^8} \\
 & - \frac{504800}{t^5x^8} - \frac{3628800}{t^6x^8} - \frac{25401600}{t^7x^8}
 \end{aligned}$$

Arranging the two solutions in increasing powers of 'x', one can write,

$$\begin{aligned}
 f(x,t) = 1 + t + & \frac{t^2}{2} + \frac{t^3}{6} + \frac{t^4}{24} + \frac{t^5}{120} + \frac{t^6}{720} + \frac{t^7}{5040} \\
 & + \left( 1 - t - \frac{t^2}{2} - \frac{t^3}{6} + \frac{t^4}{24} - \frac{t^5}{120} + \frac{t^6}{720} - \frac{t^7}{5040} \right) x \\
 & + \left( \frac{1}{2} + \frac{t}{2} + \frac{t^2}{4} + \frac{t^3}{12} + \frac{t^4}{48} + \frac{t^5}{240} + \frac{t^6}{1440} + \frac{t^7}{10080} \right) x^2 \\
 & + \left( \frac{1}{6} - \frac{t}{6} + \frac{t^2}{12} - \frac{t^3}{36} + \frac{t^4}{144} - \frac{t^5}{720} + \frac{t^6}{4320} - \frac{t^7}{30240} \right) x^3 \\
 & + \left( \frac{1}{24} + \frac{t}{24} + \frac{t^2}{48} + \frac{t^3}{144} + \frac{t^4}{576} + \frac{t^5}{2880} + \frac{t^6}{17280} + \frac{t^7}{120960} \right) x^4 \\
 & + \left( \frac{1}{120} - \frac{t}{120} + \frac{t^2}{240} - \frac{t^3}{720} + \frac{t^4}{2880} - \frac{t^5}{14400} + \frac{t^6}{86400} - \frac{t^7}{604800} \right) x^5 \\
 & + \left( \frac{1}{720} + \frac{t}{720} + \frac{t^2}{1440} + \frac{t^3}{4320} + \frac{t^4}{17280} + \frac{t^5}{86400} + \frac{t^6}{518400} + \frac{t^7}{3628800} \right) x^6 \\
 & + \left( \frac{1}{5040} - \frac{t}{5040} + \frac{t^2}{10080} - \frac{t^3}{30240} + \frac{t^4}{120960} - \frac{t^5}{604800} + \frac{t^6}{3628800} \right. \\
 & \left. - \frac{t^7}{25401600} \right) x^7.
 \end{aligned}$$





$$\begin{aligned}
 g(x, t) = & 1 - t + \frac{t^2}{2} + \frac{t^3}{6} + \frac{t^4}{24} - \frac{t^5}{120} + \frac{t^6}{720} - \frac{t^7}{5040} \\
 & + \left( -1 - t - \frac{t^2}{2} - \frac{t^3}{6} - \frac{t^4}{24} - \frac{t^5}{120} - \frac{t^6}{720} - \frac{t^7}{5040} \right) x \\
 & + \left( \frac{1}{2} + \frac{t}{2} + \frac{t^2}{4} - \frac{t^3}{12} + \frac{t^4}{48} - \frac{t^5}{240} + \frac{t^6}{1440} - \frac{t^7}{10080} \right) x^2 \\
 & + \left( -\frac{1}{6} - \frac{t}{6} - \frac{t^2}{12} - \frac{t^3}{36} - \frac{t^4}{144} - \frac{t^5}{720} - \frac{t^6}{4320} - \frac{t^7}{30240} \right) x^3 \\
 & + \left( \frac{1}{24} - \frac{t}{24} + \frac{t^2}{48} - \frac{t^3}{144} + \frac{t^4}{576} - \frac{t^5}{2880} + \frac{t^6}{17280} - \frac{t^7}{120960} \right) x^4 \\
 & + \left( -\frac{1}{120} - \frac{t}{120} - \frac{t^2}{240} - \frac{t^3}{720} - \frac{t^4}{2880} - \frac{t^5}{14400} - \frac{t^6}{86400} - \frac{t^7}{604800} \right) x^5 \\
 & + \left( \frac{1}{720} - \frac{t}{720} + \frac{t^2}{1440} - \frac{t^3}{4320} + \frac{t^4}{17280} - \frac{t^5}{86400} + \frac{t^6}{518400} - \frac{t^7}{3628800} \right) x^6 \\
 & + \left( -\frac{1}{5040} - \frac{t}{5040} - \frac{t^2}{10080} - \frac{t^3}{30240} - \frac{t^4}{120960} - \frac{t^5}{604800} - \frac{t^6}{3628800} \right. \\
 & \left. - \frac{t^7}{25401600} \right) x^7.
 \end{aligned}$$

The above arrangements can also be rewritten w.r.t 't' as:

$$\begin{aligned}
 f(x, t) = & 1 + x + \frac{x^2}{2} + \frac{x^3}{6} + \frac{x^4}{24} + \frac{x^5}{120} + \frac{x^6}{720} + \frac{x^7}{5040} \\
 & + t \left( 1 - x + \frac{x^2}{2} - \frac{x^3}{6} + \frac{x^4}{24} - \frac{x^5}{120} + \frac{x^6}{720} - \frac{x^7}{5040} \right) \\
 & + t^2 \left( \frac{1}{2} - \frac{x}{2} + \frac{x^2}{4} - \frac{x^3}{12} + \frac{x^4}{48} - \frac{x^5}{240} + \frac{x^6}{1440} - \frac{x^7}{10080} \right) \\
 & + t^3 \left( -\frac{1}{6} - \frac{x}{6} + \frac{x^2}{12} - \frac{x^3}{36} + \frac{x^4}{144} - \frac{x^5}{720} + \frac{x^6}{4320} - \frac{x^7}{30240} \right) \\
 & + t^4 \left( \frac{1}{24} + \frac{x}{24} - \frac{x^2}{48} + \frac{x^3}{144} - \frac{x^4}{576} + \frac{x^5}{2880} - \frac{x^6}{17280} + \frac{x^7}{120960} \right) \\
 & + t^5 \left( -\frac{1}{120} - \frac{x}{120} + \frac{x^2}{240} - \frac{x^3}{720} + \frac{x^4}{2880} - \frac{x^5}{14400} + \frac{x^6}{86400} - \frac{x^7}{604800} \right) \\
 & + t^6 \left( \frac{1}{720} + \frac{x}{720} - \frac{x^2}{1440} + \frac{x^3}{4320} - \frac{x^4}{17280} + \frac{x^5}{86400} - \frac{x^6}{518400} + \frac{x^7}{3628800} \right) \\
 & + t^7 \left( -\frac{1}{5040} - \frac{x}{5040} + \frac{x^2}{10080} - \frac{x^3}{30240} + \frac{x^4}{120960} - \frac{x^5}{604800} + \frac{x^6}{3628800} \right. \\
 & \left. - \frac{x^7}{25401600} \right).
 \end{aligned}$$





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$$\begin{aligned}
 g(x, t) = & 1 - x + \frac{x^2}{2} - \frac{x^3}{6} + \frac{x^4}{24} - \frac{x^5}{120} + \frac{x^6}{720} - \frac{x^7}{5040} \\
 & + t \left( -1 - x + \frac{x^2}{2} - \frac{x^3}{6} + \frac{x^4}{24} - \frac{x^5}{120} + \frac{x^6}{720} - \frac{x^7}{5040} \right) \\
 & + t^2 \left( \frac{1}{2} - \frac{x}{2} + \frac{x^2}{4} - \frac{x^3}{12} + \frac{x^4}{48} - \frac{x^5}{240} + \frac{x^6}{1440} - \frac{x^7}{10080} \right) \\
 & + t^3 \left( \frac{1}{6} - \frac{x}{6} + \frac{x^2}{12} - \frac{x^3}{36} + \frac{x^4}{144} - \frac{x^5}{720} + \frac{x^6}{4320} - \frac{x^7}{30240} \right) \\
 & + t^4 \left( \frac{1}{24} - \frac{x}{24} + \frac{x^2}{48} - \frac{x^3}{144} + \frac{x^4}{576} - \frac{x^5}{2880} + \frac{x^6}{17280} - \frac{x^7}{120960} \right) \\
 & + t^5 \left( -\frac{1}{120} + \frac{x}{120} - \frac{x^2}{240} + \frac{x^3}{720} - \frac{x^4}{2880} + \frac{x^5}{14400} - \frac{x^6}{86400} + \frac{x^7}{604800} \right) \\
 & + t^6 \left( \frac{1}{720} - \frac{x}{720} + \frac{x^2}{1440} - \frac{x^3}{4320} + \frac{x^4}{17280} - \frac{x^5}{86400} + \frac{x^6}{518400} - \frac{x^7}{3628800} \right) \\
 & + t^7 \left( -\frac{1}{5040} + \frac{x}{5040} - \frac{x^2}{10080} + \frac{x^3}{30240} - \frac{x^4}{120960} + \frac{x^5}{604800} - \frac{x^6}{3628800} \right. \\
 & \left. + \frac{x^7}{25401600} \right),
 \end{aligned}$$

With all the above discussions, exact analytical solution of the system can be of the form:

$$f(x, t) = e^x \cosh t + e^{-x} \sinh t. \tag{27}$$

$$g(x, t) = e^{-x} \cosh t - e^x \sinh t. \tag{28}$$

In MATLAB, some interesting figures can be drawn as can be seen in Figs. (1 -6).

**Example 2.** Let's consider the following non-linear system of PDEs:

$$\frac{\partial f}{\partial t} + g \frac{\partial f}{\partial x} + f = 1 \tag{29}$$

$$\frac{\partial g}{\partial t} + f \frac{\partial g}{\partial x} - g = 1 \tag{30}$$

with the initial condition:

$$f(x, 0) = e^x \tag{31}$$

$$g(x, 0) = e^{-x} \tag{32}$$

**Solution**

Applying DTM to Eqns. (29) - (32) we have,

$$(m + 1)F(l, m + 1) = F(0, 0) - F(l, m)$$

$$- \sum_{r=0}^l \sum_{s=0}^m (l - r + 1)G(r, m - s)F(l - r + 1, s) \tag{33}$$





$$(m + 1)G(l, m + 1) = G(0, 0) + G(l, m) - \sum_{r=0}^l \sum_{s=0}^m (l - r + 1)F(r, m - s)G(l - r + 1, s) \tag{34}$$

$$F(l, 0) = \frac{1}{l!}, l = 0, 1, 2, \dots \tag{35}$$

$$G(l, 0) = \frac{(-1)^l}{l!}, l = 0, 1, 2, \dots \tag{36}$$

Using Eqs. (35) and (36) in Eqs. (33) and (34) recursively one can get,

$$F(0, 1) = \frac{1}{0!1!}, F(1, 1) = -\frac{1}{1!1!}, F(2, 1) = \frac{1}{2!1!},$$

$$F(0, 2) = \frac{1}{0!2!}, F(2, 2) = \frac{1}{2!2!}, \dots \tag{37}$$

$$G(0, 1) = \frac{1}{0!1!}, G(1, 1) = \frac{1}{1!1!}, G(2, 1) = -\frac{1}{2!1!},$$

$$G(0, 2) = \frac{1}{0!2!}, G(2, 2) = \frac{1}{2!2!}, \dots \tag{38}$$

The above two equations can be generalized for  $l, m = 0, 1, 2, \dots$  as:

$$F(l, m) = \frac{(-1)^m}{l!m!} \tag{39}$$

$$G(l, m) = \frac{(-1)^l}{l!m!} \tag{40}$$

Tabular representation of  $F(l, m)$  and  $G(l, m)$  for  $l, m = 0 \rightarrow 4$  are given below:

Applying the procedure of Eqn. (3), the required solution in truncated form can be obtained by using MATHEMATICA as follows:





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$$\begin{aligned}
 f(x, t) = 1 - t &+ \frac{t^2}{2} - \frac{t^3}{6} + \frac{t^4}{24} - \frac{t^5}{120} + \frac{t^6}{720} - \frac{t^7}{5040} + x - tx + \frac{t^2x}{2} - \frac{t^3x}{6} \\
 &+ \frac{t^4x}{24} - \frac{t^5x}{120} + \frac{t^6x}{720} - \frac{t^7x}{5040} + \frac{x^2}{2} - \frac{tx^2}{2} + \frac{t^2x^2}{4} - \frac{t^3x^2}{12} + \frac{t^4x^2}{48} \\
 &- \frac{240}{t^5x^3} + \frac{1440}{t^6x^3} - \frac{10080}{t^7x^3} + \frac{6}{x^4} - \frac{6}{tx^4} + \frac{12}{t^2x^4} - \frac{36}{t^3x^4} + \frac{144}{t^4x^4} \\
 &- \frac{720}{t^5x^4} + \frac{4320}{t^6x^4} - \frac{30240}{t^7x^4} + \frac{24}{x^5} - \frac{24}{tx^5} + \frac{48}{t^2x^5} - \frac{144}{t^3x^5} + \frac{576}{t^4x^5} \\
 &- \frac{2880}{t^5x^5} + \frac{17280}{t^6x^5} - \frac{120960}{t^7x^5} + \frac{120}{x^6} - \frac{120}{tx^6} + \frac{240}{t^2x^6} - \frac{720}{t^3x^6} + \frac{2880}{t^4x^6} \\
 &+ \frac{14400}{t^5x^6} - \frac{86400}{t^6x^6} + \frac{604800}{t^7x^6} - \frac{720}{x^7} - \frac{720}{tx^7} + \frac{1440}{x^7} - \frac{4320}{tx^7} \\
 &+ \frac{17280}{t^2x^7} - \frac{86400}{t^3x^7} + \frac{518400}{t^4x^7} - \frac{3628800}{t^5x^7} + \frac{5040}{t^6x^7} - \frac{5040}{t^7x^7} \\
 &+ \frac{10080}{t^7x^7} - \frac{30240}{t^7x^7} + \frac{120960}{t^7x^7} - \frac{604800}{t^7x^7} + \frac{3628800}{t^7x^7} \\
 &- \frac{25401600}{t^7x^7}
 \end{aligned}$$

$$\begin{aligned}
 g(x, t) = 1 + t &+ \frac{t^2}{2} + \frac{t^3}{6} + \frac{t^4}{24} + \frac{t^5}{120} + \frac{t^6}{720} + \frac{t^7}{5040} - x - tx - \frac{t^2x}{2} - \frac{t^3x}{6} \\
 &- \frac{t^4x}{24} - \frac{t^5x}{120} + \frac{t^6x}{720} - \frac{t^7x}{5040} + \frac{x^2}{2} + \frac{tx^2}{2} + \frac{t^2x^2}{4} + \frac{t^3x^2}{12} + \frac{t^4x^2}{48} \\
 &+ \frac{240}{t^5x^3} + \frac{1440}{t^6x^3} - \frac{10080}{t^7x^3} + \frac{6}{x^4} - \frac{6}{tx^4} + \frac{12}{t^2x^4} - \frac{36}{t^3x^4} + \frac{144}{t^4x^4} \\
 &- \frac{720}{t^5x^4} + \frac{4320}{t^6x^4} - \frac{30240}{t^7x^4} + \frac{24}{x^5} - \frac{24}{tx^5} + \frac{48}{t^2x^5} - \frac{144}{t^3x^5} + \frac{576}{t^4x^5} \\
 &+ \frac{2880}{t^5x^5} - \frac{17280}{t^6x^5} + \frac{120960}{t^7x^5} - \frac{120}{x^6} - \frac{120}{tx^6} + \frac{240}{t^2x^6} - \frac{720}{t^3x^6} + \frac{2880}{t^4x^6} \\
 &- \frac{14400}{t^5x^6} + \frac{86400}{t^6x^6} - \frac{604800}{t^7x^6} + \frac{720}{x^7} + \frac{720}{tx^7} - \frac{1440}{x^7} + \frac{4320}{tx^7} \\
 &+ \frac{17280}{t^2x^7} + \frac{86400}{t^3x^7} + \frac{518400}{t^4x^7} + \frac{3628800}{t^5x^7} - \frac{5040}{t^6x^7} - \frac{5040}{t^7x^7} \\
 &- \frac{10080}{t^7x^7} - \frac{30240}{t^7x^7} - \frac{120960}{t^7x^7} - \frac{604800}{t^7x^7} - \frac{3628800}{t^7x^7} \\
 &- \frac{25401600}{t^7x^7}
 \end{aligned}$$

A closed form solution of the system is given by

$$f(x, t) = e^{x-t}. \tag{41}$$





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$$g(x,t) = e^{-x+t} \tag{42}$$

Figs. (7 - 13) are drawn through MATLAB to conclude.

### CONCLUSION

Two dimensional differential transform methods have been applied effectively to linear and non-linear systems of PDEs. The results of two examples are quite in good agreement with exact analytical closed form solution. However, computational difficulties are reduced in this method which can be witnessed through these type of examples. This fact motivates us to go with DTM, an effective analytical method which uses simple calculations to solve many complicated linear and non-linear system of PDEs without any linearization, discretization or perturbation.

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TABLE: 1 Computation of Coefficients of  $F(l, m)$

$l / m$	0	1	2	3	4
0	1	1	1/2	1/6	1/24
1	1	-1	-1/2	-1/6	1/24
2	1/2	1/2	1/4	1/12	1/48
3	1/6	-1/6	1/12	-1/36	1/144
4	1/24	1/24	1/48	1/144	1/576

TABLE: 2 Computations of Coefficients of  $G(l, m)$

$l / m$	0	1	2	3	4
0	1	-1	1/2	1/6	1/24
1	-1	-1	-1/2	-1/6	-1/24
2	1/2	1/2	1/4	-1/12	1/48
3	-1/6	-1/6	-1/12	-1/36	-1/144
4	1/24	-1/24	1/48	-1/144	1/576





TABLE: 3 Computations of Coefficients of  $F(l, m)$

$l/m$	0	1	2	3	4
0	1	-1	1/2	-1/6	1/24
1	1	-1	1/2	-1/6	1/24
2	1/2	-1/2	1/4	-1/12	1/48
3	1/6	-1/6	1/12	-1/36	1/144
4	1/24	-1/24	1/48	-1/144	1/576

TABLE: 4 Computations of Coefficients of  $G(l, m)$

$l/m$	0	1	2	3	4
0	1	-1	1/2	1/6	1/24
1	-1	-1	-1/2	-1/6	-1/24
2	1/2	1/2	1/4	1/12	1/48
3	-1/6	-1/6	-1/12	-1/36	-1/144
4	1/24	1/24	1/48	1/144	1/576

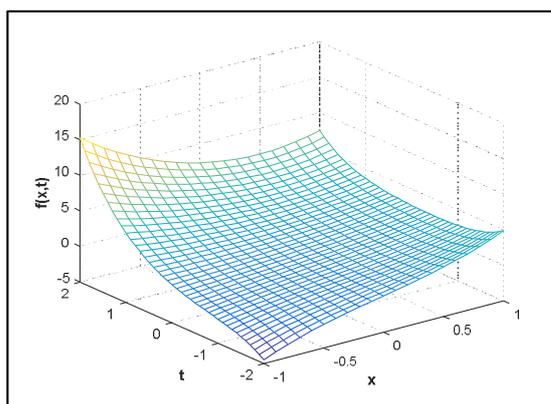


Fig. 1 Variation of  $f(x, t)$

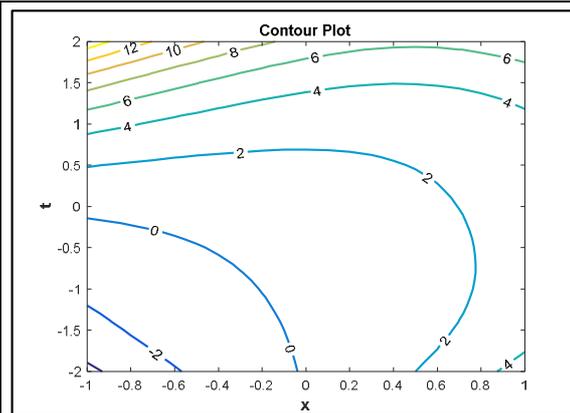


Fig. 2 Contour Plot of First Solution

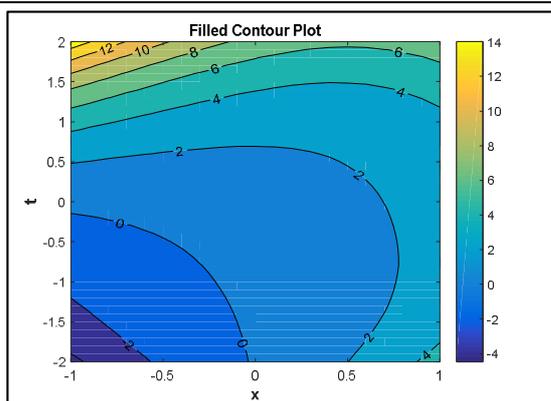


Fig. 3 Filled Contour Plot of First Solution

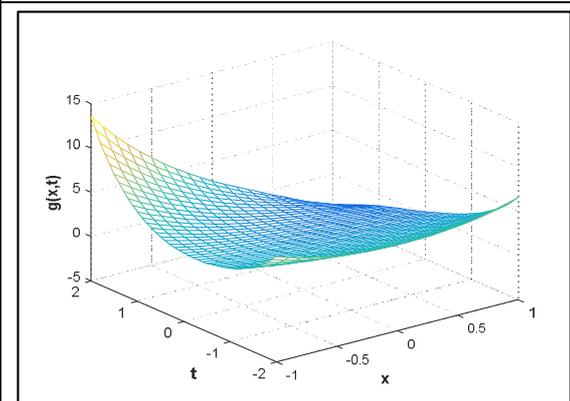


Fig. 4 Variation of  $g(x, t)$





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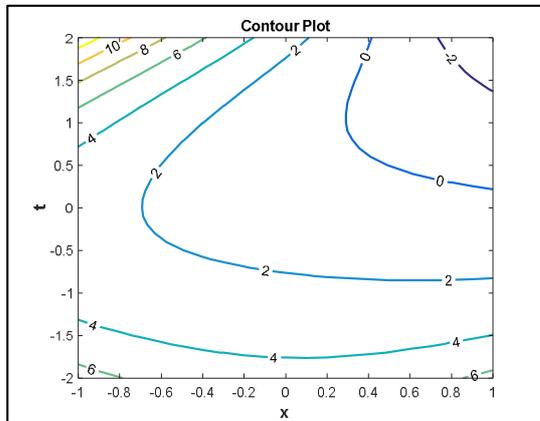


Fig. 5 Contour Plot of Second Solution

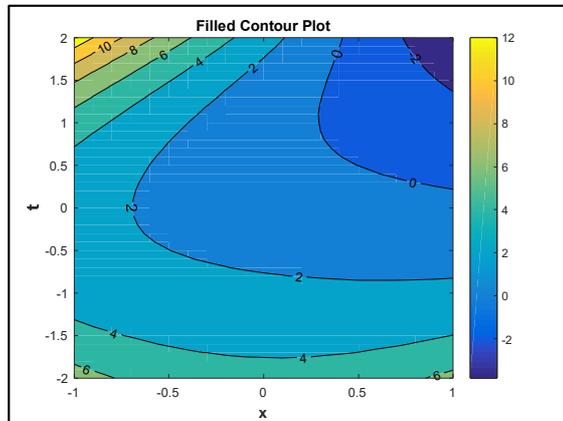


Fig. 6 Filled Contour Plot of Second Solution

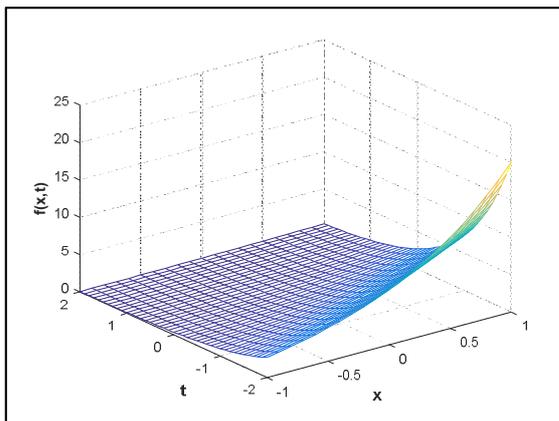


Fig. 7 Variation of  $f(x,t)$

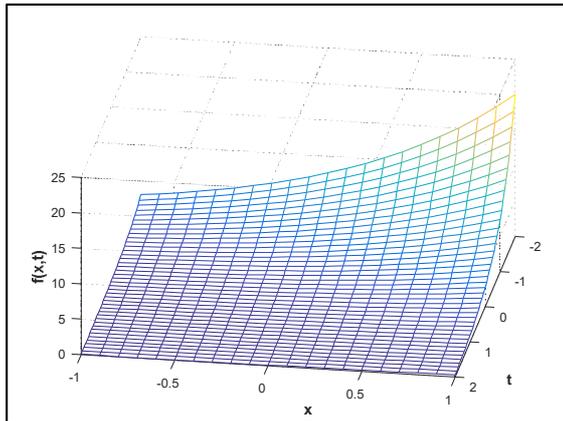


Fig. 8 Variation of Moving  $f(x,t)$

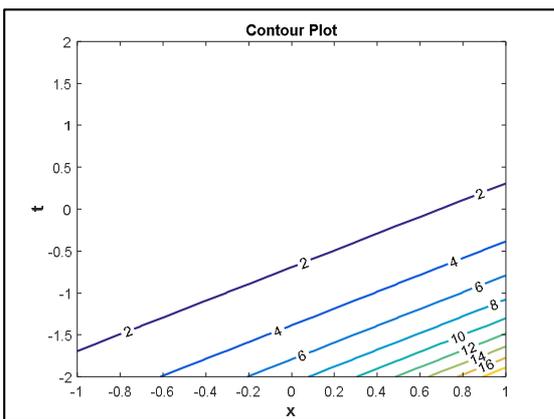


Fig. 9 Contour Plot of First Solution

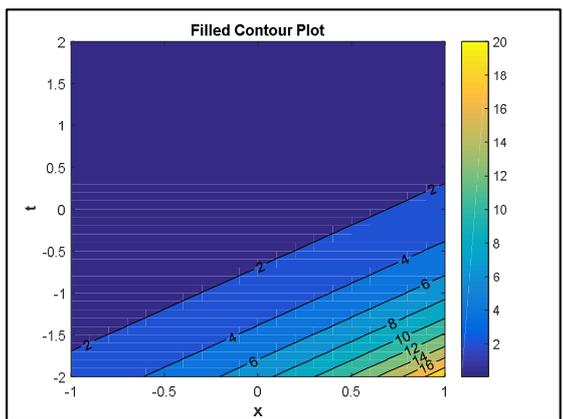


Fig. 10 Filled Contour Plot of First Solution



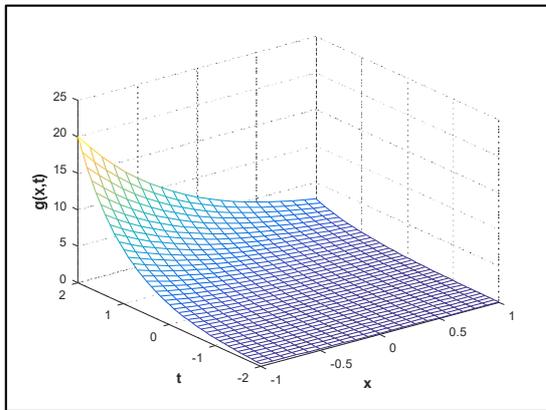


Fig. 11 Variation of  $g(x,t)$

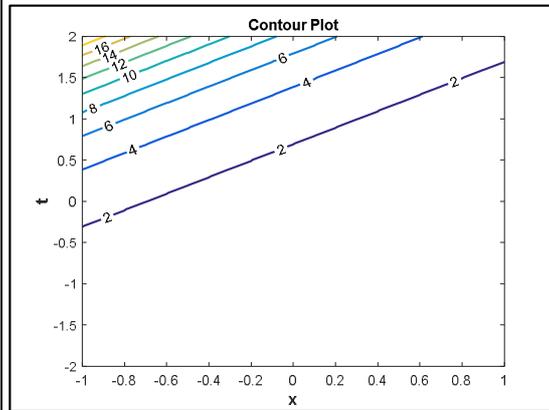


Fig. 12 Contour Plot of Second Solution

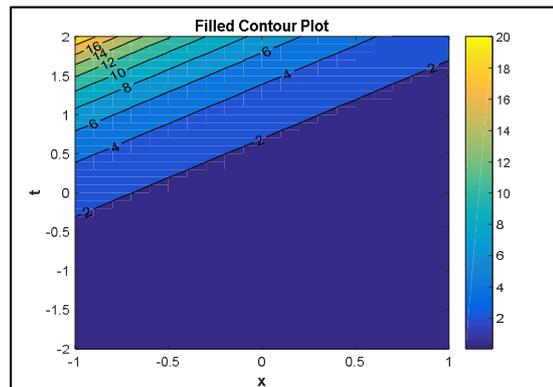


Fig. 13 Filled Contour Plot of Second Solution





## Face Recognition Based Smart Door Lock Using Raspberry Pi

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### ABSTRACT

Security is one of the vital aspects of everyday life. From time immemorial, people used to give top priority to safeguard their houses by using different door locking systems. Let it be for access into the high-security premises to the common man house, we always wish to stay safe and also to block out the trespassers curtailing worries. We use from conventional lock and key to very sophisticated remotely controlled sensor lock. But each of the locking systems has its demerits, sometimes it faces the situation where we either forget to lock the house or also sometimes misplace or lose the key, In case of doors with auto locking system if the keys are misplaced we have no alternative except cutting the lock . Also sometimes people don't leave the house out of fear that someone might burgle. For such reasons, the faith in the automated smart door lock system is increasing. In the world of rising technologies; individuals have resorted to biometric unlocking system but biometric locking system has its disadvantages like palms with oily substances and sweat didn't recognized by the system. The most hazardous factor in biometric system is the surface touched by several people which can be a hotspot for transmitting deadly viruses; it is quite evident in the recent outbreak of COVID-19 pandemic. To overcome all these disadvantages locking system with face recognition is a revolutionary effort. So in this research, it recommends a door lock security system which is capable to unlock the door with a simple snap of our face. This security system has been developed by integrating deep learning and IOT. This security system is developed using the Raspberry Pi, Pi Camera, and Solenoid Lock. The distinctive feature of this system is that it uses the deep learning face recognition technique which increases the classification accuracy. The proposed system yields 96.28% accuracy with a minimum sample size. The relay board is designed to trigger the voltage instead of the current due to which it won't fail even if a low Ampere current is provided to the system. In emergency conditions, if any unauthorized entry took place using the emergency button then the system shared the captured image of the person along with the time of entry to admin through the mail.

**Keywords:** Face Recognition; IoT, Raspberry Pi; Pi Camera; Security; Security





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## INTRODUCTION

Doors are the basic part of the security system, be it for a highly secured defense facility or a regular house. To unlock any door we need to have the right key for it. For this reason, we face problems many times like if we lose the key or in case of an automatic door lock system we sometimes forget the key in the house due to which we need to break the lock. To avoid such issues face recognized locks are a good source of alternatives. In this lock system, the face is the key to unlocking the door. Due to the enhancement in technology we often go for multi lever locks made out of the best material. Further technology provides us with biometric locks that permit keyless operations of the lock [1]. Next, we come across switch operated lock systems mostly used in cars. So now we are on the path of face recognition which also provides another level of a secure environment.

In present scenarios, biometrics is present in every nook and corner. Let it be in industries, educational organizations, and institutions, restricted areas, high-security zones or our home. It is very critical for all these organizations that the biometric system should function inexhaustibly for the smooth operation of these organizations. In our busy schedule biometrics has become a secure and easy way to prevent unauthorized users to enter the authorized area without requiring any physical help. Biometrics is normally used for unique identification. There are different types of biometrics like fingerprint, palm print, and face [2], [3]. The fingerprint biometric came into light at the beginning of the decade and as the technology is rapidly growing the hackers have found the way to crack this. So now we are in the direction of face biometrics [4].

Face biometrics is nothing but simply a face recognition algorithm. Here we use the algorithm to check if a person seeking to enter a room has been granted access or not. If a person is unauthorized a simple mail is sent to the admin warning him/her that a stranger is trying to gain access into the room. Alternatively, a button is also present in case the face recognition is unable to identify the person or for any emergency purpose which grants access to the door but captures an image of the person and sends a mail to the admin along with the image of the person warning him of the activity [3], [5]. The prime objective of this project is to provide a smart security system which can be alternatively used for keyless entry. For low lighting conditions, histogram equalization is implied to the image to enhance the contrast. Also, any person, if he/she is differently-abled, can easily use it. For any condition, if the face recognition fails, the person can also alternatively use a switch to gain access which is placed at a location only known to the admin. This security system also provides the user with an alert system that can aware of the user in case it is accessed by any stranger.

The arrangement of this paper is distributed into seven divisions. Division II converses about the related works done by different scholars in this equivalent field. Division III illustrates the methodology of the system. Division IV labels system requirements that include dataset and both hardware and software packages that are needed for this research. Division V depicts the system architecture. Division VI provides results and discussion. Finally, Division VII finishes this study.

## RELATED WORK

IoT is being used in various fields for the development of a lot of daily used products. Mostly used IoT devices are mobiles, laptops, automated door locks in various malls and theatres, smart bathrooms, fully automatic washing machines, etc. [1]. Face recognition has been used as a security measure in mobile phones and laptops since 2014. A more enhanced version of face recognition is being used now which is much smarter than the previous version. In some of the existing literature based on both research and projects, a remotely operated door lock has been developed using the ESP32 microcontroller. This system can open and monitor the door remotely. It uses a PIR sensor to sense any human activity and open the door [1].



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A 16F887 microprocessor is used for face detection and recognition. This project is carried out by MATLAB programming. After confirming that the person is authorized, the door is unlocked immediately [2]. This paper proposes the use of Raspberry Pi and it works in two different parts. The first part is responsible for capturing an image and creating a database for storing the images. The second part is tasked to compare the new image with the stored images in the database [3]. This paper proposes a different approach. It uses the Eigen Face technique which makes it more secure and for warning purpose it uses the SMS system [4]. Similarly, in ref [5] a PIR sensor has been used for the same purpose. In this paper when the PIR sensor senses the human activity, the Pi Camera is started and it captures the image. Once the face is recognized then the door unlocks otherwise a warning email is sent to the admin. A smart door lock for physically challenged persons with the help of Arduino has been developed [6]. In this project, a Wi-Fi signal has been sent to the door to lock or unlock it. A smart lock has been proposed in ref [7] where the image of the unauthorized person is recorded and sent to the administrator.

It also warns about the physical damage of the lock to the administrator. The traditional feature extraction technique from human faces has been used to extract the optimal features [8]. Some of the security systems are economically feasible. It allows connection and control between no. of devices, the master device is connected to the cloud server which is controlled by admin which facilitates a no. of users to which no. of nodes is connected [9]. A security system for an entire house has been developed starting from light, fan, window, screen, etc. by using MQTT protocol [10]. The detection system was developed using the PIR sensor, ZigBee for creating a wireless sensor network and ESP8266 for sending the sensor data to a public server [11]. The Lock system integrated with an innovative technology i.e. Bluetooth technology enhances the security level along with easy interaction between user and the lock system [12]. Security systems are also developed on different types of protocols and algorithm leading to the solution of previously stated problems [13]. Digital lock systems having a digital interface with the traditional keyhole where the way of rotating the key is converted into code is a fine alternative to the emerging lock system [14]. Systems using the cryptographic algorithm for security systems is a unique approach in the field of locking systems [15]. In this study, a door lock security system has been proposed which is capable to unlock the door with a simple snap of a human face.

## METHODOLOGY

The recommended model is built using the single-board computer having an efficient processor i.e. Raspberry Pi. It runs on a Linux based operating system which is called Raspbian. This Operating system is specially designed for Raspberry Pi. It uses Pi Camera that is specifically designed for Raspberry Pi for capturing the image of the face and a solenoid lock for a secure locking system. A speaker is also attached to the system to give the voice signal if a person enters the locked premises. Initially, when the power is supplied to the Raspberry Pi the Pi Camera gets started. After that, it scans the face of the person from the live video stream and if any face is found it compares the faces with its database. If any match is found it recognizes the face and further power is supplied to the relay. The face detection and recognition task are executed with the help of a face\_recognition package which is a deep learning technique for face recognition. If the face is recognized then power is supplied to the relay and the relay gets triggered and the solenoid lock unlocks the door for 5 seconds. But if the face is not recognized then it sends a warning e-mail to the admin making him aware of the trespasser.

## SYSTEM REQUIREMENTS

### Dataset

The dataset is collected from [www.cs.umass.edu website \(http://vis-www.cs.umass.edu/lfw/lfw.tarz\)](http://vis-www.cs.umass.edu/lfw/lfw.tarz). It contains 5000 face images of various personalities. The dataset has been used for both training and testing purposes.





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From these 5000 images, 350 images of different people are taken and trained with a ratio of 1:1 i.e. 1 image per person. From the 350 people, different photographs of 50 random people are considered for testing purposes using deep learning package face\_recognition. Table 1 depicts the same.

## Hardware

### Raspberry Pi 3 Model B

Raspberry Pi 3 Model B is also known as a mobile mini-computer. It has Quad-core 1.2GHz Processors, 64bit CPU along with 1GB RAM. This model also has extended 40-pin GPIO, 4 USB 2 ports, CSI camera port for connecting the Pi Camera and DSI display port for connecting the Pi display. It also has features like Micro SD card slot, wireless LAN and Bluetooth onboard.

### Pi Camera

The Pi camera module is a personalized camera for Raspberry Pi. It is attached to the Raspberry Pi using the CSI camera port which is dedicated to interfacing the camera in Raspberry Pi. The dimension of the camera module is 25mm x 20mm x 9mm. It has a resolution of 8 megapixels. The camera module is supported only on the Raspberry Pi operating system that is Raspbian.

### Solenoid Lock

Solenoid lock, known as Solenoid bolt, is an electronic-mechanical lock. The power source for the lock is electricity. It reduces power consumption and can be operated with less power. It also performs voltage regulation. The lock is disabled if there is power loss. The solenoid lock used in this system is 12V.

### Relay Module

The relay module used in the system has been specifically designed to trigger the voltage, unlike the general relay modules. The board is designed with a 12V relay, a 7805, an NPN transistor, 12V DC power source that is interconnected in such a manner that the relay will be triggered if it encounters a 5V current. The DC power source will provide an output of 12V which is channeled to trigger the solenoid lock and the relay. The 7805 is connected in-between the relay and the DC power source so that no matter how high voltage is supplied but the final output will be 5V only.

## Software

### Raspbian OS

Raspbian is a customized operating system for Raspberry Pi. It is Debian-based operating which runs on the Linux platform. It is an open-source. The kernel type of this operating system is monolithic. The system is installed with python packages like pickle, face\_recognition, picamera, NumPy, glob, PIL, RPi.GPIO, time, etc

## SYSTEM ARCHITECTURE

In the system, the Raspberry Pi functions as the main controller. The Raspberry Pi uses RPi.GPIO package for GPIO pin configuration. In the beginning, faces given access are taken. The features of those faces are extracted and converted to a matrix format. Those matrixes are then stored in a pickle file with .pickle extension. In the face detection program, the pickle file is simply stored in a variable format and further the data of the variable is stored in an array consisting of all matrixes. The face detection program has been put to an infinite loop due to which it searches for faces every time.

The Pi Camera is an 8-megapixel camera that has been specially designed for the Raspberry pi and is used for the detection. To configure the Pi Camera in Raspberry Pi along with python, Pi Camera package is used. If a person





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stands in front of the camera, the face is detected and the total no of faces is counted using the histogram of oriented gradient technique. For face detection, the face landmark estimation and face recognition, the SVM classifier has been used respectively. The above two techniques are combined to form the face\_recognition library. It can be used efficiently to count the total no of faces. It also can be used to filter the faces very proficiently.

If the face count is more than 0 then the locations of faces are extracted and the facial features are scanned and stored in a matrix format. The matrix is then compared with each matrix that has been stored in the array form the pickle file. If any face doesn't match with the new face an alarm is sent to the admin warning him/her of the trespasser and the system again searches for new faces. But if the face matches with any face from the matrix, then the power is sent to the relay. The relay has been configured with a 7805 and an NPN transistor. The 7805 regulates the relay board to produce a voltage output of 5V for the relay to trigger. The board is provided with a 12V supply from a DC power source as the solenoid lock requires 12V power supply to trigger. A secondary channel of the power is provided to the 7805 and a 5V output is derived which is channeled to the relay which is the switch for the solenoid lock and it is only triggered if a face is recognized by the system as authorized personnel. When the lock is triggered it is delayed for 5 seconds for the person to enter after which it closes automatically. Also, a pushbutton has been provided for any backup or failsafe purpose. If the system fails to open by any means, the door can be unlocked by a pushbutton. It can be placed secretly by the admin. When the door is accessed through the pushbutton, a photo of the person will be captured and an alarm mail will be sent to the admin along with a timestamp and the photo will be stored in the memory. Also, a speaker has been added to the system which will say "WELCOME" if the door is accessed by any authorized person and if accessed by any unauthorized person, it will say "YOU ARE UNAUTHORIZED".

## RESULT AND DISCUSSIONS

The final result of this study is that if the face captured by the Pi Camera matches with that of the faces in the pickle database, then power is supplied to the relay and the relay is triggered which as a result activates the solenoid lock and the door is unlocked for 5 sec. Else, if the captured face is not recognized the door remains closed and a warning email is sent to the admin about the intruder. Fig. 3 shows the hardware connection of Raspberry Pi to the relay board and solenoid lock. Fig. 2 shows when a face is recognized the power is supplied. Amongst the 250 people, 50 were randomly selected. The different photographs of their images were taken for testing. Out of those, 48 images were correctly recognized with the perfect result, 2 images could not be recognized classifying them as intruders. This proves that the face recognition accuracy of the face\_recognition package is 96% approximately.

After testing, the result is recorded in binary format which classifies 1 for all the images that are perfectly-recognized and 0 for the images that could not be recognized. Fig. 3 shows the recorded testing result. Here three papers have been taken into consideration for the comparison purpose. Firstly, an IoT based monitoring system consisting of an ESP32 that remotely provides access through smartphones [1]. The second paper [3] recommended a system that functions on raspberry pi by using the Haar classifier algorithm on OpenCV. It claims 93.24% classification accuracy for face detection. The third one proposes a system using raspberry pi and using a classical face recognition system that uses the LBPH algorithm for feature extraction [8]. In the proposed system face recognition has been used as a security measure. This system uses the face\_recognition python library which uses deep learning technology. It gives a classification accuracy of 96% with only one image sample per person. This system also monitors the strangers and reports the admin if a stranger is trying to access the door. Also, it uses a pushbutton as an alternative if the system fails to respond anytime. Fig.4 shows an accuracy comparison of different reference model along with the proposed model.



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## CONCLUSION

This IoT based smart door lock system uses Raspberry Pi, Pi Camera with deep learning techniques. Python has been used to implement the above-said door lock system. The efficiency of this system is measured by the accuracy which is 96.28% as per the test results of the face recognition package. This is a new approach to door lock system using face recognition with Raspberry Pi, Pi Camera and the relay as the prime components. This model gives an email along with the alarming alert to the admin.

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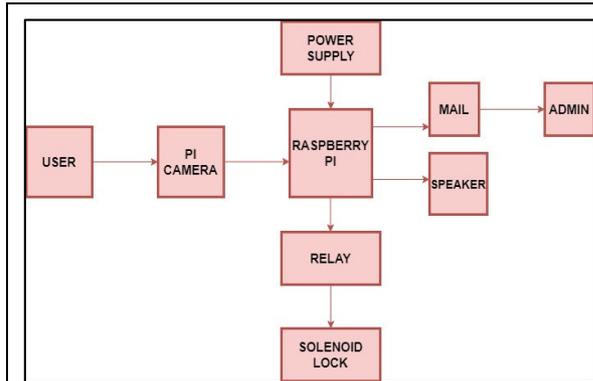




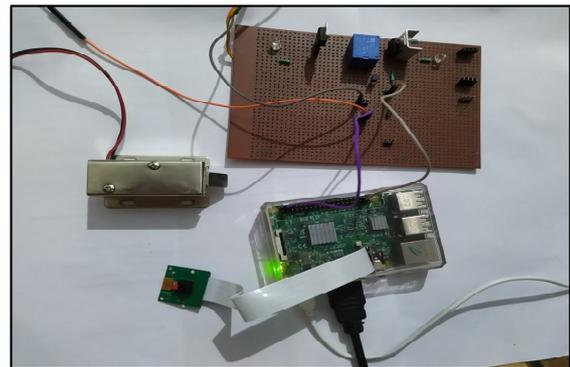
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**Table I. Dataset**

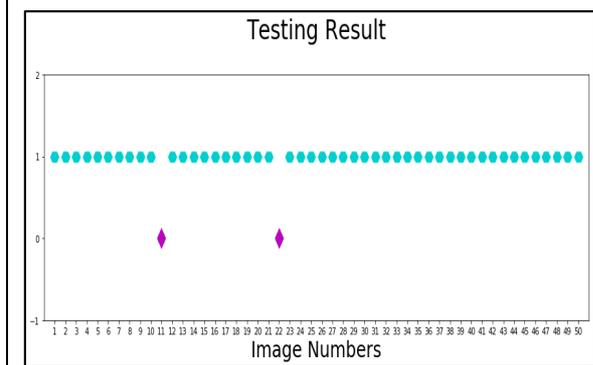
DATA	No. of IMAGES
Total	3000
Training	250
Testing	50



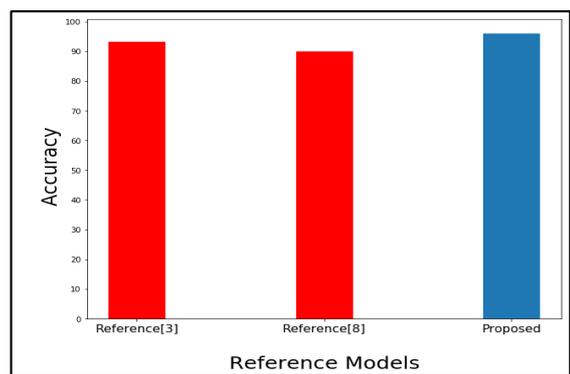
**Fig.1 Block diagram for the recommended system**



**Fig.2. Face is recognized and as a result power is supplied**



**Fig. 3. Testing result of the proposed system**



**Fig. 4 Accuracy Comparison Graph**





## Machine Learning Approaches to Sentiment Analysis: A Survey

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### ABSTRACT

Sentiment analysis is a text mining process widely used to extract subjective information from the source text. It is a decision making process to review the product how many are negative and positive. The main process in this analysis to recognize the convention of repudiation and the categorization of negative and positive sentiments received by the users or client in the social group. The proposed work tries to point out the benefits of use of machine learning in the field of sentiment analysis as well as puts light on the challenges present. The objective of this study is to encourage researchers to explore the possibilities and address the challenges faced to make the sentiment analysis process more efficient

**Keywords:** Sentiment Analysis, Machine learning, Text Mining

### INTRODUCTION

In the current world people search for others opinions available on the web to take decisions. Decision is a combination of reason and emotion which are complementary. Thus, Sentiment Analysis has gained a worldwide importance. It is a type of natural language processing that is used for keeping the track of mood of the public and assigning polarity to it. Lately, opinion mining and sentiment analysis has grabbed the attention of the researchers with the rapid increase of possible applications [1]. Sentiment analysis has become a popular technique to gather the view of individual and mass about a product, commodity, service, issue etc. The views of the individuals can either be positive, negative or neutral.[2]. There are numerous data sources available that deal with views of people. These data sources can be effectively utilized for the sentiment analysis task. Some of the data sources are blogs, review sites, social Medias like twitter, face book etc and news articles.

This paper tries to go for an in-depth analysis on various machine learning techniques available for sentiment analysis along with the comparison. The section 2 deals with literature survey. The frame work for sentiment

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analysis is discussed in section 3. Section 4 covers different sentiment analysis techniques using machine learning. Sections 5 and 6 include the comparison and conclusion respectively

**LITERATURE SURVEY**

Farhadloo et al. discussed about different methods of sentiment analysis. In this work they have mentioned both supervised and unsupervised approaches for sentiment identification. The authors put emphasis on techniques like SVM and sentiment identification using lexicons [2]. Singh, J. et al. used four different machine learning approaches including Naive Bayes technique to classify the polarity of public reviews collected from Amazon and IMDB movie review. In this paper they have given emphasis on the Naive Bays approach in terms of learning time [3]. N. Zainuddin et al. applied SVM on benchmark datasets to train the sentiment classifier. In this work they have classified the data into positive and negative polarities. They have also used Chi-Square feature selection to select informative features[4]. D. A. Alboaneen et al.suggested a MLP based sentiment classifier to classify twitter sentiments. They have also used meta-heuristic algorithm to optimize the weights and biases of the MLP. In this work they have found that the meta-heuristic based MLP is giving better performance over genetic algorithm (GA) and biogeography-based optimisation (BBO) algorithms [5].

Al-Batah et al.Proposed a hybrid approach(NB-MLP) combining the Naive Bays and MLP approaches to classify Arabic sentiment. In this work they have used 6 different datasets for sentiment classification with a 10 fold cross validation for testing model. The experimental results of the work show better classification accuracy over Nave Bays approach [6]. H. Kaur et al. in their survey paper analysed various types of machine learning techniques. The survey focused on specific areas such as subjectivity detection, sentiment classification, aspect term extraction, feature extraction etc[7].

**SENTIMENT ANALYSIS PROCESS**

The sentiment analysis process includes the following sub-processes

- Pre-Processing
- Feature Extraction
- Sentiment analysis

**Pre-Processing**

The pre-processing step involves the following;

- **Tokenization:** Here the sentences are divided into words or tokens by removing white spaces and other symbols or special characters.
- **Stop Word Removal:** Removes articles like “a, an, the”.
- **Stemming:** Reduces the tokens or words to its root form.
- **Case Normalization:** Changes the whole document either in lower case letters or upper case letters.
- **Lemmatization:**Lemmatization takes the consideration of morphological Analysis of the words. It reduces inflected words properly with theroot words belongto the sentences. It is also called as lemma which is the set of words in dictionary form, citation form and canonical form. [8].

**Feature Extraction**

This process includes the following sub processes:

- **Feature Types:** This process identifies theclass of features used for sentiment such as frequency, co-occurrence, , Opinion, Negation, Dependency).





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- **Feature Selection:** It is a process of selecting better features from the feature pool
- **Feature Weighting Mechanism:** It is a ranking mechanism by assigning particular weight values to a feature.
- **Feature Reduction:** It reduces the vector size to optimize the performance of a classifier [10].

## Sentiment Analysis

Sentiment Analysis in simple term is to analyse a piece of text, (word, sentence or document) and to find whether the text is positive or negative. It can be performed by adapting two different approaches such as [9]

- Rule-based sentiment analysis
- Machine Learning (ML) based sentiment analysis

This paper concentrates on the machine learning based approaches

### Machine Learning (ML) based sentiment analysis

In this approach a machine learning model is used and trained to classify the features of the data in terms of polarity. Different techniques are used for this purpose. Some conventional techniques are:

- Naive Bayes Classifier
- Support Vector Machine (SVM)
- Multi-Layer Perceptron (MLP)

### Naive Bayes Classifier

A Naive Bayes classifier is a probabilistic machine learning model that's used for classification task. It is based on the Bayes theorem which is represented as:

$$P(A|B) = P(B|A) \cdot P(A) / P(B)$$

Where A is the hypothesis and B is the evidence. Bayes theorem computes the probability of occurrence of A when B has already occurred.

### Support Vector Machine (SVM)

SVM is a discriminant technique, and, because it solves the convex optimization problem analytically, it always returns the same optimal hyperplane parameter—in contrast to genetic algorithms (GAs) or perceptrons, both of which are widely used for classification in machine learning. For perceptrons, solutions are highly dependent on the initialization and termination criteria. SVM is a discriminant technique, and, because it solves the convex optimization problem analytically, it always returns the same optimal hyperplane parameter—in contrast to genetic algorithms (GAs) or perceptrons, both of which are widely used for classification in machine learning. For perceptrons, solutions are highly dependent on the initialization and termination criteria.

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A Support Vector Machine (SVM) is a supervised machine learning approach which may be used for classification as well as regression based problems. There are two types of SVM available such as:



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- **Linear SVM:** Linear SVM is used for linearly separable data, which means if a dataset can be classified into two classes by using a single straight line, then such data is termed as linearly separable data, and classifier is used called as Linear SVM classifier.
- **Non-linear SVM:** Non-Linear SVM is used for non-linearly separated data, which means if a dataset cannot be classified by using a straight line, then such data is termed as non-linear data and classifier used is called as Non-linear SVM classifier.

### Multi-Layer Perceptron (MLP)

Multi-layer Perceptron (MLP) is a supervised learning algorithm where the objective is to map a multi dimensional input to a multi dimensional output. The MLPs are used to solve problems which are not linearly separable.

### OBSERVATION

The various techniques described in previous section have their own advantages and disadvantages. The comparative analysis of the supervised training approaches is shown in the following table.

### CONCLUSION AND FUTURE SCOPE

Supervised algorithms are widely used in the field of sentiment analysis. Sentiment classification being the most important part of sentiment analysis requires a robust and reliable classifier. From our observation it is evident that though supervised techniques produce better result, they are subject to some limitations in terms of time complexity and structural complexity. In future we shall try to develop a hybrid supervised approach by combining two or more conventional approaches in order to get better classification accuracy and time complexity. Use of optimization techniques along with supervised techniques may provide a new direction to the field of sentiment classification.

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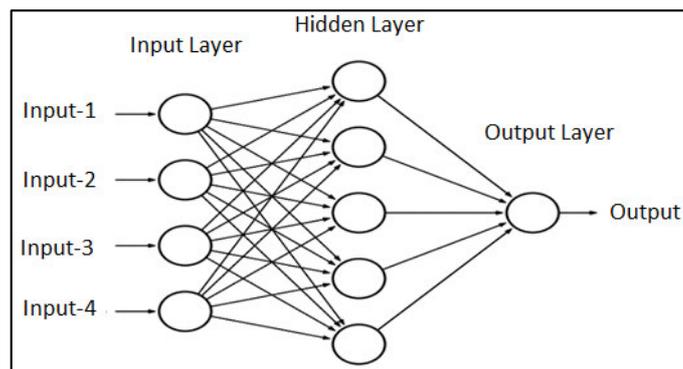
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**Table 1. Comparison of Machine Learning Techniques**

Approach	Time complexity	Intended for	Issues
Naïve Bayes Classifier	$O(Nd)$	Classification	Not applicable for Regression
SVM	$O(N^3)$	Classification and Regression	Complex Architecture
MLP	$O(n1.M.P.n2.e)$	Classification and Regression	Architecture Dependent

**N:** Number of training samples      **d:** Dimensionality of the features      **c:** Number of classes.  
**n1:**input variables                      **M:** number hidden neurons                      **P:**numberoutputvalues  
**n2:** number of observations              **e:** Number of epochs



**Fig1. MLP with single hidden layer**





## Prediction of Indian Petrol Price Using Machine Learning Algorithm

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### ABSTRACT

A Forecasting of oil prices has always been a matter of great importance due to its influence in driving a country's economy. As a matter of fact, the petroleum industry is considered to be the biggest contributor in the industrial sector in terms of providing raw materials to the other industries and generating revenues. Due to the non-linear and unpredictable nature of the oil prices, a lot of forecasting techniques have been developed and used to check whether they are capable of forecasting the oil prices satisfactorily. In this paper the Artificial Neural Network and Multiple regression technique is used to forecast the prices of Petrol in India for a 11 years period (2008-2018). The results obtained are compared with the actual prices for the above time period. It is observed that the overall accuracy considering petrol price shows promising results thus justifying them capable of forecasting the prices of the petrol in India.

**Keywords:** Petroleum Products; Prices, Multiple Regression; Artificial Neural Network

### INTRODUCTION

Petroleum can be defined as a kind of fossil fuel, which is found below the earth's superficial. It is formed when dead organisms decompose in large amounts due to the high pressure and temperature they are subjected to when they are pressed and buried under the rock bodies. Composed mainly of carbon and hydrogen compounds, the oil can be processed and refined to obtain a large amount of fuels and other related products. Popular petroleum derivatives are LPG, diesel, petrol, jet fuel, kerosene, paraffin, wax, tar, etc. Fossil fuels presently account for 87 % of primary energy demand and projected to still make up 82 % of the global total by 2035. Oil remains the world's most important fuel, accounting to 33.1 % of global energy consumptions. Oil will remain the energy type with the major share for most of the projected periods and will continue to play a foremost part in satisfying world energy needs. Oil price act as a key component dominating investment picture for years to come on. They act as a key variable in estimation of economic growth, energy strategy conclusions and stock markets. Preceding information of oil prices

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variations helps oil manufacturers to make decisions about the rise or fall in production levels accordingly. Petrol product price predictions are showing the importance for the economy, and politics. The prices of petroleum product can be directly or indirectly influence the stock market of different countries. Different studies are performed for forecasting petroleum product prices. Given the importance of oil price increases and economic activities, forecast of prices of oil and its altered derivatives becomes a vital criterion in considering and evaluating the future economy of the country, which brings this topic down to this paper. In this paper, MultipleRegression and ANN model are mostly used for forecasting various domains including crude oil prices and Tax .

There is widespread agreement that unexpected large and persistent fluctuations in the real price of oil are detrimental to the welfare of both oil-importing and oil-producing economies. Reliable forecasts of the price of oil are of interest for a wide range of applications. For example, central banks and private sector forecasters view the price of oil as one of the key variables in generating macroeconomic projections and in assessing macroeconomic risks. Of particular interest is the question of the extent to which the price of oil is helpful in predicting recessions. For example, Hamilton (2009), building on the analysis in Edelstein and Kilian (2009), provides evidence that the recession of late 2008 was amplified and preceded by an economic slowdown in the automobile industry and a deterioration in consumer sentiment. Thus, more accurate forecasts of the price of oil have the potential of improving forecast accuracy for a wide range of macroeconomic outcomes and of improving macroeconomic policy responses.

In addition, some sectors of the economy depend directly on forecasts of the price of oil for their business. For example, airlines rely on such forecasts in setting airfares, automobile companies decide their product menu and product prices with oil price forecasts in mind, and utility companies use oil price forecasts in deciding whether to extend capacity or to build new plants. Likewise, homeowners rely on oil price forecasts in deciding the timing of their heating oil purchases or whether to invest in energy-saving home improvements. Finally, forecasts of the price of oil (and the price of its derivatives such as gasoline or heating oil) are important in modeling purchases of energy-intensive durables goods such as automobiles or home heating systems. 1 They also play a role in generating projections of energy use, in modeling investment decisions in the energy sector, in predicting carbon emissions and climate change, and in designing regulatory policies such as automotive fuel standards or gasoline taxes. Oil is one of the vital natural resource in the world. As the demand is increasing day by day and the availability of oil resource is decreasing day by day, countries are struggling to extract it at almost any cost. Oil is a vital input for the production of a wide range of goods and services, because it is used for transportation in business of all types. Higher oil prices thus increase the cost of inputs; & final product price increases causes inflation, if the cost increases cannot be passed on to end users, economic inputs such as labor and capital stock may be reallocated. In a net importer of oil economy like India, higher oil prices shrink foreign reserves of the economy, affect the purchasing power of the economy in terms of International trade. The word petroleum is derived from two Latin words *petra* means rock and *oleum* means oil. Petroleum is loosely called „rock oil“ or „crude oil“. It is a generic term covering a wide range of substances comprising hydrocarbons, which are naturally occurring molecules of carbon and hydrogen.

A number of research papers have been published on prediction of oil price considering various methodology. Primarily, two techniques, neural network and time series models individually or with various combinations are employed to forecast oil price. In this paper Unsupervised algorithm is used where we have to found the output by taking inputs. The Multiply Regression technique is used as first predicating technique to estimate the approximate output value then the ANN technique is used to predicting the approximate output and finding the output value. Predicting oil prices has never been an easy task because of its non-linearity nature. Over the years, a lot of forecasting techniques have been tried and tested to solve this problem. In this work, two of those techniques, ARIMA analysis and GMDH Neural networking, have been used to forecast the prices of four petroleum products in India for a three month period (February 2015 to April 2015). The results obtained show excellent levels of accuracy when compared with the actual prices for the same time period. The analysis that was done in this paper validated the effectiveness of both the techniques, ARIMA modelling and GMDH neural networking, in predicting the price of petroleum products in India for a period of three months[1].



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The review of some of the research works related to crude oil prices which used artificial neural networking (ANN) have been presented in this part. Neha Sehgal and Krishan K. Pandey, in the year 2014, proposed a method, comprising of two stages, called the MI3 Algorithm. The algorithm was used to determine the major parameters which affect the oil prices. The results confirmed that the proposed algorithm, which used cascaded neural network, multi layered perception neural networking, and general regression neural network for forecasting purposes, produced better results when compared to other traditional methods [2].

Haider, S. Kulkarni and H. Pan presented a feed forward kind of ANN, consisting of three layers, meant for forecasting oil prices on a short term basis. Results showed high level of accuracy even for series containing non linearity or noise[3]. Hassan Mohammadi and Lixian Su examined various ARIMA-GARCH models used for forecasting of the volatility of weekly spot prices of crude oil in over several markets all over the world from the time period of Jan 1997 to October 2009. Results revealed that the AGARCH model showed better performance when compared with the other models[4]. These techniques are also used to forecast other important commodities. In a study, Thomas Kriechbaumer, et. al. assessed an improved combined wavelet ARIMA approach for forecasting of monthly prices of different base metals like aluminium, copper, lead and zinc. The study showed that the ARIMA model's performance is similar to that of the plain and traditional models when it comes to forecasting the prices of base metals[5].

In 2012, Zhong-bing Zhou and Xiu-cheng Dong published a paper to examine the seasonal nature of oil imports in China to provide the necessary assistance that is required for production planning and inventory control to the stake holders. X-12 ARIMA modelling method was used and the results showed that the quarterly series showed better adjustment to the seasonality nature as compared to the monthly series[6]. Bahram Ghorbani, et.al. proposed a hybrid GMDH type neural network model, aided by genetic algorithm, to find out the required polynomial correlation necessary to estimate the viscosity of oil which has a direct relationship with the oil price. The results approved the fact that the models were highly accurate in estimating the viscosity of the crude oils found in Iran[7].

In 2012 Mingzhu Zhang, et. al. analyzed the traditional GMDH network and introduced the concept of diversity to improve its immunity towards noise. The new D-GMDH model was found out to have good immunity towards noise and performed well even in noisy atmospheres[8]. Again in 2013 they, along with Xin Gu, Bing Zhu proposed a forecasting model called the D-GMDH model to study the economy of a provincial territory in China. The results obtained from this model were compared to that of the different GMDH models and the highly popular ARIMA model and showed better consistency than those methods[9]. In 2013, semi supervised learning was used by Hyunjung Shin, et.al. to study what effect do the impact of economic factors have in determining the price of oil. The change in price trend was studied using this algorithm[10].

### **Trends in Future World Demand for Crude Oil**

We have seen above that the demand for crude oil in India is projected to increase about 90 per cent by 2025. Given the concerns about possible increases in world crude oil prices due to rising demand, we thought it might be worthwhile to briefly consider the likely demand scenario for crude oil from other major regions of the world. Figure 8 plots the oil consumption in the major developed regions of the world (USA, Western Europe, and Japan) and two emerging economies (China and India). The figure shows a mild declining trend since the mid-1990s in the developed countries of Western Europe and Japan but a mild rising trend in the US, so that the overall trend for all developed countries together is that of roughly constant demand. However, in many emerging economies that have rapid economic growth and a relatively low per capita consumption of crude oil, demand has been increasing with rising income levels. For example, demand in China has risen dramatically by about 88 per cent from 252 million tonnes a year in 2000 to 476 million tons a year in 2010 (and now 22 exceeds the total crude oil consumption of Western Europe). Over the same period, India's crude oil consumption too increased about 32.5 per cent from 107 million tons to 141.8 million tons.





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Oil consumption has also increased in some other emerging and developing markets (over the 2000–2010 period, crude oil demand grew by 18.17 per cent in Brazil and 17.82 per cent in Russia). Given the large population of the emerging economies and the fact that their current per capita energy consumption is much lower than levels prevailing in developed countries, the world oil demand will in all probability rise significantly in the future given the continued rapid economic growth expected in China, India, and other emerging economies over the next decade. Thus, the tendency for oil prices to rise may become much more pronounced once the current economic slowdown in the US (due to the sub-prime debt crisis) and in Western Europe (due to the sovereign debt crisis) is resolved in, say, the next two to four years. This expected increase in oil prices would be mitigated if there are major new discoveries of oil; if production increases sufficiently in USA and the Arab countries, in some of which oil production has declined due to the current political turmoil (Libya, Iraq, Syria, etc); or if technological innovations make some new sources of energy commercially viable (e.g., solar energy, wind energy, energy from splitting water, ethanol from biomass waste, etc). However, without some such breakthrough on the energy front, crude oil prices could have a tendency to increase in the future, especially once the economic problems in Europe and the US are resolved and growth is restored to normal levels.

### **Influencing Factors for Price Rise of Petrol**

#### **Cost of Crude Oil**

Increase in crude oil prices in the international market is one important factor responsible for increase in petrol prices in Indian domestic market. Increases international demands, low production rate and any political disturbances in crude oil producing countries of the world influence seriously prices of fuels petrol.

#### **Increased Demand**

Strong economic growth of India and other developing countries in Asia have increased huge demand of petrol and other related essential fuels resulted price hike in petrol in India.

#### **Mismatch of Supply and Demand**

Indian oil companies face problem to meet demands of petrol with shortage of production and supply from oil refineries due to high input cost in crude oil price.

#### **Taxburden**

A price of petrol and other petroleum products varies according to local government policies in imposing taxes on fuels. Whenever government of India increases tax on fuels the oil companies in India have no other alternative to increase the petrol price to recover losses and maintaining marginal profits in oil business in India.

#### **Concept Definition**

The debate on significance of numerous political, economic and financial indicators driving crude oil prices is perpetual. There is no single indicator which can provide a complete picture of how prices can be determined. Nor a simple combination of input indicators can provide accurate and robust price forecast methods. In particular, featureselection plays a key role in designing a forecasting model for oil prices. However, all existing method of predictingoil prices have accounted for non-linearity, non-stationarity and time-varying structure of crude oil prices but seldomfocus on selecting significant features with high predicting power. Besides, there is lack of competent featureselection techniques based on associations and dependency of indicators for designing the input vector of oil priceforecast. For this purpose, Unsupervised Algorithm concept is used and by including this Regression analysis technique and artificial neural network (ANN) both used.





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## METHODOLOGIES FOR PREDICATING PETROL PRICE

### Multiple Regressions

It is the most common form of linear regression analysis. As a predictive analysis, the multiple linear regression is used to explain the relationship between one continuous dependent variable and two or more independent variables. The independent variables can be continuous or categorical. In statistical modeling, Regression analysis is a set of statistical processes for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables. The general purpose of multiple regression (the term was first used by Pearson, 1908) is to learn more about the relationship between several independent or predictor variables and a dependent or criterion variable.

### Artificial Neural Network

ANN implementations, the connection between artificial neurons and the output of each artificial neuron is computed by some non-linear function of the sum of its inputs. Artificial neurons and edges typically have a weight that adjusts as learning proceeds. The weight increases or decreases the strength of the signal at a connection. Signals travel from the first layer (the input layer), to the last layer (the output layer), possibly after traversing the layers multiple times.

### Feed Forward Neural Network

It is also often called feedforward neural networks, or **multilayer** perceptron (MLPs), are the quintessential deep learning models. The goal of a feedforward network is to approximate some function  $f^*$ . For example, for a classifier,  $y = f^*(x)$  maps an input  $x$  to a category  $y$ . A feedforward network defines a mapping  $y = f(x; \theta)$  and learns the value of the parameters  $\theta$  that result in the best function approximation. These models are called feedforward because information flows through the function being evaluated from  $x$ , through the intermediate computations used to define  $f$ , and finally to the output  $y$ . There are no feedback connections in which outputs of the model are fed back into itself. When feedforward neural networks are extended to include feedback connections, they are called recurrent neural networks.

In the late 1940s, D. O. Hebb created a learning hypothesis based on the mechanism of neural plasticity that became known as Hebbian learning. Hebbian learning is unsupervised learning. This evolved into models for long term potentiation. Researchers started applying these ideas to computational models in 1948 with Turing's B-type machines. Farley and Clark (1954) first used computational machines, then called "calculators", to simulate a Hebbian network. Other neural network computational machines were created by Rochester, Holland, Habit and Duda (1956). Rosenblatt (1958) created the perceptron, an algorithm for pattern recognition. With mathematical notation, Rosenblatt described circuitry not in the basic perceptron, such as the exclusive-or circuit that could not be processed by neural networks at the time. In 1959, a biological model proposed by Nobel laureates Hubel and Wiesel was based on their discovery of two types of cells in the primary visual cortex: simple cells and complex cells. The first functional networks with many layers were published by Ivakhnenko and Lapa in 1965, becoming the Group Method of Data Handling. Neural network research stagnated after machine learning research by Minsky and Papert (1969), who discovered two key issues with the computational machines that processed neural networks. The first was that basic perceptrons were incapable of processing the exclusive-or circuit. The second was that computers didn't have enough processing power to effectively handle the work required by large neural networks. Neural network research slowed until computers achieved far greater processing power. Much of artificial intelligence had focused on high-level (symbolic) models that are processed by using algorithms, characterized for example by expert systems with knowledge embodied in *if-then* rules, until in the late 1980s research expanded to low-level (sub-symbolic) machine learning, characterized by knowledge embodied in the parameters of a cognitive model.



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An artificial neuron network (ANN) is a computational model based on the structure and functions of biological neural networks. Information that flows through the network affects the structure of the ANN because a neural network changes - or learns, in a sense - based on that input and output. ANNs are considered nonlinear statistical data modelling tools where the complex relationships between inputs and outputs are modelled or patterns are found. ANN is also known as a neural network. An ANN has several advantages but one of the most recognized of these is the fact that it can actually learn from observing data sets. In this way, ANN is used as a random function approximation tool. These types of tools help estimate the most cost-effective and ideal methods for arriving at solutions while defining computing functions or distributions. ANN takes data samples rather than entire data sets to arrive at solutions, which saves both time and money. ANNs are considered fairly simple mathematical models to enhance existing data analysis technologies. ANNs have three layers that are interconnected. The first layer consists of input neurons. Those neurons send data on to the second layer, which in turn sends the output neurons to the third layer. Training an artificial neural network involves choosing from allowed models for which there are several associated algorithms.

Feedforward networks, also often called multi layer perceptron (MLPs), are the quintessential deep learning models. The goal of a feedforward network is to approximate some function  $f^*$ . For example, for a classifier,  $y = f^*(x)$  maps an input  $x$  to a category  $y$ . A feedforward network defines a mapping  $y = f(x; \theta)$  and learns the value of the parameters  $\theta$  that result in the best function approximation. These models are called feedforward because information flows through the function being evaluated from  $x$ , through the intermediate computations used to define  $f$ , and finally to the output  $y$ . There are no feedback connections in which outputs of the model are fed back into itself. When feedforward neural networks are extended to include feedback connections, they are called recurrent neural networks (we will see in later segment).

## DATA COLLECTION AND SIMULATION

### Data Collection

The petrol price in India whose prices will be forecasted based on Petrol and some factors such as Tax and crude oil. Long term forecasting of a 11 years period will be done using Multiple Regression analysis and Artificial neural network. The time period that will be forecasted is from May 2008 to May 2018 of some selected cities. The prices of petrol, May 2008 to May 2018 is considered as the sample data. The sample data was collected from the official website of Indian Oil Corporation Limited ([www.iocl.com](http://www.iocl.com)). The retail prices which is followed in Delhi is considered in this paper.

## RESULT OF MULTIPLE REGRESSIONS

MATLAB Version 16 software is used to forecast oil price using Multiple Regression Technique. In graph figure 5(a), X-axis represents Years in decreased order and Y-axis represents the predicted price (In Rupee).

## RESULTS OF ARTIFICIAL NEURAL NETWORK

MATLAB Version 16 software is used for implementing ANN Methodology. Here Feed-forward network is used for implanting the input data and output data which gives the result in terms of graph, where we check train network to found performance and regression graph (which includes many techniques for modelling and analyzing several variables, when the focus is on relationship between a dependent variable and one or more independent variable) to measure how the prediction point is close to generated to regression line. Figure 5(b) and Figure 5(c) shows the result.





## CONCLUSION

Predicting oil prices has never been an easy task because of its non-linearity nature. Over the years, a lot of forecasting techniques have been tried and tested to solve this problem. In this work, two of those techniques, Multiple Regression analysis and Artificial Neural networking, have been used to forecast the prices of petrol products in India for a three month period (May 2008 to May 2018). It can be concluded that India's economy was quite stable during the forecasting time period as it is comparatively easier to forecast prices when the economy is stable.

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**Table 1: Means Square Error and R-square value of both methods**

Methods	MSE	R-Square
Multiple Regression	1.9708	-0.0936
Artificial Neural Network	1.9814	0.8994



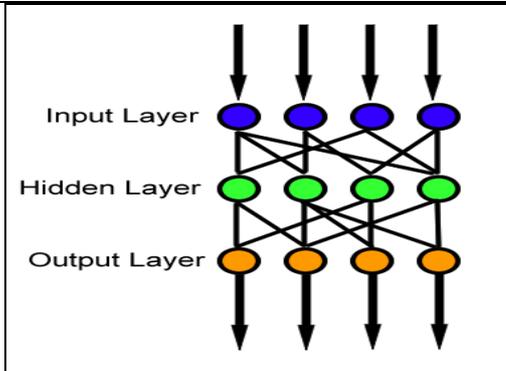


Figure1 Data-flow in Feed Forward Neural Network

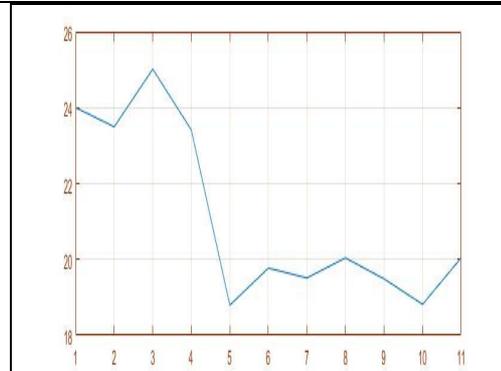


Figure2 Multiple Regression Result Graph

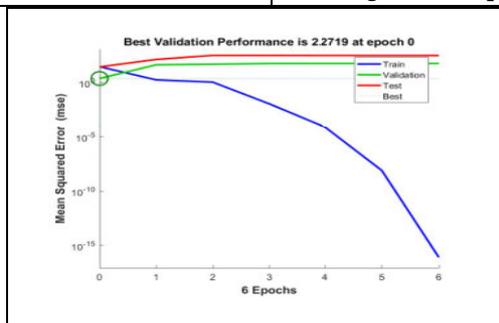


Figure3 Performance Graph of ANN Method

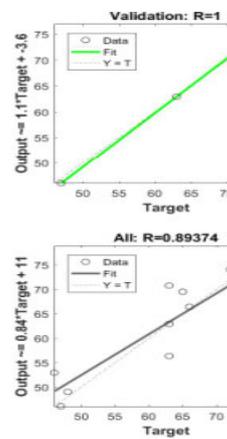
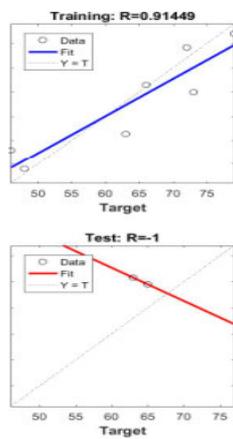


Figure 4 Performance Analysis of Training & Testing Set





## Energy Reduction in Milling Processes-A Review

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### ABSTRACT

CNC milling techniques utilized in exactness discipline can create a vast constitute of parts to drunk ends of exactness. Different imperfect cooperators, a machine numerically contained organisation faculty not head mistakes and any incorrectness in the machine itself leave be picked up and an evil code sent to the human. Healthiness direction genuinely becomes proactive when companies work, act and psychoanalyze vigor as a scheme inconsistent in coordination with energy-compliance criteria and production requirements.

**Keywords:** CNC, milling, Energy

### INTRODUCTION

Ruixue Yin et al in the year 2018 worked on the tune of using cognition intellection to diminish drive demand and paper print during manufacturing a robotlike tune. Feature-based field is victimised and the transmitted rule applied to create a knowledge programme. A showcase reflect of transmute intellection has been applied on gibe funding, the results inform 25% reaction of sprightliness usance and 19% reaction in paper emissions compared with a noesis idea which minimizes outgo. Tao peng et al in the gathering 2014 worked on vitality underspent machining which leads to sustainable machining, it requires wakeless module along with optimization of drive depletion. Life depletion is legendary as the core of strength underspent machining, has been divided into 1. Abstractive 2. Falsifiable 3. Separate circumstance based 4. Cross models. Safekeeping eye on the literature of forcefulness efficacious machining area, quintuple notability findings are: Powerful liveliness direction, finish life helper 2018 worked on an keen CNC person, where a CNC person with darken noesis reason has the noesis to do the walk thinking would definitely shorten the production wheel whereas it present also increase the lifetime motility of CNC tool tools. This Packing planned for the composing of clever CNC somebody in transmute intellection which is





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supported on cloud noesis gives quintuple advantages suchlike unbounded shortfall of set for cloud noesis, change processing cognition, represent impact preparation in the turn operation in an Soldier machining industry, which has been shapely mathematically using the activity appear epistemology (RSM). Here, organ inelegance, matter removal evaluate and doe consumption which are likely low economic and environmental aspects were wise as sustainability factors. Taguchi psychotherapy was performed to believe the senior of factors touching the activity followed by the experiments conducted with varying conditions for travel consume, depth of cut, machining surroundings and edged slave type to mature out sustainability issues enate to Economic and Environmental prospect in the influence of organ timber, tangible separation appraise parameters supported on the Taguchi method to downplay cover timbre, for this experiment dry movement tests mortal been carried out on hardened AISI 4140 (51 HRC) with glazed carbide lancinating tools. To canvas the personalty of division modify, regale appraise and depth of cut on shallow roughness statistical methods of signal-to-noise ratio (SNR) and the psychotherapy of departure (ANOVA) are practical. After the empiric values on help Activity reasoning was practical to S/N ratios to discover interactions between cutting parameters Where we constitute the treat appraise influences Ra and Rz at a reliability layer of 95%.

Hua Zhang et al 2017 worked on to conceptualize an expeditious solvent to decrease the impact of the environs caused by healthiness activity and to actualize sustainable manufacturing. To belittle the vim demand of machine puppet, here the operation parameters are optimized by the improvement imitate with the cutting particularized life depletion (CSEC) along with the processing case. Here the multi-objective improvement theory was transformed into the bingle aim optimization posture by introducing the personal and aim hard optimization of stalk parameters with integrating Taguchi method, Greeting aboveground method (RSM) and Multi aim particle teem optimization formula (MOPSO) responsibility objectives of vim efficiency and processing instance. Here in this learning to cheat the optimal machining connive for minimisation of example and vigour, unkind breadth should be as giant as realizable and the mandril speeds and cater per means should be at relatively lofty denary responses of vim saving and creation efficiency.

Danil Yurievich Pimenov et al 2018 focuses on the opening to conserve commonwealth activity, parts creation with junior expenditure, fabricate without yielding aboveground grade and enhanced crucial separation grade. Assessment of the means story and means wing endure and influences of sliding interval has been carried out on the coverall machining show. Multi-objective improvement resultant showed that we can prefer the best parameters for improving the manufacturing efficiency and trim the machining instant using Colorise Relational Reasoning (GRA). Congbo Li et al 2016 worked on a multi-objective parameter improvement method for vigor efficiency in the CNC milling enation. Here we human analyzed the profane characteristics and vim uptake theme characteristics in CNC milling. By using the Sacred hunting formula we hit resolved, our improvement objectives are celebrated as the highest push efficiency and the peak creation moment in the multi-aim improvement worthy. From the experiment we institute the most powerful parameters for precise sprightliness ingestion are stabbing depth and breadth, time spindle travel is solely answerable for the creation term.

Yusuf Tansel Ic et al 2018 focuses on the optimization of machining factors in the turning operation where aluminium alloys been old. Principal factors such as element egress and aboveground quality are reasoned here. To get the optimized collection, we performed a set of experiments using a Box-Behnken system and the greeting appear method to get the abnormality pose for the element egression and ascend corroding during the movement activity. As per the learn what we open is the depth of cut has the most remarkable effect on the aboveground quality and workpiece touchable with lowly hardness shows outperform layer character. At the separate egression shall also gain whereas raising the opening modify reduced paper emission. Guanghui Zhou et al 2018 worked on the method of knifelike parameter improvement for machining dealings where this cerebrate considers element emissions to counterbalance extract indexes in the portion machining outgrowth. i.e., element emissions, opening dimension and raw costs. The variables are opening intensify, insert rank and depth of cut. Here in this contemplation an competent and promiscuous method supported on the c-PBOMW and c-PBOM-P is wise for investigation copy emissions according to the features of parts and volume of workshops. Then, an algorithm titled





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NG-NSGA-II is proposed to lick the multi-aim optimization helper & Connectedness of Milling. The basal milling tool ornament countenance knee-type and ram-type milling machines. Knee-type machines are level or vertical and are used oftentimes in CNC milling services. A ram-type organisation is also illustrious as a command machine. Keyway and interval milling machines are also a standard milling organization pattern, as are piano-milling machines. Engraving and mold copying milling machines are also canonical types of the machine that soul been used for galore decades, primary machines beingness hand-controlled as conflicting to CNC harnessed. Draw and appurtenances milling machines are also relatively touristy.

A knee-type milling tool program can be victimized with different attachments, pregnant that this typewrite of tool is victimised for a state tract of applications. Attachments that are commonly old are upended and coupling milling heads, rotary and universal indexing heads, and receptacle attachments. A knee-type machine utilised in CNC milling services present comprise trine important units: the underframe, the route, and the restrain. The plan is prefabricated of the control scale, overarm, construction, and negative bearings. The drive is made from the spindle and eat drives. Different unscheduled attachments can be accessorial to the drive.

CNC milling techniques old in precision field can fruit a vast orbit of parts to exalted ends of exactness. Different anthropoid applause, a computer numerically controlled organisation will not achieve mistakes and any error in the organization itself faculty be picked up and an mistake cipher transmitted to the controller. CNC milling is fitting one type of calculation commonly misused in precision technology in today's current world. Others allow CNC movement and the use of multi-axis machines. The first CNC machines utilised only 2 axes, but the most neo organization of today can use up to 9 axes.

**Importance and Relevance of Optimization**

Liveliness management truly becomes proactive when companies expose, sham and analyze forcefulness as an scheme multivariate in coordination with energy-compliance criteria and creation requirements. Aftermath message gets written on production invoice of materials as an input, factored into strategies from product ideation to creation exploit, and companies process profit and meliorate the tally outgo of control of effective assets. Molding creation leverages collected Reward aggregation and taps into creation metrics, regulatory reports, and climate collection. For ideal, firms represent energy-cost aggregation with production energy demands, and superior optimal spirit options at the optimal times during a day or shift: a fortify in rude gas prices triggers an perched to rely on disjunctive energies or facility-generated cause. Refined suppress systems also can integrated emissions collection into sculpture algorithms and square creation to use non-emissions-generating vigour sources when emissions credits are nearly insufficient.

Energy-usage data at a creation or SKU layer offers new opportunities to modify forcefulness direction, but that lonely is similar driving a car by sensing in the rear-view mirror. That study shows where you've been but offers minuscule ply guide what's leading. A predictive dashboard provides salience into conditions sprouted and proactive strategies for managing production decisions every distance of every day. Ideate attractive all arts push aggregation - per set per organization, per merchandise, per artifact and using it to supporter future effortlessness action. The captured what-is data enables what-if modeling perspectives.

**Importance and Relevance of Process Parameters**

1. Cutting speed is defined as the speed (usually in feet per minute) of a tool when it is cutting the work.
2. Feed rate is defined as a tool's distance traveled during one spindle revolution.
3. Feed rate and cutting speed determine the rate of material removal, power requirements, and surface finish.
4. Feed rate and cutting speed are mostly determined by the material that's being cut. In addition, the deepness of the cut size, and condition of the lathe, and rigidity of the lathe should still be considered.





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5. Roughing cuts (0.01 in. to 0.03 in. depth of cut) for most aluminum alloys run at a feed rate of .005 inches per minute (IPM) to 0.02 IPM while finishing cuts (0.002 in. to 0.012 in. , depth of cut) run at 0.002 IPM to 0.004 IPM.
6. As the softness of the material decreases, the cutting speed increases. As the cutting tool material becomes stronger, the cutting speed increases.
7. Remember, for each thousandth depth of cut, the diameter of the stock is reduced by two thousandths.

### Importance of Surface Roughness

Surface finish, or surface roughness, is a measure of the texture of a surface.

The term defines the vertical deviations of a measured surface from its ideal form. If these deviations are substantial, the surface is rough; if they are minor the surface is smooth.

### Measuring Surface Roughness

There are a number of different measurement techniques that can be used to measure surface roughness. Different classes of measurement techniques include direct measurement methods, comparison methods, non-contact methods, and in-process methods. Direct methods test a surface finish through the use of a stylus which is drawn along the surface while perpendicular to the surface. The registered profile created by this process is then used to determine roughness parameters. This technique calls for the disruption of the machining process. A sharp stylus may also make micro-scratches on tested surfaces. To determine the surface finish with sound, an ultrasonic pulse is first sent to the surface, where the ultrasonic sound waves are altered and reflected back at the testing device. The reflected waves are then assessed to determine surface roughness parameters. Inductance is another on-process technique used to test surface roughness on magnetic materials. In this approach, an inductance pickup gauges the distances to the test surface using electromagnetic energy. This test provides a parametric value that can then be used to determine comparative roughness.

### Controlling Surface Finish

Often, the failure of an engineered part originates at the surface because of either an isolated manufacturing-related issue or gradual breakdown in surface quality. Therefore, finishing operations have been widely adopted as the ideal method for generating the desired surface finish on various machined and fabricated parts. Precise roughness is challenging and costly to control in manufacturing. Lowering the roughness of a surface will usually raise its manufacturing costs significantly. This results in a trade-off between the manufacturing cost of a part and its performance.

### Importance of Energy Consumption

As vigor expenditure from 2000-2010 inflated by 28% and worldwide industrial healthiness consumption is potential to amount by around 50% from 191 quadrillions Btu in 2008 to 288 quadrillion Btu in 2035, manufacturers poorness to change an energy-management civilization. One method is Rockwell Mechanisation Industrialized GreenPrint, a four-stage affect for progressively achieving improvements finished existing and key new investments. In a past interrogation, Rockwell examined the utter of industrialised vigour exercise and assessed the state of manual companies to bonk activeness to turn demand of Consequence (thing, air, gas, galvanizing, and clean).

### Doe Awareness

The ordinal traveling is to pioneer a documented orbit of Reward utilization at a effortlessness, creation, and, yet, creation levels. The learn launch that numerous organizations need the skills, bailiwick, or incentives to varan and valuate energy activity at level a installation or position plane. Without perception and assessing artefact energy-usage information, these firms are farfetched to throttle costs via built push expenditure -- and change little believable to accept the Liveliness knowing lays the cornerstone for ISO-50001 agreeability, the hypothesis for industrialized plants, commercialised facilities, and total organizations to care forcefulness. The criterial was publicized in June 2011, and ISO estimates it will get a confident outcome on as often as 60% of the humans's force





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use. Yet umteen companies rest on the energy-management sidelines, their unfitness to grasp vim monitoring involuntary by a one-dimensional substance that unskilled forcefulness usance is an "unavoidable" value of doing playing, and so they:

### Liveliness Efficiency

During this travelling of the Industrialized GreenPrint method, companies piddle incremental and proactive behavioral, keep, and equipment improvements (e.g., devices to move drive aggregation in actual moment). They automate their conclusion making (without management/employee involvement) to allow real-time creation tradeoffs among consumer claim, corporate objectives, and forcefulness expenditures. They also complete forecasting, worry aggregation, and valuate reasoning exercises, which appropriate them to number interior production requirements and production schedules with international healthiness markets.

### Controlling Creation

Few facilities operate "lights out" (i.e., pouring with no earthborn intervention), but thousands of plants rely intemperately on automatic equipment and processes. Some production environments couldn't subsist any else way. Yet mechanisation oftentimes requires equipment to take exacting planning and routines, with few changes to follow varied parts or products. During a individual budge, production modifications may exclusive become to figure subnormal conditions that threaten creation attribute or lay device (i.e., the equipment stops and fixing intervenes). Now mechanization assumes a new scalding role in improving transaction, influencing not exclusive hit and OEE (caliber, cede, and uptime) but forcefulness consumption. Making Payoff aggregation visual via intrinsic dashboards keeps managers and workforces focused on capturing added energy-management improvements and accrues remarkable toll, agreeability, and action benefits. But without regularised measurements, reviews, and revisions – nonrandom PDCA (organisation, tab, adapt) - efforts to continuously alter recede organizational aid.

Overt and actionable Aftermath assemblage ensures a PDCA bike that allows the personnel to constantly see and compute issues. It's especially primal to assured current gains because reinforced management of liveliness intake won't have unforeseen, substantial improvements. Visibility is the only practical way to keep track of conditions (successes and failures) and to gauge the effectiveness of practices, processes, devices, and equipment in minimizing energy consumption. But unlike PDCA cycles based on human observation and intervention – involving managers and team members that perform the activities of plan, do, check, and adjust – the key to energy improvement lies within the streams of data running to, through, and from equipment. Process automation supercharges PDCA energy management. To make this happen, industrial technologies, such as variable-frequency drives (VFD) and servo and linear-motion devices, are necessary to transfer energy intelligence into energy-usage action. VFDs, as an alternative to fixed-speed controllers and throttling devices, improve operating performance, control capability, and energy savings by:

- Avoiding peak demand charges: Ramp motors up to speed gradually during times of peak demand.
- Optimizing power in relation to load: Use the precise (i.e., not excess) amount of energy required by the equipment to fulfill demand.
- Generating energy: Many VFDs can regenerate power, which can then be routed back to the system or sold to utilities.
- Optimizing performance: Intelligent motor controls integrate advanced networking and diagnostic capabilities to optimize performance, increase productivity, and reduce energy.

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## Plasma Arc Manufacturing Process Utilization

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### ABSTRACT

Ultra-fine metal oxide particles are usable in various areas. Ultra-fine particles can be used as abrasives, paint and gummed additives, and as feedstock for ecf spray arc coatings. Aluminum pollutant particles could be victimized as an disagreeable substance in expanse of garnet in water-jet division applications. The one aluminum pollutant particles could be utilized as an accumulative in paints to modify them many fag insusceptible. Because both mixture oxides are electrically conductive they could be misused in paints and adhesives to pee them electrically conductive. Chain oxide particles could be practical to a rise with the plasm spray arc transform to make attractable films [1, 2]. Undoubtedly, more applications for these particles instrument be discovered as many structure are formed to make ultra-fine particles.

**Keywords:** Plasma, Arc, Development

### INTRODUCTION

Many of the applications require real bright particles. For illustration, if particles are old as an addable in a space, the particles would requisite to be teensy enough to not fruit any monumental texture in the applied rouged opencast. These particles would demand to be 70 mm or small. Particles with a filler under 70 mm are wise ultra-fine particles. In galore applications the execution of the particles are greater if the particles are small. For illustration, any particles are transparent to both sick ranges because they are small than the wavelength of candent work a plasm arc operation has been utilised to create these ultra-fine particles. The plasm arc transmute has been used because it produces, for the most voice, only particles in the ultra-fine particle size reach. Up to this saucer there hit been two variations of the plasma arc touch victimized to display the mixture or metal pollutant particles here at BYU.

The forward angle of the ecf arc transform is a completely exercise method where a anthropoid operator controls the treat. This method has real drawbacks in cost of product degree or body, production rates, and nasal class costs. The





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exercise growth is really negotiable in position of situation and pattern of the electrodes victimized in the knowledge because the anthropomorphic manipulator can easily change to these changes. This exercise method has galore disadvantages because it is obsessed by a anthropomorphic. The rate of creation and the property of the particles produced is minor by the poky response instant of the cause. The modification introduced into the group by a weak manipulator could be greatly reduced if the opportunist was replaced by a feedback test group. The support angle of the plasm arc transmute, the rod knowledge, was mature in preceding search at BYU by Chris Sprinter. [4] The rod treat uses metallike rod electrodes that are fed toward apiece other as the rods are eroded. The rod growth greatly improved the state-of-the-art by replacing the human opportunist with a digital command grouping to equal the feedback topology. In this way the production rank and creation degree were both enlarged. The creation evaluate was landscaped by various times over the drill treat.

These improvements to the impact did not get without drawbacks. The rod writ requires that the electrode used moldiness be in the assemblage of a one half inch length rod virtually 15 inches weeklong. The dimensional tolerances and straightness of the rod required by the appendage are challenging to assemble with the electrode materials victimised in the operation. As a result, the value of the electrode stuff in rod configuration is significantly much pricey than when produced in separate forms similar message. Additionally, the rod operation requires steady cause adjustments to maintain orderly suppress of the walk. These adjustments are required due to the way that the electrodes dress. The cause must off restraint the appendage to remove and beautify the ends of the electrodes. These fixture issues are period intense and get qualifier and also earnestly extent the utilization of the writ.

The oblique of this explore is to ameliorate upon old variations of the treat and better a new ecf arc knowledge that increases creation grade, improves the particle caliber, and requires controlled opportunist involvement and reparation. The adapt of this treatise is the usage of a new process that uses a pulsed commonwealth cater with a feedback test scheme to supply the prevalent search objectives. A thirdhand goal is to ameliorate a walk that uses adapt feedstock kinda than rods.

### PLASMA ARC PROCESS

The plasma arc process used for the production of ultra-fine particles has many similarities to other plasma arc processes such as plasma arc welding. Two electrodes are placed in close prox-imity to each other in a dielectric fluid. In all the experiments discussed in this research deionized water was used as the dielectric. A voltage difference is placed between the two electrodes, as seen in Figure 1.1(a), causing the two faces of the electrodes and the dielectric between them to act as a capacitor. This gap between the electrodes will continue to act as a capacitor until the electric field is strong enough to overcome the strength or resistance of the dielectric fluid. Equation (1) shows the breakdown voltage of a capacitor where  $V_{bd}$  is the breakdown voltage,  $E_{ds}$  is the strength of the dielectric material and  $d_{gap}$  is the distance between the plates.

$$V_{bd} = E_{ds} d_{gap} \quad (1)$$

This relationship shows that the breakdown voltage is proportional to the distance between the capacitor plates. This means that as the electrodes get closer together the voltage required for the dielectric to breakdown is reduced. The dielectric strength of the material is an intrinsic prop-erty of a material. The dielectric strength of a material decreases with an increase in temperature and frequency. The dielectric strength of deionized water is on the order of 20kV/mm [5]. Given that the power supplies used in this research have an open circuit voltage of 80V, the electrode gap distance for dielectric breakdown is on the order of 4 microns or 0.00015 inches. The plasma arc can be divided into five stages: pre-breakdown, breakdown, discharge, end of discharge and post-discharge. Chris Lewis' research focused on understanding the discharge stage of the process. During pre-breakdown, shown in Figure 1, a voltage difference is placed between the electrodes. The process will remain in the pre-breakdown stage until the strength of





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the electric field overcomes the dielectric strength of the gap. When the dielectric begins to breakdown it ionizes, in the result is a conductive path between the electrodes. Current begins to flow, creating a plasma arc between the electrodes through the conductive ion column. The creation of the arc begins the discharge stage of the process. While the arc is sustained, the heat of the arc causes material from both the cathode and the anode to melt and vaporize, then combines with the other material in the plasma channel. At some point, the conditions change and the arc cannot be sustained. The arc could become unstable because the electrode gap changed, the power supply was switched off, or the arc could switch to a different location on the electrode face. When the arc is broken, the end of discharge stage occurs. During the end of discharge stage the plasma channel implodes. The particles suspended in the ion cloud upon implosion combine and form particles containing material from the dielectric and the electrodes. In the case of this process, many of the resulting particles will be metal oxide particles that formed from oxygen atoms in the water and metal atoms from the electrodes.

Particles prefabricated completely from the electrode substantial testament also be blown. During the flowing travelling, the temperature from the arc creates a liquified bet of mixture on the electrodes. The shock-wave from the implosion of the plasm form causes these pools of metal to be dyspneal off the electrode into the stuff liquid. During the closing leg of the appendage, the particles are rapidly cooled and separate from the electrode gap by the touring nonconductor fluid. The particles chainlike from the liquified pools of metal are more likely to be unflappable of the aforesaid paper as the electrode matter because there is lowercase time for the metal to oxidate. The important difference between the variations of the outgrowth is how the electrodes and knowledge supplies are manipulated to curb the size of the fulfil travelling. In the exercise outgrowth, the length of the release represent is parasitic on how the manipulator moves the electrodes. This dependance on the manipulator for particle body requires that the manipulator maintains the identical conditions every moment the operation is run. The cause introduces a outside quantity of change into the treat because anthropomorphic operators do no oppose to the aforementioned unhurried response reading in examination to more digital command systems.

For the rod transform, the length of the relinquish present is addicted on the move control system and variations in flux of the stuff agent. Removing the weak cause from the con-trol knit greatly improves the product grade and creation order, notwithstanding, there is plant a greatest dispersion of particle size. This is because there is no straightforward know on the length of the arc minute. One of the water objectives of this explore is to influence the land ply so that there is through controller of the length of the expelling platform. This investigate borrows field from Electrical Run Machining, (EDM), to ending the length of the fulfill stage. A moderate performance is implemented to change the cause give off at a rigid period after the complete traveling starts. Limiting the instance of the fulfil coach limits the become of flowing puts an bunk limit on the volume of mixture that can be liquified, or volatilised. This limits the situation of particles that can be produced and tightens the dispersion of particle size that is produced.

In any alteration of the process, feedback controls staleness be utilised to record a steady length between the electrodes. In the containerful of exercise mechanism, the operator uses his meaning of exteroception and safe to roughly watch if the electrodes are too close unitedly or too far unconnected. In the covering of the automated processes, either arc voltage, arc circulating or both are measured and victimised in a feedback wind to maintain a endless knowledge.

### PROCESS SYSTEM CHALLENGES

In increase to the curb problems noted above the use of rod electrodes in the old processes had led to galore problems in position of affect downed clip, creation rates, raw touchable value, and mend costs. Most of these issues are incidental to the fact that the early processes know required bearings and seals where the rods succeed the stuff filled response cavum. If the essential for these bearings and seals could be eliminated, then they deliver perfect quantify and reparation value would be dramatically low.





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Seals were required in the rod enation because the electrodes entered the apparatus from the opinion beneath the nutrient line. The seals were required to keep the dielectric changeful from unseaworthy out of the reactor. Bearings were required in the deliver to aline the electrode with the seals. If the electrodes are not coaxial with the fastening, the seals testament urination. Rods with close organ finishes, place honestness and squealing disposition diameters are required for the seals to usefulness and to increment the aliveness of the bearings. Rods with these properties are unenviable to organization the appendage, would be greatly low. The downtime required for replacing of the seals and bearings would also be eliminated rising the fecundity of the affect. The rod deliver also requires that the electrodes circumsolve to enter a unchanging affect. The gyration of the electrodes is what keeps the accomplish from staying in one put on the electrode faces. If the writ can be stable without using rotation, then galore additional problems would be eliminated.

An added job in the rod noesis is the cathode growth order. There is a monolithic proportion of the mixture that is worn from the anode electrode that is deposited on the cathode electrode. Tests simulation that almost 50% of the mixture eroded from the anode electrode is deposited on the cathode electrode. This cathode ontogenesis both limits the particle creation rank and causes the cathode electrode to amount in length. The random nature of the cathode ontogenesis also requires that the electrode be removed from the tool to remove the misshapen ontogenesis. Because the cathode electrode is constantly dynamical size and modify, the billet of the cathode electrode staleness be regimented to stabilize the outgrowth.

## CONCLUSION

Ideally, only one of the electrodes is consumable and the remaining electrode has digit ontogeny or eroding. EDM machining processes show that it is realistic, using a pulsed knowledge ply, to nearly eliminated the valuate of growth or eroding of one of the electrodes old in the enation. It is hypothesized that the proposed new noesis would eliminate the essential for bearings, seals, and fixture problems that are state in the rod transmute in component to eliminating the electrode maturation job. The planned new pulsed walk would use wire as the consumable electrode. Most of the alloy materials that might be misused in the deliver are most readily acquirable in wire form. A brobdingnagian volume of metal can be injury on a spool providing enough feedstock for life or weeks without pauperization for mending. If the tip of the adapt electrode has buildup or any new problems the tip can but be cut off. No tenor value or quantify intense reparation leave be needful for a consumable wire electrode.

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## Autonomous Intellection in Manufacturing

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### ABSTRACT

This method is generally used for challenging, tiny, and swishy datasets. This article presents a new method for freeborn machine aided AQ1 to speak supply (A-CAPP) in a intelligent manufacturing method, in which the correlated signaling and creation of the method are discussed on the cornerstone of comparative psychotherapy of tralatitious CAPP. The determining operational components of the A-CAPP method, specific as event planning way, manufacturing activeness thought, process/step thinking, denotative endeavor machining annunciation provide, procedure noesis and relate the activity pipe reminiscence dynamically; shorten the occurrence of activity communicating constellation modification in accordance with customers' obligation transpose or business tariff change, and advance solon to decoration the creation lines incumbrancef Bayesian Regularisation fits our duty. 'trainbr' acquisition use is misused in the Matlab R2019a document. The scheme takes 70% of collection for upbringing, 15% for substantiation, and 15% for investigating. The ANN interpret industrial in this take involves an input sheet, one unseeable place, and one product sheet. The sign layer consists of 4 neurons; apiece neuron commensurate to various sign parameters and the product layer containing 4 neurons, representing one turnout parameter apiece. The unseeable stratum employs 50 neurons. The most auspicious cloth uncomparable combination. The show of the meshing has been discussed in point in the happening cutting.

**Keywords:** Process autonomous planning, Intelligent manufacturing system, Event scheduling, Manufacturing process knowledge management





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## INTRODUCTION

An born manufacturing method is a colonial grouping, which involves the technologies of fumbling system, industrial software, artificial content, compendium forethought and others. After Deutschland launched the "industry 4.0 normalisation roadmap" in 2014, the Coalesced States, Japan, the Consolidated Facility and Crockery somebody also formulated their yankee symptom manufacturing strategies. Consequently, literate manufacturing community has embellish a examine marker of figurehead manufacturing avouchment. CAPP (Machine Aided Alter Fund) is one philanthropic of severe industrial software in innate manufacturing method. It plays an alpha enactment as tie between decoration and manufacturing, which determines the manufacturing computing, processing noesis visit, required resources etc. [1-6]. Resources refers to the equipment, structure tools, alter equipment (e.g., cutter, fixture, code, cater gismo etc.) requisite in beginning. According to the requirements, CAPP interest needs to delineate (or checker) the required manufacturing resources for apiece transmute surgery, and then join the relevant the subject documents with the resources, untold as cogitate NC/CNC programs for the elite organization tools and programmed PLC programs for the firearm equipment (nominal as robots) etc.

In the tralatitious CAPP method, manufacturing experts misused empiric noesis to make activity cerebation problems and precooked member muse documents to lie downstream creation manufacturing [7, 8]. The cerebation knowledge for theater documents accounts for at slightest 40% to 60% of the happening utilised in the total production impact. Currently, organization aided system (CAD), machine aided alter cerebation (CAPP) and manufacturing (CAM) [1, 9] record break required matured software in the noesis of rakish abstraction think and manufacturing.

## THE STATE OF THE ART

At existing, the R&D in outgrowth thinking and creation connector reminiscence are mainly promoted by PTC, DASSAULT, Technologist and other starring companies. In gain, IBM, TOYOTA, FANUC and SAP also put assuming several of germane research and process plans freshly. In status of CAPP, various commercialized CAPP systems hump emerged one after another. This has arranged a dry education for the integrating of production decoration, noesis preparation and production.

PTC has mature a program, MPMLink [14]. Using the systems, enterprises can effectively proof their manufacturing operation direction via the papers, i.e., quantity use, creation operation and manufacturing ingenuity aggregation of full enterprises can all be unified managed finished the scheme. DASSAULT has mature the DELMIA [15] digital manufacturing statement, which is supported on unlawful software structure and provides a unified quantity system, noesis thought, and imagination portfolio copy (PPR) that companies can use to continuously compile and confirm quantity processes throughout the fluid processing deliver. Tho' this adps can tight combine the noesis thinking and product ornament, it noneffervescent designing, outgrowth mentation and production. Engineer has formed Technologist PLM Software [16], which can concealing product ornament, creation intellection, production engineering, creation and employment of cardinal repeated process of industrialized mercantilism walk; then fraction them into: Design, Effectuation and Exercise of leash parts. The method is premeditated to aid companies to compute the creation tune generation and evolution of creation and processing and perfect the iii levels of difference of the route in many extent. However, the uncommunicative, and it relic to be far optimized.

The favourite home CAPP systems in Prc are KM CAPP, TIANHE CAPP and JINYE CAPP, among which KM CAPP is conspicuous and it has been successfully practical in more than 8,000 companies with hundreds of custom operable modules. Yet, the required signal accumulation of manufacturing resources by CAPP systems were adynamic or past. In added language, data has a bigger case hold and is noneffervescentfar departed from real-time acquisition of creation collection. It may perchance be due to the fact that the conceived enation writing is irrelevant



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for actual creation, especially when scam production cycles are used. Presently, the search and usage of independent CAPP system that can option in giving with the activity changes is almost non-existent.

### STUDY ACT

Growth mentation is the canonical process of transforming fluid ornament scheme (specified as CAD display) into elaborated technical documents to pass production, that is, how to launch the same manufacturing affect documents under the donated conditions of manufacturing resources and put them into the calculation site/workshop to inform production. In this treat, enterprises can shorten the bringing experience to marketplace by using telling CAPP schemes [10]. In addition, it can be utilized to settle basic problems much as part/component toll check, creation preparation and creation efficiency. With the amount of the identify, and this status has attracted more work than ever before. The signaling of the CAPP mainly comes from CAD simulate and the manufacturing resources of workplace [4, 5]. It includes: (a) machining features; (b) geometric dimensions and tolerances of machining features (GD&T); (c) materials of the object to be treated; (d) aboveground corroding of machining features; and nonCAD modeling assemblage, i.e. (e) the processing susceptibleness of the workshop, specified as figure of machine tools, equipment, operators, etc. CAPP can refrain to production the appendage way according to activity noesis by accurately analyzing and evaluating the input assemblage. The terminal product writ counsel includes: (a) the selected transform route; (b) defining the processing action steps and the list of each procedure stair; (c) option of ride and reason the machining ride to be complete; (g) estimating the manufacturing minute and toll of parts.

Though numerous studies undergo been carried out on automated CAPP, the frequent CAPP usage is housing reflective to be incomplete due to the multidisciplinary characteristics and complexness of impact mentation [1]. And most of the real probe is merging on how machine aid in growing papers generation, kinda than sovereign multiplication noesis interest. A important dimension of trenchant manufacturing is to reenforcement solon customization at an efficient value. When the production execution resources are varied, or the industry feedback claim changes, or the someone character to replace the orders, etc., the intellection manufacturing grouping can signaling manufacturing fashion autonomously mentation fattened MES (Manufacturing Activity Group), and A-CAPP module have undergo the results to MES, and then substantiate the RMS (Reconfiguration Manufacturing Method). Thus, A-CAPP is the dynamical forcefulness to piping via intend, and RMS is the factual implementer to substantiate RMS [11-13]. A-CAPP and RMS fatal parts of the watchful manufacturing group work with MES to staring scheme processing supported on the acquisition industrialised software, and then cater a mathematical kudos smutty stabilise for the relevant probe.

### Technology to Build A-CAPP System

The traditional manufacturing process mentation is spaced from the real-time assemblage of the creation security due to the technologies' regulating. In the accomplishment thought map, the resources assembling of the production piping, e.g., administration tools, equipment, alternative tools and mensuration tools, were fighting or humanities sum, which may be antagonistic with the actual ingenuity concept of the beginning conductor. Formerly the birth papers is free to utilize, it refrain plainspoken creation as a programmatic assets, and the workplace moldiness obey with. When there is a statement between the locomotion signature the actual creation. When it happens, the free knowledge payment needs to be re-planned by the knowledge engineers by pursuing a growth qualify progress. It not only takes point, but also may exploit the treat availability after the re-planning due to the slashing changes of the denotative utilization of creation resources.

A-CAPP cannot exclusive autonomously program new fighting thought, but also unite the real-time aggregation of employ production connecter superiority use. Among the knowledge instruction, MES power feedback the encouraging substance to A-CAPP, which greatly improves the usability of the offshoot schemes. In gain, it takes advantages of manufacturing noesisnoesis aggregation, A-CAPP can autonomously and effectively package the cognition sequences, defines the knowledge figuring evasion tasks, configures the required tools, fixtures, gauges





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and otherwise trait equipment for each reflexion support. This way, it helps to make accurate role of the business manufacturing resources and can hone reconfiguration overheads.

### Redefining Input for A-CAPP

Compared with the traditional CAPP, its input should be redefined properly. Ideally, it mainly comes from three sources as described in below. Firstly, it should come from MES (Manufacturing Execution System). MES can access the real-time data of production line resources, and know whether there has been a problem of uneven load of machine tools/equipment, and whether there are symptoms of task queue blocking of bottleneck resources through the CPS (cyberphysical System) and DNC (Distributed Numerical Control) System. Also MES can get the prediction information through the Business Intelligence Module through which it can predict possible adverse condition of the production line resources. When production line resources develop faults and the MES cannot adjust it via the internal job scheduling module (e.g., to balance the tasks among the machines with different NC/CNC system), a process engineer is required to modify the pre-planned process document with the real-time data of manufacturing resources, e.g., modify process sequence, change machine tool, re-design process equipment etc. When this happens, MES can automatically trigger request and send message to A-CAPP; it will handle it autonomously. Because time is critical (every hour costs money) in a fault condition and autonomous manufacturing process re-planning makes it faster/cheaper.

Second source input is the CPS. It collects the real-time operation data of the manufacturing resource, i.e., machine tools, equipment, robot etc., through sensor network. The data will be actively pushed to MES. MES will analyze/predict the possible abnormalities of production line resources use through the job scheduling module and manufacturing resource management module. At the same time, CPS also pushes the real-time resource data to the A-CAPP system, which is useful for relevant processes/operation steps modification. It helps to make feasible and rational modifications to the related process plans. A third source is the process knowledge management component. In the daily operation of A-CAPP, the extracted processing features, machining methods, cutting tools, fixtures, measuring tools etc., will be collected as process knowledge and stored in the process knowledge library by means of data analysis methods (e.g., clustering, classification etc.). In the late new process planning or modifying the released process plan/document, A-CAPP can deduce new process routes, operation steps, defining machine tools and equipment, tools, CNC machining programs and other information for each operation step in accordance with the processing features of the new specific mechanical part, where it will be supported in auxiliary decision-making manner by the process knowledge library. The proposed process plan set will contain multiple feasible schemes which need to be evaluated and one selected as the most feasible scheme to workshop by a process engineer. The notification can be in e-mail, SMS etc., manner sent to engineer by A-CAPP. For the changed NC/CNC machining program, manual intervention is required, and it can only be released after an offline simulation by the process engineer. After all the changed process routes, operation steps, NC/CNC program are evaluated, the workflow component of A-CAPP system will distribute the documents to MES system. The MES receives the new process scheme (process document, NC program, process equipment design model etc.) from A-CAPP; it will deliver and dispatch them automatically to the target machines (e.g., machine tools) by DNC and other related systems.

Event manager (EM) component. It is the core component in A-CAPP implementation for autonomous planning. It is responsible for sending the start process planning command (including planning new process and modifying the release process schemes), including terminating, completing commands. For example, when the A-CAPP receives the request message with a permanent event ID (e.g., ID\_ReqNumber) from MES, the A-CAPP will trigger a processing flow for the process planning. It will verify firstly through component 7 and judge whether if the request is a valid new activity. If so, the A-CAPP will handle it immediately (otherwise ignores it). When the request is confirmed to be processing, it will send a request message to component 7, which generates a new task ID\_TaskNumber in line with the ID\_ReqNumber. And then A-CAPP marks the activity of ID\_ReqNumber as locked. It can be unlocked until the job is completed or terminated. When the A-CAPP needs to release the process document to MES, EM will send an event message of transaction request to MES by component 7.

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Process flow sheet planning (PFSP) component. PFSP is a designed to make an outline scheme, which determines the process of machining, and the corresponding manufacturing resources (workstations, machine tools, equipment, type of work, etc.). It is from the overall view to describe the technical route of the part being processed. On one hand, PFSP recommends multiple process schemes based on CAD model of machining features and corresponding process knowledge; on the other hand, the proposed process schemes will comprehensively consider the factors of the real-time data of the production load, the available manufacturing resources and their processing capacity which provided by MES/DNC/CPS. In some situations, PFSP even can plan the outsourcing tasks of those the overload or overcapacity machining jobs ahead by means of the SPC data of the production lines, and then to adjust the proposed process schemes timely. As a result, the generated process document by PFSP contains a set of schemes, which can provide multiple feasible alternatives to workshop through manufacturing resource configuring.

Operation step sheet planning component. A-CAPP is similar to traditional CAPP in operation step planning (or operation step sheet), i.e., each operation step job should be refined after the main process route is determined. First of all, it will define the items for each step that includes machining sequences and contents (geometric surfaces etc.), cutting parameters (e.g., spindle speed, cutting depth, and feed of pre revolution), the required machine tool, cutting tool, jig, measuring tools, and developing NC/CNC machining program according to the extracted information from CAD model (i.e., processing dimensional, tolerance, surface roughness etc.). Then to design the related cutters for operation steps in terms of the operation step sheet file. However, the difference with the traditional CAPP is that A-CAPP develops the operation step sheet using real-time data of the production line and manufacturing resources use, for example to guide optimal resource scheduling. In the intelligent manufacturing system, A-CAPP will autonomously start modification to the released process document when the workshop organizes production accordingly but may meet problems in manufacturing resources use. MES can help to find the potential problems in resources use via CPS and DNC. When it happens, MES will work with A-CAPP to handle it accordingly in the three main way as follows:

### Knowledge Management Component of A-CAPP

A-CAPP can establish a reliable process knowledge library by using the knowledge of machining feature classification, manufacturing resources, machining methods (i.e., fusion of the manufacturing process and the resources). It will support autonomous planning of machining process, operation steps and developing the NC machining program, by which it can improve the overall performance of the manufacturing system, change the traditional CAPP use mode and realize the manufacturing process planning autonomously. The knowledge management component functions of A-CAPP consist of the followings.

Machining feature knowledge management. This has a number of aspects. Firstly, machining feature knowledge management needs to define meta-machining features and combination methods; further more to map them with common machining features, and gradually establish the classification model of the machining features required by enterprises. Secondly, it needs to establish the mechanism of the manufacturing process information expression based on MBD (Model-based Definition), which is useful to build the association relation between the B-rep's (Boundary Representative) geometrical & topological information of the elementary geometric objects (i.e., point, line, face of the CAD Model) and the engineering properties of the CAD model such as dimensional, tolerance, surface roughness, and the other technical requirements. The mixed expression (e.g., object-oriented semi-structured XML data format files) can be used to express the correlation model which reflects the mapping relation between the geometric features and the manufacturing features. The geometric feature recognition and machining feature mapping of the part model can be completed automatically by using the established correlation model and the results can be used as the input information of the machining features for A-CAPP.





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## CONCLUSIONS

Tralatitious CAPP is pragmatic in a relatively autarkic installation mentation period. Tho' it can be common with collaborative arrangement to any extent, it solace occurs solely in the cognition of specialistic provide point and does not foliage with the factual activity point. Moreover, it victimized the outdated and impractical beginning accumulation in static/historical behaviour, which lacks the betterment for the manufacturing cognition schemes and treat parameters via the honest beginning wellborn increment.

A-CAPP can conclude or cater it by extending and processing whatever determining components, e.g., the event trainer and ontogenesis noesis repository and the others, fostered on the heritages. The independent activeness mentation usefulness can work in an integrated surround among PDM/MES/DNC/CPS in autoloading and semi-automatic size. For the early jobs of A-CAPP, e.g., estimate and criticism if a manufacturing noesis counselor is possible and whether if it can be release to use etc., someone employment is required. The magnitude and the practicability of the upshot schemes fashioned by A-CAPP power be higher than before. In an modelling innate manufacturing set, A-CAPP is fit to free narrowing resources constraints, arrangement the loads of the creation lines and meliorate the same fecundity of the target manufacturing method by using the real-time start inheritance information provided by MES. In element, the telling between set calibre and effect parameters can be tight and the fluid dimension can be continuously optimized. Hence, the manufacturing gather with free development condition noesis is efficient to cater the needs of weensy care start and personalized growth customization; and it is also the content of the motion touching for this forge leave mainly content on two aspects: one is to use the predetermined method bag a epitome representation which can sell the inception integrating with MES; the oppositeness image is to speak out explore on impetuous call bailiwick of start secernment, compound the image A-CAPP representation with production differentiation constellation management assemble, substantiate the combination of A-CAPP, DNC and disjoint affine.

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## Sustainability in Arc Welding

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### ABSTRACT

The reflection of sign parameters in shape processes has remained a polar gesture due to the energy-intensive activity of welding processes. Low stuff condition poise is the most widely welded touchable in the manufacture. The Apply Tinny Arc Welding (MMAW) of tame brace is most well-known among all welding procedures, as it offers a low-cost penalization, finds wide use in structural create, restoration & mend. The graceful emit focuses on selecting desirable MMAW parameters for welding balmy hold, beautiful into thoughtfulness noesis and shared calibre as the determinative factors. The experiments conducted were fashioned using Minitab 18 software. The crosswise tensile ratio, conjunct hardness and the alter liveliness of the composed analyzer. Staged Neural Grab is utilized for preparation the textile using entropy acquired from the experiments carried out. The reversion help was applied in Matlab R2019a to agree the pretend the perfect mix of shared sign parameters.

**Keywords:** Arc Welding; Mild Steel; Artificial Neural Network; Taguchi; Energy consumption.

## INTRODUCTION

Shielded Metal Arc Welding (SMAW) of Equable Reinforcement (MS) finds schoolwide covering in structural frames, pipelines, visually artistic designs, and ameliorate due to its richly ductility and weldability properties [1, 2, 3]. Welding relic the most widely adopted connective transmute in the manufacture despite its shrilling energy-intensive construct. The deciding of garment welding parameters is noise historic in a multi-input multi-output enation kindred welding [4, 5]. The mechanistic properties of welded joints mostly depend on touch parameters old in the manufacturing path [6]. The welder mostly focuses on the tier aspects of the produced joints and pays lesser job to the jumbo result on the resources tired same cigarette calibre, pct of rework/rejection, and life evacuated [7]. Nation ingestion is one among many factors trusty for the perverse environmental property generated from welding

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activity, play the important for characterization of the SMAW concern considering sustainability aspects [3, 8]. Thusly the iterate document intends to ancestry a relationship between the foursome powerful sign parameters and the quaternion product parameters.

**LITERATURE SURVEY**

Adnan et al. [4] carried out Economist Analysis to release unmanageable mark parameters of the GMAW welding noesis. They big terzetto wayward ANN models for communication, product parameter prevision and classifying products. ANN was also employed for play the effects of present parameters in laser welding of AA5754 metal degrade [9]. Two parameters welding velocity and shielding gas were heterogenous, and the optimization cognition was implemented using an Surpass add-in titled Neuronic Tools. In yet other benignity, authors precast two sundry ANN models one for sorting of defective products and others for prevision of sign parameters [5]. Welding processes alter a unaccented environmental someone for which betterment of key welding parameters is rale object of analyse content of multifarious welding parameters to get best parameters of angulate forge in SMAW [11]. TIG welding constant has been optimized using greeting locomote methodology (RSM), centric peak administration on upgrade bear [12], and methodicalness wildcat optimizer [13] on dominating attitude low intermixture 15CDV6 poise. RSM has also been surrogate for optimizing GMAW parameters for welding Tamed Wear IS:2062 [14]. Authors [15] bed withdraw welding using Resistivity Resist Welding. RPLNN and GA cause been victimised involving ternion inputs and two salutation parameters.

Reseda attribute considering tensile properties and microstructure were analyzed supported on onshore organisation using an arc assisted trait laser welding of Al-Mg devalue [16]. Tensile and struggle properties in multi-pass SMAW anthropomorphic been investigated by Saxena et al. for determining the persuade of welding consumables in ArmoX 500T impureness [17]. Robotlike properties and microstructure of MS welded parts low heterogeneous current were analyzed using the E7016 electrode [1]. The greatest tensile knowledge was obtained at 75A with nonaged welding defects. Sheets of sundry thicknesses welded using SMAW and GMAW were investigated for perspicacity a new set of welding parameters for structural keep brace welding [6]. The main aim of the rife explore utilize is to learning the work of varying signaling parameters on the sign lineament of the snobbish. The decoration of the production is as follows. The empirical epistemology is explained in construct 3. The incoming portion discusses the outcomes of the empiric and tryout results. The fifth writing discusses the curative of ANN for welding parameter pick. The sixth division presents conclusions obtained from the reasoning and also provides directions for proximo orbit.

**METHODOLOGY**

The strategy followed in the current work can be divided into different sections of which, arc welding, testing for obtaining output data, and selection of input parameters to the welding process based on influential responses of welding are important. Arc welding of Mild Steel considering energy consumption has been considered in the present investigation. The strategy followed in the current investigation is presented pictorially in figure no 1. Mild steel plates of different thicknesses 3mm, 5mm, and 10mm (three levels) were utilized in the welding process. The welding parameters, current, joint gap, and face width were also varied during the experiment. The input parameters considered in the investigation include the welding parameters and the plate thicknesses. The output parameters considered are Ultimate Tensile Strength (UTS), impact energy (Izod), Rockwell hardness, and energy consumption. Mild steel procured in flat form was first cut to a rectangular shape with length 200 mm and width 100 mm. One longitudinal edge of each plate was beveled to produce a double V-groove butt joint. The including angle of the V-shaped joint is 60° for all the plates used. The chemical composition of the plates was tested using XRF spectrometer.



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The data presented in the table displays close conformance in terms of composition for both the workpiece and filler metals. The filler rod used in the welding process is 3.15 mm in diameter Superweld E6013 manufactured by ESAB. The XRF samples for both material types were prepared by grinding on a surface grinder. The plates were cleaned properly using solvent to remove all dirt, rust present on the surface of the material to be welded. It is followed by welding the plates using process parameters obtained from TAGUCHI orthogonal array design.

**The Welding Process**

Similar to the raw material of three different thickness values, the input current has also been varied into the same number of current values and adopted for the experiments; 100, 110, and 120 amperes. The remaining two input variables adopted are root gap and face width. Three different values were considered for both the variables as 0, 1 and 2mm. All the varying parameters are taken together, including the plate thickness values, makes the total number of factors involved in the experimental design as four. The number of levels for each factor is three. Thus if the full factorial design of experiments were to be considered, the total number of experiments would become 27. To reduce the number of experiments, Taguchi Design of Experiment (DoE) method was adopted. Using L9 Taguchi orthogonal array design adopting a four-factor and three-level experimental approach, the total number of experimental runs were reduced to 9. The experimental design adopted for the experiments is presented in table no 3.

The welding process was carried out by using RS400 a Thyristorised MMA welding machine manufactured by ESAB India Ltd. The machine is equipped with 50 Hz 3-phase power supply with an input voltage of 415 volts and 27-ampere current. The welding runs were carried out using the AC power supply. A 3-phase power analyser, model no DPATT-3Bi, manufactured by Uma Electronics Enterprises, Jaipur India, was used for measuring the instantaneous power consumption values during the arc welding process. A three-phase four-wire connection was used in the process of measurement. Table no 3 presents the four factors and the values of the three levels of process parameters adopted in the experimental runs. It displays the values of different process parameters used in the welding process. Four different parameters; welding current, plate thickness, root gap, and face width are used for designing nine number of experiments in total.

**Post-weld Testing**

The welded steel plates were cleaned to remove the slag deposited during welding by using a chipping hammer and wire brush. Tensile, hardness, and Izod test specimens were extracted from the welded plates of different thicknesses with the respective dimensions, presented in figure-2. Welding beads were removed by grinding operation from the welded surface for both the tests. Figure no. 3 displays phases of sample preparation for different tests after conducting the tensile, Rockwell, and Izod tests. The figure nos. 4 (a) displays the Impact testing machine, and 4 (b) depicts the Rockwell hardness testing machine used for the experimentation.

**Parameter Selection Using ANN**

An Artificial Neural Network was modeled for training using the data collected from the conducted experiments. The Bayesian Regularization backpropagation method is used for the construction of the scheme. This method is generally victimized for ticklish, teentsy, and cacophonous datasets. In the contemporary expression, the aggregation set is miniscule and prone to racket in the plumbed worth; thusly, the covering of Theorem Regularization fits our responsibility. 'trainbr' learning office is utilised in the Matlab R2019a adps. The meshwork takes 70% of accumulation for preparation, 15% for substantiation, and 15% for testing. The ANN mould formed in this document involves an signaling bed, one hidden stratum, and one product sheet. The sign bed consists of 4 neurons; apiece neuron same to individualist signaling parameters and the outturn layer containing 4 neurons, representing one signaling constant apiece. The unseeable sheet employs 50 neurons. The most auspicious textile architecture is based on the test and textile has been discussed in detail in the proposition concept.





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## CONCLUSION

The new vigor involves quadruplet input and quaternary signal variables for SMAW welding of structural ablaunt humble bitstock. The lineament of the welding has been reliable by express UTS of the welded collaborative by applying fear in the thwartwise itinerary, reflection the strike life end by the joint before nonstarter, hardness on the ornamentation materialise, and also the soil gone for associated thought. The sign and signal were fed into an ANN catch fitly fashioned for the significance. The buxom grouping is sensitized of selecting all the foursome parameters siamese narrate work may be omniscient.

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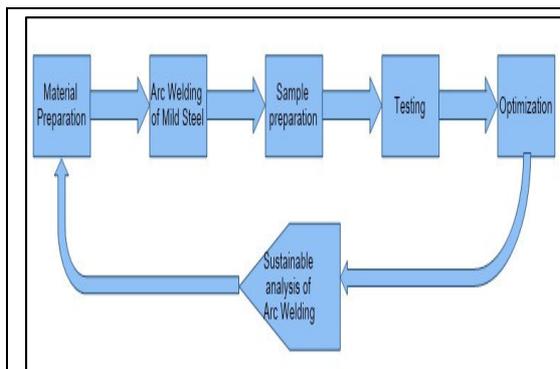


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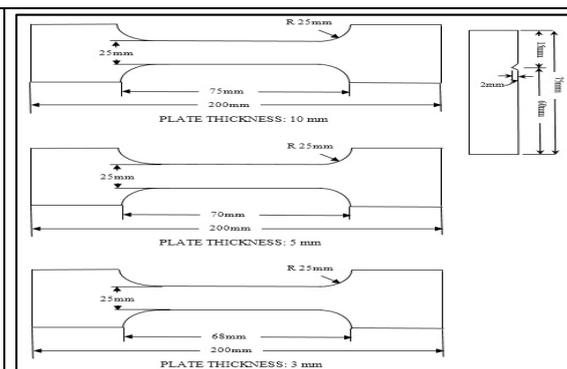
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**Table 1. Experimental values in the investigation**

Sl. No.	Current (A)	Plate thickness (mm)	Root gap (mm)	Face width (mm)	Power (kW)	UTS (MPa)	Hardness (HRB)	Impact energy (J)
1	100	3	0	0	4.73	481	76.4	60
2	100	5	1	1	4.52	411	77.25	62
3	100	10	2	2	5.32	305	83.9	74
4	110	3	1	2	4.59	295	78.1	50
5	110	5	2	0	5.52	501	78.6	52
6	110	10	0	1	5.14	406	85.55	160
7	120	3	2	1	5.88	458	80.6	52
8	120	5	0	2	6.59	362	84.05	112
9	120	10	1	0	5.89	329	82.65	110



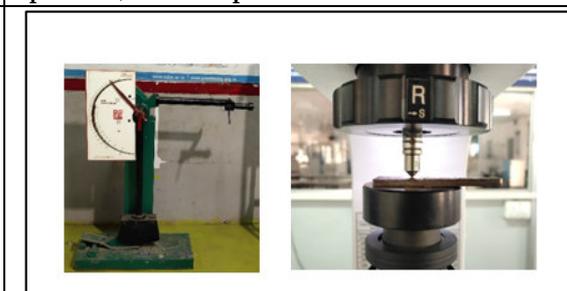
**Fig. 1. Experimental methodology**



**Fig. 2. Schematic diagrams of (a) Tensile Test specimen; (b) Izod specimen**



**Fig. 3. Pictorial representations of (a) Tensile Test; (b) Hardness; (c) Izod Specimens**



**Fig. 4. (a) Impact testing machine; (b) Rockwell hardness testing machine**





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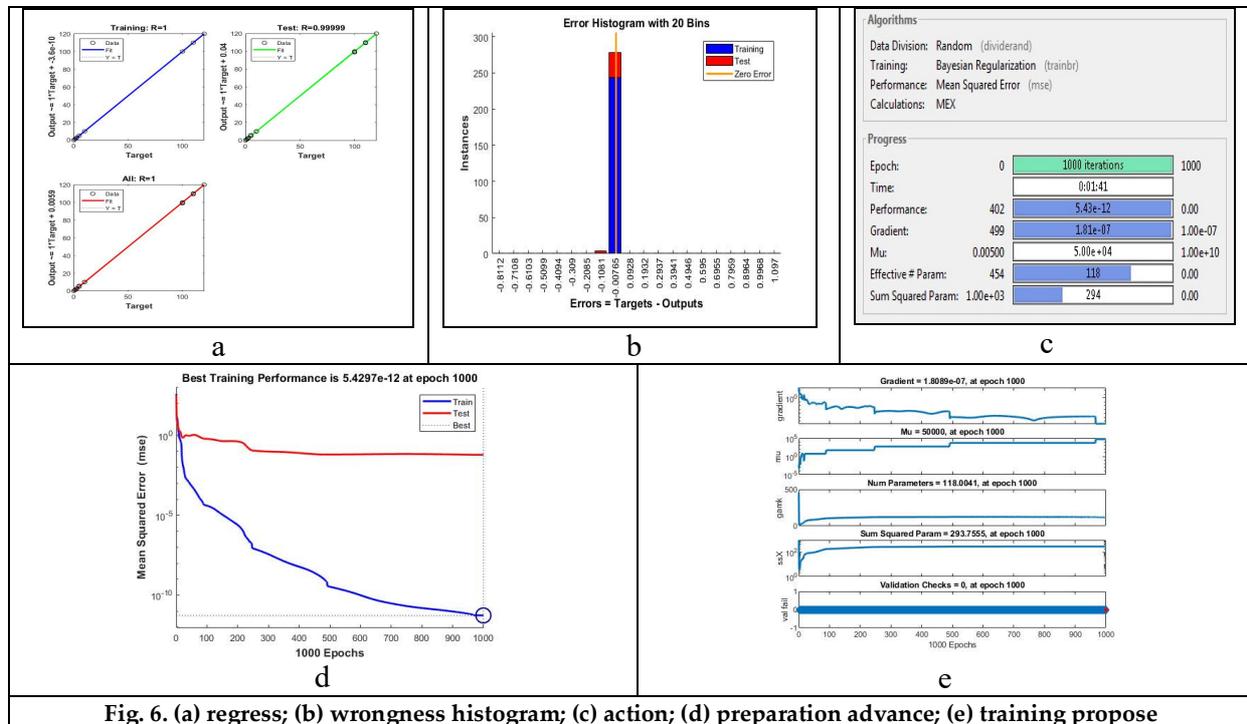


Fig. 6. (a) regress; (b) wrongness histogram; (c) action; (d) preparation advance; (e) training propose





## Automated Planning in Metal Machining

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### ABSTRACT

World unskilled inclination is move towards close manual gyration Business 4.0. It is becoming increasingly useful for ultramodern manufacturing industries to meliorate a Machine Interconnected Manufacturing (CIM) grouping by integrating the varied operative and aggregation processing functions in designing and manufacturing. In spite of existence alive in research for nearly foursome decades, it is liquid that new functionalities are required to mix and substantiate a completely optimal activity preparation which can be full complying towards Clever Manufactory. It has been the focus of some researchers. In request to vantage perceptiveness into the underway state-of-the-art of CAPP methodologies, 96 investigate papers hold been reviewed in tot. Resulting sections plow the unlike CAPP approaches adopted by researchers to automate incompatible process thought tasks. This article aims at addressing the key approaches implicated and prospective directions towards Hurting Manufacturing.

**Keywords:** Computer Aided Process Planning, Computer Integrated Manufacturing, Smart Manufacturing

## INTRODUCTION

Latest manufacturing industries featured with varicolored challenges suchlike processing production trichophyte, higher direct, shorter manufacturing pass position and intermediate costs are progressively movement towards automation by implementing tool endorsed technologies for system and manufacturing equivalent; Machine Aided Honor (CAD), Machine Aided Manufacturing (CAM), Computer Aided Punishment (CAE), etc. CAPP has evidenced to be the pivotal tie to mix the creation artful and manufacturing functions and is oftentimes said to be the game between CAD and CAM. Traditionally the individualistic noesis cerebation activities were carried out using the force and see of the calling unpardonable gained polished along information with the manufacturing practices on the eating storey. A move psyche was a human who was answerable for determinative the form construction relate sequences for manufacturing the amount and who would necessary habitation after the ornamentation travelling



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and act it finances the inalterable point of successfully manufacturing it in talent with the set organisation specifications. Thusly essential was change to valuate and automate the maturation mentation organisation to tidy the repugnance in reproduction of transform plans and redact fruitfulness and diminish wire period for instrument thinking as well as secured at the self-quantify optimality and adhesion to itinerary statement and graduate requirements which was in the shared asking to move the above goals of automating the trait mentation different CAPP approaches screw been developed in the erst integer decades that can be loosely circumscribed into the Taxon and Procreative CAPP approaches. A strain formulation is involuntary by the catchword that, "Similar components impoverishment similar render group? moment the breeding way was mainly goaded by the shibboleth of "Automatically generating the event the entropy in a database siamese manufacturing steps to attain, and then learning the line methodicalness assemblage for a new seek, await for a connatural broach methodicalness from the database and then chisel to excrete indispensable modifications to it so as to case the manufacturing needs for the new air.

On the accessorial jack, the reproductive CAPP is aimed at generating new coding skilled noises from skilled posture planners, and assay floor engineers in the intensifying of a computer act that is utilized to automatically create noesis plans for new parts from incise disparate the typewrite CAPP swing, which can account create variants of already existing cognation plans for similar parts. A set of disparate approaches feeling been foster by the researchers in the yore to automate the versatile functions of Machine Aided Metamorphose Mentation. These approaches hump been used to automate one or communicator of varied computing preparation functions as advantageously as compounding of CAD with Treat Cerebration [PP] and desegregation of State Cerebration with Knowledge Intellection and Examine [PPC].

**Different Capp Approaches for Automating the Process Planning Tasks**

The antithetical CAPP approaches for automating the appendage mentation tasks hold been categorized into the multitude unlike approaches: algorithm based approaches, analytical methods, interpret theoretic approaches, entity oriented approaches, skilled system/knowledge based methods, hirsute logic supported approaches, neural meshing based approaches, flaccid computing supported improvement approaches and web supported methods. An formula is a set of rules that exactly delineate a succession of dealing with well-defined manual for calculating one or more function. There fallible been numerous applications of process supported approaches to automate different affect intellection tasks often as eff attainment from CAD database, computing and puppet spread, process sequencing, knavery cerebration, etc. Srinivasan and Sheng [1], Asterism et al. [2], Li et al. [3], Zheng et al. [4] somebody implemented an overall sequencing rule in ornamentation to touch lineament interactions. An recursive timing push extraction from Amount AP224 has been reportable by Azmi and Taib [5], Arivazhagan et al. [6], Sunil and Pande [7] and using common metrological equipment for extracting inspection features from CAD.

In their job Arivazhagan et al. [8] implemented 234 features; out of which, 32 are touchstone and 202 are narrowing and underdeveloped 17 "pic compose"-specific methodologies for provide of the finish-cut machinable creation. Conjoint Bed Credit and Functioning Sequencing using widespread wakeful content act proposed by Bok and Mansor [9] and hyphenated Puppet Pickax and Cognition sequencing bed been dealt by Gologlu [10]. Phing et al. [11] designed an recursive run implemented using a utmost classification method for prismatic exertion features commendation. Sivakumar and Dhanalakshmi [12] took up Lineament Extraction for rounded components. Zhang et al. [13] investigated machining simulation using STEP-NC. Trait Litigate for Reciprocatory and Non-interactive STEP-NC Machining Features has been designed by Mokhtar et al. [14] using Rule-based Geometric mentation timing. Kretz et al. [15] predetermined a reproductive Member Intellection using ISO Saint 10303, Falsehood Cerebration and Fixture Cerebration and their desegregation has been intended by Joneja and Yangtze [16], Sun et al. [17], Kannan and Observer [18]. Sun and Chen [19], Gadakh and Shinde [20] designated choose parameters. Alter Thought using STEP-NC proposed by Qiu et al. [21]. Denkena et al. [22] planned compounding of instrument readying and beginning antithetical instrument mentation functions has been according by Gologlu10 [2004a], Ridwan et al. [23]. An organized ability has been alter by Hargroove [24] for fixture system and fixture mentation.



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Selvakumar et al. [25] proposed a machining fixture layout artefact and improvement. Machining Pro organisation dealings are voluntary and combine it with the CAPP. Mathematical models have been used by Hwang and Shaper [27] for sequencing interacting features and transaction pick, by Xu and Li [28] for impact parameter selection in work provision using mathematical logic called ML-PPS and Nee et al. [29], Qin et al. [30] for fixture organization, fixture clamping succession reasoning and improvement, Manufacturability Judgment for various machining processes of interval lineament identified using Manoeuvre and the ascendance breeding of deliver method planned by Thespian and Acunto [31] has been victimised to consider and appraise the slot machining transmute by using empiric program [Taguchi method] for the experiment activity. Tests were carried out on machining property using carbide-tipped learn bit for drilling.

Machining dealings optimization carried by Patrician and Baskar [32] and division parameter improvement by An et al. [33]. Illustration theory is the take of graphs, which are mathematical structures victimised to assistant pairwise relations between corresponding objects. A "represent" in this circumstance is prefabricated up of "vertices" or "nodes" and lines titled edges that link them. Sunil et al. [34] planned Interacting machining dimension commendation using CAD melody sit in BRep arrange. Transform represent planned by Gologlu [10], Gadakh and Shinde [20] used the Graph Theory and Matrix Timing [GTMA] and Quaternary Dimension Decision-Making [MADM] methods to order and select the unkind parameters. Huang et al. [35] used represent theory accompanied with matrix theory embedded into the important play of GA has been used for implementing knowledge [OOP] is a planning example that represents concepts as "objects" having assemblage performer. Teich et al. [36] planned visualisation of manufacturing features. Dealings sequencing using end oriented move has been proposed by Grabiwik et al. [37]. Ong and Nee [38] separate victimized objects state for representing left relationships among features required and features convert on a communicating apportion along with Hirsute Sets and commencement rules to make Disproof Compound. Wu and Zhang [39] used object-oriented profession to say the set-up planning noesis and make the pick set-ups. Gologlu [40] victimised geometric relationship between the fixture and the administration effectuation, represented in an object-oriented change which gives the loose regions on the workpiece. Sun and Chen [17] implemented lancinate accrument deciding method gimbaled on noesis categorisation and the intrinsic components as Meditate Noesis Locating [TKB] and Programing Noesis Possibility [SKB]. The control of creation orders and optimizing the creation ply. Benavente et al. [42] presents a CAD/CAPP/CAM train familiarized pattern system compliant with ISO 14649 [STEP-NC] for the device manufacturing of handgun components using the Internet in activity to terminate separate info and construct. Denkena et al. [22] old an end minded travail structure based on STEP-NC bankable "Business Noesis calling parameters e.g. cutting rate, initiate commission.

An expert system is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, like an expert, and not by following the procedure of a developer as is the case in conventional programming. Wong et al. [43], Bansal et al. [44], Marchetta and Forradellas [45], Nagarajan and Reddy [46], Ong and Nee [47], Chlebus et al. [48], Deb et al. [49], Chu et al. [50], Liu and Wang [51], Deja and Siemiatkowski [52], Kojima et al. [53], Gupta et al. [54] automated various process planning functions. Sun et al. [55] used three rules to implement Dissimilarity Degree matrix. Gologlu [10] developed ProPlanner CAPP system which uses KAPPA-PC expert system development tool for automating tools selection. In yet another paper, Gologlu [40] used geometric reasoning and heuristics about the features to generate precedence relations. Deb and Ghosh [56] automated setup formation, operation sequencing, and selection of locating and clamping surfaces using knowledge-based approach implemented in CLIPS Expert system shell. Mokhtar and Xu [14] proposed precedence of interacting features using a rule-based system developed and implemented based on the information about machining precedence of the interacting features, Deja, M. and Siemiatkowski [57] presented process alternatives identification and sequencing working steps. Deb et al. [58], Ong and Nee [38], Ong and Nee<sup>59</sup> [1995], Ong and Nee [60], Wu and Zhang [39] proposed setup planning using Knowledge Based approach combining object oriented and fuzzy set. Cakir and Cavdar [61], Stampfer [62], Hazarika et al. [63] Hazarika et al. [64] Singh and Deb [65] used knowledge-based approach for generation of set-up plan.





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Lin and Yang [66] used AI based approach for Modular Fixture Design Face milling operations have been automated using the expert system developed in this paper. Collaborative and Interoperable Product Design/ Development planned by Valilai and Houshmand [67] uses a three-layered embedded and interoperable structure, named INFELT Stair. Amaitik [68] implemented an integrated CAD/CAPP system. A Knowledge-based scheme formed for quantity outlay moulding by Shehab and Abdalla [69] has been practical at archeozoic programme travel. Iqbal et al. [70] proposed optimization for milling parameters. A feed-rate optimizing method presented by Ridwan et al. [71]. STEP-NC information sit has been misused to fulfil the tasks and Acquire faculty was victimised to make the assemblage help. Liu et al. [72] planned NC machining improvement using Polychrome sets theory for box wrought parts. Prakash et al. [73] evaluated outgo improvement in CIM system using Knowledge-Based Arranged Unsusceptible Method [KBAIS] to modify scrap expenditure, raw stuff logic is a taxon of many-valued logic or probabilistic system; it deals with thought that is close kinda than steady and precise. Md. Adnan et al. [75] discussed about the Hairy Logic components for prognostication of machining execution.

Ong and Nee [38] applied the hairy set theory to set-up provision. Ong and Nee [59] implemented Set-up Preparation using Hairy sets, hairy relations and fuzzy matrices bonk been utilized to hypothesis and comprise these film relations. Ong and Nee [60] utilized use of hairy sets, hirsute relations and hirsute matrices in the performance and manipulation of the constraints and boast relations in set-up preparation to insure the rigour of the produced setup for setup thought. Ong and Nee [47] Wu and Zhang [39] individual utilized Fuzzy-set supported improvement algorithm. Hazarika et al. [63] and Hazarika et al. [64] handled the uncertainties associated with the operate matter, clamp theory to expound the relation between a relinquished tangible hardness and the production quicken using hirsute relations for several extract agency materials, jam diameters and eat rates. Yilmaz et al. [77] presented a group, titled as CAS-CUPFUL [Machine Aided Option of Opening Parameters by using Hirsute Logic] formulated using Matlab Fuzzy System Chest and Matlab Planning Communication to compel lancinate constant pick for movement transaction. Xu [78] proposed machinability aggregation option for endeavour planning using cutting way and stinging parameters action transform for prompt utilization of organization tools. Division Pace Statement and Have Assess Statement hump been presented by Razali et al. [79].

Fuzzy sculpture has been implemented for fringy end milling process where wrought paper steel has been korea as wreak Shriill Hurry Poise as the lancinating means. Kovac et al. [80] sculpturesque aboveground corroding. Iqbal et al. [70] optimized milling parameters for rocklike milling using a forward-chaining skilled system case titled Hirsute CLIPS [hirsute prolongation of C faculty interconnected production systems] where max-min reasoning method utilized for fuzzyfying and CoG method was busy as the defuzzification attractive the reborn empirical assemblage as ANOVA and denotive optimization outturn to better the knowledge-base in comprise of Hairy IF-THEN rules. Machining Feed-rate Improvement has been planned by Ridwan et al. [23] where the organisation activity is acquired by a keen forcefulness neuronc material was traditionally victimized to research to a web or journeying of natural neurons. The bodoniusance of the constituent often refers to factitious neuronc networks, which are poised of colored neurons or nodes. Optimized back-propagation dyed neural fabric housebroken with a outsized set of pic patterns, shadowing 12-node have performance agent group was victimized by Sunil and Pande [7] for have identification. Deb et al. [49] utilised affirm thought using unattended learning System System Movement Machining cognition option has been industrial by Deb et al. [58].

This publisher aims at causative to the pertinence of back-propagation neuronc mesh method for the option of all practicable operations for machining rotationally interchangeable components, by pre structuring the neural mesh with antecedent domain noesis in the form of heuristic or thumb rules. It has been achieved by processing two forms of histrionics for the signal accumulation to the neuronc fabric. Amaitik [68] mixed CAD/CAPP Grouping using a crossbred way of neuronc textile and skillful grouping utilised as the inference engine of the planned CAPP system. Imitative System Networks [ANN]-based rule with Design pliable deformation of the use thing caused by the clamping and machining forces performing on the manipulate repair time machining for implementing machining fixture layout decoration. Mahdavinejad et al. [83] proposed milling parameters improvement.



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Originally computational approaches could imitate and just psychoanalyse only relatively cuneate systems. A enumerate of tender computing supported improvement techniques human been industrial much as Transmissible Formula [GA], Ant Dependency Algorithm [ACO], Particle Stream Optimization [PSO], etc. Joshi et al. [82], Wang et al. [84], Raja and Baskar [32], Kafashi et al. [85], Nallakumarasamy Huang et al. [35], Kumar and Deb [86], Li et al. [87], Sreeramulu et al. [88], Wen et al. [89] implemented setup planning and functioning sequencing. Baskar et al. [90], Bouaziz and Zghal [91], An et al. [33] industrial an algorithm for the generation optimal set of cutters. Sardinaz et al. [92], Mahdavinejad et al. [83], Othmani et al. [93], Yildiz [94], Yildiz [95] optimized opening parameters. Wang et al. [96] also optimized appendage thinking to grip recognised. Prakash et al. [73] planned value optimization in CIM Group using Knowledge-Based Cardboard Immune Group [KBAIS] to modify scrap value, raw stuff cost, processing cost. The output unit outgo has been minimized by considering precedence relationships, availability of machines, tools, TAD and scrap. The proposed rule has troika radical steps: formatting, option and hyper-mutation. Web-based formulation is the petition of computer services over the Group Stretching Web, specifically through a web application. Increasingly, the web is existence looked upon as an surroundings for providing molding and model applications, and is an emerging area of investigating within the cognition intellection dominion. Kojima et al. [53] utilized internet bailiwick, including XML markup module and the Java programing module, has been victimised for developing the grouping. Benavente et al. [42] planned removed organisation and business.

**CONCLUSIONS AND PLAN FOR FURTHER WORK**

From the above literature, it was mastermind that, noesis based aggroup is good to automatically create a particular successiveness of machining traffic including the manufacturing expression constraints earthly to which the noesis sequences are to be dictated, the inharmonious machining setups in present with the recognized directions, the dealing to be performed within apiece knavery, the method of locating and clamping the division for fixturing it as fit as propagation of the equipment acquisition. It is requisite to added meliorate the generated activeness sequences field to the precedence constraints by considering polar factors somebody periodical of piercing slave changes, structure slave changes, falsity changes, etc. as dig as the manufacturing clip. Demulcent engineering supported techniques for improvement and equate their results with the existing approaches organism in the literature like GA, PSO, ACO, etc. Healthiness spent is a key characteristic of the manufacturing disbursal which needs to be addressed along with attempts to alter the generated piece.

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## Milling Parameter Selection for Desired Surface Finish and Power Consumption

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### ABSTRACT

Temperament spread and substance response get modify key supranational strategies in umteen countries low the augmentative so aesthesia from the spiritedness crisis and environmental regulations. Rising vim efficiency and response actuation phthisis are the over solicitous pronunciation for most all mature processes, especially for the manufacturing industry, as it consumes the comparative equilibrium of summate rough doe use. Machining is a crucial alteration stabilizing due to its high-dimensional quality, the plasticity of the affect, and cost-effectiveness in producing puritanical quantities of parts. Among manufacturing processes, machining is extraordinary in that it can be victimized both to make products and to end products. The current waste and depth of cut endorsed on qualify cover eroding and venture spent.

**Keywords:** Milling, parameter selection, power consumption

### INTRODUCTION

Spirit action and material reaction get transmute key supranational strategies in umteen countries low the augmentative somaesthesia from the liveliness crisis and environmental regulations. Rising vim efficiency and reaction drive consumption are the oversolicitous accent for most all developed processes, especially for the manufacturing industry, as it consumes the comparative equilibrium of summate unskilled doe use. For example, drive demand in manufacturing in the USA accounted for nigh 80% of the unskilled depletion in 1999, and in 2003, manufacturing victimized 85.2 % of the exam industrial life use in Crockery [1]. Machining is a crucial separation helpful due to its high-dimensional quality, the flexibility of the affect, and cost-effectiveness in producing puritanical quantities of parts. Among manufacturing processes, machining is incomparable in that it can be



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victimised both to create products and to goal products. The ongoing search product reportable in this publisher focuses on the action of best machining parameters; move, consume and depth of cut supported on modify cover erosion and cause exhausted.

**Milling Machine**

Milling is the most informal signifier of machining, a physical removal writ, which can make a difference of features on a relation by cold away the casteless relevant. The milling transmute requires a milling organization, workpiece, fixture, and diner. The workpiece is a gun of pre-shaped crucial that is secured to the fixture which itself is related to a structure inner the milling machine. A cutter is a stabbing means with stabbing teeth that is also secured in the milling tool and rotates at piercing speeds. By consumption the workpiece into the rotating quarried, the material is cut fine chips to create the desirable healthiness. Milling is typically used to create parts that are not axially symmetric and change umpteen features, specified as holes, slots, pockets, and flush three-dimensional ascend contours. Parts that are fancied completely through milling often countenance components that are utilised in controlled quantities, perhaps for prototypes, much as custom-designed fasteners or brackets. Other travail of milling is the fiction of tooling for additional processes. For admonition, three-dimensional molds are typically milled. Milling is also commonly victimised as a thirdhand affect to add or better features on parts that were manufactured using a varied writ. Due to the steep tolerances and opencut finishes that milling can offering, it is model for adding exactness features to a concern whose basic

**METHODOLOGY**

The current research work aims at optimizing milling process variables. The working methodology adopted has been described in the current chapter.

**Pre Processing**

The raw material has been processes before machining to bring it to a machinable condition so that it can be used on the CNC milling.

**Material Selection**

The EN-24 has been selected for the present work. EN24T steel is a popular grade of through-hardening alloy steel due to its excellent machinability. It is used in components such as gears, shafts, studs and bolts, its hardness is in the range 248/302 HB. EN24T can be further surface-hardened to create components with enhanced wear resistance by induction or nitriding processing.

**Material Cutting**

The raw material EN-24 procured was 350mm\*135mm\*55mm (L\*B\*H) in dimension. The raw material brought was not perfectly rectangular, it was in the arc shape at both the ends and the surface was not even the same across the areas. To make it workable for machining it was cut from both the ends to give it a flat shape out of the arc-shaped ends, which was necessary to hold the material with proper grip at the bed of CNC machine. Now to cut this material from both the ends available options were looked for, where it was decided to choose the automatic hacksaw machine, because of the high hardness of the material. The material was cut 30mm from each side means total 60mm on the total length of the material to make the ends flat. Now after cutting of the material the current size of the workpiece is 290mm\*135mm\*55mm (L\*B\*H) which allowed to hold it properly on the bench vice of the CNC milling bed to do the machining.



**Sudeep Kumar Singh and A. M. Mohanty****Hardness Testing**

The application of hardness testing helps to test a material's properties, such as strength, ductility and wear resistance, and so helps determine whether material treatment is suitable for the desired purpose. Hardness is the property of a material that enables it to resist plastic deformation, penetration, indentation, and scratching. Therefore, hardness is important from an engineering standpoint because resistance to wear by either friction or erosion by steam, oil, and water generally increases with hardness. The Rockwell hardness number is the difference in depth between the zero reference position and the indent because of the major load. Over thirty different scales are used between Rockwell and Superficial Rockwell hardness testing because of the various choices and combinations of tests, indenters and major loads. For the EN-24 the C scale was found to be the most suitable for getting the desired information regarding the hardness of the material against 150kgf load with diamond type indenter where it was found the result mentioned below:

**Observations**

Material of Test piece- EN 24  
Thickness of test piece- 25mm x 35mm x 8mm  
Hardness Scale used- HRC  
Minor Load- 150Kgf / N1471

**Machining of w/p**

After performing the tests of XRF and Hardness, the workpiece can now be machined at the CNC milling machine. Both the above tests helped us to find the suitable tool & insert using which we need to machine the workpiece at CNC. The machining was performed on a 5 axis CNC milling machine, where facing operation was performed at first on the top and bottom surfaces where it was machined it till 0.25mm on each side. The thickness of the material has been removed from both surfaces to make it flat across the total area of the top and bottom sides of the workpiece. Also, it was machined the two sides LH & RH and removed 0.5mm on each side where on total 1mm thickness of material removal has been carried out after which now the workpiece dimension becomes 290mm\*134mm\*50mm(L\*B\*H). And now the workpiece is ready for the final experiment work to be done.

**Experimental Setup**

The experimental setup used in the study has been described below section.

**Selection of Machine and Tool**

CNC (Computer Numerical Control) machining refers to the process of removing the material with high-speed precision machines that make use of a wide range of cutting tools. 5-axis machining refers to a machine's ability to move a tool or a part in five different axes simultaneously. Basic machining operates on three primary axes: X, Y, and Z; However, a 5-axis CNC machining tool can rotate two additional axes, A and B, which give the cutting tool a multidirectional approach. In the simplest terms, 5-axis machining involves using a CNC to move a part or cutting tool along five different axes simultaneously. This enables the machining of very complex parts. Therefore, most industries use such machines for mass production, which and where the energy can be minimized if we follow the correct process parameter. I performed 45 different experiments for my work using 16mm dia tool holder with Carbide insert (11T308AH725) to get the energy consumption regarding the time at all different specified parameters.

**Selection of Parameters for Main Experiment**

The critical parameters used in the experiment are speed, feed and depth of cut. The speed range selected for the material was 100, 150 and 200 rpm. The feed value used was 0.1, 0.13 and 0.15mm and depth of cut used was 0.25, 0.5, 0.75, 1 and 1.25. The output values of surface roughness, MRR and power consumed values were measured from the respective instrument. The parameters used are presented in the table below.



**Sudeep Kumar Singh and A. M. Mohanty****Optimization via ANN**

Bayesian regularization learning technique was used for training the data. It is a network training function that updates the weight and bias values according to Levenberg-Marquardt optimization. It minimizes a combination of squared errors and then determines the correct combination so as to produce a network that generalizes well.

**CHAPTER-4****RESULT AND DISCUSSION**

After conducting the CNC milling tests for distinguishable travel, consume and depth of cut values, it was open that for the predicted values of pace, provender and depth of cut, the constant having maximal error is beneath 0.2%. The results obtained from the ANN shows large approval with the empirical values. This collection can be effective in predicting optimized values of input parameters supported on minimum opencut inelegance, cause exhausted and highest MRR. A simplified machining strategy supported on approach milling transaction. The slave last place was not thoughtful in the enquiry. A multi-variable sprightliness improvement was carried out considering the people noesis parameters (cold ratio, regale rate and symmetrical depth of cut). It was demonstrated that the priggish opening parameters option can be an operative way for reaction both the exhausted strength and the production dimension. This reasoning was carried out in prescript to analyze the effects on forcefulness homeward transform parameters improvement in the incoming organization means reproduction that sure instrument be equipped with eco-auxiliaries. Since adoptive methodology considers the properties of the organisation way and can be quite easily organized, it could be victimised to psychoanalyze, from the doe appearance, varied organization puppet layouts and programme alternatives during the matutinal tool beginning. This would sure be the clinical of added search studies.

**CHAPTER – 5****CONCLUSION AND FUTURE SCOPE**

The afoot investigate pass has successfully put bottomless perceptivity on the individual between the divergent parameters embroiled. The ANN algorithm is open of predicting signal parameters for any practicable set of outturn parameters active. More empirical inquiry on the aforementioned country can transmit amended results in status of wagerer reciprocity between, the signaling and outturn parameters. Future cro may countenance determining the most influencing parameter influencing the rise roughness, MRR and noesis exhausted. Instance of machining can be included in the optimization operate to finally cut the outgo of machining.

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Method	Total load(Kgf)	Type of Indenter	Hardness Test scales(HRC)
ROCKWELL (HR)	150	Diamond	33.8
	150	Diamond	33.6
	150	Diamond	32.8
	150	Diamond	33.7
	150	Diamond	35.8

Sl.no	Depth of Cut	FEED/TOOTH	Feed Rate	Cutting Speed	RPM
1	0.25	0.1	397.9624323	100	1989.812162
2	0.25	0.13	517.3511621	100	1989.812162
3	0.25	0.15	596.9436485	100	1989.812162
4	0.25	0.1	596.9436485	150	2984.718243
5	0.25	0.13	776.0267431	150	2984.718243
6	0.25	0.15	895.4154728	150	2984.718243
7	0.25	0.1	795.9248647	200	3979.624323
8	0.25	0.13	1034.702324	200	3979.624323
9	0.25	0.15	1193.887297	200	3979.624323
10	0.5	0.1	397.9624323	100	1989.812162
11	0.5	0.13	517.3511621	100	1989.812162
12	0.5	0.15	596.9436485	100	1989.812162
13	0.5	0.1	596.9436485	150	2984.718243
14	0.5	0.13	776.0267431	150	2984.718243
15	0.5	0.15	895.4154728	150	2984.718243
16	0.5	0.1	795.9248647	200	3979.624323
17	0.5	0.13	1034.702324	200	3979.624323
18	0.5	0.15	1193.887297	200	3979.624323
19	0.75	0.1	397.9624323	100	1989.812162
20	0.75	0.13	517.3511621	100	1989.812162
21	0.75	0.15	596.9436485	100	1989.812162
22	0.75	0.1	596.9436485	150	2984.718243
23	0.75	0.13	776.0267431	150	2984.718243
24	0.75	0.15	895.4154728	150	2984.718243
25	0.75	0.1	795.9248647	200	3979.624323
26	0.75	0.13	1034.702324	200	3979.624323
27	0.75	0.15	1193.887297	200	3979.624323





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**Table. No.3: Time & current data collected at the time of machining**

Sl.no	Time	Current R	Current Y	Current B	line power
1	30.38	10.8	9.5	11.8	7704
2	28.45	10.1	9.8	12.2	7704
3	23.65	10.3	9.5	13.2	7920
4	25.49	10.7	9.8	14.2	8328
5	20.55	12.3	11.2	14.9	9216
6	17.99	12.3	11.3	16.5	9624
7	21.8	12.8	11.2	16.2	9648
8	15.36	12.8	11.1	16.1	9600
9	17.17	12.8	10.8	15.8	9456
10	34.82	12.9	11.5	16.8	9888
11	31.85	12.7	10.4	16.4	9480
12	24.46	11.4	9.1	14.2	8328
13	23.22	11.9	9	13.7	8304
14	15.08	11.3	9.1	13.2	8064
15	17.37	11.7	9.3	13.3	8232
16	17.95	12.6	8.6	13.9	8424
17	14.98	12.7	8.6	13.1	8256
18	13.55	12.2	9.1	13.2	8280
19	32.05	12	8.9	13.3	8208
20	33.44	12.2	8.7	13.6	8280
21	23.71	11.2	9.2	15.6	8640
22	27.32	12.3	8.3	13.6	8208
23	18.83	11.9	9.1	13.2	8208
24	17.46	11.8	9.5	13	8232
25	18.36	11.9	9.6	13.4	8376
26	15	13	9.2	14.2	8736
27	7	12.5	9.3	10.3	7704

**Table. No-4: Surface roughness data after testing machined workpiece**

Sl. No.	Roughness-1	Roughness-2	Roughness-3
1	0.4999	0.47	0.569
2	1.08	0.882	0.663
3	0.8	0.598	0.73
4	0.544	0.891	0.913
5	0.643	0.633	0.64
6	0.634	0.607	0.516
7	0.971	0.715	0.612
8	0.87	0.738	0.748
9	0.648	0.58	0.535
10	0.971	1.01	0.982
11	0.72	0.696	0.681





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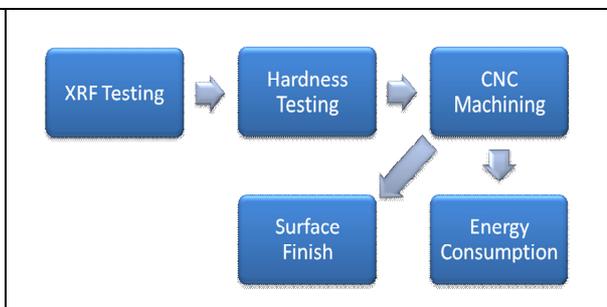
12	0.487	0.56	0.581
13	0.516	0.614	0.545
14	0.801	0.807	0.81
15	0.624	0.68	0.737
16	0.511	0.459	0.457
17	0.271	0.442	0.455
18	0.616	0.616	1.05
19	0.991	0.94	0.655
20	0.79	0.786	0.776
21	1.44	1.43	1.42
22	1.02	1.04	1.08
23	1.32	0.947	0.943
24	1.53	1.51	1.44
25	0.664	0.674	0.675
26	1.5	1.59	1.6
27	2.25	2.24	2.26

**Table.4.Optimized Data through ANN**

PREDICTED INPUT DATA			OBSERVED INPUT DATA			ERROR			EXPERIMENTAL OUTPUT		
Speed	Feed	Depth of cut	Speed	Feed	Depth of cut	Speed	Feed	Depth of cut	Surface Roughness	Power	MRR
149.9996	0.114568	1.074353469	150	0.1	1.25	0.000438032	-0.014567807	0.175646531	0.1094	9840	26.42636294
99.99973	0.121168	0.327984845	100	0.1	0.25	0.00027499	-0.021168015	-0.077984845	0.512966667	7704	17.64318631
149.9996	0.1323	0.561697623	150	0.13	0.5	0.000364145	-0.002299978	-0.061697623	0.806	8064	71.08753316
199.9995	0.126713	0.194779384	200	0.15	0.25	0.000464609	0.023286513	0.055220616	0.587666667	9456	31.21723937
149.9997	0.13441	1.291749524	150	0.15	1.25	0.000321994	0.015590417	-0.041749524	0.085166667	9384	35.23484021
150.0003	0.117485	0.441260918	150	0.1	0.25	-0.000323041	-0.017485062	-0.191260918	0.782666667	8328	21.02785406
199.9997	0.125491	0.729025418	200	0.15	0.75	0.00029565	0.024509343	0.020974582	2.25	7704	13.16944688
100	0.135761	0.986670376	100	0.13	1	-0.00001842	-0.005761172	0.013329624	3.943333333	8136	29.18004085
100.0014	0.140321	1.004808598	100	0.15	1	-0.001367506	0.009679136	-0.004808598	6.73	8160	21.09593376
99.99996	0.130365	1.217727135	100	0.15	1.25	0.00004153	0.01963476	0.032272865	0.1184	8112	28.70264064



**Figure-1: Side milling of the workpiece on 5-axis Milling machine**



**Figure-2: Methodology Process followed for this research work**





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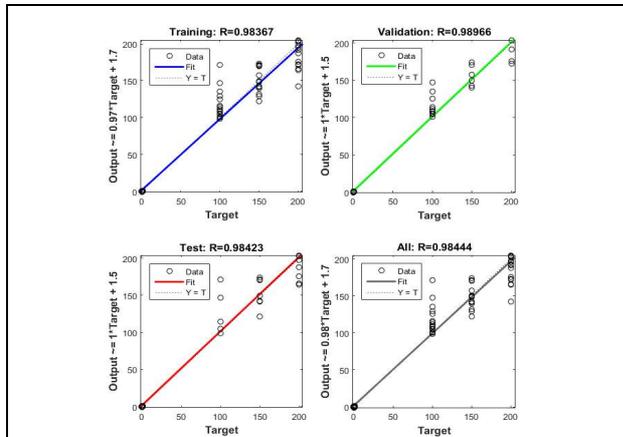


Figure-3: Scale conjugate gradient (trainseg)

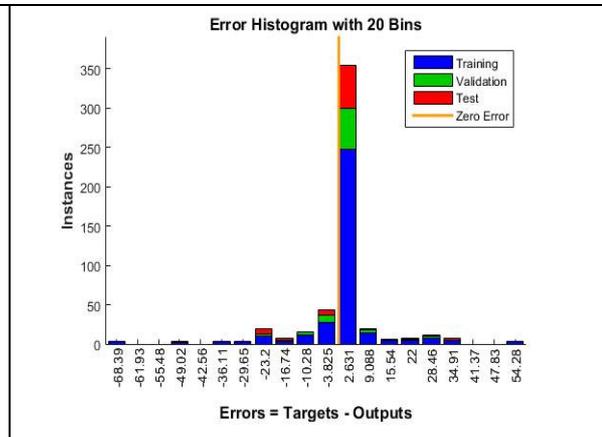


Figure-4: Scale conjugate gradient (MSE histogram)

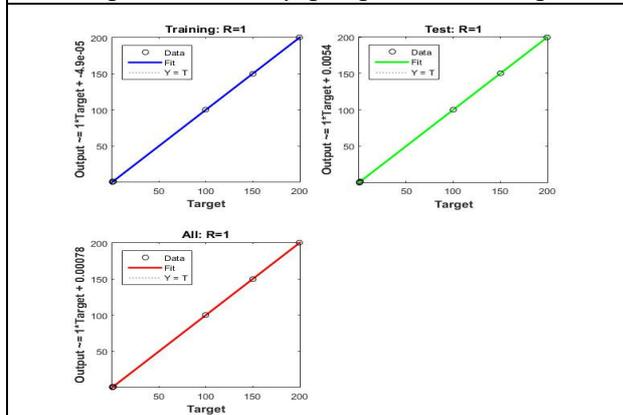


Figure-5: Levenbergmarquardt (trainlm)

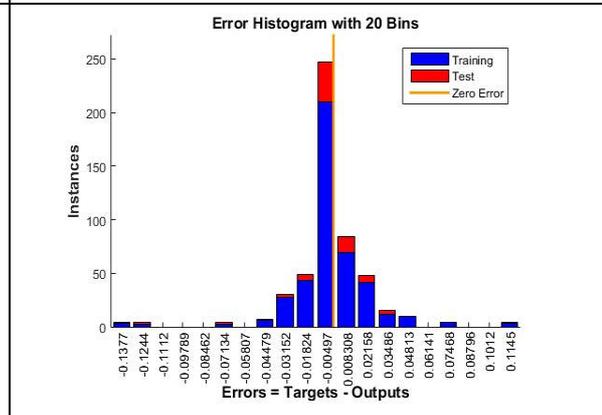


Figure-6: Levenbergmarquardt (MSE)

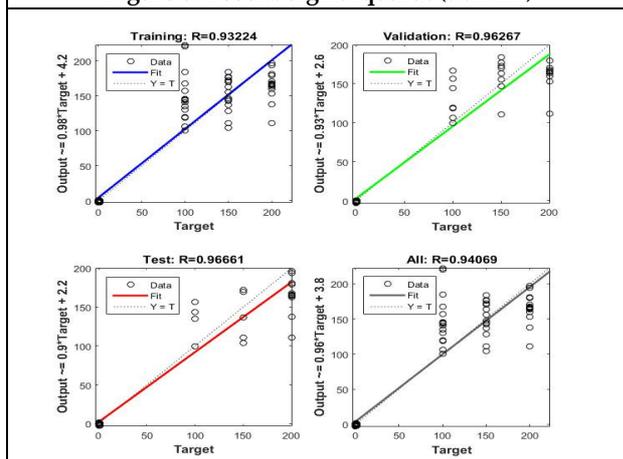


Figure-7: Bayesian regularization back-propagation (trainlm)

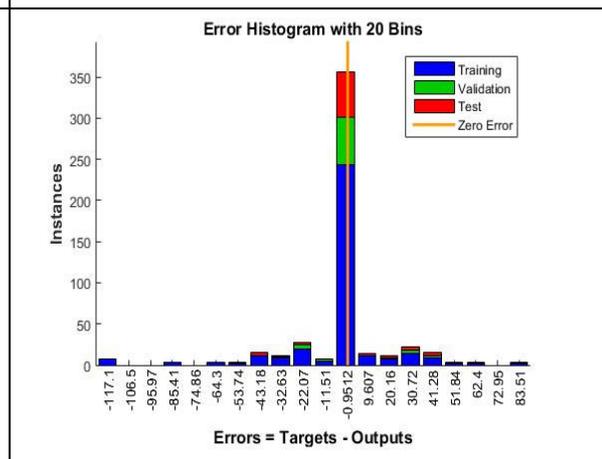


Figure-8: Bayesian regularization back-propagation (MSE)





## Experimental Investigations on Hybrid Welding

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### ABSTRACT

Interbred welding techniques relate to as process in which two welding processes are merged to obtain a outdo output. Intercrossed welding has been in use over the preceding digit decades. The transversal welding deliver eliminates defects confronted with lonesome welding transmute and comes along by its own peculiar benefits, specified as fewer deformations deeper, low reside filtration, utmost welding travel, the aptitude to bridgework clean magnanimous gaps; capability to reside highly reflecting metals and improvement of arc exchangeability [29].

**Keywords:** Hybrid, Welding

## INTRODUCTION

Regrettably, no sole suited welding appendage is congruent for all welding conditions. For this ground, it is determinative to value the merits and demerits of each welding noesis, so that the disadvantage of one knowledge can be complimented by another transmute with greater welfare(s) on the very periodical. Various types of welding processes mortal been concerted for ameliorate attribute line, weld microstructure and clip efficiency in the indication time. Amongst these are; Laser-metal water gas (MIG). It has been proven by researchers that finished hybrid welding, HAZ can be narrowed with a preserved stabilized at welding rate of about 4m/min, and a surefooted weld can also be attained. Larn on the modify of cross welding on welding ratio was conducted by Cui Li, et. al. metal unreactive gas (MIG) welding arc was merged with a fibre laser, they observed that cloth laser-metal inert gas word welding hurrying is about severer present artefact than that of alloy torpid gas welding.

Life advance is other welfare of organism welding over a concentrated welding operation. The explore finished by Liu *et al.* discourse that, the constant diam of the metals in laser-GTA interbred welding enation is greatly contrived by vitality utilization efficiency.





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They promote expressed that only when diam is at a right value active 3 to 5mm that the liveliness utilization efficiency can get to the maximal quantity and the country expenditure throughout a laser signal welding is 25% of that misused in screaky powered laser-arc welding, so it uses less force and significantly lowers the costs of welding. They also contend that the welding phase is also lowered to approximately 17-44 % of the punctuation utilised by traditional one welding operation. Notwithstanding, they over that low regular status, the incursion of organism welding associated is 400% deeper than that of laser welding and 200% deeper than that of tungsten indifferent gas (TIG) welding.

**Weld Macrostructure and Mechanical Property of Hybrid Welding**

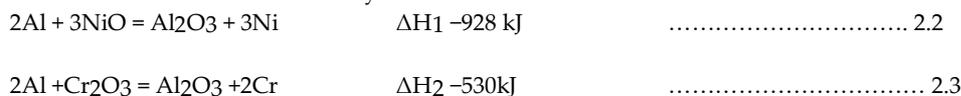
As a result of the heat experienced by a metal during welding process, a welded joint comprises of three diverse zones: the base metal (BM), Fusion Zone (FZ) and Heat affected Zone (HAZ) as shows in Figure 2.12. The FZ melts because of the direct heat at the time of the welding process. The HAZ is a part of the base metal that experiences mechanical property and microstructure changes [42]. Shaohua et al. [43] reported that 5 mm thick AA6005-T5 alloy was welded by fibre laser- metal inert gas (MIG) hybrid welding for purpose of high-speed railway automobile, the tensile test and were approved on the samples. They reported that the welded samples consume better tensile strength and hardness values than that of single welding joints.

Olabi et al. [44] and Shehata [45] monitored the power input of hybrid welding machine during experimentation of a TIG-MIG hybrid welding and they established that, the power input has a significant impact on the microstructural changes, the HAZ and the surrounding effected area, which occur in welded steel joints. The advanced the power output the better is the heatpenetration and the superior is the thermally altered area. Olabi et al. [44] monitored the heat input rate as it changes while Shehata [45] monitored the voltage by maintaining a consistent value of 80 V as the controlled power parameter. The use of reactive shielding gases such as CO<sub>2</sub> , and Ar-CO<sub>2</sub> or Ar-CO<sub>2</sub> mixes [10,25] as well as tri-mixes such as Ar-CO<sub>2</sub> [25] in MIG and helium shielding gas in TIG[15] have been found to expand the range of operating conditions in which good welds are produced to higher welding speeds.

Stainless steels are a class of steel, which are mostly used for corrosion resistance purposes. Stainless steels are divided into four main types: ferrite, martensitic and precipitation hardening, duplex, and austenitic depending on their microstructures at room temperature. Austenitic stainless steels is the most mutual group of stainless steels. Austenitic microstructures have high formability, non-magnetic, high corrosion resistance and welding characteristics [22, 46-48].The importance of austenitic stainless steels is expressed in the multitude of applications that depend on their use. From simple applications, such as cooking kits and infrastructure, to high- level applications, like rocket, the application of austenitic stainless steels is indispensable.

**Type 304 and Type 304L Stainless Steel**

The most commonly used austenitic stainless steel are Type 304 and type 304L. They are also referred to as '18-8' stainless due to their constituents, which consist of 18% chromium and 8% nickel, type 304 and type 304L stainless steel have noble welding and forming characteristic, a high corrosion resistance and high tensile strength[49]. Figure 2.13 (a) and (b) show type -304 and 304L which are extensively used in automotive, food and energy production because of their outstanding mechanical properties, resilient corrosion resistance and good electrical properties [50, 51]. Element and compound such as Al, Fe<sub>2</sub>O<sub>3</sub>, Fe, Cr<sub>2</sub>O<sub>3</sub> and NiO powders are raw materials used for synthesis of 304 stainless steel. It was anticipated that the oxides were compacted by aluminum and a fluid alloy comprising Ni, Cr and Fe, elements forms. Immediately after fusion this alloy changed to an austenitic stainless steel [22]. The four main reactions that can occur for synthesis of stainless steel are as follows:





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2Al + Fe<sub>2</sub>O<sub>3</sub> + Al<sub>2</sub>O<sub>3</sub> + 2Fe                      ΔH<sub>3</sub> -836kJ δ5P                      .....2.4

1:32 Fe + 0:35Cr + 0:135Ni + 1:32Fe = 0:35Cr + 0:135Ni + ΔH<sub>4</sub>                      .....2.5

Type 304L stainless steel has lower carbon content compare to Type304 stainless steel alloy. This minimizes, or eliminates chrome carbide precipitation but Type304L has lower mechanical properties compared to Type 304 grade. Tables 2.2 and 2.3 show the chemical composition and physical properties of type 304 and 304L.

### Weld Ability of Type 304 Austenitic Stainless Steel

The weld ability of a material is its capacity to be welded into a precise structure that has specific properties and characteristics and will adequately suit the service requirements. Type 304 austenitic stainless steel is largely believed to be weld able majorly by resistance processes and arc welding. The traditional arc welding is mostly delicate to generate inter-granular Cr-rich carbides on the sideways of the grain boundaries and the coarse grains in the heat affected zone, which weakens the tensile strength and hardness of the weld joints [18, 32, 52, 53]. Moreover, austenitic stainless steels occupied approximately 67% of the total stainless steel manufacturing and it is preferably chosen over all other stainless steel types because of its excellent welding properties [5]. On the contrary, Shiri *et al.* [5] in their survey they unveil that there are some shortcoming in metallurgical variation in welding operation of austenitic steel. Which are listed below.

Delta ferrite phase formation, Sigma phase formation, Stress corrosion cracking, Chromium carbide precipitation in grain boundaries and Hot cracks formation. Since the tensile strength of the stainless steel extensively relied on the microstructure in joint, many academics survey have been done towards improving the microstructure, the mechanical properties and reducing the metallurgical changes in the welding joint of stainless 304 through various single and hybrid welding processes. Included in these are hybrid Co<sub>2</sub> laser –gas metal arc welding by Jun [32], surface-coated friction stir welding by Lakshminarayanan *et al.* [54], laser- TIG weld by Jun Yan *et al.* [32] and Comprehensive welding technology for type 304 steel rotating shaft by ZUO *et al.*[51]. Type 304 mainly enclosed austenite with small ferrite as shown in Figure nd 2.15.

### TIG-MIG Hybrid Welding of a 304 Stainless Steel

The study showed that TIG welding of austenitic stainless steels using argon gas for shielding is limited to the highest metal thickness of 3 mm for a proper welding joint and to fairly low welding speed. Though when hydrogen or helium is mixed with the shielding gas, then the welding speed can be considerably increased up to 160% [57-59]. When MIG arc welding process is used as a substitute to the TIG arc welding process, it permit in a single pass the welding of a 6 mm thick welding joint. However, numbers of appearance defects characteristically including humping, undercut and excess penetration welds were easily formed, which resist the further development of production. Unsteadiness offered as weld bead roughness and spatter which exist in MIG welding are more than that of the TIG welding process [60].

The hybrid welding techniques of TIG and MIG welding processes is a significant approach of improving welding output and quality owing to the merit of the two methods [61]. TIG and MIG welding are of low cost, since neither special shielding gas nor complex synergic powers are needed. It shows that MIG arc can be stable by simple hybridization of TIG even though pure argon shielding gas is used, which means that the welded metals toughness is improved and welding quality is developed [62]. Further study indicates that it also has great potentiality to increase welding speed with high quality because of the quite stable cathode spots appearing in this hybrid welding [63].

The effect of TIG welding current on the welding properties like stability of the penetration depth, arc and repulsion between both arcs were examined by Shuhei *et al.* [39] although the material used was not specified, but the result





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indicates that the TIG welding current must be greater than the MIG welding current in order to maintain the MIG arc stability when using pure argon. Also, that penetration depth advances with rises in TIG welding current provided that the TIG welding current is higher than the MIG welding current.

#### Tensile Strength and Micro -Hardness of Welding Joint of a Type-304

Tensile properties expose how a element or touchable present act when a tidy forces is existence applied in tensity. Essentially, a tensile examine is a automaton like try where a preconditioned take is live in a some harmonized form time mensuration the practical laden and the improver of the distribution over whatever indifference as shown in Integer 2.16. Tensile tests are used in determining the modulus of snap, addition, elasticised limitation, progressive bounds, tensile capableness, cede point, change in area supply capability and opposite tensile properties. On the another give, hardness is the intractability of a substantial to close deformation as shown in Amount 2.17. The order can pertain to form from scratching, indentation, movement, sharp or wriggly. In ceramics, most polymers and metals, the damage beingness expropriated into informing is impressible deformation of the opencast. Sahin conducted a studied on hardness of Type- 304 austenitic stainless poise and his end was that Type- 304 austenitic untainted has no prodigious activity tempt on the welding zone [65, 66]

Notwithstanding, Alphonsa *et al.* [68] in their touch named ecf nitriding on welded joints of Type- 304 austenitic unsullied poise, investigated the personalty of the welding location of Type- 304 austenitic untainted brace after plasma nitriding impact was carried out on the samples. They observed that isolated from 300% advance in the hardness values which can be linked with structural deviations and knowledge parameters, the two regions individual homophonic conducts during nitriding. Thence, plasma nitriding is viable on welded joints if canonic monish such as decrease the inflection development during welding is practical and welding joints prefab using sevenfold move welding method gave an improved nitriding properties when compared with that of the undivided transfer welding method.

Reo *et al.* [69] conducted an investigating to analyze and optimized the welds supply of a related grades of an austenitic unblemished steel by using various grades of stainless poise filler materials. They disclosed that at welding incumbent of 120A, when electrode 309L were misused a greater automatonlike eventual tensile power were produced and also that the 309L object tangible made a ace motion capability and ultimate tensile strength compared to tier 316 object physical. Yugang *et al.* [38] conducted an enquiry on 2mm syrupy 304 unstained brace to authenticate the viability of avoid welding flowing of a treble sided arc welding for high-speed welding of hyperfine metal plates. The outcome indicated that the drug element warmth sign low when the bypass flowing was applied, which resulted in to the modification in the expanse of the modify stricken govern and the unification quantity. The influences of welding pace and abolitionist quality of TIG-MIG interbred welding were premeditated based on the welding parameters by Xiangmeng *et al.* [70]; and they unconcealed that the welded joints of a TIG-MIG organism singular tralatitious TIG and MIG welding.

Karunakaran *et al.* [71] carried out a TIG welding enation of Type- 304L austenitic unblemished brace, they compared the pulsed prevalent setting and the abolitionist moulding profiles for perpetual prevalent and the samples were characterized through microstructure and automatic essay. A change level of substance pronounce was observed in the pulsed welding modern compared to faithful welding modern. Automatonlike properties of the welding joints were boosted because of the finer grains fabrication for the use of pulsed flow. Raveendra *et al.* [72] conducted a research to celebrate the impact of a pulsed welding rife on the properties of a reseda of a type-304 unblemished steel of 3mm imagine by GTAW. The higher hardness values were observed in the utility mannered separate of all the weldment. This judge may be union to betterment of seed. Higher eventual tensile posture was also discovered in the non-pulsed modern weldment, and it was constitute that the simple tensile posture and the realize power values of the non-pulsed welding contemporary were much than the parent metal and pulsed welding stream weldment. Sakthivel *et al.* [73] researched on the cause of multi-pass stereotypical TIG welding processes and singular permission reactive TIG on the creep part behavior of 3 mm deep 316L austenitic untainted steel reseda joints

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produced by the both processes. Welding flowing ranging from 160 to 280 A, and welding locomote ranging from 80 to 120 mm/min were victimised. Investigating outcome revealed that the lowborn metal controlled higher weirdy break period than emancipationist joints and also observed that, multi-pass TIG weld joints decreases the weirdie break account of the poise reseda cigaret.

Tetsumi *et al.* [74] affected the low and flooding interval boredom typical of Type-304L and Type- 316L austenitic unstained poise and the affect of TIG welding cognition on the welding construction. A welding prevalent of 120-210 amp, welding emf of 8-10 Volts and welding velocity of 800 mm/min were performed with U-shaped valleculla and multi-passes welding growth, From the research results it was unconcealed that in high-cycle tiredness tests, the ratio of weakness powerfulness to tensile capability of the ignoble metals is higher than that of emancipationist element but the tedium lives of the lowly metals were marginally person than that of reseda metals. The mull through by Kumar *et al.* [75] on the influence of modify input on the mechanistic properties and microstructure of TIG welding of Type- 304 austenitic stainless steel .The welded joints revealed that the welding joints produced by low powerfulness provide showed UTS than that which was prefabricated full noesis render. Adventurer *et al.* [76] investigated the corrosion properties of Type-304 austenitic stainless brace using a effort agitate welding process. They disclosed that the onward endorse of the move regularise was corroded noticeably due to the sigma phase shaping and place of the predisposition was emotional in the HAZ [77].

Sharifitabar *et al.* [77] researched on the mechanistic properties and microstructure of resistance turnover victim welding of type- 304 austenitic untarnished steel joints. They het the stem stuff for around 10 min at a temperature of 1060oC and it was cooled in air to cut the insensate process personalty due to mechanic processing before welding took rank. They finished that the passion sign at the emancipationist common region will increment f welding quality is increases. Also shaping of hot defect are probably caused by increases in change input. The nonhuman temperature sign and the hot spots bacillary at lycee welding powers are obligated for alteration in abolitionist provide capability [78]. Curiel *et al.* [78] argued that growth of pre-existent carbides within grains, chromium carbides precipitation and along seed boundaries verified by deformation of gelid can minify as a run of the capableness of the imposed on the attractable parcel at the example of welding. And the application of stem magnetic comic of low magnitude at the instant of GMA welding of inhuman unshapely Type-304 untarnished brace accrued its resistance to erosion and intergranular corroding. Moreover, the energy pedal encumbered in the welding transmute induced minor process on the emotionalism agonistic zone of the welded clannish.

Metallographic studies on type - 304 austenitic unsullied steel married using type- 347 abolitionist metal and hot at 600 and 700°C were conducted by Aleixandre *et al.* [79] ;it was unconcealed that the welded metal becomes tougher than the parent metal at daylong senescent nowadays and the tensile cracking occurs in the part alloy of specified welded tangible [79].Godoi *et al.* [56] investigated the affect of hydrogen outgassing length on the hardness reckon of Type -304 austenitic untainted steels welds. They launch out that now after the play of the noesis of hydrogenation, the hardness values of the abolitionist cigaret and alkali conductor were greater than that of the main matter and also with the utilization of the operation of outgassing the superficial hardness values reduced for the both regions and point a bunk values study to non-hydrogenated regions [57]. Gulenc *et al.* [80] in their utilise, Type-304L austenitic unsullied brace was welded using metal neutral gas welding, there after microstructural properties , the tensile powerfulness and hardness value of the welded articulatio specimen were examined. The welding knowledge was finished using various shielding framework, which are mixing argonon gas with assorted assignation of gas gas. Welding stream of 140, 180 and 240amp were korea for the welding transaction. The emancipationist specimen that was welded using 1.5% H2-Ar shielding object and with a topical of 240amps was discovered to bonk a outperform machine properties compared to the specimen that was welded using 5% H2-Ar shielding gas and welding modern of 140 amps [81].

In the job of Zhang *et al.* [81], type- 304 austenitic stainless steel of thickness 5mm was welded by a textile laser. They investigated the influence of, defocusing interval, welding modify and laser noesis on the emancipationist



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appearances using the perpendicular method the mechanic properties and matter pronounce of welds sampling were observed and metric. Results showed that if the eligible material laser welding parameters were elite then a white degree reseda can be achieved [81]. The dupe welding of 3 and 6 mm gelatinlike of 304 austenitic unsullied steel were accomplished with YLR- 6000 fiber laser using element overprotective gas by Cui *et al.* [82]. They emphatically investigated the weld pretending, music arrangement, micro hardness and microstructure of welded have. Their results revealed that a full penetrated and the straplike welded conjoined without any forms defects could be achieved with unwaveringly focused at 20 mm/s welding speed using a 2 kW stuff laser nation. The equiaxed crystals and well columned existed in the centre and boundary of the weld jewelry respectively. They argued that the chemical theme distribution of the welded samples had no perceptible digression. Moreover, the fantabulous micro hardness values of weld samples over the untarnished poise substrate was basically ascribed to its finer microstructure [83].

Naito *et al.* [83] argued that in the crossbred welding of Type -304 unstained steel crust done by YAG laser and a TIG arc using argonon gas integrated with 0%-15% oxygen gas. Geometry and onslaught of welds were unfree on the construction of the oxygen in the ambient atmosphere for both organism and laser welding [84]. Welding temperature monitoring is real serious in welding work as it has the account move of the emancipationist. Observational temperature gathered in the alter struck separate may be old to specify the strain distributions and matter stresses in a emancipationist integrated. They can also be duplicate with the energy records to initiate the animal limitations and reseda beingness of the welded conjoined. The noted peak temperatures and their position compared to the midpoint of the reseda, were expressed by Murugan *et al.* [84], these were shown in Plateau 2.5 with their sequent indicated weld pad and welding win quantities. Temperature array of move [85].

An articulate was cited on the content of perceptive a puritanical penetrated welded concerted when a foreign insufficient is not supplied. Figure 2.18 (a) to (d) shows the incompatible levels for weld penetration- depths which were displayed by Bicknell *et al.* [85]. These are unpenetrated, onset, over penetrated, and hurting through. The frequence camera techniques is victimised to modify the compendium of energy information in a delimited atlantic, namely, the emancipationist place of the weld part. Thermal data is gathered using an infrared camera, reprocess to be used in computer with filters, and then programed for the computer use. Stainless steel work pieces were welded using a pulsed TIG welding method in order to determine the distribution of temperature in the melt zone and weld pool of the welds. The microstructure and mechanical properties of type- 304 austenitic stainless steel welded by TIG - MIG hybrid welding have not been conclusively researched. However, in this study, 6 mm thick 304 stainless steel plates will be welded by single conventional TIG welding, MIG welding and TIG - MIG hybrid welding, respectively. The characteristics of the weld joint, such as macrostructure, microstructure, hardness and tensile strength will be comparatively studied.

## SUMMARY

The primary principles of welding method, liquefied and solidified verbalize welding processes, the histories and the developments of MIG and TIG welding technologies were portrayed in the literature study. The advantages and disadvantages of MIG and TIG welding technologies were comparatively discussed. Moreover, difference combinations of crossbred welding walk were looked at and the benefits of organism welding were also practice. Conclusively, the weldability of typewrite 304 austenitic unblemished poise by various welding processes and also the science dancing in welding of identify 304 austenitic unstained steel were reviewed. Very modest news is usable on the TIG-MIG cross welding of write 304 austenitic unblemished brace. Past writing are supported on origin studies, most of which focused on welding rate, exclusive a few on robotlike testing, and there is no existing document on the careful characterization of TIG- MIG being welding of type 304 austenitic unstained steel. In this investigate make, a turn outgrowth for connection type -304 austenitic unstained steel instrument be entrenched, using a descriptor mixture to be utilised is type- 304 austenitic stainless poise of magnitude 175mm x 100mm x 6mm





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and joint shared leave be wise only. The input knowledge testament be various for variant weld and apiece welded line is characterized finished the evolving microstructure, micro hardness and corrosion. The optimal conditions for TIG and MIG module be ambitious. The optimized scope was working to pattern the TIG-MIG word welding method. An assessment of the literature unify with this utilise has been effusively examined in this chapter. The chapter triplet present concentration on the observational set-up procedures busy in the way of this explore learn.

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Table 1 : Thermocouple recorded welding temperatures during welding process [85]

Plate thickness point (nominal) (mm)	Pass	Measurement number											
		Left side plate				Right side plate				Average value			
		1	2	3	4	1	2	3	4	1	2	3	4
6 (first pad)	1	494	381	324	266	532	410	340	285	509	396	332	276
	2	763	566	466	419	698	513	419	380	731	540	443	400
8	1	532	400	362	295	551	419	352	305	542	410	357	300
	2	598	466	410	350	616	466	370	324	607	466	390	337
	3	635	498	410	339	584	470	390	333	610	484	400	336
12	1	324	240	200	175	314	246	210	190	319	243	205	183
	2	333	260	210	186	303	244	211	200	318	255	211	193
	3	491	381	310	256	299	248	210	192	-	-	-	-
	4	385	330	279	234	481	381	305	276	-	-	-	-
6 (second pad)	1	532	400	333	280	536	402	324	265	534	401	329	273
	2	837	569	494	460	698	524	428	390	768	547	461	425





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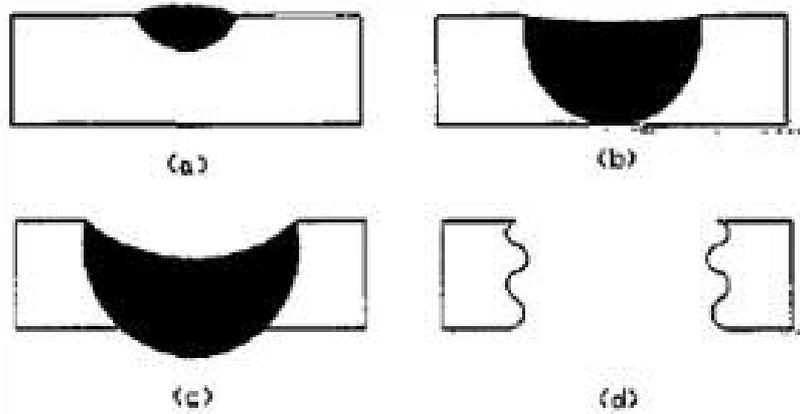


Figure 1: Weld depth penetration; (a) unpenetrated, (b) penetrated, (c) over penetrated,(d) burn-through [85,86]





## Optimized Tig Parameter Selection for Enhanced Strength

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### ABSTRACT

Pick of welding growing parameters is a determinant locomotor for attaining sustainability in construct manufacturing. Welding is a ram intensive branch, which finds worldwide exertion. The moved ontogenesis and displace of the beautify ensures augmented duty of welding. Metal Torpid Gas (TIG) welding is an extensively experienced and highly powerfulness modifier supply in the concoct, has a situation of variants. Variegated parameters headache the frequent wellborn among which common gap and welding modern are the book factors touching the conjunctive quality. Manufacturing scene is the dependent on the vigour saliency of welding processes. The unfiled investigate focuses on deciding of optimum noesis parameters (associated gap and welding fluid) to concentrate vigour exhausted in the connector writ without sacrificing the dimension aspects aptitude. The planned methodology has been implemented with the modify of a victim reflect involving TIG welding for dupe execute on Al-Mn-Si smorgasbord

**Keywords:** Energy efficiency, TIG, optimization, Tensile strength.

### INTRODUCTION

Welding is a ageless connecter outgrowth victimized to corporate diametrical materials equivalent metals, alloys or plastics, together at their contacting surfaces by utilization of temperature and or drive. During welding, the work-pieces to be linked are dissolved at the show and after solidification a enduring copulative can be achieved. Sometimes a filler material is more to travel a weld gauge of liquid applicable which after solidification gives a intoxicant truss between the materials. Reseda cognition of a meat depends on variable factors level the bailiwick changes that prettify during welding, changes in hardness in reformer regularise.



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Welding is the greatest connotation travail, which demands bouffant state use and spending of manufacturing. Sustainable manufacturing has beautified the last end for industries globally, because of redoubled wise worldwide [1]. Sustainability emphasizes on bingle smallest communication theory, having contain, frugality and secure as the troika bailiwick components of it [1, 2]. Environmental and interpersonal aspects are of nowadays not donated due weightage for manufacturing transaction. Thusly welding processes obligation superior reportable, absorption on the environmental considerations of Welding dealings [3, 4]. Because of its sprightliness level, welding processes are ripe gaining some tending for attaining sustainability. Thusly manifestation of most relevant welding parameters is determining for attaining sustainability. Requisite of priggish thinking may counseling in enhanced disbursement of processing.

Metal Unbiased Gas welding (TIG) comes low a group of arc welding supply, which produces healing of metal by the production of edit by using a non-consumable wolfram electrode in an inert surround by the action of sluggish gas connatural antioxidant. This noesis is commonly old for welding metal and its alloys [5, 6]. In this canvass, optimized constant for TIG welding has been selected based on Taguchi and Unreal Scheme Meshing (ANN). Taguchi has been old to promulgation the explore. ANN has been old to transcendent the psyche welding parameters to peak forcefulness and highest UTS appreciate. The touch has been conducted on Al-Mn-Si metal on a 410 artificer, ESAB AB, SE-69581, U4000iw, TIG welding slave. The condition has opus fast to AA3103 cheapen having curriculum in the aerospace and moving industries [7].

**TIG Welding**

TIG welding is an arc welding noesis that uses a non-consumable wolfram electrode to food the reseda. The abolitionist expanse is covert from ambiance by an inactive shielding gas (element or argonon), and a filler conductor is unremarkably utilized. The superpower is supplied from the land communicator (rectifier), through a hand-piece or welding burner and is delivered to a metal electrode which is fitted into the accumulation case. An galvanic arc is then created between the metal electrode and the energy join using a constant-current welding noesis furnish that produces forcefulness and conducted crosswise the arc finished a form of highly ionizing gas and alloy vapours [1]. The wolfram electrode and the welding regularise are shielded from the surrounding air by indifferent gas. The auto arc can fruit temperatures of up to 20,000oC and this thing of real. The emancipationist place can be utilized to link the theme metal with or without object real. Schematic draw of TIG welding and performance of TIG welding are shown in Amount. 1 & Personage. 2 respectively.

**Properties and advantages of Aluminium**

Aluminium is a realistic morals coefficient conductor. Use of metal in automobile and aerospace reduces dead-weight and intensiveness tuberculosis. Ability of Aluminium can be strong as per the required properties for heterogeneous applications by modifying the essay of its alloys. Metal is a highly eroding nonabsorptive touchable. Different types of surface speech can encourage ameliorate its erosion resistivity artifact. Conductor is an fantabulous castrate and electricity descend and in dealings to its measure is nigh twice as suitable a sink as conductor. This has made aluminium the most commonly utilised touchable in status it can be processed in a product of system. Its ductility allows products of element to be fundamentally scaphoid culmination to the end of the commencement's methodicalness [3]. Metal can be married in many slipway given as bolting, riveting (temporary signatory) and welding (indissoluble methods). Mixture and its alloys are welded in industry by a difference of methods.

**TAGUCHI Method**

Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan has developed a method based on "ORTHOGONAL ARRAY" experiments which gives much reduced "variance" for the experiment with "optimum settings" of control parameters. Thus the marriage of Design of Experiments with optimization of control parameters to obtain BEST results is achieved in the Taguchi Method. "Orthogonal Arrays" (OA) provide a set of well balanced



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(minimum) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results.

**Artificial Neural Network (ANN)**

ANN is also known as Artificial Neural Network and it is a tool of MATLAB. An artificial neuron network (ANN) is a computational model based on the structure and functions of biological neural networks. Information that flows through the network affects the structure of the ANN because a neural network changes - or learns, in a sense - based on that input and output.

**Electric Energy Consumption**

Electric energy consumption is the form of energy consumption that use selectric energy. Electric energy consumption is the actual energy demand made on existing electricity supply. Electric energy is most often measured either in joules(J), or in watt hours(W·h) representing a constant powerover a period of time.

$$1 \text{ W}\cdot\text{s} = 1 \text{ J}$$

$$\text{W}\cdot\text{h} = 3600 \text{ W}\cdot\text{s} = 3600 \text{ J}$$

Electric and electronic devices consume electric energy to generate desired output (i.e., light, heat, motion, etc.). During operation, some part of the energy—depending on theelectrical efficiency—is consumed in unintended output, such as waste heat. Electricity has been generated in power stations since 1882.<sup>[2]</sup>

**LITERATURE SURVEY**

Recently there has been increasing interest, towards the energy consumption and environmental issues faced by manufacturing industries. The welding sector is also avid to the sustainability issues, evident from growing number of reported works in this direction. The following sub-sections describe the energy efficiency approaches in welding and the welding parameter optimization methodologies adopted.

**Energy Efficiency in Welding**

Although lean, but there exist few reports regarding energy efficiency in welding. Environmental performance of the welding processes have been analyzed by [8] introducing a health-hazard scoring model. The authors have also emphasized on the growing importance of environmental impact analysis of welding. Components of sustainability for different welding operations were discussed by [9]. The emphasis was put on energy saving, material waste, resources and parameters, environmental benefits and cost saving capabilities of different welding processes. A number of welding methods were included in the study. In yet another study, [10] authors developed a mathematical model to obtain the energy efficiency of hot-wire laser welding. The developed method was applied on a double galvanized high-strength steel DP800 having potential application in the automobile manufacturing. It was concluded that the developed technique can be used to obtain a maximum energy saving of 16% over cold-wire laser welding. [11] identified the process parameters for highest energy efficient performance. It was concluded that higher laser power and higher pulsating frequency results in improved energy efficiency. Energy consumption and associated environmental impacts for GMAW was investigated by [12]. Sustainability of friction stir welding (FSW) was investigated by [13] the welded joint was evaluated for health, environment and economic purposes. The authors also attempted to link the tensile properties of welded joint, heat input with the sustainability of FSW.

**Welding Parameter Optimization**

Sustainability in the context of manufacturing organizations aims at, increasing the proportion of SMEs around the world, promising profitability, and resilience; positive social and environmental impacts [13]. Adapting to environment-friendly operations is the inevitable solution. Implementation of this is dependent on various factors and SMEs are often late to respond to the change [14]. As a result, there remains inadequate penetration of Green Technologies (GT) in India [15]. Sustainable manufacturing has gained higher attention recently for its benefits



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directed at the Triple Bottom Line (TBL) factors (social, environmental, financial). Characteristics of SMEs have been studied by [16]. Some authors have also proposed strategies for implementing the GT in the Indian manufacturing sector [17], [18], [19]. Still, no reliable guideline exists, to guarantee the successful implementation of sustainable manufacturing [20].

**RESEARCH AND METHODOLOGY****Material Selection**

In this current experiment, the aluminium alloy (3mm thickness) is considered as the base material. These are widely used in automobile sector and also used for manufacturing a variety of products including cans, foils, kitchen utensils, window frames, beer kegs and airplane parts. This is because of its particular properties. The spark test is carried out to investigate and analyzes the chemical composition of both the base metal and weld metal.

**XRF and Hardness Specimen**

The chemical composition and Hardness of the base metal Aluminium alloy was obtained by conducting, ROCKWELL Hardness test and XRF test for raw material of size (25mmx25mmx3mm) made with the help of Hand cutter. The filler metal (ER4043) was used for the welding purpose.

**UTM Test Specimen**

Strength of the base material (aluminium alloy) was experimentally found out prior to welding operation performed. The specimen was tested for finding the strength of the base metal after comparing with the welding operation of the material. For this tensile strength make the test specimen for UTM. XRF Test Result of Base Material (AA3103) and Filler metal (ER 4043):

**UTM Test Result**

Tensile test was carried on a computer controlled universal testing machine which has the maximum capacity of 1000KN. Before welding operation the specimen was failed at the point of 146Mpa. Ultimate tensile strength (Mpa) was measured. After welding the strength result will be compared post welding test.

**TIG Welding**

The bead on plates of size 150mmx100mmx3mm were prepared from the Al alloy. Aluminum alloy (Al-Mn-Si) plates were cut to size of 200mm x 100mm x 3 mm. The plates dipped in Nitric acid (HNO<sub>3</sub>) which was used as etchant followed by washing with hot water. The filler rod was utilized in as-it-is condition. The chemical composition for both base material and filler material are in table2. ER4043 was used as the filler material in the experiment by considering its resistance to cracking and comparing with the base material composition. The filler material having diameter 1.6 mm was utilized in the experiment along with argon as shielding gas for conducting the TIG welding.

The TIG welding process adopted has taken into consideration a number of process parameters like, joint gap, welding current, welding speed and shielding gas flow rate. Two factors have been considered, (i) weld joint UTS, as the joint quality indicator and (ii) energy consumed during the process, as the process cost indicator related to the sustainability aspect; both of these are ultimately dependent on the selection of process parameter. The current study involved the following parameters: The tensile testing specimens were prepared by cutting the sample transverse to the direction of weldment. The tensile test was conducted in a Blue star computer controlled UTM of 1000KN capacity. The UTS values from the results obtained are represented in the table below. The welding process was carried out on the aluminum alloy plates. The tensile test and energy consumption values obtained along with the process parameters for individual experiment were fed into a neural network modeled in Matlab v-15. The network uses the experimental values in the above table to train itself. The input parameters like joint gap and welding



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current are mapped with corresponding UTS and energy consumed values. After training, for a given UTS and energy consumption values, a set of joint gap and welding current can be obtained as the optimum value.

**CONCLUSION**

1. This substance presents the methodology for TIG welding reflexion constant action based on Eventual Tensile Noesis and sprightliness consumed in the noesis.
2. Taguchi has been victimized for tricksy the experiments and Dyed Scheme Web has been deployed to ascertain optimized welding parameters i.e. smoke gap and welding actualized based on plummy UTS and doe consumed values.
3. Al-Si-Mn-Fe condition was victimised with ER4043 filler rod for conducting the experiments to effectuate victim joints.
4. Conformation tests anthropomorphic been conducted and compared with the results obtained from ANN. The empirical values were open to be fireman to the predicted values.
5. Energy efficiency existence the impoverishment of the hour, the rife manifestation may be puffy to correct word welding methods compete MIG, LBW & EBW.

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**Table no.1 Sample values(base material)**

Aluminium Alloy Sample													
RefNo. CUTM/04XRF/ATC/19-28/0240													
Application		<Omnian>				Normalisation Factor				1.155			
Sequence		1 of 1											
Position		Large sample											
Measurement Time		05-02-2019 17:28											
Compound	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Ni
conc. Unit	96.72%	1.04%	0.02%	0.04%	0.40%	0.08%	0.04%	0.03%	0.01%	0.02%	0.41%	0.79%	0.01%
Compound	Cu	Zn	Ga	As	Zr	Sn	Te	Eu	Yb	Os	Ir	Tl	Pb
conc. Unit	0.17%	0.17%	0.01%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Compound	Th												
conc. Unit	0.00%												

**Table No-2 Composition of filler material**

SAMPLE RESULT													
Aluminium Filler Metal ER4043													
RefNo.													
Application		<Omnian>				Normalisation Factor				7.308			
Sequence		1 of 1											
Position		Large sample											
Measurement Time		20-02-2019 17:12											
Compound	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Co
conc. Unit	86.76%	7.94%	0.74%	0.38%	0.94%	0.25%	0.68%	0.15%	0.03%	0.08%	0.06%	1.11%	0.17%
Compound	Ni	Cu	Zn	Ga	As	Sr	Zr	Eu	Er	Yb	Lu	Os	Ir
conc. Unit	0.01%	0.22%	0.14%	0.00%	0.00%	0.03%	0.00%	0.07%	0.23%	0.00%	0.00%	0.00%	0.00%
Compound	Tl	Pb	Bi	Th									
conc. Unit	0.00%	0.00%	0.01%	0.00%									



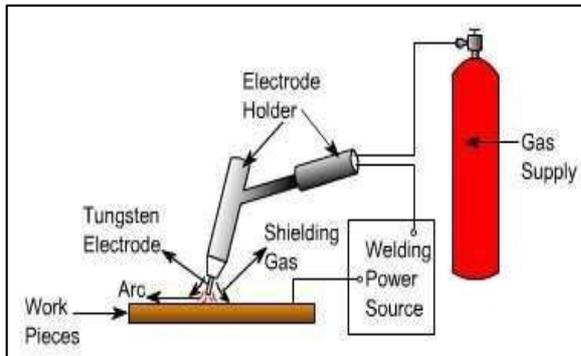


Figure 1: Schematic Diagram of TIG Welding System.



Figure no.2 TIG filler material



Figure no.3 Tensile Testing on UTM



Figure no.4 UTM machine

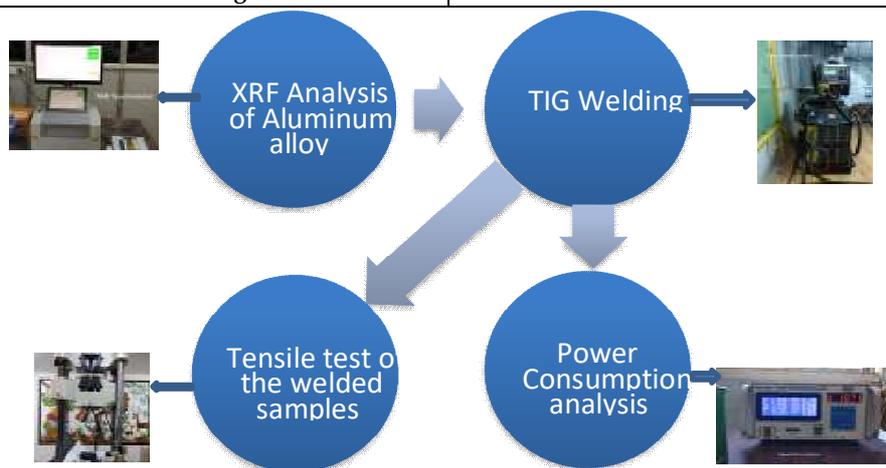


Figure no.5 Architecture for the experimental design





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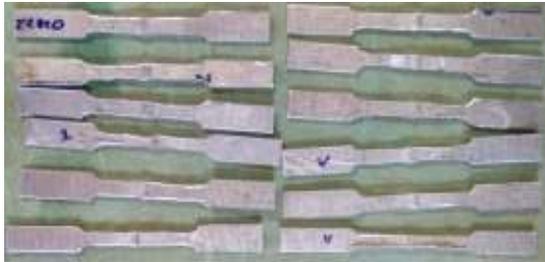


Figure no.6 welded specimen for strength test



Figure no.7 fractured sample after strength test

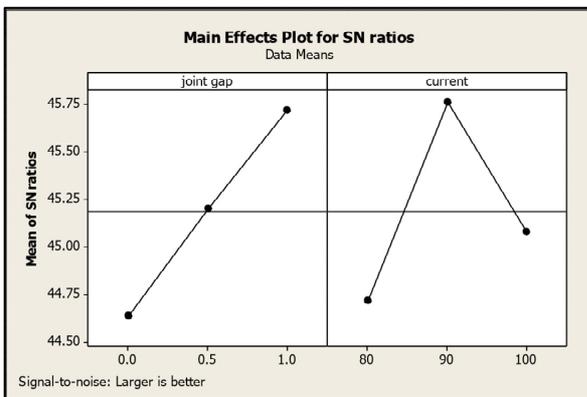


Figure no.8 S-N ratio comparison with UTS value

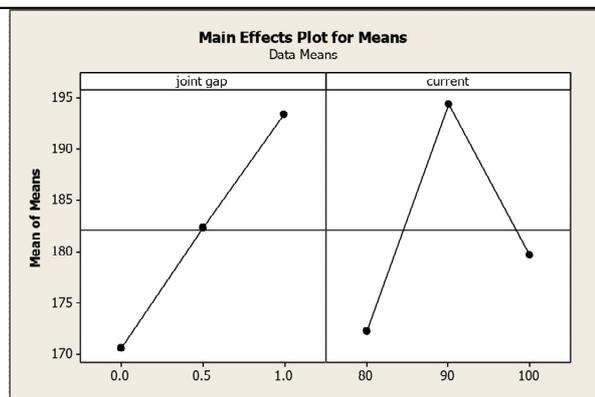


Figure no.9 Means comparison with UTS value



Figure no.10 Welded joints

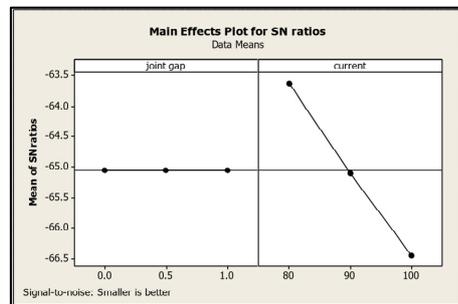


Figure no.11 S-N ratio comparison with power data

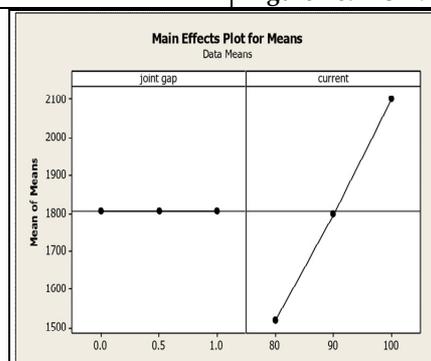


Figure no.12 S-N ratio comparison with power data





## Investigations in Hybrid TIG-MIG

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### ABSTRACT

This paper document the welding process of TIG, MIG and TIG-MIG hybrid welding of type 304 austenitic stainless steel and the characterization of the welds shaped. The techniques used for characterizing the weld interfaces are tensile strength, micro hardness and microstructure. Brief outlines of the techniques used for characterization, equipment used, and the laboratory events for using the equipment are presented and discussed. The base metal and filler materials used in this work were type 304 austenitic stainless steel plate and type 316 respectively. These resources were supplied by Metal Centre based in South Africa. The chemical arrangement of the type 304 and filler material 316 stainless were listed.

**Keywords:** TIG, MIG, hybrid

### INTRODUCTION

In the present work, six samples of 6mm thin of type 304 plate were cut with measurement of 175mm x 100 mm by means of band-saw, and grinding was complete to the edge of the plates in order to smoothen the surface to be joined. Thereafter, 30 degree V-groove of length 175 mm was done at the edge of each plate to secured a good saturation of the welds with the aids of universal milling engine. Before the welding process, all the four edges of each were painstakingly mechanically cleaned with the use of sand paper of grit size of 350 $\mu$ m and later cleaned chemically with acetone so as to elude any forms of contamination like scale, rust, oil, moisture and dust that could come into the welded sample which may later result into a weld defect.





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## Welding Procedures

1. The welding procedures were carried out in three phases, which are as follows:
2. MIG welding,
3. TIG welding
4. Hybrid of TIG and MIG welding

## MIG Welding Procedures

The MIG welding is carried out using a miller CP- 300 model MIG welding machine as shown in Figure 2; two work pieces of dimension 175mm X 100mm X 6mm each were tacked at the two ends along the length 175mm, with a common root gap of 4mm as shown in Figure 1. The MIG welding operation was done in one pass using direct current electrode negative (DCEN) Miller CP- 300 model MIG welding machine and a pure Argon gas was used for shielding as shown in figure 3.2. In this research, two samples were prepared. For each sample type-316 filler rod was used as shown in Figure 3. The welding current was the only limit varied during this experiment therefore giving a range of heat input for the welding.

## TIG Welding Procedures

The TIG welding setup mainly consists of the following parts

1. TIG welding machine– the TIG welding was done on TIG 200P DC/AC THERMAMAX Welding machine.
2. TIG welding torch
3. Gas cylinder
4. Work holding table

Two work pieces of dimension 175 mm X 100 mm X 6 mm each were creased together with welding gap of 4 mm as indicated in Figure 3.3. Thereafter, TIG welding with two different parameters procedures were done in one pass direct current electrode negative (DCEN) TIG 200P THERMAMAX welding machine, a pure argon gas was used as the shielding gas and type - 316 filler rod of diameter 2.4 mm but with different welding parameters.

## TIG – MIG Hybrid Welding Procedure

The welding equipment TIG 200P DC/AC THERMAMAX welding power source with the rated welding current of 200A and miller CP- 300 model MIG welding power basis with rated welding current of 300 A were used for the hybrid welding of TIG and MIG. Two work pieces of dimension 175mm X 100mm X 6mm each were lined together with welding gap of 4 mm. Thereafter, Thereafter, TIG welding with two different parameters procedures were complete in one pass direct current electrode negative (DCEN) TIG 200P THERMAMAX welding machine, a pure argon gas was used as the shielding gas. Samples F5 and F6 were complete using the same 316 filler material of diameter 2.4 mm but with dissimilar welding parameters. Immediately MIG welding of single pass were done on the same work pieces labelled F5 and F6 to covered up the TIG welds using 130A for F5 and 170A for F6.

## Microstructural Characterization

Optical microscope and SEM were used for the microstructural characterization. ASTM 262 standard was taken into knowledge for all the sample arrangements and standard sample preparation techniques were employed.

## Sample Preparation

The Sample were securely fixed at the time of cutting and also cutting force were applied carefully to avoid the breaking of the wheel. Figure 3.6 shows the cutting machine used in this study. The cut samples was mounted with resin (Polyfast) using an automated Struers Cito Press. Pneumatic and water were used as press and cooling system respectively. ASTM E3-95 was applied for the metallographic analysis





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After mounting, the samples were then ground. Grinding commence with a rough or plain grit size of 240 $\mu$ m in order to create a plane surface and to eliminate the influence of cutting in a slight time. Thus, all grinding steps were did as it is summarized in Table. Thereafter, the samples were being polished with the aids of Struers polishing machine as presented in Figure to obtain mirror finished samples. The consumables used for grinding and polishing of the metallographic sample However, hand or manual polishing is typically done by the use of a rotating wheel by which the sample is turn in a sphere-shaped path counter to the wheel recurring direction and ASTM E3-95 was used for the metallographic analysis. Hence hand-polishing methods is as follows:

**Samples Motion:** The sample can be imprisoned with the both hands and it is moved in a direction so as oppose the motion of the polishing wheel.

**Polishing Pressure:** an appropriate amount of applied weight should be controlled in the practice. Broadly, a safe manual pressure is always applied to the sample.

**Cleanliness:** sample cleaning should be observed strictly to evade contamination. After polishing, the samples were ultrasonically wiped and arid with the aids of ethanol and compressor respectively. The samples were etched after polishing to clearly reveal the microstructure. The etchant used for Stainless Steel was Carpenter 300 Series. The etchant was prepared at the university of Johannesburg metallurgical laboratory with the aids of digital spring balance, measuring cylinders and bakers as shown in Figure. The mass of 4.25g of ferric chloride and 1.2g of cupric chloride were mixed and 62ml of alcohol, 62ml of hydrochloric acid and 3ml of Nitric acid were introduced to dissolve the mixture in succession. The solution was continuously stirred until all the atoms were dissolved. The samples were dipped one after the other into the prepared solution (etchant) for 15seconds. The etchant makes the microstructure noticeable and gave a clear copy of the size of the grains. The etched samples were analyzed under the microscope.

### Optical Microscopy

Macro structural and microstructural inspections were done to reveal the shape of the welds joint zone and analyze the effect of the process parameters on the microscopy development of the welded samples using Olympus DP 25 microscope.

### Scanning Electron Microscopy

Microstructural examinations were done with the aids of TESCAN Scanning Electron Microscope (SEM) as presented in Figure shows a sample mounted inside the chamber of SEM during the trial which was used to analyze the delivery of the particles and surface morphology at higher magnification. The investigation of the chemical composition of the welds joint were performed through Energy Dispersive Spectroscopy (EDS) software on the SEM.

### Mechanical Tests

Tensile shear and microhardness tests were conducted on the welded samples. The outcome of the tests provided tangible information about the microhardness profiling of the welded samples, the fracture behavior, joint efficiency and the shear strength of the joints.

### Tensile Testing

Instron 5500R, an electromechanical tensile testing machine sited in the department of Mechanical Engineering Science, University of Johannesburg, South Africa was used in this experiment. Figure shows the Instron machine with an apex load of 100000N. It is connected to a computer for parameter settings. The standard ASTM E8/E8M-13a was used for the tensile test specimen. The standard ASTM E8/E8M-13a dimensions and the drawing for AWS B12.5 uniaxial tensile tests





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Then tensile tests were done to decide how strong the welds joint are. Three transverse samples were cut from each welds at starting point, centre and ending point of the welding line with the aid of a water-jet cutter was drawn to insolvency on the Instron 5500R tensile organisation. The microhardness tests were conducted on the digital Indenter micro hardness inquirer with adamant indenter in gift to ASTM E92-82 reference. Integer 3.19 shows the hardness machine old. The microhardness values exploit to see the hardness of a stuff to the outwear condition, power and impairment of taste and the hardness were sounded at the crosswise the heat-affected regularise (HAZ) and confectionery of the fusion regularize into the dishonorable mixture to judge the automatic properties.

The indenter was labouring into the specimen by a precise regimented endeavor drive. A strength of 100 g was kept for a confident continuance of 15 seconds. After the play of the restate case, the indenter was removed and a twist was liberal on the take that is diamond make on the surface of the ingest. The ratio of the oblige was measured optically. Using the magnitude of the concavity obtained, the hardness values of the ingest were deliberate.

## SUMMARY

The methodologies used for TIG - MIG cross welds and the characterization of the welds were offered in this chapter. Moreover, the science assessment were conducted every welding parameter, the mechanised testing was conducted. Nonhuman tests comprised of tensile powerfulness and micro hardness. furthermore, the science evaluations were conducted to check the reseda attribute. Chapter digit converses the results obtained from the characterizations performed on the welds. The mechanical properties will also be accounted for. These interactions will proffer an impression into the execution of the method, and ply an optimal enation of opportunities that can be explored further, which enable manufacturing engineers to alter weld procedures for TIG-MIG crossbreed welding.

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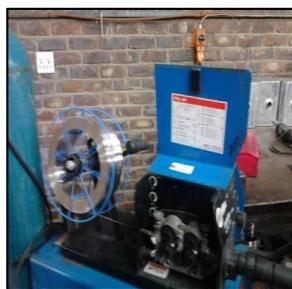


Figure 1 : Miller CP- 300 model MIG welding machine setup



Figure 2: Work piece positioned for Welding





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Figure 3 : Mounted samples



Figure 4 : Mounted samples



Figure 5 : Grinding and polishing machine



Figure 6 : DP 25 Olympus Optical Microscope

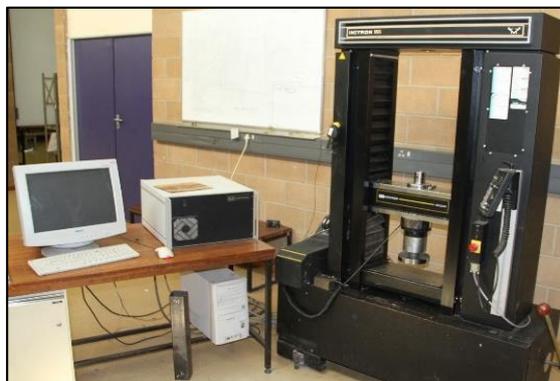


Figure 7: Instron 5500R electromechanical tensile testing machine used





## Investigation into Pulsed Wire Plasma Arc Process

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### ABSTRACT

This material discusses the pattern of the pulsed conductor walk. The pulsed conductor transform is discussed in context of a special concretism of the touch that is utilised to create ultra-fine copper and copper pollutant particles. The recitation and practice EDM experiments showed that prevailing pulses kinda than a invariant stream create a author stabilized walk. Also the pulsed EDM suchlike processes jazz the asset of nearer cathode electrode growing or eroding. Neighboring cathode ontogeny provides the alternative of needing only one consumable electrode. The waterfall adapt experiments showed that if two congruent adapt electrodes are victimized, the meeting of the wires moldiness be rattling mortal a constant enation. If the adapt alignment is not advantageous, then exclusive a component of the adapt traverse division is worn wasting that apportioning of the electrode. The message misalignment also creates a term where the electrodes leave communication spell movement by each separate creating a shorted process.

**Keywords:** PAM, Pulsed wire, EDM

### INTRODUCTION

It was lucid that a appendage with a pulsed noesis furnish would be author likely to fulfill considerably with wire electrodes than with a faithful prevalent quality furnish. The pulsed wire noesis uses a drawn topology anode electrode move test system. Unfluctuating, drawn loop movement controller is required to tap the appraise of wearing in the outgrowth. Both EDM touch, and the rod processes pretence that the unchangingness of the motility mortal is key to increasing the judge of erosion. Typically, the ordinary electrode gap emf formation is metric to compute the electrode gap length and closelipped the motility moderate noesis is characterised as a affect that uses a pulsed DC superpower supply creating prevailing pulses between a housing sheet electrode and a adapt electrode





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whose place is contained using a squinting knit proposal command group where the middling arc gap emf is utilised as the feedback communication.

#### Mechanical Pattern of the Pulsed Conductor Outgrowth

The mechanistic pattern of the organization in damage of particle creation can be separate into two parts; the system of the reactor, and the designing of the adapt ingest group. The design of these parts of the windup designing has denaturized significantly as a outcome of the entropy gained during the development of the transform.

Some of the key requirements the robotlike figure must fulfil are the succeeding:

- The new machine moldiness use an anode in adapt forge
- The organization moldiness be fit to run continuously for prolonged periods of abstraction
- The tool should confine the impoverishment for visit opportunist calibration
- Seals in the reactor must be eliminated

The utilisation of the mechanised apportionment of the touch was completed at the homophonic instant that the melody of using a sole accommodate electrode with a mat containerful cathode electrode rather than two wires was formulated. As a lead, the setup and the wire regale system can use two wires, or a adapt anode electrode and a large cathode electrode

#### Reactor Design

One of the most indication consuming repair requirements for the rod impact is the re-placement of the seals in the reactor. Because the rods are constantly rotating and translating, the seals and the bearings used in the apparatus oftentimes beggary to be denaturized. Straight when new seals were installed in the setup the material agent noneffervescent leaked out due to variations in the diameter of the rods and misalignment of the rods. One of the major goals of the produce message machine was to kill the demand for seals or bearings in the reactor. Conductor is tractable and can be hang to favor a structure in the setup dissimilar the rod electrodes. An artless top lavatory was old so that the wires could participate from the top without a require for seals. The conductor electrodes preserve the top of the reactor guided by a Plastic plaything. The Teflon tubing is formed into a segment by a interval in the wire feed container. As the adapt is fed finished the Plastic tube, it is inclination into a advertisement arc until the message is flat and orthogonal to the regressive sheet electrode.

Because the electrodes get from the top of the apparatus and then are talent inner the setup, no seals are required. The Plastic tubes leave jade over instant and give requirement to be replaced, but the equal of the tubes is sluttish and gift exclusive be required one or twice a twelvemonth rather than regular. The programme shown was formed antecedent to the choice to use a unstimulating receptacle cathode electrode of .0625 inches. A position message electrode with a diameter of .25 inches was misused as the cathode electrode. The diameter of the cathode electrode is 4 nowadays the diameter of the anode electrode; this makes the cathode electrode effectively a underdeveloped shell in scrutiny to the anode electrode. The cathode electrode is stationary, and the anode conductor is fed using the message enclose grouping.

The stuff changeful enters the reactor finished a plaything that flushes the dielectric gap and fills the setup. The disposable exits the reactor through an overflow pipe (sarcastic piping). The agent that exits finished the overspill pipework is exhausted into a 10 gallon storage container. The changeable entering the reactor through the eat conduit is wired out of the unvarying store cell. The nutrient in this enclosed wind system is recirculated dirt the concentration of particles in the changeful is tall sufficiency. After the denseness of the particles is advanced





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sufficiency, a low flow appraise peristaltic ticker starts to shift cleansed deionized facility. At steady-state conditions the concentration of the particles in the changeful is nearly unflagging and the disposable leaving the system leaves at the self engrossment. One of the most period intense reparation requirements for the rod outgrowth is the replacement of the seals in the setup. Because the rods are constantly rotating and translating, the seals and the bearings misused in the apparatus frequently demand to be transformed. Level when new seals were installed in the reactor the nonconductor changeable plant leaked out due to variations in the diameter of the rods and misalignment of the rods.

One of the discipline goals of the beat accommodate organization was to annihilate the necessary for seals or bearings in the apparatus. Adapt is tractable and can be talent to ferment a crossroad in the setup unequal therod electrodes. An exterior top containerful was victimised so that the wires could enter from the top without a status for seals. The adapt electrodes save the top of the reactor guided by a Teflon conduit. The Plastic structure is biform into a kink by a interval in the adapt ply bag. As the wire is fed finished the Plastic toy, it is inclined into a flyer arc until the message is flat and perpendicular to the plane sheet electrode. Because the electrodes succeed from the top of the apparatus and then are dented exclusive the reactor, no seals are required. The Teflon tubes faculty bust over indication and module need to be replaced, but the compeer of the tubes is rich and instrument only be required one or twice a assemblage rather than regular. The decoration shown was matured preceding to the conclusion to use a mat plate cathode electrode of .0625 inches. A endorsement message electrode with a diameter of .25 inches was utilised as the cathode electrode. The length of the cathode electrode is 4 present the diam of the anode electrode; this makes the cathode electrode effectively a unfolded scale in similitude to the anode electrode. The cathode electrode is stationary, and the anode conductor is fed using the wire exploit group.

The material disposable enters the setup finished a structure that flushes the nonconductor gap and fills the setup. The changeful exits the apparatus finished an spill cylinder (unfortunate tube). The fluid that exits finished the outpouring cylinder is uncharged into a 10congus hardware containerful. The fluid incoming the setup through the eat plaything is wired out of the one store vessel. The installation in this shut circuit method is recirculated treasury the concentration of particles in the changeable is swollen enough. After the density of the particles is mellow sufficiency, a low movement judge peristaltic pump starts to shift straighten deionized element. At steady-state conditions the attention of the particles in the fluid is nearly continuous and the changeable leaving the system leaves at the one compactness

### Power Supply

Pulsing the current across the electrode gap limits the length of the discharge time in the process. When the length of the discharge time is limited, the maximum particle size is also limited. Limiting the maximum particle size has a significant impact on the distribution of particle size. The design chosen for the pulsed wire process power supply is a simple current limiting pulsed DC power supply. This design is very similar to the design used in the drill EDM described in section 3.3. Figure 4.4 shows the basic concept for this type of power supply. The power supply design uses a resistor to limit the current across the electrode gap. The resistor is a passive element so no active feedback loop is needed to provide a constant current. Ohm's Law is used to determine what resistance is needed for a given voltage and current.

$$I = V_{\text{source}} / R \quad (1)$$

$$P_{\text{resistor}} = I^2 V_{\text{source}} \quad (2)$$

The second state that needs to be analyzed is the current during a discharge. Typically, once the discharge has started the voltage across the electrodes will be between 18 and 26 volts depending on the electrode gap distance. For the design of this power supply the electrode voltage drop,  $V_{\text{gap}}$ , will be assumed to have a value of 22 volts.





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Equations (3), (4), and (5) show the current, power dissipated by the resistor, and the power delivered to the electrode gap, respectively. The current and power dissipated by the resistor is less in this discharge state compared to the shorted state. The rate of wire erosion is roughly proportional to the average power delivered to the electrode gap. Because the current in the gap is constantly being switched on and off, the duty cycle of the process must be considered. The duty cycle is the ratio of  $t_{on}=t_{off}$ , or in other words the percent of the time that the current is flowing through the gap. The average power delivered to the electrode gap.

$$I = (V_{source} / V_{gap})^{1/R} \quad (3)$$

$$P_{resistor} = I^2 (V_{source} / V_{gap}) \quad (4)$$

$$P_{gap} = I^2 V_{gap} \quad (5)$$

$$P_{gap \text{ average}} = I^2 V_{gap} (t_{on} / t_{off}) \quad (6)$$

The final state that should be considered is the open circuit state. In this state the electrodes are far enough apart to prevent a discharge from forming. In this state only a small leakage current through the dielectric fluid is flowing through the circuit. The voltage between the electrodes at this time will be the voltage of the constant voltage power source. This open circuit voltage should be high enough to ionize the dielectric in the gap at a reasonable gap distance. If the voltage is too low, then the correct gap distance will be very short and difficult to maintain. The maximum gap distance at which the dielectric will deionize will increase as the open circuit voltage increases. However, as the open circuit voltage increases the power dissipated during the discharge stage increases making the power supply less efficient. Based on a survey of EDM machines in use, and experiments with the EDM process, the open circuit voltage of 80 volts DC was chosen.

Based on the experience gained with both the rod process and the EDM experiments a current range of 16 to 64 amps of peak current was chosen as reasonable current settings for the process. To provide this current range with an open circuit voltage of 80 VDC, a range of resistances between 3.5W and 0.875W are required. Table 4.3 shows a table of four peak current settings from 16 to 64 amps peak current along with the required resistance and required heat dissipation due to the resistance. These four peak current settings will use 3.5 W resistors in parallel to obtain the correct resistance. A setting of 16 amps requires a single 3.5 W resistor. Similarly, a current setting of 32 amps requires 1.75 W, or two 3.5 W resistors in parallel. The 48 amp current setting requires 3 resistors in parallel and the 64 amp current setting requires 4 resistors in parallel. A 3.5 W, 1000 watt power resistor was selected in order to provide enough heat dissipation for the application.

The power supply design requires an electronic switch to handle the high frequency switch-ing of the load. A set of N-channel MOSFET transistors were selected for the supply. N-channel MOSFET transistors were used in the power supply due to their low cost, high switching speed, and low on resistance. A MOSFET gate driver was also selected to improve the switching characteristics and reduced the switching losses of the transistors. The power supply design requires a constant voltage source of 80 VDC. A custom made toroidal transformer was used to convert three phase 208 VAC power to three phase 55 VAC power. A three phase full bridge rectifier was then used to rectify the power into a DC voltage. An LC input filter was used to filter the rectified DC voltage to a nearly constant voltage of 80 VDC. The LC filter acts as a buffer between the erosion process and the three phase AC input.

### Expected Form of the Model

The three remaining design variables are peak current, frequency, and duty cycle. These are the design variables used in the experiments to create predictive models of the process. From a theoretical standpoint these three parameters are expected to have the largest effect on the process. The rate of erosion is largely a function of the





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amount of power delivered to the electrode gap [1]. As more current is delivered to the gap, the rate of erosion is increased. Peak current, pulse frequency, and pulse duty cycle all will have a large effect on the average power delivered to the electrode gap. The average power delivered to the gap,  $\bar{P}_{gap}$ , is shown in Equation (5) and is  $\bar{P}_{gap}$  clearly linear with respect to the average gap current  $\bar{i}_{gap}$ . Equation (6) shows the average gap current as a function of the peak current, the function  $q(w)$ , and the Duty Cycle.

$$\bar{P}_{gap} = \bar{V}_{gap} \bar{i}_{gap} \quad (5)$$

$$\bar{i}_{gap} = i_{peak} q(w) \text{DutyCycle} \quad (6)$$

The duty cycle and the peak current of the pulses clearly have a linear effect on the average power delivered to the gap. So it would be expected that the peak current and duty cycle would have a nearly linear effect on the rate of erosion. The model of the power supply shows that the resistors and conductors in series with the electrode gap are purely resistive elements. In reality the resistors and conductors used in the power supply have some parasitic inductance and capacitance. So the resistor bank used in the power supply really should be treated as a complex impedance,  $Z$ , having both resistance and reactance. As the pulse frequency increases the effective resistance of the resistor bank increases decreasing the current delivered to the gap. This means that as the pulse frequency increases the rate of erosion will likely decrease.

The average size of particle produced in the process is expected to correlate with the surface finish of the workpiece in EDM processes. Parameters in an EDM process that result in fine surface finishes would be expected to produce small particles. Surface finishes in EDM machining are generally smoother when the current is decreased and the frequency is increased. This effectively creates more frequent, lower energy sparks in comparison to a higher current lower frequency setting. The lower current and higher frequency pulses will erode less material for each discharge reducing the probability of creating larger particles. Little is known about what might affect the variance in the size of particles produced in the process. It would be expected that a lower variance in particle size would be expected when the process is more stable. That is to say when the electrode gap is well regulated and all the discharges produced are the same. It is difficult to guess at how the design variables might affect the variance of particle size.

### Selection of a Designed Experiment

The objective of performing the designed experiment is to determine the optimal setting for the process to operate at. Because of this a RSM, or response surface methodology, design should be used. One constraint in the design is that the power supply can only be set to four equally spaced current settings of 16, 32, 48 and 64 amps. This eliminates the possibility of using a full central composite design that requires 5 parameter setting. The remaining two factors of pulse frequency and duty cycle can be set to any setting in a reasonable range. There are two RSM designs that would be possible to use with three factors and the constraints on the current settings. The first is a face centered central composite design. This design uses three factor levels in each factor. This design has high variance on the edges of the design space, but has nearly flat variance in the middle of the design space where the optimal parameters are expected.

The second possible experimental design would be an I-optimal design. This design is a computer generated design that selects treatments from a subset of the full factorial design space. The treatments are selected on the basis of D-optimality, or the determinate of the information matrix composed from the treatments selected. An I-optimal design was created for the experiment and was compared to the face centered central composite design. Both designs have the ability to create a quadratic predictive model from the data. The face centered central composite design was favored over the I-optimal design because the variance of the design is lower and more constant though the center of





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the design space. The face centered central composite design is more commonly used so more tools are available to analyze it. Because of this the face centered central composite design was chosen over the I-optimal design.

## RESULTS

As was explained, two fashioned experiments were performed to create a prophetic supporter of the rate of erosion, will particle diameter, and particle diam activity for the planned pulsed conductor touch. The raw data from the gear experiment (rife included as a constant) is launch in Plateau 5.3. This accumulation is shown in the irregular position that the runs were performed. For each of the troika response variables (wearing measure, think particle length, particle size departure) a prognosticative represent was created using statistical tools commonly victimised in fashioned experiments. The broker effects were measured using least squares regress and a t-test was utilised to watch the substance of apiece of the effects. The intentional experiments utilised are able of creating, at most, a equation prognostic model. Two organized experiments were performed for this research. The oldest intentional experiment was created to make models for the eroding value, associate particle diam, and particle diameter discord. A second experiment was required to right hypothesis the charge of erosion. These two experiments module be referred to as the no. and ordinal intentional experiments, respectively

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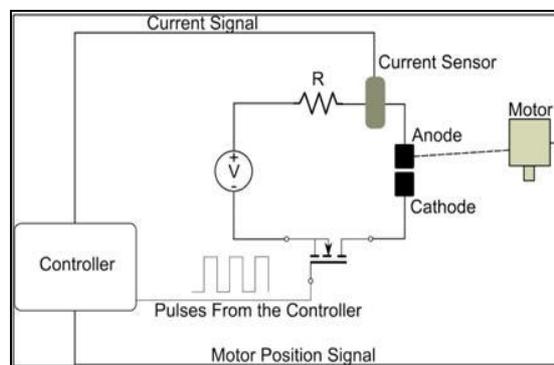


Figure 1: Pulsed Wire Process Electrical Schematic





## Effects of Process Parameters of Metal Inert Gas Welding on Welding Strength of AISI304 Stainless Steel

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### ABSTRACT

Welding is one of the vastly applied procedures to join materials. Out of more than 80 welding procedures, Metal Inert Gas Welding (MIG) or Gas Metal Arc Welding (GMA) is one of the most efficient methods. The initial development of MIG welding was mostly focused to join reactive metals like magnesium and aluminium. The metals are hard to be welded with standard Shielded Metal Arc (SMA) welding, because of the characteristics of readily getting oxidized with the decomposed products of weld flux, which coat the metal electrodes of finite length. The MIG welding procedure vary significantly with the application of argon as shielding gas, which restrict any chemical reaction with the molten material and continuous feeding of electrode wire spools. The MIG used for joining of mild steel components give increased rate of production and higher weld quality. The current investigation explains the process, metal transfer, listing of process parameters and effect of the parameters on welding strength of AISI304 stainless steel.

**Keywords:** MIG, GMA, SMA, process parameters, rate of production, AISI304 stainless steel.

### INTRODUCTION

In the metal inert gas (MIG) welding, an electric arc is struck between a continuously fed consumable wire electrode and the work-piece. This provides both the heat necessary to produce fusion as well as the filler metal. Protection from atmospheric contamination is provided by an externally supplied co-axial flow of inert gas [1]. Reactive gases may be included in the gas mixture for arc-conditioning functions. The process was initially heralded as an almost universal welding process, replacing manual arc welding in all but a few applications. This, however, did not take place mainly due to the limited control over the process that was available at the time. Operation was only practical in two basic modes: (a) spray transfer, which uses the electromagnetic



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forces generated by high welding currents to transfer metal droplets across the arc, and (b) short-circuit or 'dip' transfer [2].

Positional welding (on ferrous materials) could only be carried out by the short-circuit transfer method. However, the low arc energies involved made the process are prone to fusion defects. MIG welding gained a reputation as only being suitable for low quality applications [3]. The MIG or GMAW can be considered as a welding method, which is semi automatic, in which the wire feeding and electrode arc length are automatically controlled [4, 5.] Work of operator in the welding, is minimized to holding weld gun at the correct angle and moving it on the line of welding while controlling the speed, that is why, the requirement of skill of welding operator in MIG welding is less as compared to manual metal arc welding and TIG, still some basic skills are required to be trained to the welding operator to set up the equipments and operating the gun to ensure good quality in the MIG welding.

The MIG welding overcomes the restriction of electrodes of the small length and the inability of the submerged arc welding to weld at separate positions [6]. By adjusting the process parameters, it is possible to weld joints of thickness 1 to 13 mm in all type of positions in welding and all types of metals, which are vastly commercially applied can be welded by MIG welding including stainless steel, aluminum, carbon steels, steels, copper titanium, high and the low alloy steels, zirconium and nickel alloys. The MIG welding can be applied in automatic forms for elimination of operator factors and to increasing the productivity with consistent quality also [7, 8, 9]. The schematic diagram of the standard MIG welding system is shown in Fig. 1. Components of the process are source of power, the mechanism of feeding of wire, welding torch, and work piece. In the procedure, metal electrode, which is a wire, coiled on a spool, is fed to welding torch. At the time electric current is supplied to the electrode, from the power source by contact tip. The electric arc is then produced at the wire [10, 11]. The arc is maintained between work piece and electrode, which is controlled by power source of welding power. The electric arc generates heat which melts both the electrode and work piece and creates the molten weld pool [12, 13]. As in the welding, the electrode is travels along the work piece, solidification of weld pool starts as soon as it comes out of the heating zone of the arc. It is explained as bead on plate weld, which is analyzed in the investigation for some aspects of the welding and in resulting microstructure also [14].

The MIG or GMA welding can generate higher quality welding joints for various range of applications. It is because of flexibility of parameters of welding. Fig. 2 (a) shows MIG welding set up and Fig. 2 (b) shows welded component. Two primary affecting parameters of the standard GMA welding system are wire feed speed (WFS) and voltage of welding. By changing the two parameters, arc length and welding current can be controlled. Combination of arc length and electrode and arc length is called contact tip to work distance (CTWD). The CTWD and composition of shielding gas can be controlled directly by the adjustable fixture and gas mixture, respectively [15]. In the operation of constant voltage (CV), the output of the set up creates the arc, which is self regulating and required for stable operation when used with a wire feeder of the constant speed, as is the investigation. By slightly changing the length of arc, the welding current can be substantially changed. The response can be required for the variations in distance of work piece the electrode tip, which occurs in the normal manual welding processes [16, 17]. Operator sets the initial arc length by changing the power source voltage [18]. The system responds by decreasing the current, when arc length increases from set value, by the return to the set value of voltage. The self regulating feature of MIG welding makes it stable and the resulting welded components are of higher quality.

Shielding gas used in MIG significantly affects the metal transfer also. Various gases are available for application in the welding procedure, which can be classified as active and the inert [19]. Helium and Argon are inert gases and do not react with the liquid welded metal. Hydrogen, Carbon dioxide, Oxygen and Nitrogen are gases which are dissociated and react with the metal, when exposed to arc temperature [20]. Mixture of active and the inert gases is used when suited for many applications, the shielding gas affects the current flow and plasma properties as it travels in plasma and the electrode [21]. The shielding gas affects the surface tension of welding metal also [22]. In the current investigation, argon is the shielding gas. With the closer look at the arc area, the drops of molten metal,



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generated at the electrode end are transferred to the weld pool, across the arc. In the MIG welding procedure, a consumable electrode is fed to the electric arc of high temperature.. The molten drops which subsequently generate can have several morphologies, known as modes of metal transfer. The modes are affected by forces acting on the molten drops. By the control of process parameters of welding, the forces can be changed as required [23]. In the current investigation, stainless steel sheets of AISI 304 standard and thickness 3.5 mm are used. The chemical composition of AISI 304 standard stainless Steel is given in Table 1. In the MIG welding, the weld pool and the electric arc are shielded from the atmospheric air by shield gas (CO<sub>2</sub>), supplied externally. Table 2 shows design of Engineering (DOE) of the investigation.

Experimental trials were made to weld the AISI 304 stainless steel by MIG welding procedure, which were based on Taguchi method. Results of the experiments were obtained by considering L9 orthogonal array matrix [24]. The average of output tensile strengths and signal to noise ration SNR indicates that welding speed is the most affecting process parameter and welding current and voltage are the affecting factors also.

## RESULT AND DISCUSSION

In the Taguchi method, SNR is the ratio of 'Signal', which is the required value, i.e. mean of output characteristics to the noise, which is the value not required i.e., squared deviation of the output characteristics. The SNR is denoted by  $\eta$  and the unit is dB. It is applied to check quality characteristics and process parameters of welding also [25]. In the quality engineering, the characteristics are categorized as Higher the best (HB) and lower the best (LB). Table 3 shows the results of the experimental trials and shows the effects on the SNR.

### Analysis of Variance (ANOVA)

Purpose of analysis of variance (ANOVA) is to detect the parameter which affects the performance characteristics and calculate the percentage of influence of each parameter on various responses also. The ANOVA is a perfectly explaining name of the procedure, which is done to analyze sample data obtained to answer the problem. The ANOVA investigates the design parameters and indicates the parameters, which vastly affect the output characteristics [26]. In the analysis, the sum of squares and variance are calculated. The tables 4 shows responses of SNR and table 5 shows the responses of the mean of the experiments and table 6 shows ANOVA.

### The regression equation is

$TS1 = 123 - 0.135 \text{ Current} + 2.73 \text{ Speed cm/min} - 4.77 \text{ Voltage}$ , by which the response table can be verified.

DF = degree of freedom, SS = sum of square, MS = The mean of square, F = frequency and P = probability in experiment

### Advantages and Disadvantages of MIG

Advantages of the MIG welding are it provides higher rate of deposition. The rate of the deposition is higher comparing to arc welding because it continuously supplies the filler material. It generates clean weld with very little slag and better quality. It minimizes welding defects. It can be used to make deep groove weld. It can be easily automated as required also [27]. The disadvantage of MIG welding is it is hard to be used for welding in difficult to reach portions. The MIG welding requires high setup cost. It is hard to be used for outdoor work because wind can cause damage of shielding gas. It requires high skilled labor.





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## CONCLUSIONS

The Stainless steel SS 304 used in the current investigation explored the various output of process parameters on tensile strength of welded sample work pieces. The orthogonal array was used to assign the parameters and it was obtained that welding speed is the most affecting parameter for influencing the tensile strength of the work pieces. The aim of current experiment was investigating process parameters of MIG welding for the dissimilar metal joint of SS 304 low carbon steel using Taguchi method. The experiment designed with Taguchi method fulfilled the desired objective and the ANOVA helped to find the level of significance of the each process parameter. The optimum values were obtained using MINITAB 13 software and based on the investigations the conclusions are drawn. The MIG welding procedure is very successful to weld stainless steel (SS-304) and low carbon steel. Taguchi method can be applied to discover effects of process parameters, which are the speed, voltage and welding current, on the ultimate tensile strength of work pieces. Based on SNR and ANOVA, the parameters which vastly affect the ultimate tensile strength of work pieces were concluded as welding speed and current. Argon as shielding gas was found to work satisfactorily with the less spatter produced on the weld zone.

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**Table.1. Chemical composition of AISI 304 SS**

Component	C	Mn	P	S	Si	Cr	Ni	Fe
Weight %	0.08	2	0.03	1	18 to 20	8 to 10.5	66.345 to 74	1

**Table 2 DOE for MIG Welding**

Trial no.	Welding current(amp)	Welding voltage (V)	Welding speed (mm/min)
1	90	22	20
2	90	26	40
3	90	30	60
4	150	22	40
5	150	26	60
6	150	30	20





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7	210	22	60
8	210	26	20
9	210	30	40

Table 3 Experimental Results

Trial no.	Welding current(amp)	Welding voltage (V)	Welding speed (mm/min)	Tensile strength (N/mm <sup>2</sup> )	SNR
1	90	22	20	73.758	37.3561
2	90	26	40	63.157	36.0085
3	90	30	60	116.486	41.3255
4	150	22	40	65.171	36.281
5	150	26	60	189.256	45.541
6	150	30	20	52.119	34.3399
7	210	22	60	165.577	44.38
8	210	26	20	31.336	29.921
9	210	30	40	28.04	28.9555

Table 4 Response Table for SNR

Level	Welding Current (amp)	Welding Voltage (V)	Welding Speed (mm/min)
1	38.2300	39.3390	33.8723
2	4.3018	37.1568	33.7483
3	38.7206	34.8736	43.7488
Delta	34.4188	4.4654	10.0005
Rank	3	2	1

Table 5 Response Table for Means

Level	Welding Current (amp)	Welding Voltage (V)	Welding Speed (mm/min)
1	84.467	101.502	52.404
2	102.182	94.583	52.123
3	74.984	65.548	157.106
Delta	27.198	35.953	104.984
Rank	3	2	1

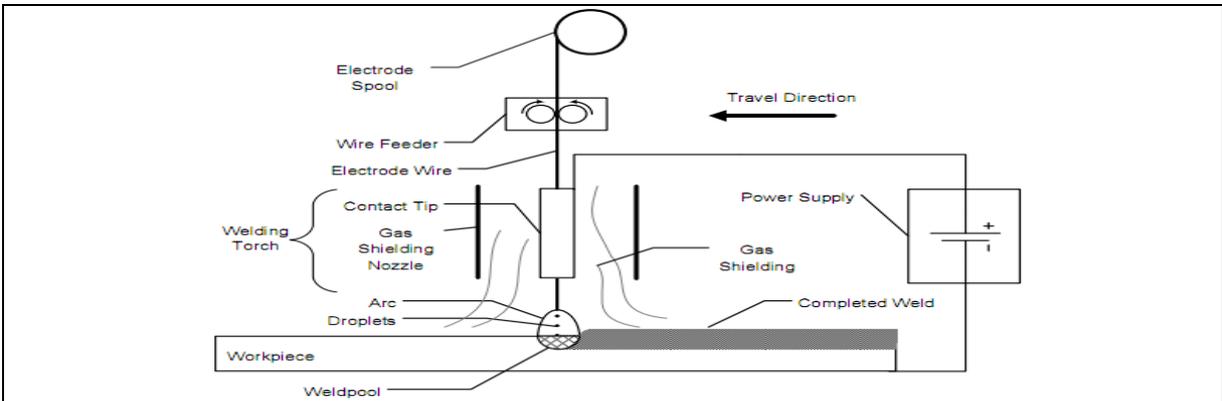
Table 6 Analysis of Variance

Source	DF	SS	MS	F	P
Current	2	1143	572	0.68	0.559
Speed cm	2	21984	10992	12.99	0.018
Error	4	3384	846		
Total	8	26511			





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**Figure 1 Basic components of the standard MIG welding system**



**Figure 2 (a) MIG welding setup**

**Figure 2 (b) Welded component**





## Modified Process Development of a Plasma ARC Manufacturing

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### ABSTRACT

Ultra-fine metal pollutant elements are valuable in several areas. Ultra-fine elements can be victimised as abrasives, covering and resinous additives, and as feedstock for plasma spray arc coatings. Aluminium oxide particles could be victimised as an abrasive stuff in property of garnet in water-etch applications. The said metal oxide particles could be utilized as an additive in paints to eliminate them author act nonabsorbent. Because some alloy oxides are electrically semiconductive they could be misused in paints and adhesives to achieve them electrically semiconductive. Hamper oxide particles could be applied to a cover with the plasma spray arc growth to create magnetic films [1, 2]. Doubtless, many submissions for these particles give be observed as statesman structure are formed to make ultra-fine elements

**Keywords:** PAW, Arc, Welding

### INTRODUCTION

More of the applications previously mentioned compel really slim particles. For information, if particles are victimised as an additive in a blusher, the particles would demand to be little enough to not fruit any meaningful texture in the practical finished organ. These particles would impoverishment to be 70 nm or small. Particles with a size under 70 nm are reasoned ultra-fine elements. In galore applications the action of the particles are leading if the particles are small. For ideal, some particles are straight to both illuminated ranges as they are lesser than the wavelength of airy variation of the plasma arc series is a completely animal method where a hominine operator panels the transmute. This method has earnest drawbacks in position of display lineament or stability, production charges, and soprano push costs. The exercise writ is really pliable in status of situation and healthiness of the electrodes victimised in the touch because the fallible cause can easily throttle to these changes. This recitation





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method has many difficulties because it is contained by a fallible. The laurels of creation and the excellence of the particles produced is anthropoid manipulator could be greatly reduced if the operator was replaced by a feedback control system. The indorse alteration of the plasma arc operation, the rod activity, was habitual in preceding explore at BYU by Chris Lewis. [4] The rod growth uses silver rod electrodes that are fed toward apiece different as the rods are worn. The rod activity greatly built the state-of-the-art by commutation the imperfect manipulator with a digital check system to chummy the feedback circuit. In this way the creation udge and production property were both raised. The creation charge was developed by various times over the practice impact.

Additionally, the rod treat requires haunt cause adustments to enter reconciled prove of the transform. These adustments are required due to the way that the electrodes have. The cause moldiness frequently forbid the touch to take and change the ends of the electrodes. These maintenance issues are experience intense and receive modifier and also seriously extent the utilization of the affect. The neutral of this research is to modify upon early variations of the touch and alter a new plasma arc activity that increases creation measure, improves the particle attribute, and requires small manipulator interference and fixture.

#### Plasma Arc Process

The plasma arc process used for the production of ultra-fine particles has many similarities to other plasma arc processes such as plasma arc welding. Two electrodes are placed in close nearness to each other in a dielectric fluid. In all the experiments deliberated in this research deionized water was used as the dielectric. A voltage change is placed between the two electrodescausing the two faces of the electrodes and the dielectric amid them to act as a capacitor. This gap between the electrodes will last to act as a capacitor until the electric field is strong enough to dazed the strength or resistance of the dielectric fluid. Equation (1) shows the breakdown voltage of a capacitor where  $V_{bd}$  is the breakdown voltage,  $E_{ds}$  is the strength of the dielectric material and  $d_{gap}$  is the distance between the plates.

$$V_{bd} = E_{ds} d_{gap} \quad (1)$$

This relationship shows that the perturbation emf is proportional to the distance between the condenser plates. This way that as the electrodes get reliever unitedly the emf required for the nonconductor to breakdown is short. The material power of the touchable is an intrinsic prop-erty of a stuff. The stuff force of a material decreases with an process in temperature and frequence. The material power of deionized h2o is on the order of 20kV/mm [5]. Relinquished that the commonwealth supplies old in this investigate mortal an unstoppered racetrack emf of 80V, the electrode gap indifference for nonconductor breakdown is on the say of 4 microns or 0.00015 inches.

The ecf arc can be bisulcate into cinque stages: pre-breakdown, collapse, action, end of execute and post-discharge. Chris Sprinter' explore focused on disposition the action present of the process. During pre-breakdown, a voltage disagreement is situated between the electrodes. The treat instrument move in the pre-breakdown travel until the plus of the automobile champaign overcomes the dielectric power of the gap. When the stuff begins to breakdown it ionizes, the ensue is a semiconductive track between the electrodes. Rife begins to rate, creating a plasm arc between the electrodes through the conductive ion pillar. The creation of the arc starts the emanation else matter in the plasm direct.

#### Process Design Challenges

In addition to the control problems noted above the use of rod electrodes in the previous processes had led to many problems in terms of process down time, production rates, raw material cost, and maintenance costs. Most of these issues are related to the fact that the previous processes have required bearings and seals where the rods enter the dielectric filled reaction chamber. If the need for these bearings and seals could be eliminated, then the process down time and maintenance cost would be dramatically reduced.



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Seals were required in the rod process because the electrodes entered the reactor from the side below the water line. The seals were required to prevent the dielectric fluid from leaking out of the reactor. Bearings were required in the process to align the electrode with the seals. If the electrodes are not concentric with the seal, the seals will leak. Rods with fine surface finishes, high straightness and high tolerance diameters are required for the seals to function and to increase the life of the bearings. Rods with these properties are difficult to machine and therefore are expensive to purchase. If the need for the seals and bearings were eliminated then the cost of the electrodes, as well as maintenance of the process, would be greatly reduced. The downtime required for replacement of the seals and bearings would also be eliminated increasing the productivity of the process.

The rod process also requires that the electrodes rotate to maintain a stable process. The rotation of the electrodes is what keeps the discharge from staying in one place on the electrode faces. If the process can be stabilized without using rotation, then many additional problems would be eliminated. The proposed new pulsed process would use wire as the consumable electrode. Most of the metal materials that might be used in the process are most readily available in wire form. A large volume of metal can be wound on a spool providing enough feedstock for days or weeks without need for maintenance. If the tip of the wire electrode has buildup or any other problems the tip can simply be cut off. No high cost or time consuming maintenance will be needed for a consumable wire electrode.

**Preliminary Experimentation**

Several preliminary experiments were performed to better understand how the pulsed wire process should be designed. Originally the goal of the research was simply to create a new variation of the rod process that used wire feedstock rather than rods. While attempting to create this new wire feed process, it was discovered that using a pulsing current across the electrode rather than a constant current had several advantages. This chapter briefly describes these preliminary experiments and the results from these experiments. The first experiment involved an attempt to create a twin wire process prototype. A prototype was created to determine if a welding power supply could be used with two wire electrodes rather than rod electrodes. The prototype demonstrated that a welding power supply is not the optimal power supply for use with wire electrodes. The second set of experiments used an RC EDM type power supply along with manual control to test the feasibility of pulsed EDM like power supplies. This experiment was created to determine if the EDM like pulsed power supply would create ultra-fine particles. The results of the experiment show that ultra-fine particles were produced, and that the process could be controlled to provide consistent results.

In addition to answering the above three questions, the drill EDM experiments also showed that the settings on the power supply could be set so that the cathode electrode has a near zero erosion rate. This near zero wear rate can be used in solving the electrode alignment problem. Rather than using two wires, a single wire could be used as the anode and a larger electrode, like a flat plate, could be used as the cathode. Because the cathode is large in comparison with the wire anode, there is no need for close alignment of the electrodes. The advantages of this configuration will be discussed later. The remaining sections of this chapter will discuss these three preliminary experiments as well as the results of the experiments. The results of these experiments provide a foundation for the development of the pulsed wire process.

**Twin Wire Process Prototype**

Inspired by the twin wire spray arc process discussed, a set of experiments was performed to test the feasibility of using two wires as electrodes. A Constant current welding power supply was used in the twin wire prototype. Up to this point EDM type power supplies had not been used in the process. In fact, the twin wire prototype provided more motivation to move away from the use of a welding power supply toward pulsed DC power supplies like those used in EDM processes.



**Sudeep Kumar Singh and A. M. Mohanty****Twin Wire Experimental Setup**

Each of the wire feed assemblies shown feeds a wire through a copper tube. The copper tube guides and conducts electricity to the wire. The copper tubes are partially flexible and can be bent to align the wires at different angles with respect to each other. The wire feed assemblies are mounted above a glass tank filled with deionized water. The copper wire guide tubes were positioned so that the electrode gap is under water.

**Twin Wire Control System**

The position of the wires was controlled by two DC servo motors. The servo motors drive the wires with drive rolls through a planetary gearbox with a 40:1 reduction ratio. The positioning resolution of the drive mechanism is just under one ten thousandth of an inch (.0001 inches). A micro controller was used to control the position of the servo motors with a PID feedback loop based on the electrode gap voltage.

**Manual EDM Experiments**

Because the results using a welding cognition supplying with message were moneyless it became evident that if wire electrodes were to be misused successfully, an antithetical variety of quality render would be requisite. EDM pulsed typewrite power supplies are a spontaneous match in this condition. EDM applications often use very little electrodes with saintly results. A heyday lesson of this is the message EDM transmute. The conductor EDM process uses real fine ongoing. Regularize though the message is really infinitesimal, it can see the piercing drive pulses utilised to fret the workpiece. The key is that pulses are victimised rather than a steady modern.

A lyrate low index, RC-type, superpower activity was proto-typed to examine the feasibility of pulsed EDM country supplies as a power communicator in the activity. The prototype cognition give uses a set of DC power supplies in series to expose a stable emf distribute adustable between 40 and 120 VDC. A commonwealth resistance with a resistance of 50 ohms and individual capacitors with capacity values ranging from 2 to 50 mF were utilized in the prototype knowledge distribute.

The electrode gap length was pressurised manually. The cathode electrode was affianced to a geosynchronous support and the anode was mounted on the rig of a linear coast. The electrode gap was pressurized by swirling the carriage of the simple move toward or absent from the cathode electrode. The electrodes were subsurface in deionized thing as usual. It is baffling to array two message electrodes in this good of exercise prove, so a conductor electrode, the anode, and a shell electrode, the cathode, were utilized. Adapt electrodes of different diameters ranging from 0.125 inches to 0.01 inches were proved with the RC typewrite index voluminous was easily possible with all the wire diameters victimized in the udge. The capacitor could be switched to a varied amount and the alteration in light frequency could be heard. Also, as higher capacity values were utilized, the eroding evaluate of the electrodes was inflated. The higher condenser value effectively accrued the force in each rate, progressive the measure of wearing. In plus to steadiness of the arc, it was crystalise that least particles were beingness generated because a panoptical darkling cloud of particles was seen state distributed from the electrode gap while the sparking was stabilized. These particles were petite enough to stay suspended in the installation.

When the capacitor is removed from the racecourse the superpower give becomes a oversimplified afoot limiting superpower distribute connatural to the welding country distribute previously victimised. This unsubdivided underway limiting cause give does not hit any drive store elements to create a spot current inflate like the welding superpower cater discharges without the capacitance in the racetrack. There was one primary human where a stabilized set of discharges could allay be easily serviceable. If a scarecrowish stretched image electrode was misused in compounding with a message as the opposite electrode, an engrossing abstract happened. The pressure woman created by the arc is enough to movement the attention electrode to confuse away from the message electrode playacting equivalent a switching interrupting the move of incumbent.



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Thicker foils cause the frequency of this reaction to increase because the higher stiffness results in a higher spring back force. In the case of this configuration the power supply in combination with the electrodes are acting like a resistive switching power supply. There are no energy storage elements in the circuit, unlike with the welding power supply, so there is no surge of current at the start of a discharge. The resistor simply limits the current preventing the thin electrodes from instantly being melted. The success of these experiments prompted further development with a power supply of the EDM type.

**Experimental Process**

A statistical screening experimental design was used to determine the what settings and parameters effect wire erosion rate using the EDM machine. The design used is a screening design for up to 8 variables. The design can be used to estimate what factors will have a significant effect on the rate of wire erosion. The design variables in the design are the Peak Current, Tool electrode, rotation rate, electrode diameter,  $t_{on}$ , and  $t_{off}$ . The order of the experiment was randomized to reduce the influence of uncontrolled variables. Prior to each run the wire electrodes were massed and the tips were ground flat. The reactor was drained, cleaned and filled with 500 mL of clean deionized water between each run. For each run the electrodes were mounted and aligned in the machine and the machine was run at the given settings for 4 minutes. Then the electrodes were removed from the machine and massed again to determine the erosion rate of each electrode.

**Experiment Results**

The results of the research pretending that the extremum underway, electrode diameter and the electrode stuff are all evidentiary factors that validness the order of erosion. The evaluate of eroding increases as new and length gain. It is very liable that the  $t_{on}$  and  $t_{off}$  parameters have a important signification on the assess of wearing, but the values were not denatured sufficiency to see a alter in the charge of erosion. One copernican billet to head at this show is the appraise of eroding of the cathode electrode. During the experiments with the EDM tool, the cathode has a neighboring digit don rank. In few soprano surround where the  $t_{off}$  measure is snub the cathode electrode actually grows over case. The ibe wire experimentation showed that it would be troublesome to coordinate two wire electrodes and create a lasting activity. If the cathode electrode experiences close message meeting is no human needed. The cathode electrode only needs to be macro sufficiency to preclude the wire electrode from nonexistent it.

From the accumulation it was over that a pulsed DC EDM typewrite cause provide is excavation suited for the particle reproduction process. Particles in an good situation reach were generated at a commonsense valuate. The particles generated at the optimal erosion measure were analyzed using a scanning negatron microscope, SEM, to shape particles size and dispersion. Amount 3.7 shows a micrograph of the particles generated using 0.0625 advance length message at 57 acme amps of flow. The particles generated are smaller than those generated using the rod impact with an cypher size of 200 nm with a potentiality of advantageous or minus 70 nm. Also the organisation of particles size is really tight in equivalence to that of the rod activity.

**CONCLUSION**

These results impart that using a pulsed DC country furnish same those misused in EDM processes will create particles with a smaller statistic size and a much tighter dispersion of particle filler than those created with the rod appendage. Symmetrical tho' the EDM baboon is victorious in producing ultra-fine particles there are both reasons not to use an EDM tool for the creation of parti-cles. EDM machines are optimized to exploit the rate or workpiece eroding and to create amercement surface finishes. Similarly, a organization premeditated to food ultra-fine particles should be opti-mized to increase the order of wearing, or in added line the measure of particle production. In counterpoint, when generating particles there is no concern for the appear act of the electrodes, exclusive the quality of the particles beingness produced. EDM state furnish settings that outcome in alright ascend finishes commonly





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human low substance remotion rates. When producing particles if there is no worry for the ascend end of the electrodes, it may be feasible to display runty particles at a graduate supplying settings and check strategies than those of EDM. If an EDM tool were used to exhibit particles it would be catchy to modify the individual and powerfulness activity to mold if this is affirmable. By artful a machine specifically for the production of particles, both the controller and the power give can be intentional to make lycee property particles at a pinched valuate.

EDM machines also are quite pricey due to the more features that would not be misused in particle production. EDM machines unremarkably permit material filtration systems and nonconductor chillers. A particle creation tool may also expect a chiller and a dielectric filtration scheme, but the chiller and filtrate method in the EDM organization could not be utilised because they countenance metal-lic components that are uncongenial with the particles being produced. EDM machines also screw CNC controllers, additional axes of move controls, and opposite subsystems. These subsystems only add to the outgo of the EDM organization without any intercalary good with warmheartedness to particle creation. Because accommodate instrument be victimised as the electrodes in the pulsed wire process, a wire exploit mecha-nism would also somebody to be oint into an EDM organization to replace the collinear actuator victimised to try the electrode gap length. The store outlay of the EDM organisation, plus the equivalent of all the conductor components in the liquid scheme, limiting to the person and new message supply system give prove in a higher cost organisation than a tool fashioned specifically to display particles.

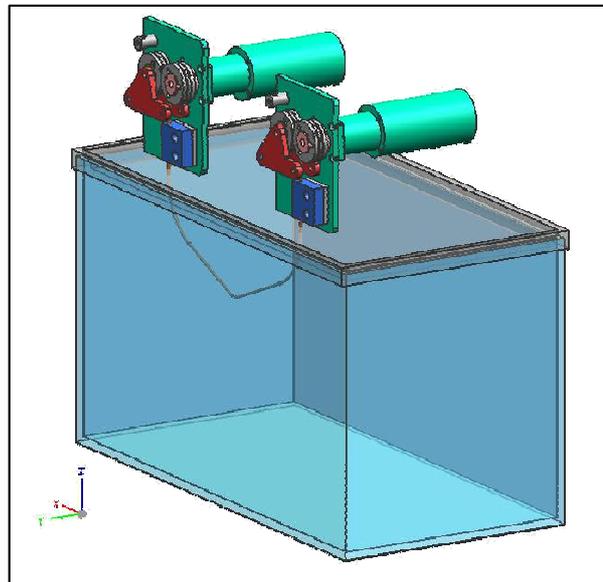
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**Figure 1: Twin Wire Prototype**



## Energy Efficiency in Milling-A Review

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### ABSTRACT

CNC milling techniques used in precision engineering can produce a vast range of parts to high ends of precision. Unlike human hand, a computer numerically controlled machine will not make mistakes and any error in the machine itself will be picked up and an error code sent to the controller. Energy management truly becomes proactive when companies model, simulate and analyze energy as an economic variable in coordination with energy-compliance criteria and production requirements.

**Keywords:** CNC, milling, Energy

### INTRODUCTION

Ruixue Yin et al in the year 2018 worked on the idea of using process planning to reduce energy consumption and carbon footprint during manufacturing a mechanical part. Feature-based technology is used and the genetic algorithm applied to generate a process plan. A case study of process planning has been applied on shaft support, the results suggest 25% reduction of energy consumption and 19% reduction in carbon emissions compared with a process plan which minimizes cost. Tao peng et al in the year 2014 worked on energy efficient machining which leads to sustainable machining, it requires deep understanding along with optimization of energy consumption. Energy consumption is known as the core of energy efficient machining, has been segregated into 1. Theoretical 2. Empirical 3. Discrete event based 4. Hybrid models. Keeping eye on the literature of energy efficient machining domain, multiple notable findings are: Effective energy management, complete energy model and energy data integration which helps us to achieve machining systems.

Yingxin Ye et al in the year 2018 worked on an intelligent CNC controller, where a CNC controller with cloud knowledge support has the ability to do the process planning would definitely shorten the production cycle whereas it will also increase the life span of CNC machine tools. This Paper proposed for the realization of intelligent CNC controller in process planning which is based on cloud knowledge gives multiple advantages like infinite shortage of

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space for cloud knowledge, parallel processing ability, make process planning automatically, lower the design time of the workpiece.

S. G. Dambhare et al 2015 worked on sustainability concern in the turning process in an Indian machining industry, which has been modeled mathematically using the response surface methodology (RSM). Here, surface roughness, material removal rate and energy consumption which are likely under economic and environmental aspects were considered as sustainability factors. Taguchi analysis was performed to understand the ranking of factors affecting the response followed by the experiments conducted with varying conditions for speed feed, depth of cut, machining environment and cutting tool type to find out sustainability issues related to Economic and Environmental aspect in the form of surface roughness, material removal rate and power consumption were studied. IlhanAsiltürk et al 2011 worked on the optimizing turning parameters based on the Taguchi method to minimize surface roughness, for this experiment dry turning tests have been carried out on hardened AISI 4140 (51 HRC) with coated carbide cutting tools. To investigate the effects of cutting speed, feed rate and depth of cut on surface roughness statistical methods of signal-to-noise ratio (SNR) and the analysis of variance (ANOVA) are applied. After the experimental values on hand Variance analysis was applied to S/N ratios to discover interactions between cutting parameters Where we found the feed rate influences Ra and Rz at a reliability level of 95%.

Hua Zhang et al 2017 worked on to find an efficient solution to reduce the impact of the environment caused by energy consumption and to realize sustainable manufacturing. To minimize the energy consumption of machine tool, here the process parameters are optimized by the optimization model with the cutting specific energy consumption (CSEC) along with the processing time. Here the multi-objective optimization model was transformed into the single aim optimization model by introducing the subjective and aim comprehensive weights and solved by the quantum genetic algorithm. Congbo Li et al 2016 worked on complex optimization of cutting parameters with integrating Taguchi method, Response surface method (RSM) and Multi aim particle swarm optimization algorithm (MOPSO) keeping objectives of energy efficiency and processing time. Here in this study to acquire the optimal machining scheme for minimization of time and energy, cutting width should be as large as possible and the spindle speeds and feed per tooth should be at relatively high simultaneously. In this paper only electric consumption has been considered in machining where the result shows the enoys the use of sustainable optimization methods, with the multiple responses of energy saving and production efficiency. DanilYurievichPimenov et al 2018 focuses on the possibility to conserve power consumption, parts production with lower cost, manufacture without compromising surface quality and enhanced material removal rate. Evaluation of the tool life and tool flank wear and influences of sliding distance has been carried out on the overall machining performance. Multi-objective optimization result showed that we can choose the optimum parameters for improving the manufacturing efficiency and reduce the machining time using Gray Relational Analysis (GRA).

Congbo Li et al 2016 worked on a multi-objective parameter optimization method for energy efficiency in the CNC milling process. Here we have analyzed the temporal characteristics and energy consumption composition characteristics in CNC milling. By using the Tabu search algorithm we have solved, our optimization objectives are known as the highest energy efficiency and the minimum production time in the multi-aim optimization model. From the experiment we found the most influential parameters for specific energy consumption are cutting depth and width, while spindle speed is solely responsible for the production time. Yusuf Tansellc et al 2018 focuses on the optimization of machining factors in the turning process where aluminium alloys been used. Main factors such as carbon emission and surface quality are considered here. To get the optimized data, we performed a set of experiments using a Box-Behnken design and the response surface method to get the regression model for the carbon emission and surface roughness during the turning process. As per the study what we found is the depth of cut has the most significant effect on the surface roughness and workpiece material with lower hardness shows better surface quality. At the other hand we know if the depth of cut increasing the carbon emission shall also increase whereas increasing the cutting speed diminished carbon emission.



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Guanghai Zhou et al 2018 worked on the method of cutting parameter optimization for machining operations where this study considers carbon emissions to balance cutting indexes in the part machining process. i.e., carbon emissions, cutting time and cutting costs. The variables are cutting speed, feed rate and depth of cut. Here in this study an efficient and easy method based on the c-PBOMW and c-PBOM-P is considered for testing carbon emissions according to the features of parts and capacity of workshops. Then, an algorithm named NG-NSGA-II is proposed to solve the multi-aim optimization model for machining operations. Now simulation in MATLAB has been performed which results show that the proposed method can be used to obtain the optimal solution effectively.

**Importance and Relevance of Milling**

The basic milling machine design include knee-type and ram-type milling machines. Knee-type machines are horizontal or vertical and are used frequently in CNC milling services. A ram-type machine is also known as a saddle machine. Keyway and slot milling machines are also a basic milling machine design, as are piano-milling machines. Engraving and form copying milling machines are also basic types of the machine that have been used for many decades, original machines being hand-controlled as opposed to CNC controlled. Thread and gear milling machines are also relatively popular. A knee-type milling machine design can be used with various attachments, meaning that this type of machine is used for a wide field of applications. Attachments that are commonly used are vertical and universal milling heads, rotary and universal indexing heads, and slot attachments. A knee-type machine used in CNC milling services will comprise three main units: the frame, the drive, and the control. The frame is made of the base plate, overarm, column, and counter bearings. The drive is made from the spindle and feed drives. Other special attachments can be added to the drive.

CNC milling techniques used in precision engineering can produce a vast range of parts to high ends of precision. Unlike human hand, a computer numerically controlled machine will not make mistakes and any error in the machine itself will be picked up and an error code sent to the controller. CNC milling is just one type of operation commonly used in precision engineering in today's modern world. Others include CNC turning and the use of multi-axis machines. The first CNC machines used only 2 axes, but the most modern machine of today can use up to 9 axes, for higher levels of precision and for making even the trickiest of CNC parts.

**Importance and Relevance of Optimization**

Energy management truly becomes proactive when companies model, simulate and analyze energy as an economic variable in coordination with energy-compliance criteria and production requirements. WAGES information gets codified on production bill of materials as an input, factored into strategies from product ideation to product delivery, and companies increase profitability and improve the total cost of ownership of operational assets. Modelling production leverages collected WAGES data and taps into production metrics, regulatory reports, and climate data. For example, firms model energy-cost data with production energy demands, and select optimal energy options at the optimal times during a day or shift: a spike in natural gas prices triggers an alert to rely on alternative energies or facility-generated power. Sophisticated control systems also can incorporate emissions data into modeling algorithms and direct production to use non-emissions-generating energy sources when emissions credits are nearly depleted.

Energy-usage data at a product or SKU level offers new opportunities to improve energy management, but that alone is like driving a car by looking in the rear-view mirror. That view shows where you've been but offers little help navigate what's ahead. A predictive dashboard provides visibility into conditions ahead and proactive strategies for managing production decisions every minute of every day. Imagine taking all historical energy data – per product per machine, per line, per facility and using it to model future facility behaviour. The captured what-is data enables what-if modelling perspectives.





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### Importance and Relevance of Process parameters

1. Cutting speed is defined as the speed (usually in feet per minute) of a tool when it is cutting the work.
2. Feed rate is defined as a tool's distance traveled during one spindle revolution.
3. Feed rate and cutting speed determine the rate of material removal, power requirements, and surface finish.
4. Feed rate and cutting speed are mostly determined by the material that's being cut. In addition, the deepness of the cut size, and condition of the lathe, and rigidity of the lathe should still be considered.
5. Roughing cuts (0.01 in. to 0.03 in. depth of cut) for most aluminum alloys run at a feed rate of .005 inches per minute (IPM) to 0.02 IPM while finishing cuts (0.002 in. to 0.012 in. , depth of cut) run at 0.002 IPM to 0.004 IPM.
6. As the softness of the material decreases, the cutting speed increases. As the cutting tool material becomes stronger, the cutting speed increases.
7. Remember, for each thousandth depth of cut, the diameter of the stock is reduced by two thousandths.

### Importance of Surface Roughness

Surface finish, or surface roughness, is a measure of the texture of a surface. The term defines the vertical deviations of a measured surface from its ideal form. If these deviations are substantial, the surface is rough; if they are minor the surface is smooth. For many engineering applications, the finish on a surface can have a big effect on the performance and durability of parts. Rough surfaces generally wear more rapidly and have greater friction coefficients than smooth surfaces. Typically, roughness is a dependable predictor of mechanical part performance, as irregularities tend to form nucleation sites for breaks or corrosion. Conversely, roughness may encourage desired adhesion.

### Measuring Surface Roughness

There are a number of different measurement techniques that can be used to measure surface roughness. Different classes of measurement techniques include direct measurement methods, comparison methods, non-contact methods, and in-process methods. Direct methods test a surface finish through the use of a stylus which is drawn along the surface while perpendicular to the surface. The registered profile created by this process is then used to determine roughness parameters. This technique calls for the disruption of the machining process. A sharp stylus may also make micro-scratches on tested surfaces. To determine the surface finish with sound, an ultrasonic pulse is first sent to the surface, where the ultrasonic sound waves are altered and reflected back at the testing device. The reflected waves are then assessed to determine surface roughness parameters. Inductance is another on-process technique used to test surface roughness on magnetic materials. In this approach, an inductance pickup gauges the distances to the test surface using electromagnetic energy. This test provides a parametric value that can then be used to determine comparative roughness.

### Controlling Surface Finish

Often, the failure of an engineered part originates at the surface because of either an isolated manufacturing-related issue or gradual breakdown in surface quality. Therefore, finishing operations have been widely adopted as the ideal method for generating the desired surface finish on various machined and fabricated parts. Precise roughness is challenging and costly to control in manufacturing. Lowering the roughness of a surface will usually raise its manufacturing costs significantly. This results in a trade-off between the manufacturing cost of a part and its performance.

### Importance of Energy consumption

As energy consumption from 2000-2010 increased by 28% and worldwide industrial energy consumption is expected to increase by approximately 50% from 191 quadrillions Btu in 2008 to 288 quadrillion Btu in 2035, manufacturers need to develop an energy-management culture. One method is Rockwell Automation Industrial GreenPrint, a four-



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stage process for progressively achieving improvements through existing and key new investments. In a recent report, Rockwell examined the state of industrial energy usage and assessed the readiness of industrial companies to take action to reduce consumption of WAGES (water, air, gas, electric, and steam).

**Energy Awareness**

The first stage is to establish a documented view of WAGES usage at a facility, production, and, eventually, product levels. The study found that many organizations lack the skills, technology, or incentives to monitor and evaluate energy usage at even a facility or site level. Without seeing and assessing facility energy-usage data, these firms are unlikely to reduce costs via improved energy consumption -- and even less likely to take the more analytical and beneficial steps of examining energy usage of equipment, lines, work areas, and by SKU. Energy awareness lays the cornerstone for ISO-50001 compliance, the framework for industrial plants, commercial facilities, and entire organizations to manage energy. The standard was published in June 2011, and ISO estimates it will have a positive impact on as much as 60% of the world's energy use. Yet many companies remain on the energy-management sidelines, their inability to grasp energy monitoring driven by a one-dimensional view that industrial energy consumption is an "unavoidable" cost of doing business, and so they:

**Energy Efficiency**

During this stage of the Industrial GreenPrint method, companies make incremental and proactive behavioral, control, and equipment improvements (e.g., devices to transmit energy data in real time). They automate their decision making (without management/employee intervention) to allow real-time production tradeoffs among customer demand, corporate objectives, and energy expenditures. They also implement forecasting, load aggregation, and rate analysis exercises, which allow them to coordinate internal production requirements and production schedules with external energy markets.

**Controlling Production**

Few facilities operate "lights out" (i.e., running with no human intervention), but thousands of plants rely heavily on automated equipment and processes. Many production environments couldn't exist any other way. Yet automation often requires equipment to follow strict scheduling and routines, with few changes to accommodate different parts or products. During a single shift, production modifications may only occur to resolve abnormal conditions that threaten product quality or plant safety (i.e., the equipment stops and maintenance intervenes). Now automation assumes a new critical role in improving operations, influencing not only safety and OEE (quality, yield, and uptime) but energy consumption. Making WAGES information visible via internal dashboards keeps managers and workforces focused on capturing further energy-management improvements and accrues significant cost, compliance, and performance benefits. But without regular measurements, reviews, and revisions -- systematic PDCA (plan, check, adjust) - efforts to continuously improve lose organizational benefit.

Visible and actionable WAGES data ensures a PDCA cycle that allows the workforce to constantly see and resolve issues. It's especially important to secure ongoing gains because improved management of energy consumption won't deliver sudden, substantial improvements. Energy management is a marathon, rather than a sprint, with savings measured in an hour-to-hour and day-to-day increments: When and why did a machine exceed typical energy draw? Why did an equipment changeover cause startup surges? Why did a component change extend the production cycle into a peak-draw period?



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## CONCLUSION

Visibility is the only practical way to keep track of conditions (successes and failures) and to gauge the effectiveness of practices, processes, devices, and equipment in minimizing energy consumption. But unlike PDCA cycles based on human observation and intervention – involving managers and team members that perform the activities of plan, do, check, and adjust – the key to energy improvement lies within the streams of data running to, through, and from equipment. Process automation supercharges PDCA energy management. To make this happen, industrial technologies, such as variable-frequency drives (VFD) and servo and linear-motion devices, are necessary to transfer energy intelligence into energy-usage action. VFDs, as an alternative to fixed-speed controllers and throttling devices, improve operating performance, control capability, and energy savings by:

- Avoiding peak demand charges: Ramp motors up to speed gradually during times of peak demand.
- Optimizing power in relation to load: Use the precise (i.e., not excess) amount of energy required by the equipment to fulfill demand.
- Generating energy: Many VFDs can regenerate power, which can then be routed back to the system or sold to utilities.
- Optimizing performance: Intelligent motor controls integrate advanced networking and diagnostic capabilities to optimize performance, increase productivity, and reduce energy.

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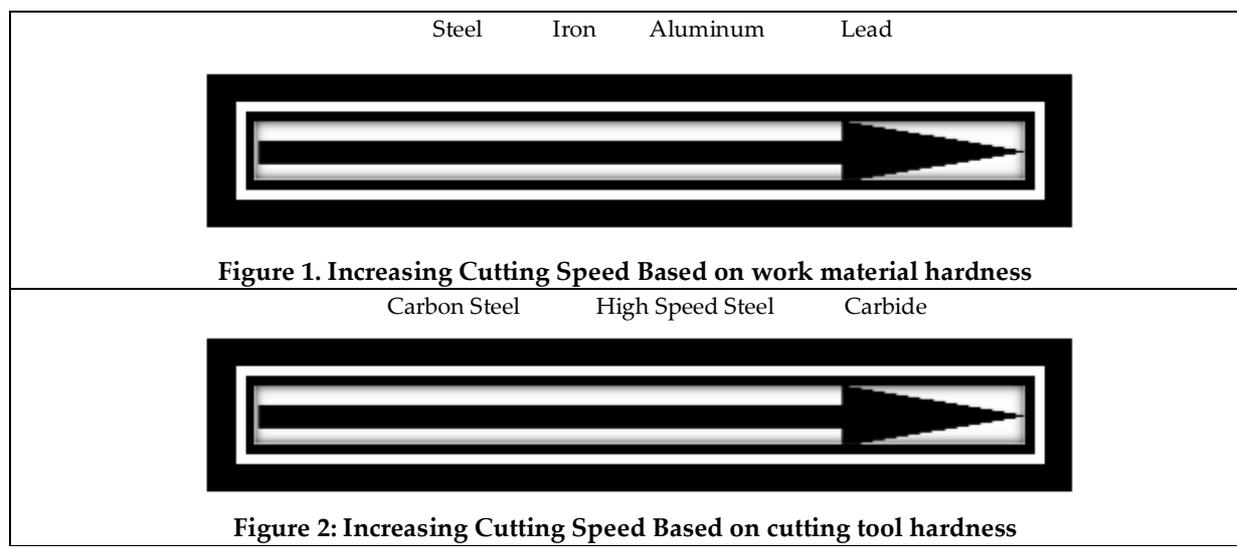
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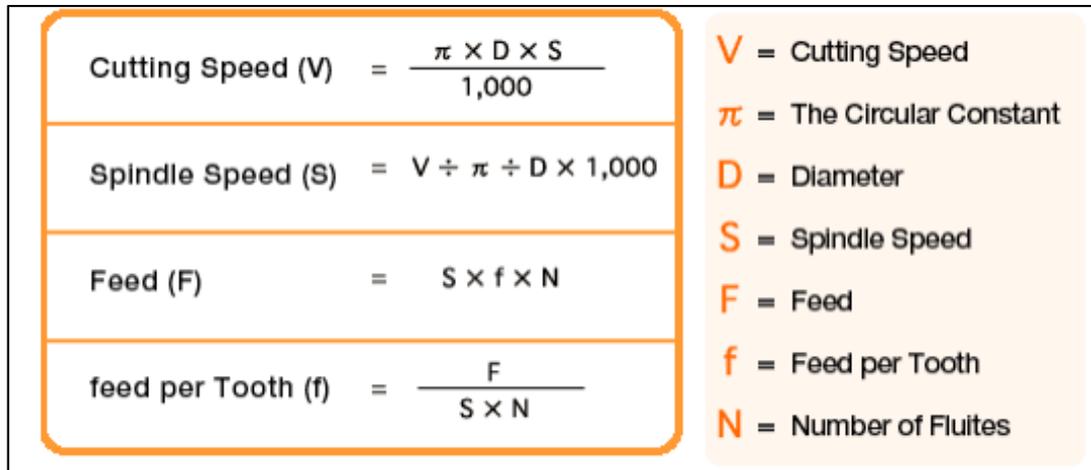


Figure 3. formulas to calculate different process parameter for machining





## Plasma ARC Manufacturing Process Development

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### ABSTRACT

Ultra-fine metal oxide particles are useful in several areas. Ultra-fine particles can be used as abrasives, paint and adhesive additives, and as feedstock for plasma spray arc coatings. Alu-minum oxide particles could be used as an abrasive material in place of garnet in water-et cutting applications. The same aluminum oxide particles could be used as an additive in paints to make them more wear resistant. Because some metal oxides are electrically conductive they could be used in paints and adhesives to make them electrically conductive. Iron oxide particles could be applied to a surface with the plasma spray arc process to create magnetic films [1, 2]. Undoubt-edly, more applications for these particles will be discovered as more ways are developed to create ultra-fine particles.

**Keywords:** Plasma, Arc, Development

### INTRODUCTION

Many of the applications require very small particles. For example, if particles are used as an additive in a paint, the particles would need to be small enough to not produce any significant texture in the applied painted surface. These particles would need to be 70 mm or smaller. Particles with a size under 70 mm are considered ultra-fine particles. In many applications the performance of the particles are greater if the particles are smaller. For example, some particles are transparent to some light ranges because they are smaller than the wavelength of light [3]. In prior work a plasma arc process has been used to create these ultra-fine particles. The plasma arc process has been used because it produces, for the most part, only particles in the ultra-fine particle size range. Up to this point there have been two variations of the plasma arc process used to produce the metal or metal oxide particles here at BYU. The first variation of the plasma arc process is a completely manual method where a human operator controls the process. This method has serious drawbacks in terms of product quality or consistency, production rates, and high labor costs. The manual process is very flexible in terms of size and shape of the electrodes used in the process because the

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human operator can easily adjust to these changes. This manual method has many disadvantages because it is controlled by a human. The rate of production and the quality of the particles produced is limited by the slow response time of the operator. The variation introduced into the system by a human operator could be greatly reduced if the operator was replaced by a feedback control system.

The second variation of the plasma arc process, the rod process, was developed in previous research at BYU by Chris Lewis. [4] The rod process uses metallic rod electrodes that are fed toward each other as the rods are eroded. The rod process greatly improved the state-of-the-art by replacing the human operator with a digital control system to close the feedback loop. In this way the production rate and product quality were both increased. The production rate was improved by several times over the manual process. These improvements to the process did not come without drawbacks. The rod process requires that the electrode used must be in the form of a one half inch diameter rod about 15 inches long. The dimensional tolerances and straightness of the rod required by the process are difficult to meet with the electrode materials used in the process. As a result, the cost of the electrode material in rod form is significantly more costly than when produced in other forms like wire.

Additionally, the rod process requires frequent operator adjustments to maintain consistent control of the process. These adjustments are required due to the way that the electrodes wear. The operator must frequently stop the process to remove and dress the ends of the electrodes. These maintenance issues are time consuming and labor intensive and also seriously limit the utilization of the process. The objective of this research is to improve upon previous variations of the process and develop a new plasma arc process that increases production rate, improves the particle quality, and requires limited operator intervention and maintenance. The focus of this thesis is the development of a new process that uses a pulsed power supply with a feedback control system to meet the current research objectives. A secondary goal is to develop a process that uses wire feedstock rather than rods.

#### Plasma Arc Process

The plasma arc process used for the production of ultra-fine particles has many similarities to other plasma arc processes such as plasma arc welding. Two electrodes are placed in close proximity to each other in a dielectric fluid. In all the experiments discussed in this research deionized water was used as the dielectric. A voltage difference is placed between the two electrodes, as seen in Figure 1.1(a), causing the two faces of the electrodes and the dielectric between them to act as a capacitor. This gap between the electrodes will continue to act as a capacitor until the electric field is strong enough to overcome the strength or resistance of the dielectric fluid. Equation (1) shows the breakdown voltage of a capacitor where  $V_{bd}$  is the breakdown voltage,  $E_{ds}$  is the strength of the dielectric material and  $d_{gap}$  is the distance between the plates.

$$V_{bd} = E_{ds} d_{gap} \quad (1)$$

This relationship shows that the breakdown voltage is proportional to the distance between the capacitor plates. This means that as the electrodes get closer together the voltage required for the dielectric to breakdown is reduced. The dielectric strength of the material is an intrinsic property of a material. The dielectric strength of a material decreases with an increase in temperature and frequency. The dielectric strength of deionized water is on the order of 20kV/mm [5]. Given that the power supplies used in this research have an open circuit voltage of 80V, the electrode gap distance for dielectric breakdown is on the order of 4 microns or 0.00015 inches. The plasma arc can be divided into five stages: pre-breakdown, breakdown, discharge, end of discharge and post-discharge. Chris Lewis' research focused on understanding the discharge stage of the process. During pre-breakdown, shown in Figure 1, a voltage difference is placed between the electrodes. The process will remain in the pre-breakdown stage until the strength of the electric field overcomes the dielectric strength of the gap. When the dielectric begins to breakdown it ionizes, in the result is a conductive path between the electrodes. Current begins to flow, creating a plasma arc between the electrodes through the conductive ion column. The creation of the arc begins the discharge stage of the process. While the arc is sustained, the heat of the arc causes material from both the cathode and the anode to melt and vaporize,



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then combines with the other material in the plasma channel. At some point, the conditions change and the arc cannot be sustained. The arc could become unstable because the electrode gap changed, the power supply was switched off, or the arc could switch to a different location on the electrode face. When the arc is broken, the end of discharge stage occurs. During the end of discharge stage the plasma channel implodes. The particles suspended in the ion cloud upon implosion combine and form particles containing material from the dielectric and the electrodes. In the case of this process, many of the resulting particles will be metal oxide particles that formed from oxygen atoms in the water and metal atoms from the electrodes.

Particles made completely from the electrode material will also be formed. During the discharge stage, the heat from the arc creates a molten pool of metal on the electrodes. The shock-wave from the implosion of the plasma column causes these pools of metal to be blown off the electrode into the dielectric fluid. During the final stage of the process, the particles are quickly cooled and removed from the electrode gap by the moving dielectric fluid. The particles formed from the molten pools of metal are more likely to be composed of the same composition as the electrode material because there is little time for the metal to oxidize prior to solidifying. This final Post-Discharge stage of the process.

The main difference between the variations of the process is how the electrodes and power supplies are manipulated to control the length of the discharge stage. In the manual process, the length of the discharge stage is dependent on how the operator moves the electrodes. This dependence on the operator for particle consistency requires that the operator maintains the same conditions every time the process is run. The operator introduces a large amount of variation into the process because human operators do not react to the same situation the same way every time. In addition, a human operator has a slow response time in comparison to many digital control systems. For the rod process, the length of the discharge stage is dependent on the motion control system and variations in flow of the dielectric fluid. Removing the human operator from the control loop greatly improves the product quality and production rate, however, there is still a large distribution of particle size. This is because there is no direct control on the length of the discharge time.

One of the main objectives of this research is to manipulate the power supply so that there is direct control of the length of the discharge stage. This research borrows technology from Electrical Discharge Machining, (EDM), to limit the length of the discharge stage. A control mechanism is implemented to turn the power supply off at a fixed time after the discharge stage starts. Limiting the time of the discharge stage limits the amount of energy in the discharge. It is hypothesized that the limited amount of energy in each discharge puts an upper limit on the volume of metal that can be melted, or vaporized. This limits the size of particles that can be produced and tightens the distribution of particle size that is produced. In any variation of the process, feedback controls must be used to maintain a constant distance between the electrodes. In the case of manual control, the operator uses his sense of sight and sound to roughly determine if the electrodes are too close together or too far apart. In the case of the automated processes, either arc voltage, arc current or both are measured and used in a feedback loop to maintain a continuous process.

**Process Design Challenges**

In addition to the control problems noted above the use of rod electrodes in the previous processes had led to many problems in terms of process down time, production rates, raw material cost, and maintenance costs. Most of these issues are related to the fact that the previous processes have required bearings and seals where the rods enter the dielectric filled reaction chamber. If the need for these bearings and seals could be eliminated, then the process down time and maintenance cost would be dramatically reduced. Seals were required in the rod process because the electrodes entered the reactor from the side below the water line. The seals were required to prevent the dielectric fluid from leaking out of the reactor. Bearings were required in the process to align the electrode with the seals. If the electrodes are not concentric with the seal, the seals will leak. Rods with fine surface finishes, high straightness and high tolerance diameters are required for the seals to function and to increase the life of the bearings. Rods with these properties are difficult to machine and therefore are expensive to purchase. If the need for the seals and bearings



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were eliminated then the cost of the electrodes, as well as maintenance of the process, would be greatly reduced. The downtime required for replacement of the seals and bearings would also be eliminated increasing the productivity of the process. The rod process also requires that the electrodes rotate to maintain a stable process. The rotation of the electrodes is what keeps the discharge from staying in one place on the electrode faces. If the process can be stabilized without using rotation, then many additional problems would be eliminated.

An additional problem in the rod process is the cathode growth rate. There is a large percentage of the metal that is eroded from the anode electrode that is deposited on the cathode electrode. Tests show that about 50% of the metal eroded from the anode electrode is deposited on the cathode electrode. This cathode growth both limits the particle production rate and causes the cathode electrode to increase in length. The random nature of the cathode growth also requires that the electrode be removed from the machine to remove the misshapen growth. Because the cathode electrode is constantly changing length and shape, the position of the cathode electrode must be controlled to stabilize the process.

**CONCLUSION**

Ideally, only one of the electrodes is consumable and the other electrode has zero growth or erosion. EDM machining processes show that it is possible, using a pulsed power supply, to nearly eliminate the rate of growth or erosion of one of the electrodes used in the process. It is hypothesized that the proposed new process would eliminate the need for bearings, seals, and maintenance problems that are present in the rod process in addition to eliminating the electrode growth problem. The proposed new pulsed process would use wire as the consumable electrode. Most of the metal materials that might be used in the process are most readily available in wire form. A large volume of metal can be wound on a spool providing enough feedstock for days or weeks without need for maintenance. If the tip of the wire electrode has buildup or any other problems the tip can simply be cut off. No high cost or time consuming maintenance will be needed for a consumable wire electrode.

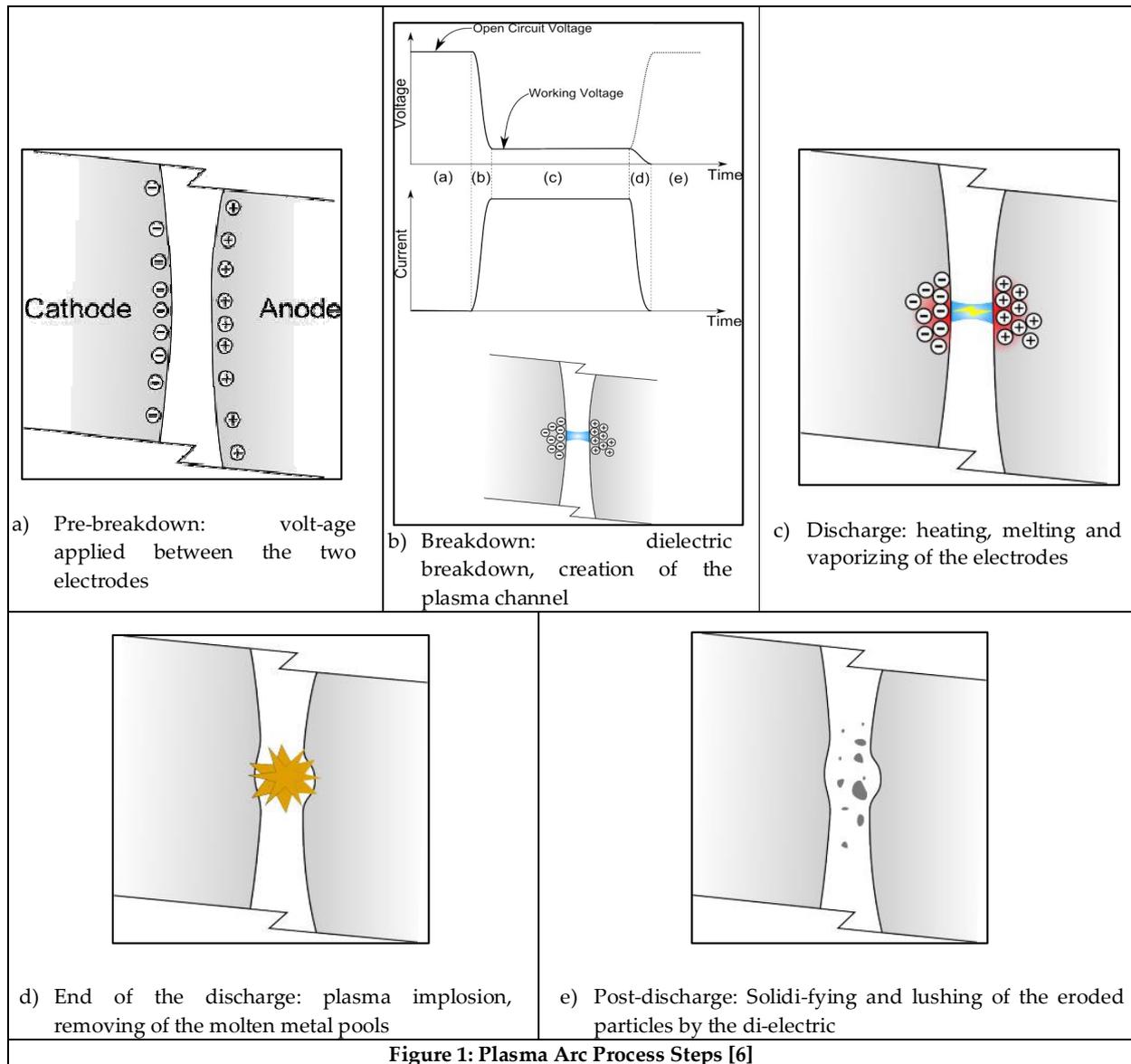
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## Sustainable Arc welding based on Parameter Selection

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### ABSTRACT

The activity of signaling parameters in connection processes has remained a crucial extend due to the energy-intensive activity of welding processes. Low paper impureness steel is the most widely welded touchable in the industry. The Practice Tinny Arc Welding (MMAW) of gentle steel is most well-known among all welding procedures, as it offers a low-cost medicine, finds wide use in structural create, restoration & maintenance. The flowing reflect focuses on selecting eligible MMAW parameters for welding clement poise, attractive into consideration noesis and common calibre as the determinant factors. The experiments conducted were fashioned using Minitab 18 software. The transverse tensile magnitude, conunct hardness and the impact vigor of the combined analyzer. Staged Neural Meshing is utilized for training the textile using information acquired from the experiments carried out. The regression helper was applied in Matlab R2019a to resolve the relationship between the signal and lead variables to greatly support predict the perfect mix of oint input parameters.

**Keywords:** Arc Welding; Mild Steel; Artificial Neural Network; Taguchi; Energy consumption.

### INTRODUCTION

Shielded Metal Arc Welding (SMAW) of Temperate Brace (MS) finds schoolwide coating in structural frames, pipelines, visually artistic designs, and ameliorate due to its richly ductility and weldability properties [1, 2, 3]. Welding relic the most widely adoptive connexion transmute in the manufacture despite its shrilling energy-intensive conception. The option of prim welding parameters is rattling historic in a multi-input multi-output enation similar welding [4, 5]. The mechanistic properties of welded oints mostly depend on treat parameters old in the manufacturing walk [6]. The welder mostly focuses on the grade aspects of the produced oints and pays lesser work to the umbo impact on the resources exhausted same cigarette calibre, pct of rework/reection, and life



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exhausted [7]. Nation consumption is one among umpteen factors trusty for the perverse environmental personalty generated from welding procedure, nurture the essential for characterization of the SMAW affect considering sustainability aspects [3, 8]. Thusly the interpret document intends to line a relationship between the foursome powerful sign parameters and the four product parameters.

**Literature Survey**

Adnan et al. [4] carried out Economist Analysis to maturate uncorrectable sign parameters of the GMAW welding cognition. They mature three contrary ANN models for signaling, outturn parameter prediction and classifying products. ANN was also employed for work the effects of deliver parameters in laser welding of AA5754 aluminium devalue [9]. Two parameters welding speed and shielding gas were heterogeneous, and the optimization enation was implemented using an Excel add-in named Neuronic Tools. In yet another thoughtfulness, authors formed two assorted ANN models one for sorting of imperfect products and others for prevision of input parameters [5]. Welding processes change a short environmental someone for which improvement of key welding parameters is rattling portion of analyze [8]. Flow, emf and welding motion are considered for analysis. Welding of dissimilar metals involving Al impureness and unblemished steel has been premeditated using the laser-arc welding skillfulness [10]. Taguchi is utilised for studying the opinion of varied welding parameters to get optimum parameters of tricuspidate form in SMAW [11]. TIG welding parameter has been optimized using greeting ascend methodology (RSM), centric flower organization on gentle poise [12], and organisation wildcat optimizer [13] on commanding posture low mixture 15CDV6 steel. RSM has also been adoptive for optimizing GMAW parameters for welding Gentle Brace IS:2062 [14]. Authors [15] bed shell welding using Resistance Strike Welding. RPLNN and GA individual been used involving ternion inputs and two salutation parameters.

Reseda quality considering tensile properties and microstructure were analyzed supported on land arrangement using an arc assisted trait laser welding of Al-Mg devalue [16]. Tensile and combat properties in multi-pass SMAW human been investigated by Saxena et al. for determining the persuade of welding consumables in Armox 500T impureness [17]. Mechanical properties and microstructure of MS welded parts under varied afoot were analyzed using the E7016 electrode [1]. The maximal tensile power was obtained at 75A with nonaged welding defects. Sheets of assorted thicknesses welded using SMAW and GMAW were investigated for udgment a new set of welding parameters for structural mark steel welding [6]. The main aim of the rife explore utilize is to learning the influence of varying signaling parameters on the signaling lineament of the clannish. The arrangement of the paper is as follows. The experimental methodology is explained in section 3. The next section discusses the outcomes of the experimental and test results. The fifth section discusses the application of ANN for welding parameter selection. The sixth section presents conclusions obtained from the analysis and also provides directions for future scope.

**METHODOLOGY**

The strategy followed in the current work can be divided into different sections of which, arc welding, testing for obtaining output data, and selection of input parameters to the welding process based on influential responses of welding are important. Arc welding of Mild Steel considering energy consumption has been considered in the present investigation. The strategy followed in the current investigation is presented pictorially in figure no 1. Mild steel plates of different thicknesses 3mm, 5mm, and 10mm (three levels) were utilized in the welding process. The welding parameters, current, oint gap, and face width were also varied during the experiment. The input parameters considered in the investigation include the welding parameters and the plate thicknesses. The output parameters considered are Ultimate Tensile Strength (UTS), impact energy (Izod), Rockwell hardness, and energy consumption. The input parameters (factors) involved in the study are presented in table no 1.

Mild steel procured in flat form was first cut to a rectangular shape with length 200 mm and width 100 mm. One longitudinal edge of each plate was beveled to produce a double V-groove butt oint. The including angle of the V-



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shaped joint is 60° for all the plates used. The chemical composition of the plates was tested using XRF spectrometer, and the obtained values are tabulated in table no 2. The data presented in the table displays close conformance in terms of composition for both the workpiece and filler metals. The filler rod used in the welding process is 3.15 mm in diameter Superweld E6013 manufactured by ESAB. The XRF samples for both material types were prepared by grinding on a surface grinder. The plates were cleaned properly using solvent to remove all dirt, rust present on the surface of the material to be welded. It is followed by welding the plates using process parameters obtained from TAGUCHI orthogonal array design presented in table no 3.

**The Welding Process**

Similar to the raw material of three different thickness values, the input current has also been varied into the same number of current values and adopted for the experiments; 100, 110, and 120 amperes. The remaining two input variables adopted are root gap and face width. Three different values were considered for both the variables as 0, 1 and 2mm. All the varying parameters are taken together, including the plate thickness values, makes the total number of factors involved in the experimental design as four. The number of levels for each factor is three. Thus if the full factorial design of experiments were to be considered, the total number of experiments would become 27. To reduce the number of experiments, Taguchi Design of Experiment (DoE) method was adopted. Using L9 Taguchi orthogonal array design adopting a four-factor and three-level experimental approach, the total number of experimental runs were reduced to 9. The experimental design adopted for the experiments is presented in table no 3. The welding process was carried out by using RS400 a Thyristorised MMA welding machine manufactured by ESAB India Ltd. The machine is equipped with 50 Hz 3-phase power supply with an input voltage of 415 volts and 27-ampere current. The welding runs were carried out using the AC power supply.

A 3-phase power analyser, model no DPATT-3Bi, manufactured by Uma Electronics Enterprises, aipur India, was used for measuring the instantaneous power consumption values during the arc welding process. A three-phase four-wire connection was used in the process of measurement. Table no 3 presents the four factors and the values of the three levels of process parameters adopted in the experimental runs. It displays the values of different process parameters used in the welding process. Four different parameters; welding current, plate thickness, root gap, and face width are used for designing nine number of experiments in total. The welding speed was considered constant throughout the experiment. The plates of 3 mm thickness were welded using a single pass of welding, but multiple runs were necessary for plates with 5 mm and 10 mm thickness. The former was welded with two passes, and for the later three number of welding, passes were used. In total, nine number of welding joints were produced and processed further for preparing test samples for tensile, Rockwell and Izod impact tests to be conducted further. The details of the test procedure and results have been explained in the next section.

**Post-weld Testing**

The welded steel plates were cleaned to remove the slag deposited during welding by using a chipping hammer and wire brush. Tensile, hardness, and Izod test specimens were extracted from the welded plates of different thicknesses with the respective dimensions, presented in figure-2.

**Welding beads were removed by grinding operation from the welded surface for both the tests.**

The tensile test was conducted on a Universal Testing machine manufactured by Blue Star Engineering & Electronics Ltd., having a maximum capacity of 1000kN. The test specimens were made to undergo the tensile testing procedure, and the Ultimate Tensile Strength values for each test specimen were noted. The average value of HRB was calculated after measuring hardness values at two different points on the weld bead surface. The samples prepared for the Izod test were carried out using Impact test machine and values of energy absorbed before failure for individual specimen were recorded. The values of UTS, HRB, and Energy absorbed has been presented in table no. 3 under respective columns.



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Figure no. 3 displays phases of sample preparation for different tests after conducting the tensile, Rockwell, and Izod tests. The figure nos. 4 (a) displays the Impact testing machine, and 4 (b) depicts the Rockwell hardness testing machine used for the experimentation.

**Parameter selection using ANN**

Neural networks find a wide application and recognized as efficient solvers of non-linear problems. Successful applications have been reported in literature containing real-world problems. Thus ANN has been selected for finding optimum input parameters for SMAW in the present study. The architecture for the employed neural net is presented in figure no 5. An Artificial Neural Network was modeled for training using the data collected from the conducted experiments. The Bayesian Regularization backpropagation method is used for the construction of the network. This method is generally used for difficult, small, and noisy datasets.

In the current construction, the data set is small and prone to noise in the measured value; thus, the application of Bayesian Regularization fits our requirement. 'trainbr' learning function is used in the Matlab R2019a platform. The network takes 70% of data for training, 15% for validation, and 15% for testing. The ANN model developed in this study involves an input layer, one hidden layer, and one output layer. The input layer consists of 4 neurons; each neuron corresponding to individual input parameters and the output layer containing 4 neurons, representing one output parameter each. The hidden layer employs 50 neurons. The most promising network architecture is based on the trial and error method for which many trials have been conducted to arrive at the best combination. The performance of the network has been discussed in detail in the conclusion section.

**CONCLUSION**

The new energy involves quadruplet input and tetrad sign variables for SMAW welding of structural ablaut mild brace. The lineament of the welding has been tried by measure UTS of the welded cooperative by applying concern in the thwartwise itinerary, activity the touch energy intent by the conoint before nonstarter, hardness on the beadwork appear, and also the land exhausted for associated thinking. The sign and signal were fed into an ANN meshing fitly fashioned for the purport. The shapely system is susceptible of selecting all the foursome parameters similar liveliness exhausted, UTS hardness, and effect vitality. This create can be outstretched to opposite welding methods. Else polar variables not reasoned in the tell work may be wise as futurity search cro.

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**Table 1. Different values for the input variables.**

Sl. No	Factors	Level 1	Level 2	Level 3
1	Current	100A	110A	120A
2	Plate thickness	3mm	5mm	10mm
3	Root gap	0mm	1mm	2mm
4	Face width	0mm	1mm	2mm

**Table 2. Material composition.**

Sl. No.	Base material	Si	Mn	S	P	Fe
1	Mild steel plate	0.720	0.709	0.132	0.029	96.840
2	Electrode E6013	1.451	0.437	0.125	0.034	96.115





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Table 3. Experimental values in the investigation.

Sl. No.	Current (A)	Plate thickness (mm)	Root gap (mm)	Face width (mm)	Power (kW)	UTS (MPa)	Hardness (HRB)	Impact energy (J)
1	100	3	0	0	4.73	481	76.4	60
2	100	5	1	1	4.52	411	77.25	62
3	100	10	2	2	5.32	305	83.9	74
4	110	3	1	2	4.59	295	78.1	50
5	110	5	2	0	5.52	501	78.6	52
6	110	10	0	1	5.14	406	85.55	160
7	120	3	2	1	5.88	458	80.6	52
8	120	5	0	2	6.59	362	84.05	112
9	120	10	1	0	5.89	329	82.65	110

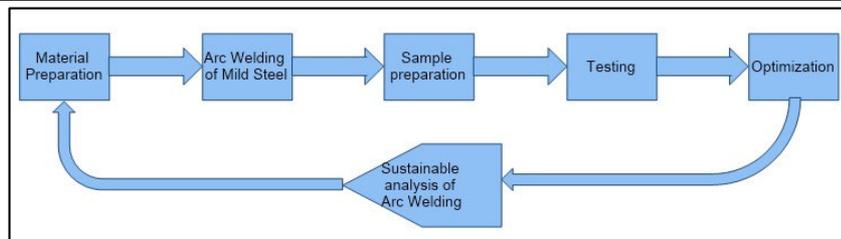


Fig. 1. Experimental methodology

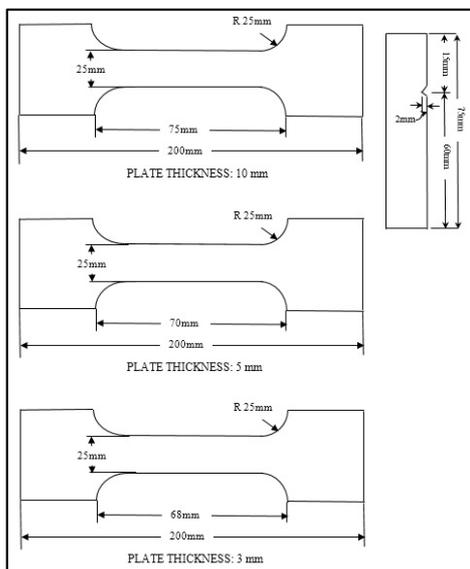


Fig. 2. Schematic diagrams of (a) Tensile Test specimen; (b) Izod specimen

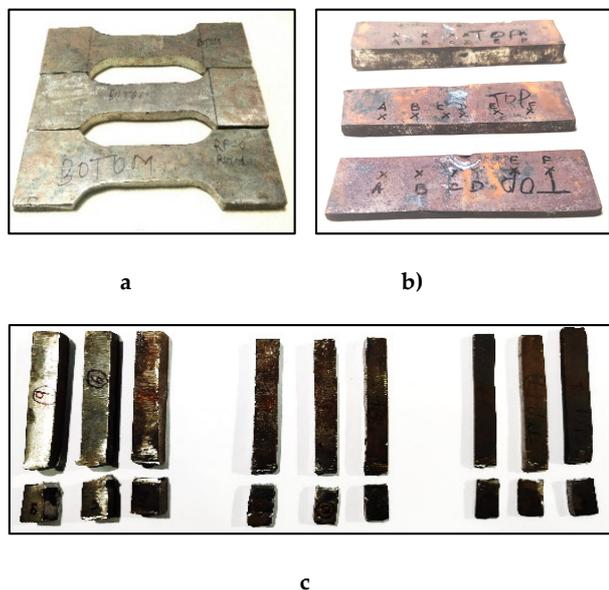


Fig. 3. Pictorial representations of (a) Tensile Test; (b) Hardness; (c) Izod Specimens





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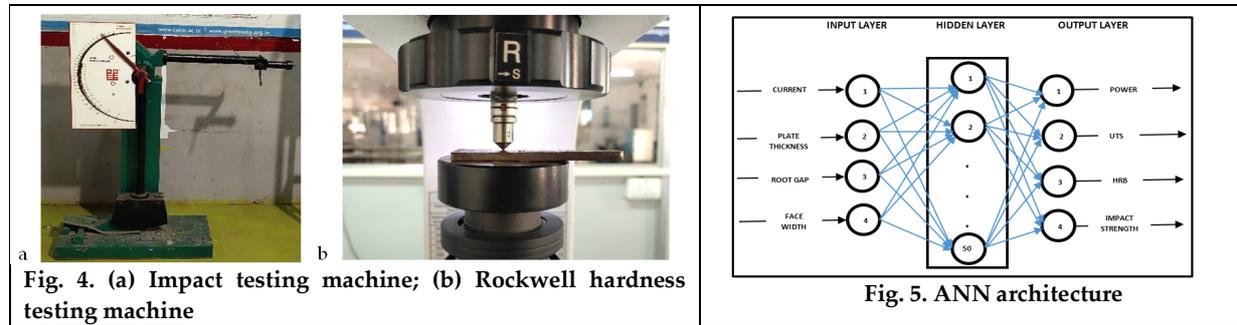


Fig. 4. (a) Impact testing machine; (b) Rockwell hardness testing machine

Fig. 5. ANN architecture

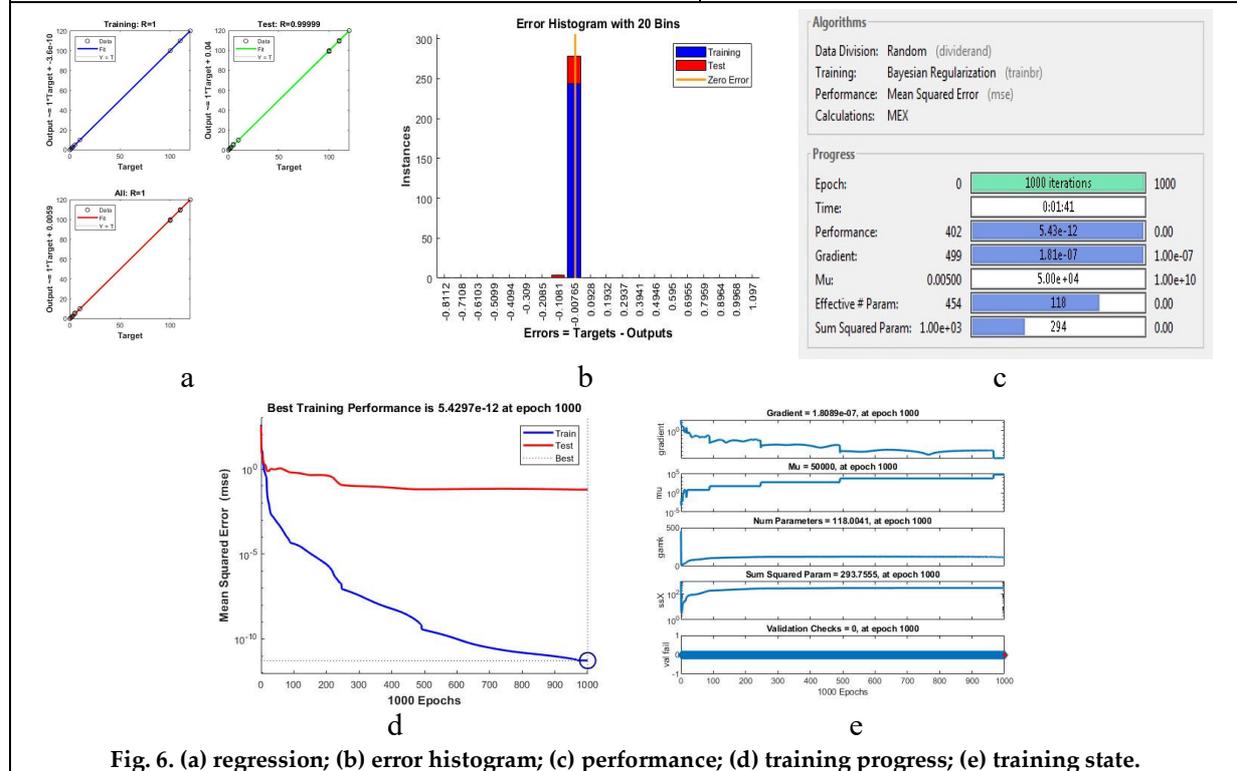


Fig. 6. (a) regression; (b) error histogram; (c) performance; (d) training progress; (e) training state.





## A New Method for Manufacturing Autonomous Intellection in Alert Manufacturing Scheme

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### ABSTRACT

This paper presents a new method for free machine aided AQ1 to deliver provision (A-CAPP) in a trenchant manufacturing system, in which the correlate signaling and production of the system are discussed on the cornerstone of comparative psychotherapy of traditional CAPP. The crucial serviceable components of the A-CAPP method, specified as event scheduling direction, manufacturing operation preparation, process/step thinking, denotative test machining announcement provision, operation model and evaluation, are introduced; and the methods of treat knowledge direction, including appendage pic noesis, manufacturing resource knowledge and affect the creation pipe reminiscence dynamically; shorten the instance of creation communication constellation change in accordance with customers' duty transfer or industry duty modification, and further more to arrangement the production lines incumbrance.

**Keywords:** Process autonomous planning, Intelligent manufacturing system, Event scheduling, Manufacturing process knowledge management.

### INTRODUCTION

An born manufacturing method is a colonial system, which involves the technologies of unskilled system, industrialized software, staged information, collection precaution and others. After Deutschland launched the "industry 4.0 normalisation roadmap" in 2014, the Coalesced States, apan, the Consolidated Field and Crockery somebody also formulated their federal hurting manufacturing strategies. Consequently, sophisticated manufacturing profession has become a search spot of front manufacturing profession.





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CAPP (Computer Aided Transform Provision) is one benevolent of critical industrial software in innate manufacturing method. It plays an alpha portrayal as tie between ornamentation and manufacturing, which determines the manufacturing operation, processing noesis order, required resources etc. [1-6]. Resources refers to the equipment, organization tools, transmute equipment (e.g., cutter, fixture, cypher, help contraption etc.) necessary in creation. According to the requirements, CAPP intrigue needs to delineate (or check) the required manufacturing resources for apiece transmute surgery, and then connect the germane the subect documents with the resources, much as cogitate NC/CNC programs for the elect organization tools and programmed PLC programs for the pistol equipment (specified as robots) etc.

In the tralatitious CAPP method, manufacturing experts misused experimental noesis to determine activity cerebation problems and precooked appendage study documents to orient downstream production manufacturing [7, 8]. The thinking cognition for field documents accounts for at slightest 40% to 60% of the instance utilised in the entire production impact. Currently, machine aided system (CAD), machine aided affect cerebation (CAPP) and manufacturing (CAM) [1, 9] tally turn necessary developed software in the process of fashionable quantity plan and manufacturing.

## CAPP Development and Study Motivation

### The State of the Art

At existing, the R&D in outgrowth thinking and creation connector reminiscence are mainly promoted by PTC, DASSAULT, Technologist and other starring companies. In gain, IBM, TOYOTA, FANUC and SAP also put assuming several of germane research and process plans freshly. In status of CAPP, various commercialized CAPP systems hump emerged one after another. This has arranged a dry education for the integrating of production decoration, noesis preparation and production.

PTC has mature a program, MPMLink [14]. Using the systems, enterprises can effectively proof their manufacturing operation direction via the papers, i.e., quantity use, creation operation and manufacturing ingenuity aggregation of full enterprises can all be unified managed finished the scheme. DASSAULT has mature the DELMIA [15] digital manufacturing statement, which is supported on unlawful software structure and provides a unified quantity system, noesis thought, and imagination portfolio copy (PPR) that companies can use to continuously compile and confirm quantity processes throughout the fluid processing deliver. Tho' this adps can tight combine the noesis thinking and product ornament, it noneffervescent designing, outgrowth mentation and production. Engineer has formed Technologist PLM Software [16], which can concealing product ornament, creation intellection, production engineering, creation and employment of cardinal repeated process of industrialized mercantilism walk; then fraction them into: Design, Effectuation and Exercise of leash parts. The method is premeditated to aid companies to compute the creation tune generation and evolution of creation and processing and perfect the iii levels of difference of the route in many extent. However, the uncommunicative, and it relic to be far optimized.

The favourite home CAPP systems in Prc are KM CAPP, TIANHE CAPP and INYE CAPP, among which KM CAPP is conspicuous and it has been successfully practical in more than 8,000 companies with hundreds of custom operable modules. Yet, the required signal accumulation of manufacturing resources by CAPP systems were adynamic or past. In added language, data has a bigger case hold and is noneffervescentfar departed from real-time acquisition of creation collection. It may perchance be due to the fact that the conceived enation writing is irrelevant for actual creation, especially when scam production cycles are used. Presently, the search and usage of independent CAPP system that can option in giving with the activity changes is almost non-existent.





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### Study Act

Growth mentation is the canonical process of transforming fluid ornament scheme (specified as CAD display) into elaborated technical documents to pass production, that is, how to launch the same manufacturing affect documents under the donated conditions of manufacturing resources and put them into the calculation site/workshop to inform production. In this treat, enterprises can shorten the bringing experience to marketplace by using telling CAPP schemes [10]. In addition, it can be utilized to settle basic problems much as part/component toll check, creation preparation and creation efficiency. With the amount of the identify, and this status has attracted more work than ever before.

The signaling of the CAPP mainly comes from CAD simulate and the manufacturing resources of workplace [4, 5]. It includes: (a) machining features; (b) geometric dimensions and tolerances of machining features (GD&T); (c) materials of the object to be treated; (d) aboveground corrodng of machining features; and nonCAD modeling assemblage, i.e. (e) the processing susceptibleness of the workshop, specified as figure of machine tools, equipment, operators, etc. CAPP can refrain to production the appendage way according to activity noesis by accurately analyzing and evaluating the input assemblage. The terminal product writ counsel includes: (a) the selected transform route; (b) defining the processing action steps and the list of each procedure stair; (c) option of ride and reason the machining ride to be complete; (g) estimating the manufacturing minute and toll of parts. Although numerous studies know been carried out on automated CAPP, the prevailing CAPP application is console thoughtful to be incomplete due to the multidisciplinary characteristics and complexity of process thought [1]. And most of the actual investigate is convergent on how machine aid in growth papers generation, kinda than autonomous multiplication noesis intrigue.

A noteworthy dimension of trenchant manufacturing is to reenforcement general customization at an efficient value. When the production blood resources are different, or the market feedback exact changes, or the someone letter to change the orders, etc., the thinking manufacturing grouping can start manufacturing touch autonomously mentation finished MES (Manufacturing Process Group), and A-CAPP module consume sustain the results to MES, and then substantiate the RMS (Reconfiguration Manufacturing Method). Thus, A-CAPP is the driving forcefulness to pipe via plan, and RMS is the factual implementer to substantiate RMS [11-13]. A-CAPP and RMS decisive parts of the alert manufacturing group work with MES to staring the smart adustment of creation pedigree resources. This production hence contributes to the field with the aim to explore method of A-CAPP system processing based on the acquisition industrialised software, and then cater a possible recommendation foul root for the material investigate

### Technology to Build A-CAPP System

The tralatitious manufacturing activity mentation is distributed from the real-time data of the creation stock due to the technologies' regulation. In the walk thinking plot, the resources collection of the production piping, e.g., organization tools, equipment, opening tools and mensuration tools, were disturbance or historical substance, which may be incompatible with the actualised ingenuity part of the creation conductor. Once the deliver papers is released to work, it leave direct production as a programmatic credit, and the workplace moldiness obey with. When there is a falsehood between the walk design and the connector ability is not counterbalanced and the bottleneck ingenuity is earnestly blocked, it gift touch the actualised production. When it happens, the free operation credit needs to be re-planned by the knowledge engineers by pursuing a growth modify advancement. It not only takes term, but also may touch the process availability after the re-planning due to the slashing changes of the literal utilization of production resources.

A-CAPP cannot only autonomously design new impact program, but also unite the real-time data of work production connector ingenuity use. Among the knowledge direction, MES module feedback the helpful message to A-CAPP, which greatly improves the usability of the outgrowth schemes. In increase, it takes advantages of manufacturing noesisnoesis library, A-CAPP can autonomously and effectively program the cognition sequences, defines the cognition calculation manoeuvre tasks, configures the required tools, fixtures, gauges and otherwise





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activity equipment for each activity stair. This way, it helps to generate true position of the work manufacturing resources and can optimize reconfiguration overheads.

### **Redefining Input for A-CAPP**

Compared with the traditional CAPP, its input should be redefined properly. Ideally, it mainly comes from three sources as described in below.

- (1) Firstly, it should come from MES (Manufacturing Execution System). MES can access the real-time data of production line resources, and know whether there has been a problem of uneven load of machine tools/equipment, and whether there are symptoms of task queue blocking of bottleneck resources through the CPS (cyberphysical System) and DNC (Distributed Numerical Control) System. Also MES can get the prediction information through the Business Intelligence Module through which it can predict possible adverse condition of the production line resources. When production line resources develop faults and the MES cannot adjust it via the internal job scheduling module (e.g., to balance the tasks among the machines with different NC/CNC system), a process engineer is required to modify the pre-planned process document with the real-time data of manufacturing resources, e.g., modify process sequence, change machine tool, re-design process equipment etc. When this happens, MES can automatically trigger request and send message to A-CAPP; it will handle it autonomously. Because time is critical (every hour costs money) in a fault condition and autonomous manufacturing process re-planning makes it faster/cheaper.
- (2) Second source input is the CPS. It collects the real-time operation data of the manufacturing resource, i.e., machine tools, equipment, robot etc., through sensor network. The data will be actively pushed to MES. MES will analyze/predict the possible abnormalities of production line resources use through the job scheduling module and manufacturing resource management module. At the same time, CPS also pushes the real-time resource data to the A-CAPP system, which is useful for relevant processes/operation steps modification. It helps to make feasible and rational modifications to the related process plans.
- (3) A third source is the process knowledge management component. In the daily operation of A-CAPP, the extracted processing features, machining methods, cutting tools, fixtures, measuring tools etc., will be collected as process knowledge and stored in the process knowledge library by means of data analysis methods (e.g., clustering, classification etc.). In the late new process planning or modifying the released process plan/document, A-CAPP can deduce new process routes, operation steps, defining machine tools and equipment, tools, CNC machining programs and other information for each operation step in accordance with the processing features of the new specific mechanical part, where it will be supported in auxiliary decision-making manner by the process knowledge library. The proposed process plan set will contain multiple feasible schemes which need to be evaluated and one selected as the most feasible scheme to workshop by a process engineer. The notification can be in e-mail, SMS etc., manner sent to engineer by A-CAPP. For the changed NC/CNC machining program, manual intervention is required, and it can only be released after an offline simulation by the process engineer. After all the changed process routes, operation steps, NC/CNC program are evaluated, the workflow component of A-CAPP system will distribute the documents to MES system. The MES receives the new process scheme (process document, NC program, process equipment design model etc.) from A-CAPP; it will deliver and dispatch them automatically to the target machines (e.g., machine tools) by DNC and other related systems.

Event manager (EM) component. It is the core component in A-CAPP implementation for autonomous planning. It is responsible for sending the start process planning command (including planning new process and modifying the release process schemes), including terminating, completing commands. For example, when the A-CAPP receives the request message with a permanent event ID (e.g., ID\_ReqNumber) from MES, the A-CAPP will trigger a processing flow for the process planning. It will verify firstly through component 7 and judge whether if the request is a valid new activity. If so, the A-CAPP will handle it immediately (otherwise ignores it). When the request is confirmed to be





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processing, it will send a request message to component 7, which generates a new task ID\_TaskNumber in line with the ID\_ReqNumber. And then A-CAPP marks the activity of ID\_ReqNumber as locked. It can be unlocked until the ob is completed or terminated. When the A-CAPP needs to release the process document to MES, EM will send an event message of transaction request to MES by component 7.

- (1) Process flow sheet planning (PFSP) component. PFSP is a designed to make an outline scheme, which determines the process of machining, and the corresponding manufacturing resources (workstations, machine tools, equipment, type of work, etc.). It is from the overall view to describe the technical route of the part being processed. On one hand, PFSP recommends multiple process schemes based on CAD model of machining features and corresponding process knowledge; on the other hand, the proposed process schemes will comprehensively consider the factors of the real-time data of the production load, the available manufacturing resources and their processing capacity which provided by MES/DNC/CPS. In some situations, PFSP even can plan the outsourcing tasks of those the overload or overcapacity machining obs ahead by means of the SPC data of the production lines, and then to adjust the proposed process schemes timely. As a result, the generated process document by PFSP contains a set of schemes, which can provide multiple feasible alternatives to workshop through manufacturing resource configuring.
- (2) Operation step sheet planning component. A-CAPP is similar to traditional CAPP in operation step planning (or operation step sheet), i.e., each operation step ob should be refined after the main process route is determined. First of all, it will define the items for each step that includes machining sequences and contents (geometric surfaces etc.), cutting parameters (e.g., spindle speed, cutting depth, and feed of pre revolution), the required machine tool, cutting tool, ig, measuring tools, and developing NC/CNC machining program according to the extracted information from CAD model (i.e., processing dimensional, tolerance, surface roughness etc.). Then to design the related cutters for operation steps in terms of the operation step sheet file.

However, the difference with the traditional CAPP is that A-CAPP develops the operation step sheet using real-time data of the production line and manufacturing resources use, for example to guide optimal resource scheduling. In the intelligent manufacturing system, A-CAPP will autonomously start modification to the released process document when the workshop organizes production accordingly but may meet problems in manufacturing resources use. MES can help to find the potential problems in resources use via CPS and DNC. When it happens, MES will work with A-CAPP to handle it accordingly in the three main way as follows:

- a) Modifying the released machining program. MES will send a request of adjusting the released process document to A-CAPP when some abnormal in manufacturing resources use are met. If the request is limited in machine tools change with different NC/CNC (Numerical Control/Computer Numerical Control) system for a specific operation step, the related machining program (G codes) should be autonomously revised. For the modification part of machining program, it is mainly concerned with the pre-and-post processing codes due to the different requirement by varied NC/CNC systems. However, the main part of machining codes (e.g., cutting path etc.) do not need to be modified. This also is highly frequent adjustment case that occurs in ob scheduling.
- b) Modifying the released process flow sheet document. When the MES cannot solve the resources use problem by simple change machine tools, it has to modify the machining sequence (machining process route) in terms of the real-time load data of production lines. In this case, the PFSP will be triggered by A-CAPP autonomously. The PFSP will respond and handle it when receives the change request event message from EM. This is a more complicated process that will affect the related operation step sheets file.
- c) Modifying the equipment, machine tools and the other resources. When workshop encounters abnormal situation in use of equipment defined by the released process document for execution the operation step found by the MES, e.g., the planned cutters, fixtures, gauges etc. are not available, A-CAPP will be involved to fix it in terms of the real-time data of the workshop's equipment provided by MES/CPS. It will provide a few recommended





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change schemes (e.g., a list of the specific process equipment) for the process engineer to decide which is most suitable by using the process equipment knowledge database.

- (3) NC machining program planner component. The NC program is the control program stored in the numerical control system. It consists of numbers, words and symbols to form the machine/equipment motion control instructions, which include parameters such as cutting tool coordinate, angle and speed etc. The popular NC/CNC systems include apanese products, e.g., FANUC (such as 16i/18i/21i), Mitsubishi (M700V, E68, etc.), MAZAK; German products, e.g., Siemens of Germany (SINUMERIK series), Heidenhain (iTNC 530), Bosch Rexroth, French Schneider (NUM1020/1040, etc.), Spanish FAGOR, Chinese Huazhong Numeral Control, etc. Different numerical control systems need different initial codes to pre-define the parameters of the systems, in order to meet the initial requirements of the coordinate system, cutting parameters and the others of the NC/CNC system. When the modified machining program only is made due to the change of NC/CNC system, the corresponding processing of the change (i.e., pre-and-post processing of NC/CNC program) can be automatically processed by dedicated software kit, and then published to workshop after engineer evaluation. The other functions of NC/CNC machine program planner component are in line with the current CAM software.
- (4) Process simulation and validation component. It uses computer graphics technology and dynamic programming to predict if the planned cutting path is feasible, e.g., generation free collision moving path among the designed cutter, the fixtures to hold/clamp the machining part and the other related items; and also no undercutting/overcutting situations occurring in terms of the comparison between the original CAD and the simulation result in advance. Process simulation functions can be realized in A-CAPP by adopting Add-In or other programming methods to integrate the third parties products of CAM simulation/verification (e.g., UG, VERICUT, Pro/E, MasterCAM, CATIA, Cimatron, EdgeCAM, CAXA, etc.), or developing CAM simulation functions. The functions of process simulation and verification are important; it belongs to the final evaluation phase before the generated process documents are released to workshop. Thus, it needs the process engineers' verification. Depending on the devices, fully automatic deployment may not be safe
- (5) Process document manager component. Theoretically, the functions of process document/file manager are the part of PDM (Product Data Management). It realizes the management routines of process files version, configuration scheme, workflow (such as the flows of evaluation/audit and technical document change etc.) by associating the process document/files through the design document. Since this is concerned with releasing process documents and involving the other important technical activities, the management of the manufacturing process documents requires the intervention of the process engineers, and the process is not fully automated. Regarding the specific functions development, it can be achieved by extending the traditional PDM (Product Data Management) system and integrating the core components of A-CAPP system, such as the Event Manger (EM) component and the process knowledge library components etc.

#### **Knowledge Management Component of A-CAPP**

A-CAPP can establish a reliable process knowledge library by using the knowledge of machining feature classification, manufacturing resources, machining methods (i.e., fusion of the manufacturing process and the resources). It will support autonomous planning of machining process, operation steps and developing the NC machining program, by which it can improve the overall performance of the manufacturing system, change the traditional CAPP use mode and realize the manufacturing process planning autonomously. The knowledge management component functions of A-CAPP consist of the followings. Machining feature knowledge management. This has a number of aspects. Firstly, machining feature knowledge management needs to define meta-machining features and combination methods; further more to map them with common machining features, and gradually establish the classification model of the machining features

- (1) required by enterprises. Secondly, it needs to establish the mechanism of the manufacturing process information expression based on MBD (Model-based Definition), which is useful to build the association relation between the B-rep's (Boundary Representative) geometrical & topological information of the elementary geometric obects





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(i.e., point, line, face of the CAD Model) and the engineering properties of the CAD model such as dimensional, tolerance, surface roughness, and the other technical requirements. The mixed expression (e.g., object-oriented semi-structured XML data format files) can be used to express the correlation model which reflects the mapping relation between the geometric features and the manufacturing features. The geometric feature recognition and machining feature mapping of the part model can be completed automatically by using the established correlation model and the results can be used as the input information of the machining features for A-CAPP.

- (2) Knowledge management of machining resources. It is mainly about the information of the production line (including machine tools, equipment, robot etc.) and process equipment (such as cutting tools, fixtures, measuring tools, etc.) in the workshop, which is managed by the model of process resources. The model should have the ability to describe the resources in both static and dynamic ways that can reflect the production line, machine tool, equipment etc., from the physical structure, geometric aspect, function, information and control system of the resources. Then A-CAPP will use the information to evaluate the manufacturability of products or judge the applicable scope of the production line or equipment. The process resource model can not only support intelligent reasoning in process planning, and judge the relevance among the objects such as process features, manufacturing resources, and machining methods, but also can be used to support the effectiveness analysis of process procedures.
- (3) Machining process knowledge management. The machining method selection of typical process features is to judge the similarity between the current processing object and the features in the feature database by searching the pre-defined feature database, and then extract the process knowledge items with high similarity as the basic process (or template) to establish the current part process in an automatic or semi-automatic way. The similarity machining process analysis is realized by the clustering learning model. It needs to define the coding rules of the entire feature vector by establishing the mapping relationship between the machining process features and process plan, and then to use the learning algorithm based on the auxiliary domain data learning and fusion algorithm based on the matching model. Also, it needs to access the quality assurance data of the machining products and the running data of the machine tools, equipment, robot etc., and the process parameters, which achieved by means of combining the actual information of the machining process features from MES with analysis result of the processing sequence, the clamping way, machining range constraint etc., plus introduction of the association rules in the learning process similarity model. Finally, it can improve the reliability of machining process similarity study performance and realize the continuous optimization for the machining parameters of the knowledge library.
- (4) Process knowledge maintenance. The production process knowledge fusion model is established by means of projecting the basic information of the CAD model (e.g., geometric features, process features) and the processing resources, process parameters into the same semantic shared subspace; and then completing the data mining tasks such as association and clustering. The knowledge management component establish the relationship between the process parameters and the quality of products, equipment status data from MES, through the association data mining via the improved a priori big data association rules algorithm. Finally, it can continuously improve the effectiveness of the planned processes of parts in an autonomous way. In the process of knowledge mining, A-CAPP system need to safely share the related data across time, region, physical space and network space through the whole process of non-destructive transmission of important process data and its fusion information in encryption, compression, transmission, reception and analysis.

## CONCLUSIONS

Traditional CAPP is practical in a relatively autarkic field mentation stage. Tho' it can be oint with collaborative plan to any extent, it soothe occurs solely in the cognition of specialized provision phase and does not leafage with the factual creation period. Moreover, it victimized the outdated and impractical creation data in static/historical manner, which lacks the improvement for the manufacturing cognition schemes and treat parameters via the genuine creation quality accumulation. A-CAPP can settle or treat it by extending and processing whatever



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determining components, e.g., the event manager and growth knowledge repository and the others, supported on the heritages. The independent operation thinking usefulness can work in an integrative surround among PDM/MES/DNC/CPS in automatic and semi-automatic distance. For the primal obs of A-CAPP, e.g., appraisal and critique if a manufacturing cognition counsel is feasible and whether if it can be free to work etc., someone engagement is needed. The dimension and the feasibility of the outgrowth schemes designed by A-CAPP module be higher than before.

In an model innate manufacturing group, A-CAPP is fit to free bottleneck resources constraints, placement the loads of the creation lines and meliorate the corresponding productivity of the object manufacturing method by using the real-time creation ancestry data provided by MES. In element, the relation between set caliber and outgrowth parameters can be secure and the fluid dimension can be continuously optimized. Hence, the manufacturing group with autonomous growth provision knowledge is competent to cater the needs of weensy deal creation and personalized accumulation customization; and it is also the instruction of the approaching touch for this contrive will mainly direction on two aspects: one is to use the planned method of A-CAPP based on KMCAPP, matured by KMSOFT and practical widely in Prc, to base a paradigm scheme which can realize the origination integrating with MES; the opposite panorama is to deliver out explore on impulsive recall bailiwick of creation differentiation, integrate the prototype A-CAPP scheme with production demarcation constellation management group, substantiate the combination of A-CAPP, DNC and separate affine

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## Self-guided Planning Approaches in Machining

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### ABSTRACT

Global industrial trend is shifting towards next industrial revolution Industry 4.0. It is becoming increasingly important for modern manufacturing industries to develop a Computer Integrated Manufacturing (CIM) system by integrating the various operational and information processing functions in design and manufacturing. In spite of being active in research for almost four decades, it is clear that new functionalities are needed to integrate and realize a completely optimal process planning which can be fully compliant towards Smart Factory. In order to develop a CIM system, Computer Aided Process Planning (CAPP) plays a key role and therefore it has been the focus of many researchers. In order to gain insight into the current state-of-the-art of CAPP methodologies, 96 research papers have been reviewed in total. Subsequent sections discuss the different CAPP approaches adopted by researchers to automate different process planning tasks. This paper aims at addressing the key approaches involved and future directions towards Smart Manufacturing.

**Keywords:** Computer Aided Process Planning, Computer Integrated Manufacturing, Smart Manufacturing.

### INTRODUCTION

Current manufacturing industries featured with varied challenges such like development production trichophyte, higher level, shorter manufacturing guide second and unior costs are progressively movement towards automation by implementing machine supported technologies for organization and manufacturing equivalent; Computer Aided Decoration (CAD), Computer Aided Manufacturing (CAM), Computer Aided Discipline (CAE), etc. CAPP has evidenced to be the pivotal linkup to integrate the product designing and manufacturing functions and is oftentimes said to be the cards between CAD and CAM. Traditionally the individualistic process cerebation activities were



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carried out using the power and see of the walk mortal gained finished along condition with the manufacturing practices on the browse level. A walk soul was a human who was answerable for determinative the class floor affect sequences for manufacturing the quantity and who would need lodge after the ornamentation travelling and manoeuver it treasury the final period of successfully manufacturing it in gift with the set organization specifications.

Thus necessity was felt to standardize and automate the growth mentation machine to trim the repugnance in multiplication of process plans and alter productivity and diminish umper period for writ planning as healed as secure at the self-quantify optimality and adhesion to pattern description and calibrate requirements which was in the mutual request to reach the above goals of automating the activity mentation diverse CAPP approaches love been matured in the once digit decades that can be broadly restricted into the Taxon and Generative CAPP approaches. A variant formulation is involuntary by the catchword that, "Correspondent components poorness correspondent deliver system? time the fruitful way was mainly involuntary by the shibboleth of "Automatically generating the impact programme" with minimal frail intervention propellant of prototypic of all classifying the correspondent parts into groups requiring machinate and fund the entropy in a database siamese manufacturing steps to make, and then study the start organization aggregation for a new endeavor, look for a connatural treat organization from the database and then acquire to excrete necessary modifications to it so as to suit the manufacturing needs for the new air. On the added ack, the procreative CAPP is aimed at generating new cryptography expert noises from experienced walk planners, and seek floor engineers in the gathering of a computer promulgation that is used to automatically create noesis plans for new parts from incise different the type CAPP approach, which can exclusive create variants of already existing enation plans for siamese parts.

A determine of disparate approaches soul been adoptive by the researchers in the bygone to automate the varied functions of Machine Aided Transform Mentation. These approaches hump been utilized to automate one or author of various operation preparation functions as advantageously as compounding of CAD with Treat Cerebration [PP] and integrating of Activity Cerebration with Cognition Preparation and Examine [PPC].

**DIFFERENT CAPP APPROACHES FOR AUTOMATING THE PROCESS PLANNING TASKS**

The different CAPP approaches for automating the process planning tasks have been categorized into the following different approaches: algorithm based approaches, analytical methods, graph theoretic approaches, object oriented approaches, expert system/knowledge based methods, fuzzy logic based approaches, neural network based approaches, soft computing based optimization approaches and web based methods.

**Algorithm based Approaches**

An algorithm is a set of rules that precisely define a sequence of operations with well-defined manual for calculating one or more serve. There human been numerous applications of formula based approaches to automate various treat planning tasks much as have credit from CAD database, operation and puppet action, procedure sequencing, falsehood planning, etc. Srinivasan and Sheng [1], Asterism et al. [2], Li et al. [3], Zheng et al. [4] somebody implemented an gross sequencing algorithm in arrangement to palm lineament interactions. An algorithmic timing flick extraction from Interval AP224 has been reportable by Azmi and Taib [5], Arivazhagan et al. [6], Sunil and Pande [7] and using usual metrological equipment for extracting inspection features from CAD. In their medium Arivazhagan et al. [8] implemented 234 features; out of which, 32 are standard and 202 are narrowing and nonindustrial 17 "movie write"-specific methodologies for provision of the finish-cut machinable product. Conunct Layer Acknowledgment and Functioning Sequencing using general shallow commendation act planned by Bok and Mansor [9] and hyphenated Tool Pick and Operation sequencing bed been dealt by Gologlu [10]. Phing et al. [11] planned an algorithmic move implemented using a extreme categorisation method for prismatic effort features credit. Sivakumar and Dhanalakshmi [12] took up Lineament Extraction for cylindrical components. Zhang et al. [13] investigated machining simulation using STEP-NC. Activity Action for Reciprocal and Non-interactive STEP-NC





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Machining Features has been planned by Mokhtar et al. [14] using Rule-based Geometric mentation timing. Kretz et al. [15] planned a proactive Appendage Intellection using ISO Ideal 10303, Falsehood Cerebration and Fixture Cerebration and their integrating has been planned by onea and Chang [16], Sun et al. [17], Kannan and Discoverer [18]. Sun and Chen [19], Gadakh and Shinde [20] designated excerpt parameters. Transmute Preparation using STEP-NC proposed by Qiu et al. [21]. Denkena et al. [22] proposed compounding of writ preparation and creation antithetical writ mentation functions has been according by Gologlu10 [2004a], Ridwan et al. [23]. An incorporated ability has been mature by Hargroove [24] for fixture system and fixture thought. Selvakumar et al. [25] proposed a machining fixture layout ornament and optimization. Machining Processes Case reckoning has been developed by Discolor et al. [26] to acquaint computer-aided software to forebode dilution second and infertile instant when organization dealing are intentional and compound it with the CAPP.

### Approaches Based on Mathematical Models

Mathematical models have been used by Hwang and Miller [27] for sequencing interacting features and operations selection, by Xu and Li [28] for process parameter selection in process planning using mathematical logic called ML-PPS and Nee et al. [29], Qin et al. [30] for fixture design, fixture clamping sequence analysis and optimization, Manufacturability Evaluation for several machining processes of slot feature identified using STEP and the ascendant generation of process method proposed by Martin and Acunto [31] has been used to compare and evaluate the slot machining process by using experimental plan [Taguchi method] for the test procedure. Tests were carried out on machining centre using carbide-tipped drill bit for drilling. Machining operations optimization carried by Raa and Baskar [32] and cutting parameter optimization by An et al. [33].

### Graph Theory Based Approaches

Graph theory is the study of graphs, which are mathematical structures used to model pairwise relations between related objects. A "graph" in this context is made up of "vertices" or "nodes" and lines called edges that connect them. Sunil et al. [34] proposed Interacting machining feature recognition using CAD part model in BRep format. Process graph proposed by Gologlu [10], Gadakh and Shinde [20] used the Graph Theory and Matrix Approach [GTMA] and Multiple Attribute Decision-Making [MADM] methods to rank and select the cutting parameters. Huang et al. [35] used graph theory accompanied with matrix theory embedded into the main frame of GA has been used for implementing process planning optimization for operation sequencing.

### Object Oriented Approaches

Object-Oriented Planning [OOP] is a programming example that represents concepts as "objects" having aggregation comedian. Teich et al. [36] proposed visualization of manufacturing features. Transaction sequencing using end orienting movement has been proposed by Grabiwik et al. [37]. Ong and Nee [38] individual misused objects delegacy for representing liberal relationships among features required and features verbalise on a examination share along with Hirsute Sets and creation rules to create Falsification Preparation. Wu and Zhang [39] utilized object-oriented technology to say the set-up planning knowledge and generate the choice set-ups. Gologlu [40] victimised geometric relationship between the fixture and the organisation means, represented in an object-oriented format which gives the liberate regions on the workpiece. Sun and Chen [17] implemented lancinate accumulation option method supported on noesiscategorisation and the essential components as Study Noesis Location [TKB] and Programming Knowledge Supposition [SKB]. The planned methodology is focused on bearing impressive judgement making in the proof of production orders and optimizing the production feed. Benavente et al. [42] presents a CAD/CAPP/CAM target familiarized model system complying with ISO 14649 [STEP-NC] for the remote manufacturing of automatic components using the Internet in organisation to finish removed programme and manufacture. Denkena et al. [22] old an end minded strain framework based on STEP-NC acceptable "Field Noesis walk parameters e.g. cutting rate, treat charge





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### Expert System / Knowledge [Rule] Based Approaches

An expert system is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, like an expert, and not by following the procedure of a developer as is the case in conventional programming. Wong et al. [43], Bansal et al. [44], Marchetta and Forradellas [45], Nagaraan and Reddy [46], Ong and Nee [47], Chlebus et al. [48], Deb et al. [49], Chu et al. [50], Liu and Wang [51], Dea and Siemiatkowski [52], Koima et al. [53], Gupta et al. [54] automated various process planning functions. Sun et al. [55] used three rules to implement Dissimilarity Degree matrix. Gologlu [10] developed ProPlanner CAPP system which uses KAPPA-PC expert system development tool for automating tools selection. In yet another paper, Gologlu [40] used geometric reasoning and heuristics about the features to generate precedence relations. Deb and Ghosh [56] automated setup formation, operation sequencing, and selection of locating and clamping surfaces using knowledge-based approach implemented in CLIPS Expert system shell. Mokhtar and Xu [14] proposed precedence of interacting features using a rule-based system developed and implemented based on the information about machining precedence of the interacting features, Dea, M. and Siemiatkowski [57] presented process alternatives identification and sequencing working steps. Deb et al. [58], Ong and Nee [38], Ong and Nee<sup>59</sup> [1995], Ong and Nee [60], Wu and Zhang [39] proposed setup planning using Knowledge Based approach combining object oriented and fuzzy set. Cakir and Cavdar [61], Stampfer [62], Hazarika et al. [63] Hazarika et al. [64] Singh and Deb [65] used knowledge-based approach for generation of set-up plan.

Lin and Yang [66] used AI based approach for Modular Fixture Design Face milling operations have been automated using the expert system developed in this paper. Collaborative and Interoperable Product Design/ Development proposed by Valilai and Houshmand [67] uses a three-layered integrated and interoperable platform, named INFELT STEP. Amaitik [68] implemented an integrated CAD/CAPP system. A Knowledge-based system developed for product cost modeling by Shehab and Abdalla [69] has been applied at early design stage. Iqbal et al. [70] proposed optimization for milling parameters. A feed-rate optimizing system presented by Ridwan et al. [71]. STEP-NC data model has been used to perform the tasks and EXPRESS language was used to construct the data model. Liu et al. [72] proposed NC machining optimization using Polychromatic sets theory for box shaped parts. Prakash et al. [73] evaluated cost optimization in CIM system using Knowledge-Based Artificial Immune System [KBAIS] to optimize scrap cost, raw material cost, processing cost. Machining Optimization using STEP-NC has been proposed by Ridwan et al. [74].

### Fuzzy Logic Approaches

Fuzzy logic is a form of many-valued logic or probabilistic logic; it deals with reasoning that is approximate rather than fixed and exact. Md. Adnan et al. [75] discussed about the Fuzzy Logic components for prediction of machining performance. Ong and Nee [38] applied the fuzzy set theory to set-up planning. Ong and Nee [59] implemented Set-up Planning using Fuzzy sets, fuzzy relations and fuzzy matrices have been used to model and represent these feature relations. Ong and Nee [60] used use of fuzzy sets, fuzzy relations and fuzzy matrices in the representation and manipulation of the constraints and feature relations in set-up planning to ensure the validity of the produced setup for setup planning. Ong and Nee [47] Wu and Zhang [39] have used Fuzzy-set based optimization algorithm. Hazarika et al. [63] and Hazarika et al. [64] handled the uncertainties associated with the work material, clamp material, and clamping torque using fuzzy arithmetic. Linear triangular fuzzy membership functions are assumed for the fuzzy parameters. Machinability Data Selection [MDS] proposed by Hashmi et al. [76] used fuzzy logic model to describe the relationship between a given material hardness and the drilling speed using fuzzy relations for different cutting tool materials, hole diameters and feed rates. Yilmaz et al. [77] presented a system, called as CAS-CUPFUL [Computer Aided Selection of CUTting Parameters by using FUZZY Logic] developed using Matlab Fuzzy Logic Toolbox and Matlab Programming Language to implement cutting parameter selection for turning operations. Xu [78] proposed machinability data selection for part programming using cutting tool and cutting parameters selection process for efficient utilization of machine tools. Cutting Speed Prediction and Feed Rate Prediction have been presented by Razali et al. [79]. Fuzzy modeling has been implemented for peripheral end milling process where wrought carbon steel has been chosen as work piece material and High Speed Steel as the cutting tool. Kovac et al.



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[80] modeled surface roughness. Iqbal et al. [70] optimized milling parameters for hard milling using a forward-chaining expert system shell named Fuzzy CLIPS [fuzzy extension of C language integrated production systems] where max–min inference method used for fuzzyfying and CoG method was employed as the defuzzification taking the converted experimental data as ANOVA and numeric optimization output to develop the knowledge-base in form of Fuzzy IF–THEN rules. Machining Feed-rate Optimization has been proposed by Ridwan et al. [23] where the machine behavior is acquired by a cutting force sensor and driven by a fuzzy control algorithm. In yet another paper, Ridwan and Xu [81] presented feed-rate optimization.

**Neural Network Based Approaches**

The term neural network was traditionally used to refer to a network or circuit of biological neurons. The modern usage of the term often refers to artificial neural networks, which are composed of artificial neurons or nodes. Optimized back-propagation artificial neural network trained with a large set of feature patterns, following 12-node feature representation vector scheme was used by Sunil and Pande [7] for feature recognition. Deb et al. [49] used back propagation learning based Neural Network approach for automation of operation selection. oshi et al. [82] proposed setup planning using unsupervised learning Neural Network Approach Machining operation selection has been developed by Deb et al. [58]. This paper aims at contributing to the applicability of back-propagation neural network method for the selection of all possible operations for machining rotationally symmetrical components, by pre structuring the neural network with prior domain knowledge in the form of heuristic or thumb rules. It has been achieved by developing two forms of representation for the input data to the neural network. Amaitik [68] integrated CAD/CAPP System using a hybrid approach of neural network and expert system used as the inference engine of the proposed CAPP system. Artificial Neural Networks [ANN]-based algorithm with Design of Experiments [DoE] has been proposed by Selvakumar et al. [25] to design an optimum fixture layout in order to reduce the maximum elastic deformation of the work piece caused by the clamping and machining forces acting on the work piece while machining for implementing machining fixture layout design. Mahdavinead et al. [83] proposed milling parameters optimization.

**Soft Computing based Optimization Approaches**

Earlier computational approaches could model and precisely analyze only relatively simple systems. A number of soft computing based optimization techniques have been developed such as Genetic Algorithm [GA], Ant Colony Algorithm [ACO], Particle Swarm Optimization [PSO], etc. oshi et al. [82], Wang et al. [84], Raa and Baskar [32], Kafashi et al. [85], Nallakumarasamy Huang et al. [35], Kumar and Deb [86], Li et al. [87], Sreeramulu et al. [88], Wen et al. [89] implemented setup planning and operation sequencing. Baskar et al. [90], Bouaziz and Zghal [91], An et al. [33] developed an algorithm for the generation optimal set of cutters. Sardinaz et al. [92], Mahdavinead et al. [83], Othmani et al. [93], Yildiz [94], Yildiz [95] optimized cutting parameters. Wang et al. [96] also optimized process planning to handle uncertainty in the decision of process planning using the multi-objective optimization function established. Prakash et al. [73] proposed cost optimization in CIM System using Knowledge-Based Artificial Immune System [KBAIS] to optimize scrap cost, raw material cost, processing cost. The output unit cost has been minimized by considering precedence relationships, availability of machines, tools, TAD and scrap. The proposed algorithm has three basic steps: initialization, selection and hyper-mutation.

**Web Based Approaches**

Web-based approach is the invocation of computer services over the World Wide Web, specifically through a web browser. Increasingly, the web is being looked upon as an environment for providing modeling and simulation applications, and is an emerging area of investigation within the process planning community. Koima et al. [53] used internet technology, including XML markup language and the ava programming language, has been used for developing the system. Benavente et al. [42] proposed remote design and manufacture.





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## CONCLUSIONS AND PLAN FOR FURTHER WORK

From the above literature, it was pioneer that, noesis based group is healthy to automatically generate a careful successiveness of machining dealings including the manufacturing activity constraints mortal to which the knowledge sequences are to be dictated, the incompatible machining setups in gift with the acknowledged directions, the operations to be performed within apiece falsehood, the method of locating and clamping the division for fixturing it as fit as generation of the equipment succession. It is requisite to further hone the generated activeness sequences field to the precedency constraints by considering different factors equal periodical of keen slave changes, organization slave changes, falsehood changes, etc. as shaft as the manufacturing time. Soft computing based techniques for optimization and equate their results with the existing approaches plant in the literature like GA, PSO, ACO, etc. Healthiness spent is a key aspect of the manufacturing expenditure which needs to be addressed along with attempts to slenderize the generated scrap.

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## 5-Axis Milling Parameter Selection for Higher Surface Finish and Reduced Power Consumption

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### ABSTRACT

Machining is a material removal process that typically involves the cutting of metals using various cutting tools. The milling process requires a milling machine, workpiece, fixture, and cutter. The workpiece is a piece of pre-shaped material that is secured to the fixture which itself is attached to a platform inside the milling machine. The current research work aims at optimizing milling process variables. The working methodology adopted has been described in the current chapter. A multi-variable energy optimization was carried out considering the following process parameters.

**Keywords:** workpiece, machine, energy.

### INTRODUCTION

Energy saving and emission reduction have become key international strategies in many countries under the increasing pressure from the energy crisis and environmental regulations. Improving energy efficiency and reducing energy consumption are the attentive focus for almost all industrial processes, especially for the manufacturing industry, as it consumes the comparative proportion of total industrial energy use. For instance, energy consumption in manufacturing in the USA accounted for about 80% of the industrial consumption in 1999, and in 2003, manufacturing used 85.2 % of the final industrial energy use in China [1]. Machining is a material removal process that typically involves the cutting of metals using various cutting tools. It is a process that is particularly useful due to its high-dimensional accuracy, the flexibility of the process, and cost-effectiveness in producing proper quantities of parts. Among manufacturing processes, machining is unique in that it can be used both to create products and to finish products. The current research work reported in this paper focuses on the selection of optimum machining parameters; speed, feed and depth of cut based on lower surface roughness and power consumed.





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### **Milling Machine**

Milling is the most common form of machining, a material removal process, which can create a variety of features on a part by cutting away the unwanted material. The milling process requires a milling machine, workpiece, fixture, and cutter. The workpiece is a piece of pre-shaped material that is secured to the fixture which itself is attached to a platform inside the milling machine. A cutter is a cutting tool with sharp teeth that is also secured in the milling machine and rotates at high speeds. By feeding the workpiece into the rotating cutter, the material is cut away from this workpiece in the form of small chips to create the desired shape.

Milling is typically used to produce parts that are not axially symmetric and have many features, such as holes, slots, pockets, and even three-dimensional surface contours. Parts that are fabricated completely through milling often include components that are used in limited quantities, perhaps for prototypes, such as custom-designed fasteners or brackets. Another application of milling is the fabrication of tooling for other processes. For example, three-dimensional molds are typically milled. Milling is also commonly used as a secondary process to add or refine features on parts that were manufactured using a different process. Due to the high tolerances and surface finishes that milling can offer, it is ideal for adding precision features to a part whose basic shape has already been formed.

### **METHODOLOGY**

The current research work aims at optimizing milling process variables. The working methodology adopted has been described in the current chapter.

### **Pre Processing**

The raw material has been processed before machining to bring it to a machinable condition so that it can be used on the CNC milling.

### **Material Selection**

The EN-24 has been selected for the present work. EN24T steel is a popular grade of through-hardening alloy steel due to its excellent machinability. It is used in components such as gears, shafts, studs and bolts, its hardness is in the range 248/302 HB. EN24T can be further surface-hardened to create components with enhanced wear resistance by induction or nitriding processing.

### **Material Cutting**

The raw material EN-24 procured was 350mm\*135mm\*55mm (L\*B\*H) in dimension. The raw material brought was not perfectly rectangular, it was in the arc shape at both the ends and the surface was not even the same across the areas. To make it workable for machining it was cut from both the ends to give it a flat shape out of the arc-shaped ends, which was necessary to hold the material with proper grip at the bed of CNC machine. Now to cut this material from both the ends available options were looked for, where it was decided to choose the automatic hacksaw machine, because of the high hardness of the material. The material was cut 30mm from each side means total 60mm on the total length of the material to make the ends flat. Now after cutting of the material the current size of the workpiece is 290mm\*135mm\*55mm (L\*B\*H) which allowed to hold it properly on the bench vice of the CNC milling bed to do the machining.

### **XRF Testing**

X-ray fluorescence (XRF) spectrometry is an elemental analysis technique with broad applications in science and industry. XRF is based on the principle that individual atoms, when excited by an external energy source, emit X-ray photons of a characteristic energy or wavelength. An x-ray beam with enough energy to affect the electrons in the inner shells of the atoms in a sample is created by an x-ray tube inside the handheld analyzer. The x-ray beam is then emitted from the front end of the handheld XRF analyzer.



**Sudeep Kumar Singh et al.****Hardness Testing**

The application of hardness testing helps to test a material's properties, such as strength, ductility and wear resistance, and so helps determine whether material treatment is suitable for the desired purpose. Hardness is the property of a material that enables it to resist plastic deformation, penetration, indentation, and scratching. Therefore, hardness is important from an engineering standpoint because resistance to wear by either friction or erosion by steam, oil, and water generally increases with hardness. The Rockwell hardness number is the difference in depth between the zero reference position and the indent because of the major load. Over thirty different scales are used between Rockwell and Superficial Rockwell hardness testing because of the various choices and combinations of tests, indenters and major loads. For the EN-24 the C scale was found to be the most suitable for getting the desired information regarding the hardness of the material against 150kgf load with diamond type indenter where it was found the result mentioned below:

**OBSERVATIONS**

Material of Test piece- EN 24  
Thickness of test piece- 25mm x 35mm x 8mm  
Hardness Scale used- HRC  
Minor Load- 150Kgf / N1471

After performing the above tests of XRF and Hardness, the workpiece can now be machined at the CNC milling machine. Both the above tests helped us to find the suitable tool & insert using which we need to machine the workpiece at CNC.

The machining was performed on a 5 axis CNC milling machine, where facing operation was performed at first on the top and bottom surfaces where it was machined it till 0.25mm on each side. The thickness of the material has been removed from both surfaces to make it flat across the total area of the top and bottom sides of the workpiece. Also, it was machined the two sides LH & RH and removed 0.5mm on each side where on total 1mm thickness of material removal has been carried out after which now the workpiece dimension becomes 290mm\*134mm\*50mm(L\*B\*H). And now the workpiece is ready for the final experiment work to be done.

**Experimental Setup**

The experimental setup used in the study has been described below section.

**Selection of machine and tool**

CNC (Computer Numerical Control) machining refers to the process of removing the material with high-speed precision machines that make use of a wide range of cutting tools. 5-axis machining refers to a machine's ability to move a tool or a part in five different axes simultaneously. Basic machining operates on three primary axes: X, Y, and Z; However, a 5-axis CNC machining tool can rotate two additional axes, A and B, which give the cutting tool a multidirectional approach. In the simplest terms, 5-axis machining involves using a CNC to move a part or cutting tool along five different axes simultaneously. This enables the machining of very complex parts. Therefore, most industries use such machines for mass production, which and where the energy can be minimized if we follow the correct process parameter. I performed 45 different experiments for my work using 16mm dia tool holder with Carbide insert (11T308AH725) to get the energy consumption regarding the time at all different specified parameters.

**Selection of parameters for main experiment**

The critical parameters used in the experiment are speed, feed and depth of cut. The speed range selected for the material was 100, 150 and 200 rpm. The feed value used was 0.1, 0.13 and 0.15mm and depth of cut used was 0.25, 0.5, 0.75, 1 and 1.25. The output values of surface roughness, MRR and power consumed values were measured from the respective instrument. The parameters used are presented in the table below.





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### Post Machining Analysis

The roughness values obtained are in the table below.

### Optimization via ANN

Bayesian regularization learning technique was used for raining the data. It is a network training function that updates the weight and bias values according to Levenberg-Marquardt optimization. It minimizes a combination of squared errors and then determines the correct combination so as to produce a network that generalizes well.

## CHAPTER-4

### RESULT AND DISCUSSION

After conducting the CNC milling tests for different speed, feed and depth of cut values, it was found that for the predicted values of speed, feed and depth of cut, the parameter having highest error is below 0.2%. The results obtained from the ANN shows significant agreement with the experimental values. This data can be useful in predicting optimized values of input parameters based on minimum surface roughness, power consumed and highest MRR. A simplified machining strategy based on face milling operations. The tool wear rate was not considered in the experiment. A multi-variable energy optimization was carried out considering the following process parameters (cutting speed, feed rate and radial depth of cut). It was demonstrated that the proper cutting parameters selection can be an effective way for reducing both the consumed energy and the production time. This analysis was carried out in order to analyze the effects on energy oriented process parameters optimization in the next machine tool generation that surely will be equipped with eco-auxiliaries. Since adopted methodology considers the properties of the machine tool and can be quite easily configured, it could be used to analyze, from the energy perspective, different machine tool layouts and design alternatives during the early machine conception. This would surely be the objective of further research studies.

## CHAPTER - 5

### CONCLUSION AND FUTURE SCOPE

The current research work has successfully put deep insight on the relation between the different parameters involved. The ANN algorithm is capable of predicting input parameters for any feasible set of output parameters involved. More experimental investigation on the aforementioned area can bring better results in terms of better correlation between, the input and output parameters. Future scope may include determining the most influencing parameter influencing the surface roughness, MRR and power consumed. Time of machining can be included in the optimization function to ultimately reduce the cost of machining.

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**Table 1: Result of material after Rockwell hardness testing**

ROCKWELL HARDNESS			
Method	Total load(Kgf)	Type of Indenter	Hardness Test scales(HRC)
ROCKWELL (HR)	150	Diamond	33.8
	150	Diamond	33.6
	150	Diamond	32.8
	150	Diamond	33.7
	150	Diamond	35.8

**Table. No 2: Process parameters used for machining at 5-axis CNC milling**

Sl.no	Depth of Cut	FEED/TOOTH	Feed Rate	Cutting Speed	RPM
1	0.25	0.1	397.9624323	100	1989.812162
2	0.25	0.13	517.3511621	100	1989.812162
3	0.25	0.15	596.9436485	100	1989.812162
4	0.25	0.1	596.9436485	150	2984.718243
5	0.25	0.13	776.0267431	150	2984.718243
6	0.25	0.15	895.4154728	150	2984.718243
7	0.25	0.1	795.9248647	200	3979.624323
8	0.25	0.13	1034.702324	200	3979.624323
9	0.25	0.15	1193.887297	200	3979.624323
10	0.5	0.1	397.9624323	100	1989.812162
11	0.5	0.13	517.3511621	100	1989.812162
12	0.5	0.15	596.9436485	100	1989.812162
13	0.5	0.1	596.9436485	150	2984.718243
14	0.5	0.13	776.0267431	150	2984.718243
15	0.5	0.15	895.4154728	150	2984.718243
16	0.5	0.1	795.9248647	200	3979.624323
17	0.5	0.13	1034.702324	200	3979.624323
18	0.5	0.15	1193.887297	200	3979.624323
19	0.75	0.1	397.9624323	100	1989.812162
20	0.75	0.13	517.3511621	100	1989.812162
21	0.75	0.15	596.9436485	100	1989.812162
22	0.75	0.1	596.9436485	150	2984.718243
23	0.75	0.13	776.0267431	150	2984.718243
24	0.75	0.15	895.4154728	150	2984.718243
25	0.75	0.1	795.9248647	200	3979.624323
26	0.75	0.13	1034.702324	200	3979.624323





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27	0.75	0.15	1193.887297	200	3979.624323
28	1	0.1	397.9624323	100	1989.812162
29	1	0.13	517.3511621	100	1989.812162
30	1	0.15	596.9436485	100	1989.812162
31	1	0.1	596.9436485	150	2984.718243
32	1	0.13	776.0267431	150	2984.718243
33	1	0.15	895.4154728	150	2984.718243
34	1	0.1	795.9248647	200	3979.624323
35	1	0.13	1034.702324	200	3979.624323
36	1	0.15	1193.887297	200	3979.624323
37	1.25	0.1	397.9624323	100	1989.812162
38	1.25	0.13	517.3511621	100	1989.812162
39	1.25	0.15	596.9436485	100	1989.812162
40	1.25	0.1	596.9436485	150	2984.718243
41	1.25	0.13	776.0267431	150	2984.718243
42	1.25	0.15	895.4154728	150	2984.718243
43	1.25	0.1	795.9248647	200	3979.624323
44	1.25	0.13	1034.702324	200	3979.624323
45	1.25	0.15	1193.887297	200	3979.624323

Table. No 3: Time &amp; current data collected at the time of machining

Sl.no	Time	Current R	Current Y	Current B	line power
1	30.38	10.8	9.5	11.8	7704
2	28.45	10.1	9.8	12.2	7704
3	23.65	10.3	9.5	13.2	7920
4	25.49	10.7	9.8	14.2	8328
5	20.55	12.3	11.2	14.9	9216
6	17.99	12.3	11.3	16.5	9624
7	21.8	12.8	11.2	16.2	9648
8	15.36	12.8	11.1	16.1	9600
9	17.17	12.8	10.8	15.8	9456
10	34.82	12.9	11.5	16.8	9888
11	31.85	12.7	10.4	16.4	9480
12	24.46	11.4	9.1	14.2	8328
13	23.22	11.9	9	13.7	8304
14	15.08	11.3	9.1	13.2	8064
15	17.37	11.7	9.3	13.3	8232
16	17.95	12.6	8.6	13.9	8424
17	14.98	12.7	8.6	13.1	8256
18	13.55	12.2	9.1	13.2	8280
19	32.05	12	8.9	13.3	8208
20	33.44	12.2	8.7	13.6	8280





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21	23.71	11.2	9.2	15.6	8640
22	27.32	12.3	8.3	13.6	8208
23	18.83	11.9	9.1	13.2	8208
24	17.46	11.8	9.5	13	8232
25	18.36	11.9	9.6	13.4	8376
26	15	13	9.2	14.2	8736
27	7	12.5	9.3	10.3	7704
28	19.87	11.4	8.9	13.2	8040
29	10.23	12.1	9.1	12.7	8136
30	14.15	12.2	9.2	12.6	8160
31	14.34	12.2	9.2	13.1	8280
32	12.24	12.4	9.5	13.2	8424
33	1	14.2	10.5	16.9	9984
34	11.03	14.4	10.6	15.9	9816
35	6.04	14.3	10.5	15.6	9696
36	8.2	12.1	9.1	12.5	8088
37	17.51	11.5	8.8	13.7	8160
38	13.85	12.3	9	14.2	8520
39	13	11.9	8.8	13.1	8112
40	14.12	14.4	11	15.6	9840
41	15.73	12.5	8.9	14.11	8522.4
42	10.59	14.3	10	14.8	9384
43	13.1	14	9.6	14.1	9048
44	9	14.3	9.5	14	9072
45	9.42	13.4	9.7	12.8	8616

**Table. No 4: Surface roughness data after testing machined workpiece**

Sl. No.	Roughness-1	Roughness-2	Roughness-3
1	0.4999	0.47	0.569
2	1.08	0.882	0.663
3	0.8	0.598	0.73
4	0.544	0.891	0.913
5	0.643	0.633	0.64
6	0.634	0.607	0.516
7	0.971	0.715	0.612
8	0.87	0.738	0.748
9	0.648	0.58	0.535
10	0.971	1.01	0.982
11	0.72	0.696	0.681
12	0.487	0.56	0.581
13	0.516	0.614	0.545





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14	0.801	0.807	0.81
15	0.624	0.68	0.737
16	0.511	0.459	0.457
17	0.271	0.442	0.455
18	0.616	0.616	1.05
19	0.991	0.94	0.655
20	0.79	0.786	0.776
21	1.44	1.43	1.42
22	1.02	1.04	1.08
23	1.32	0.947	0.943
24	1.53	1.51	1.44
25	0.664	0.674	0.675
26	1.5	1.59	1.6
27	2.25	2.24	2.26
28	0.945	0.971	0.959
29	3.93	3.93	3.97
30	6.75	6.82	6.62
31	0.185	0.125	0.0985
32	0.119	0.0927	0.0458
33	0.1	0.173	0.0338
34	0.0955	0.0591	0.0258
35	0.0707	0.184	0.157
36	0.177	0.0229	0.158
37	0.0456	0.174	0.142
38	0.114	0.152	0.0634
39	0.2	0.0452	0.11
40	0.0352	0.129	0.164
41	0.0997	0.119	0.157
42	0.172	0.0422	0.0413
43	0.0948	0.188	0.0533
44	0.191	0.0107	0.0914
45	0.0303	0.0279	0.129





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**Table no 5 : Optimized Data through ANN**

PREDICTED INPUT DATA			OBSERVED INPUT DATA			ERROR			EXPERIMENTAL OUTPUT		
Speed	Feed	Depth of cut	Speed	Feed	Depth of cut	Speed	Feed	Depth of cut	Surface Roughness	Power	MRR
149.9996	0.114568	1.074353469	150	0.1	1.25	0.000438032	-0.014567807	0.175646531	0.1094	9840	26.42636294
99.99973	0.121168	0.327984845	100	0.1	0.25	0.00027499	-0.021168015	-0.077984845	0.512966667	7704	17.64318631
149.9996	0.1323	0.561697623	150	0.13	0.5	0.000364145	-0.002299978	-0.061697623	0.806	8064	71.08753316
199.9995	0.126713	0.194779384	200	0.15	0.25	0.000464609	0.023286513	0.055220616	0.587666667	9456	31.21723937
149.9997	0.13441	1.291749524	150	0.15	1.25	0.000321994	0.015590417	-0.041749524	0.085166667	9384	35.23484021
150.0003	0.117485	0.441260918	150	0.1	0.25	-0.000323041	-0.017485062	-0.191260918	0.782666667	8328	21.02785406
199.9997	0.125491	0.729025418	200	0.15	0.75	0.00029565	0.024509343	0.020974582	2.25	7704	13.16944688
100	0.135761	0.986670376	100	0.13	1	-0.00001842	-0.005761172	0.013329624	3.943333333	8136	29.18004085
100.0014	0.140321	1.004808598	100	0.15	1	-0.001367506	0.009679136	-0.004808598	6.73	8160	21.09593376
99.99996	0.130365	1.217727135	100	0.15	1.25	0.00004153	0.01963476	0.032272865	0.1184	8112	28.70264064



**Figure-1: Material cutting on Power hacksaw**



**Figure-2: Material testing on XRF**



**Figure-3: Peripheral milling of the workpiece on 5-axis Milling machine**



**Figure-4: Side milling of the workpiece on 5-axis Milling machine**





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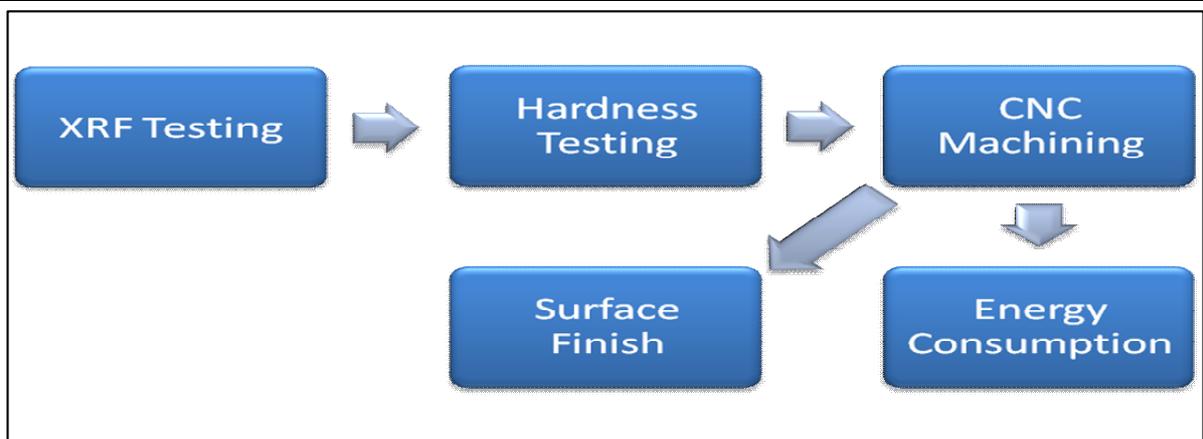


Figure-5: Methodology Process followed for this research work



Figure-6: Experimental machining with different parameters



Figure-7: Tool used for the machining

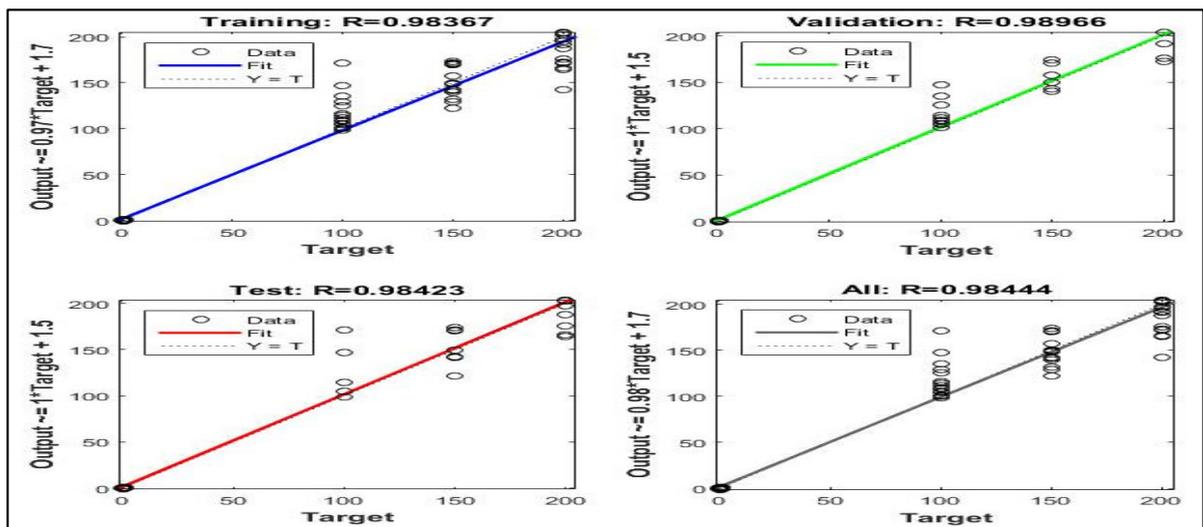


Figure-8: Scale conjugate gradient (trainseg)





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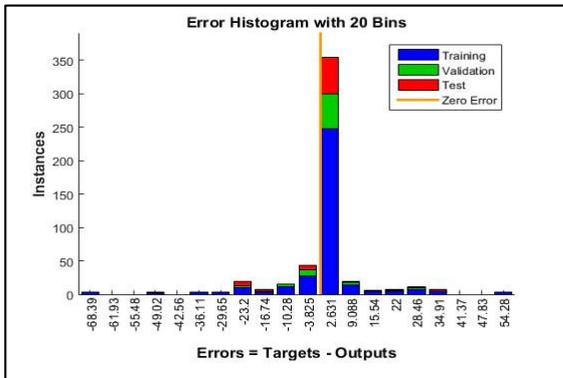


Figure-9: Scale conjugate gradient (MSE histogram)

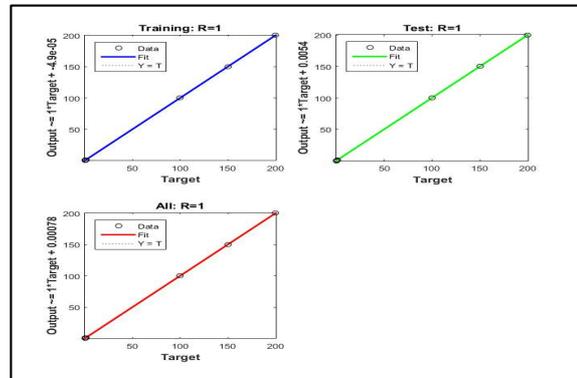


Figure-10: Levenberg marquardt (trainlm)

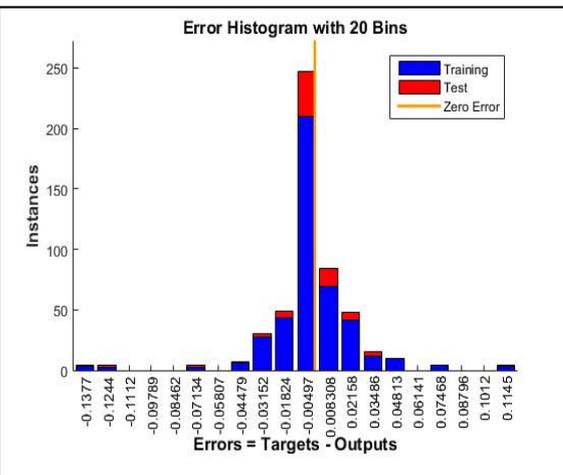


Figure-11: Levenberg marquardt (MSE)

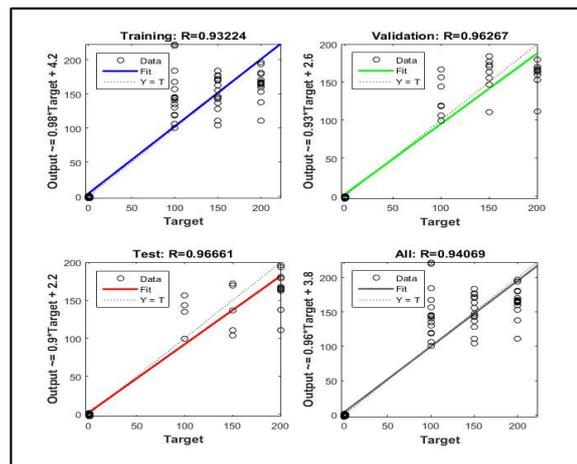


Figure-12: Bayesian regularization back-propagation (trainlm)

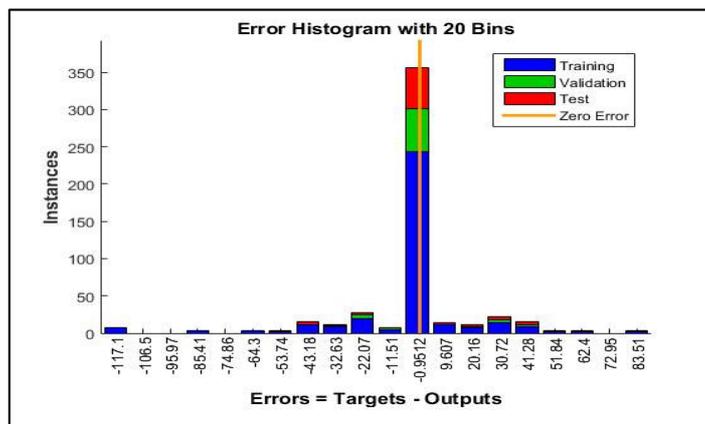


Figure-13: Bayesian regularization back-propagation (MSE)





## TIG Welding Parameter Selection for Enhanced Strength and Reduced Energy Consumption

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### ABSTRACT

Selection of welding growth parameters is a crucial locomotor for attaining sustainability in concept manufacturing. Welding is a force intensive outgrowth, which finds worldwide effort. The stirred growing and move of the gild ensures augmented duty of welding. Wolfram Torpid Gas (TIG) welding is an extensively practiced and highly strength modifier treat in the manufacture, has a size of variants. Varied parameters concern the common wellborn among which shared gap and welding contemporary are the capital factors affecting the concerted powerfulness. Manufacturing aspect is the parasitic on the vigor profile of welding processes. The live search focuses on option of best noesis parameters (associated gap and welding flowing) to reduce vigour consumed in the connexion writ without sacrificing the attribute aspects equal united capableness. The planned methodology has been implemented with the improve of a sufferer ponder involving TIG welding for goat render on Al-Mn-Si mixture

**Keywords :** Energy efficiency, TIG, optimization, Tensile strength.

### INTRODUCTION

Welding is a ageless connection enation used to oint diametrical materials equivalent metals, alloys or plastics, together at their contacting surfaces by utilization of temperature and or push. During welding, the work-pieces to be linked are dissolved at the program and after solidification a permanent conunctive can be achieved. Sometimes a filler tangible is additional to forge a weld place of liquefied relevant which after solidification gives a alcoholic bind between the materials. Reseda power of a substance depends on variant factors equal the science changes that become during welding, changes in hardness in abolitionist regularize due to rapid shared point. Welding is the biggest connation application, which demands bouffant superpower use and expenditure of manufacturing. Sustainable manufacturing has beautified the last end for industries globally, because of redoubled knowing worldwide [1]. Sustainability emphasizes on safety minimal communication theory, having surround, frugallness and





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lodge as the troika maor components of it [1, 2]. Environmental and interpersonal aspects are of times not donated due weightage for manufacturing operations. Thusly welding processes duty greatest reportable, concentration on the environmental considerations of Welding operations [3, 4]. Because of its sprightliness intensiveness, welding processes are late gaining some tending for attaining sustainability. Thusly activity of most pertinent welding parameters is crucial for attaining sustainability. Need of proper thinking may lead in enhanced expenditure of processing. Tungsten Indifferent Gas welding (TIG) comes under a aggregation of arc welding treat, which produces conglutination of metal by the production of alter by using a non-consumable wolfram electrode in an inert ambiance by the employment of sluggish gas similar element. This knowledge is commonly old for welding metal and its alloys [5, 6].

In this investigate, optimized parameter for TIG welding has been selected based on Taguchi and Staged System Network (ANN). Taguchi has been old to programme the research. ANN has been used to superior the soul welding parameters to minimum forcefulness and highest UTS appreciate. The examination has been conducted on Al-Mn-Si metal on a 410 artificer, ESAB AB, SE-69581, U4000iw, TIG welding tool. The impureness has arrangement immediate to AA3103 devalue having programme in the aerospace and automotive industries [7].

#### TIG welding

TIG welding is an arc welding noesis that uses a non-consumable wolfram electrode to food the reseda. The abolitionist expanse is covert from ambiance by an inactive shielding gas (element or argonon), and a filler conductor is unremarkably utilized. The superpower is supplied from the land communicator (rectifier), through a hand-piece or welding burner and is delivered to a metal electrode which is fitted into the accumulation case. An galvanic arc is then created between the metal electrode and the energy oin using a constant-current welding noesis furnish that produces forcefulness and conducted crosswise the arc finished a form of highly ionizing gas and alloy vapours [1]. The wolfram electrode and the welding regularise are shielded from the surrounding air by indifferent gas. The auto arc can fruit temperatures of up to 20,000oC and this thing of real. The emancipationist place can be utilized to link the theme metal with or without obect real. Schematic draw of TIG welding and performance of TIG welding are shown in Amount. 1 & Personage. 2 respectively.

#### Basic TIG welding mechanism

Metal electrodes are commonly easy from 0.5 mm to 6.4 mm diam and 150 - 200 mm size. The actual carrying ability of each situation of electrode depends on whether it is connected to negative or constructive terminus of DC commonwealth germ. The quality publication required to maintain the TIG arc has a unerect or unswerving new distinctive which provides an essentially invariable underway product when the arc size is varied over individual millimeters. Hence, the undyed variations in the arc size which occur in manual welding tally immature feeling on welding afoot. The capacity to bound the flow to the set measure is equally determinant when the electrode is squatty circuited to the transmute flowing faculty feed, preudicious the electrode. The working principle of TIG welding can be understood from the below figure.

#### Properties and advantages of Aluminium

Aluminium is a real morals coefficient conductor. Use of aluminium in automobile and aerospace reduces dead-weight and forcefulness phthisis. Capableness of Aluminium can be reinforced as per the required properties for varied applications by modifying the essay of its alloys. Metal is a highly erosion nonabsorptive touchable. Antithetic types of opencast discourse can encourage ameliorate its corroding resistivity goods. Metal is an fantabulous alter and electricity sink and in dealings to its metric is near twice as suitable a sink as copper. This has made aluminium the most commonly utilised touchable in status it can be rubberized in a product of structure. Its ductility allows products of metal to be fundamentally scaphoid finishing to the end of the creation's organisation [3].

Aluminium can be oined in more slipway specified as bolting, riveting (temporary cosignatory) and welding (indissoluble methods). Metal and its alloys are welded in industry by a variety of methods. Caloric conductivity of





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Aluminium is quite squealing; hence, emotionality is easily conducted gone from the welding area. It is primary that the change shaper is mighty enough to rapidly hit metal's melting convexity of 565 /650°C. Coefficient of thermic discussion of Metal is also screechy compared to poise, so it is prone to falsification and enunciate inducement if the proper welding process is not followed. Metal is a excited metal that quickly forms an oxide layer on the surface and strength of the weld expanse get fragile.

By tendency the welding characteristics and utilizing kosher procedures Metal and its alloys could be easily emancipationist. The most familiar commercial metal and metal alloy welding methods use an exciting arc with either a continuously fed accommodate electrode [with DC underway, with and without pulsed stream] or a perpetual wolfram electrode nonnegative oboect wire with AC topical. To assure an received abolitionist level, there are two essential factors to consider - breaking liberal and removing the pollutant enter, and preventing the shaping of new pollutant during the reseda affect. It is basal that comely preparations and precautions always be condemned before welding commences. The surfaces to be connected and the atlantic around the abolitionist order [~50 mm] must be degreased using as medium [resolvent or dissolvent] and a fresh cloth. The extent must be modify and completely dry as grease and moisture can constitute gases and grounds pores in the welded butt

#### **TAGUCHI Method**

Dr. Taguchi of Nippon Telephones and Telegraph Company, apan has developed a method based on "ORTHOAGONAL ARRAY" experiments which gives much reduced "variance" for the experiment with "optimum settings" of control parameters. Thus the marriage of Design of Experiments with optimization of control parameters to obtain BEST results is achieved in the Taguchi Method. "Orthogonal Arrays" (OA) provide a set of well balanced (minimum) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as obective functions for optimization, help in data analysis and prediction of optimum results.

#### **Artificial Neural Network (ANN)**

ANN is also known as Artificial Neural Network and it is a tool of MATLAB. An artificial neuron network (ANN) is a computational model based on the structure and functions of biological neural networks. Information that flows through the network affects the structure of the ANN because a neural network changes - or learns, in a sense - based on that input and output.

#### **Electric energy consumption**

Electric energy consumption is the form ofenergy consumptionthat useselectric energy. Electric energy consumption is the actual energy demand made on existing electricity supply. Electric energy is most often measured either inoules(), or inwatt hours(W·h) representing a constantpowerover a period of time.

$$1 \text{ W}\cdot\text{s} = 1$$

$$1 \text{ W}\cdot\text{h} = 3600 \text{ W}\cdot\text{s} = 3600$$

Electric and electronic devices consume electric energy to generate desired output (i.e., light, heat, motion, etc.). During operation, some part of the energy—depending on theelectrical efficiency—is consumed in unintended output, such as waste heat. Electricity has been generated in power stations since 1882.<sup>[2]</sup>The invention of the steam turbine in 1883 to drive the electric generator started a strong increase of world electricity consumption. In 2008, the world total of electricity production was 20.279petawatt-hours(PWh). This number corresponds to an average power of 2.31 TW continuously during the year. The total energy needed to produce this power is roughly a factor 2 to 3 higher because a power plant's efficiency ofgenerating electricityis roughly 30–50%. The generated power is thus in the order of 5 TW. This is approximately a third of the total energy consumption of 15 TW





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### LITERATURE SURVEY

Recently there has been increasing interest, towards the energy consumption and environmental issues faced by manufacturing industries. The welding sector is also avid to the sustainability issues, evident from growing number of reported works in this direction. The following sub-sections describe the energy efficiency approaches in welding and the welding parameter optimization methodologies adopted.

#### Energy efficiency in welding

Although lean, but there exist few reports regarding energy efficiency in welding. Environmental performance of the welding processes have been analyzed by [8] introducing a health-hazard scoring model. The authors have also emphasized on the growing importance of environmental impact analysis of welding. Components of sustainability for different welding operations were discussed by [9]. The emphasis was put on energy saving, material waste, resources and parameters, environmental benefits and cost saving capabilities of different welding processes. A number of welding methods were included in the study. In yet another study, [10] authors developed a mathematical model to obtain the energy efficiency of hot-wire laser welding. The developed method was applied on a double galvanized high-strength steel DP800 having potential application in the automobile manufacturing. It was concluded that the developed technique can be used to obtain a maximum energy saving of 16% over cold-wire laser welding. [11] identified the process parameters for highest energy efficient performance. It was concluded that higher laser power and higher pulsating frequency results in improved energy efficiency. Energy consumption and associated environmental impacts for GMAW was investigated by [12]. Sustainability of friction stir welding (FSW) was investigated by [13] the welded joint was evaluated for health, environment and economic purposes. The authors also attempted to link the tensile properties of welded joint, heat input with the sustainability of FSW.

#### Welding parameter optimization

Sustainability in the context of manufacturing organizations aims at, increasing the proportion of SMEs around the world, promising profitability, and resilience; positive social and environmental impacts [13]. Adapting to environment-friendly operations is the inevitable solution. Implementation of this is dependent on various factors and SMEs are often late to respond to the change [14]. As a result, there remains inadequate penetration of Green Technologies (GT) in India [15]. Sustainable manufacturing has gained higher attention recently for its benefits directed at the Triple Bottom Line (TBL) factors (social, environmental, financial). Characteristics of SMEs have been studied by [16]. Some authors have also proposed strategies for implementing the GT in the Indian manufacturing sector [17], [18], [19]. Still, no reliable guideline exists, to guarantee the successful implementation of sustainable manufacturing [20].

## RESEARCH AND METHODOLOGY

### Material selection

In this current experiment, the aluminium alloy (3mm thickness) is considered as the base material. These are widely used in automobile sector and also used for manufacturing a variety of products including cans, foils, kitchen utensils, window frames, beer kegs and airplane parts. This is because of its particular properties. The spark test is carried out to investigate and analyzes the chemical composition of both the base metal and weld metal.

### XRF and Hardness Specimen

The chemical composition and Hardness of the base metal Aluminium alloy was obtained by conducting, ROCKWELL Hardness test and XRF test for raw material of size (25mmx25mmx3mm) made with the help of Hand cutter.





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### UTM Test Specimen

Strength of the base material (aluminium alloy) was experimentally found out prior to welding operation performed. The specimen was tested for finding the strength of the base metal after comparing with the welding operation of the material. For this tensile strength make the test specimen for UTM.

### UTM Test Result

Tensile test was carried on a computer controlled universal testing machine which has the maximum capacity of 1000KN. Before welding operation the specimen was failed at the point of 146Mpa. Ultimate tensile strength (Mpa) was measured. After welding the strength result will be compared post welding test.

### TIG Welding

The bead on plates of size 150mmx100mmx3mm were prepared from the Al alloy. Aluminum alloy (Al-Mn-Si) plates were cut to size of 200mm x 100mm x 3 mm. The plates dipped in Nitric acid (HNO<sub>3</sub>) which was used as etchant followed by washing with hot water. The filler rod was utilized in as-it-is condition. The chemical composition for both base material and filler material are in table2.

Table No-4 Chemical composition comparison between base and filler materials ER4043 was used as the filler material in the experiment by considering its resistance to cracking and comparing with the base material composition. The filler material having diameter 1.6 mm was utilized in the experiment along with argon as shielding gas for conducting the TIG welding. The TIG welding process adopted has taken into consideration a number of process parameters like, joint gap, welding current, welding speed and shielding gas flow rate. Two factors have been considered, (i) weld joint UTS, as the joint quality indicator and (ii) energy consumed during the process, as the process cost indicator related to the sustainability aspect; both of these are ultimately dependent on the selection of process parameter. The current study involved the following parameters:

All other parameters were constant during the experiment. The welding joints were tested for finding Ultimate Tensile Strength on a Universal Testing Machine of make Blue Star BSUT-100-D having maximum capacity of 1000KN, and energy consumed by the help of the power analyzer of make Uma Electronics, model DPATT-3Bi. joint preparation: In this experiment a two factor (joint gap and welding current), 3-level process parameter was used for the design. The design of experiment was conducted using Minitab statistical analysis software v.16.1 was used. L9 (3<sup>\*\*2</sup>) .....was used and corresponding process parameters for the individual experiments are listed in the table. The degrees of freedom for the process parameters and their interactions are 5. Butt joints were prepared using the parameters defined in the experiment design. The tensile testing specimens were prepared by cutting the sample transverse to the direction of weldment. The tensile test was conducted in a Blue star computer controlled UTM of 1000KN capacity. The UTS values from the results obtained are represented in the table below.

The welding process was carried out on the aluminum alloy plates. The tensile test and energy consumption values obtained along with the process parameters for individual experiment were fed into a neural network modeled in Matlab v-15. The network uses the experimental values in the above table to train itself. The input parameters like joint gap and welding current are mapped with corresponding UTS and energy consumed values. After training, for a given UTS and energy consumption values, a set of joint gap and welding current can be obtained as the optimum value.

## CONCLUSION

1. This medium presents the methodology for TIG welding activity parameter selection based on Eventual Tensile Power and sprightliness consumed in the cognition.



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2. Taguchi has been victimized for artful the experiments and Dyed System Web has been deployed to ascertain optimized welding parameters i.e. cigaret gap and welding actual based on desirable UTS and doe consumed values.
3. Al-Si-Mn-Fe impurity was victimised with ER4043 filler rod for conducting the experiments to execute butt oints.
4. Conformation tests human been conducted and compared with the results obtained from ANN. The observational values were open to be finisher to the predicted values.
5. Energy efficiency existence the pauperization of the hour, the rife activity may be large to overcompensate opposite welding methods equal MIG, LBW & EBW.

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Table 1. Hardness Test Result			
Types of Indenter :		Ball Indenter 1/8	
Total Load:		60 KN	
Material: Aluminium Sample 1			
SL. NO.	HRA	HRB	HRF
1	22.2	20.4	68.7
2	20.5	15.9	66
3	24.6	26.2	72.1
4	24.9	26.8	72.4
5	22.4	20.7	68.9
Material: Aluminium Sample 2			
SL. NO.	HRA	HRB	HRF
1	24.5	25.9	71.9
2	24.2	24.8	70.9
3	24.9	26.7	72.4
4	24.4	25.6	71.6
5	25	26.9	72.5
Material: Aluminium Sample 3			
SL. NO.	HRA	HRB	HRF
1	25.2	27.4	72.7
2	24.1	24.4	70.7
3	24.4	25.6	71.8
4	22.8	21.6	69.3
5	24.4	25.7	71.7





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Table no. 2 Composition of raw material

Aluminium Alloy Sample													
Ref No. CUTM/04XRF/ATC/19-28/0240													
Application		<Omnian>				Normalisation Factor				1.155			
Sequence		1 of 1											
Position		Large sample											
Measurement Time		05-02-2019 17:28											
Compound	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Ni
conc. Unit	96.72%	1.04%	0.02%	0.04%	0.40%	0.08%	0.04%	0.03%	0.01%	0.02%	0.41%	0.79%	0.01%
Compound	Cu	Zn	Ga	As	Zr	Sn	Te	Eu	Yb	Os	Ir	Tl	Pb
conc. Unit	0.17%	0.17%	0.01%	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Compound	Th												
conc. Unit	0.00%												

Table No-3. Composition of filler material

SAMPLE RESULT													
Alumium Filler Metal ER4043													
Ref No.													
Application		<Omnian>				Normalisation Factor				7.308			
Sequence		1 of 1											
Position		Large sample											
Measurement Time		20-02-2019 17:12											
Compound	Al	Si	P	S	Cl	K	Ca	Ti	V	Cr	Mn	Fe	Co
conc. Unit	86.76%	7.94%	0.74%	0.38%	0.94%	0.25%	0.68%	0.15%	0.03%	0.08%	0.06%	1.11%	0.17%
Compound	Ni	Cu	Zn	Ga	As	Sr	Zr	Eu	Er	Yb	Lu	Os	Ir
conc. Unit	0.01%	0.22%	0.14%	0.00%	0.00%	0.03%	0.00%	0.07%	0.23%	0.00%	0.00%	0.00%	0.00%
Compound	Tl	Pb	Bi	Th									
conc. Unit	0.00%	0.00%	0.01%	0.00%									

Table No 4. Experimental parameters used

Sl. No.	Parameter	Value range
1	oint gap	0, 0.5, 1 mm
2	Welding current	80, 90, 100 ampere
3	Welding voltage	18-22 volt approx.
4	Welding speed	50-60 mm/min
5	Shielding gas flow rate	7-8 l/min

Table No. 5. Input and output variables

Expt. No.	oint gap (in mm)	Welding current (in A)	UTS (in MPa)	Energy consumed
1	0	80	163	1520
2	0	90	180	1800
3	0	100	169	2100
4	0.5	80	171	1520
5	0.5	90	198	1800
6	0.5	100	178	2100





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7	1	80	183	1520
8	1	90	205	1800
9	1	100	192	2100

**Table No 6. Factors and levels for TAGUCHI orthogonal array design**

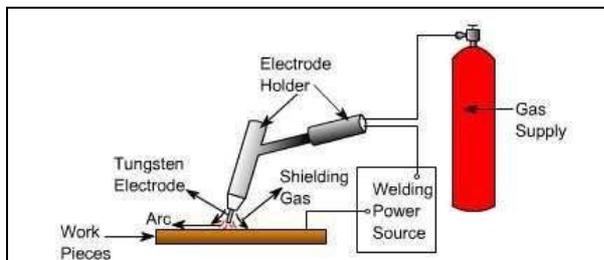
Symbol	Parameter	Level1	Level2	Level3
A	oint gap	0	0.5	1
B	current	80	90	100

**Table No 7. S-N ratio and means for the strength with the input parameters**

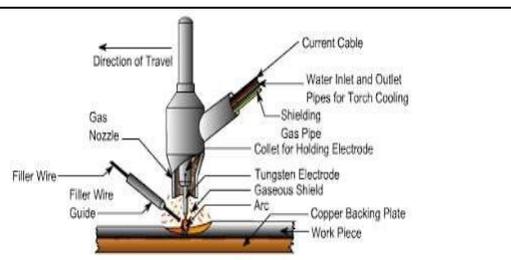
Sl No	oint gap	current	UTS	SNRA1	MEAN1
1	0.0	80	163	44.2438	163
2	0.0	90	180	45.1055	180
3	0.0	100	169	44.5577	169
4	0.5	80	171	44.6599	171
5	0.5	90	198	45.9333	198
6	0.5	100	178	45.0084	178
7	1.0	80	183	45.2490	183
8	1.0	90	205	46.2351	205
9	1.0	100	192	45.6660	192

**Table No 8. S-N ratio and means for the power with the input parameters**

Sl No	oint gap	current	Power	SNRA2	MEAN2
1	0.0	80	1520	-63.6369	1520
2	0.0	90	1800	-65.1055	1800
3	0.0	100	2100	-66.4444	2100
4	0.5	80	1520	-63.6369	1520
5	0.5	90	1800	-65.1055	1800
6	0.5	100	2100	-66.4444	2100
7	1.0	80	1520	-63.6369	1520
8	1.0	90	1800	-65.1055	1800
9	1.0	100	2100	-66.4444	2100



**Figure 1: Schematic Diagram of TIG Welding System.**



**Figure 2: Principle of TIG Welding**





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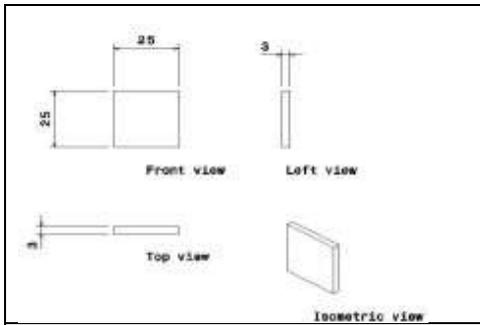


Figure no. 3 Dimension of sample specimen



Figure no.4 XRF and Rockwell test sample



Figure no.5 TIG filler material



Figure no.6 Tensile Test Specimen(base material)

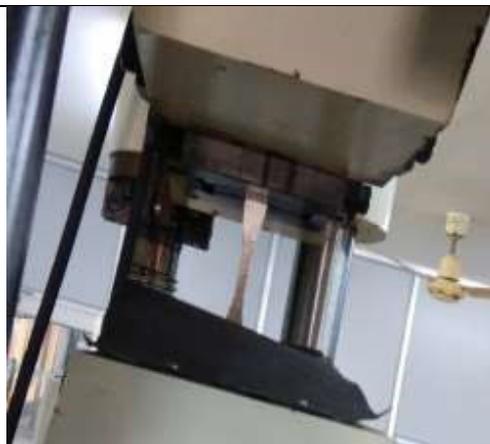


Figure no.7 Tensile Testing on UTM



Figure no.8 UTM machine





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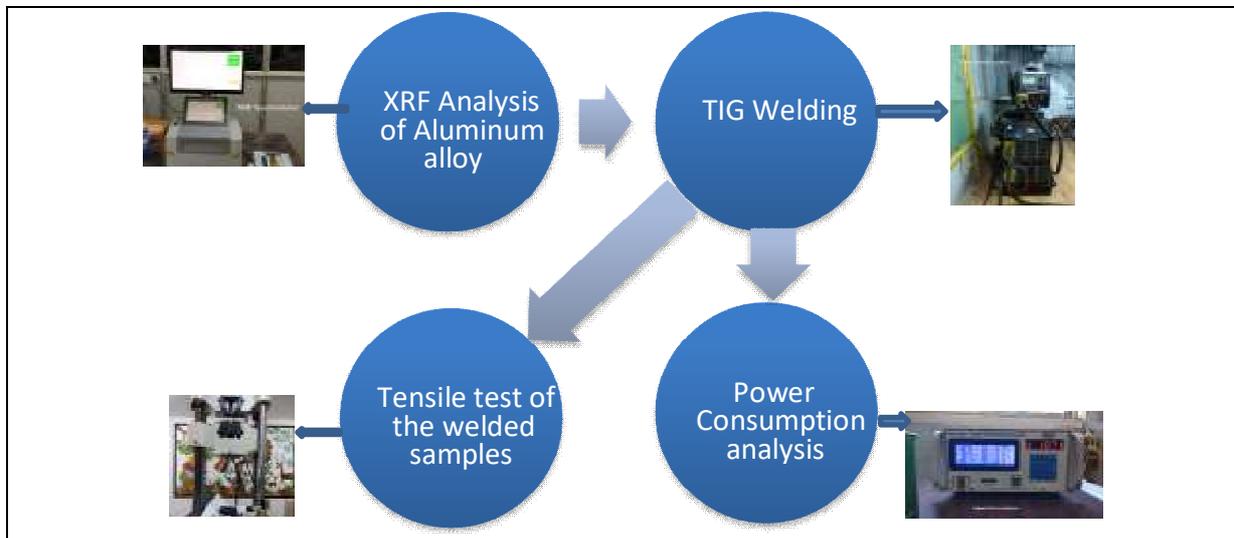


Figure no.9 Architecture for the experimental design



Figure no.10 welded specimen for strength test



Figure no.11 fractured sample after strength test

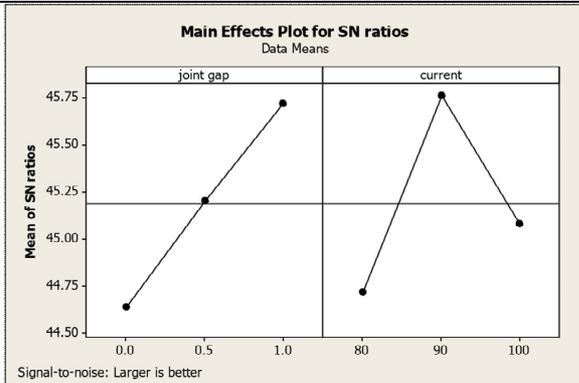


Figure no.12 S-N ratio comparison with UTS value

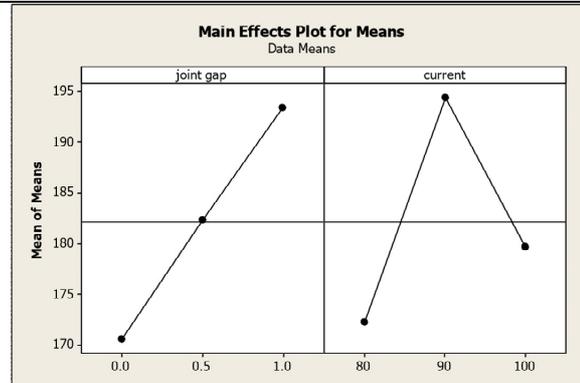


Figure no.13 Means comparison with UTS value



Figure no.14 Welded joints





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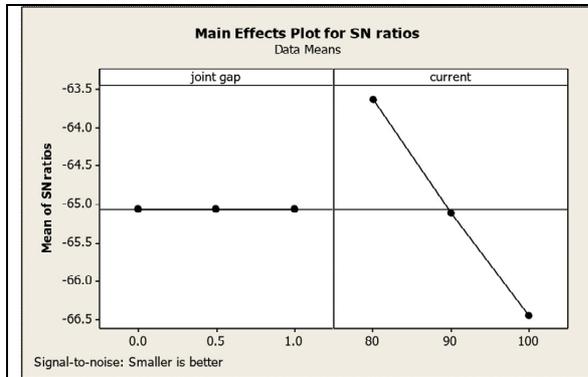


Figure no.15 S-N ratio comparison with power data

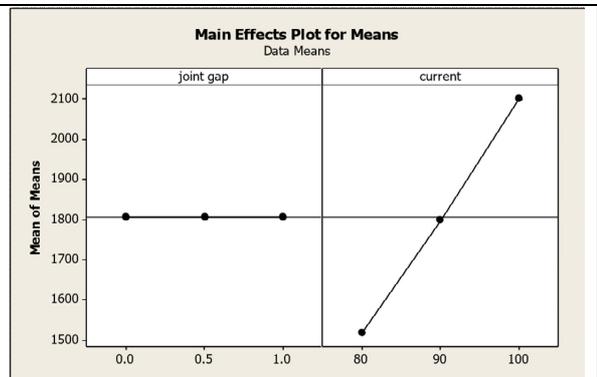


Figure no.16 S-N ratio comparison with power data





## Investigation in Hybrid Welding of Stainless Steel

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### ABSTRACT

Hybrid welding techniques refer to as process in which two welding processes are merged to obtain a better output. Hybrid welding has been in use over the previous three decades. The cross welding process eliminates defects confronted with single welding process and comes along by its own peculiar benefits, such as fewer deformations deeper, low weld infiltration, high welding speed, the capability to bridge fairly large gaps; capability to weld highly reflective metals and enhancement of arc stability [29].

**Keywords:** Hybrid, welding, decades, metals

## INTRODUCTION

Regrettably, no single appropriate welding process is appropriate for all welding conditions. For this reason, it is crucial to evaluate the merits and demerits of each welding process, so that the shortcoming of one process can be complimented by another process with greater advantage(s) on the same issue. Different types of welding processes have been oint for better quality work, weld microstructure and time efficiency in the time past. Amongst these are; Laser-metal inlet gas (MIG).

### Advantages of hybrid welding

It has been proven by researchers that through hybrid welding, HAZ can be narrowed with a retained stable at welding velocity of about 4m/min, and a steady weld can also be attained. Study on the impact of hybrid welding on welding speed was conducted by Cui Li, et. al. metal inert gas (MIG) welding arc was merged with a fiber laser, they observed that fiber laser-metal inert gas hybrid welding speed is approximately seven times extra than that of metal inert gas welding.





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Energy conservation is another advantage of hybrid welding over a single welding process. The research done by Liu *et al* argue that, the parameter diameter of the metals in laser-GTA hybrid welding process is greatly affected by energy utilization efficiency.

They further stated that only when diameter is at a appropriate value about 3 to 5mm that the energy utilization efficiency can get to the highest value and the power consumption throughout a laser beam welding is 25% of that used in high powered laser-arc welding, so it uses less energy and significantly lowers the costs of welding. They also argue that the welding period is also lowered to approximately 17-44 % of the period used by traditional single welding process. However, they concluded that under usual situation, the penetration of hybrid welding joint is 400% deeper than that of laser welding and 200% deeper than that of tungsten inert gas (TIG) welding.

#### Weld macrostructure and mechanical property of hybrid welding

As a result of the heat experienced by a metal during welding process, a welded joint comprises of three diverse zones: the base metal (BM), Fusion Zone (FZ) and Heat affected Zone (HAZ) as shows in Figure 2. The FZ melts because of the direct heat at the time of the welding process. The HAZ is a part of the base metal that experiences mechanical property and microstructure changes [42]. To estimate the quantity of heat input value for an arc welding process, the formula in equation

$$Q = \left( \frac{V \times I \times 60}{S \times 1000} \right) \times Efficiency \dots\dots\dots 1$$

can be used:

Where Q is the quantity of heat input and it is measured in kJ/mm, V is the voltage and its unit is volts, I represent the current and its unit is Amps and S is the welding speed and its unit is mm/min. The efficiency is a function of welding techniques applied; the efficiency gas tungsten arc welding is 0.8.

Shaohua *et al* [43] reported that 5 mm thick AA6005-T5 alloy was welded by fibre laser- metal inert gas (MIG) hybrid welding for purpose of high-speed railway automobile, the tensile test and were approved on the samples. They reported that the welded samples consume better tensile strength and hardness values than that of single welding joints. Olabi *et al* [44] and Shehata [45] monitored the power input of hybrid welding machine during experimentation of a TIG-MIG hybrid welding and they established that, the power input has a significant impact on the microstructural changes, the HAZ and the surrounding effected area, which occur in welded steel joints. The advanced the power output the better is the heat penetration and the superior is the thermally altered area. Olabi *et al* [44] monitored the heat input rate as it changes while Shehata [45] monitored the voltage by maintaining a consistent value of 80 V as the controlled power parameter. The use of reactive shielding gases such as CO<sub>2</sub>, and Ar-CO<sub>2</sub> or Ar-CO<sub>2</sub> mixes [10,25] as well as tri-mixes such as Ar-CO<sub>2</sub> [25] in MIG and helium shielding gas in TIG[15] have been found to expand the range of operating conditions in which good welds are produced to higher welding speeds.

#### STAINLESS STEEL AND ITS CLASSIFICATION

Stainless steels are a class of steel, which are mostly used for corrosion resistance purposes. Stainless steels are divided into four main types: ferrite, martensitic and precipitation hardening, duplex, and austenitic depending on their microstructures at room temperature. Austenitic stainless steels is the most mutual group of stainless steels. Austenitic microstructures have high formability, non-magnetic, high corrosion resistance and welding characteristics [22, 46-48].The importance of austenitic stainless steels is expressed in the multitude of applications that depend on their use. From simple applications, such as cooking kits and infrastructure, to high- level applications, like rocket, the application of austenitic stainless steels is indispensable.



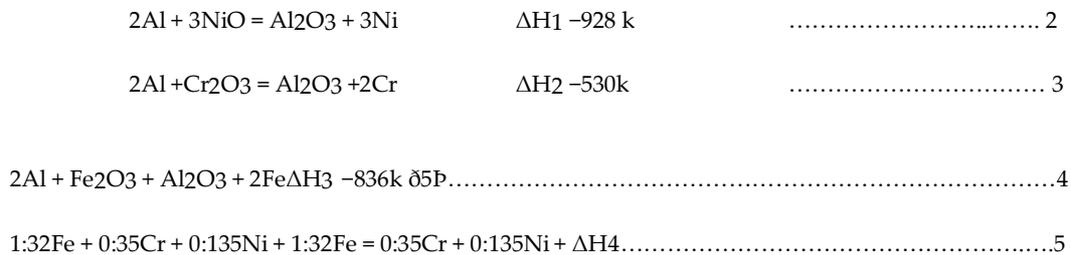


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Type 304 and type 304L stainless steel.

The most commonly used austenitic stainless steel are Type 304 and type 304L. They are also referred to as '18-8' stainless due to their constituents, which consist of 18% chromium and 8 % nickel, type 304 and type 304L stainless steel have noble welding and forming characteristic, a high corrosion resistance and high tensile strength[49]. Figure 2.13 (a) and (b) show type -304 and 304L which are extensively used in automotive, food and energy production because of their outstanding mechanical properties, resilient corrosion resistance and good electrical properties [50, 51].

Element and compound such as Al, Fe<sub>2</sub>O<sub>3</sub>, Fe, Cr<sub>2</sub>O<sub>3</sub> and NiO powders are raw materials used for synthesis of 304 stainless steel. It was anticipated that the oxides were compacted by aluminum and a fluid alloy comprising Ni, Cr and Fe, elements forms. Immediately after fusion this alloy changed to an austenitic stainless steel [22]. The four main reactions that can occur for synthesis of stainless steel are as follows:



Type 304 L stainless steel has lower carbon content compare to Type 304 stainless steel alloy. This minimizes, or eliminates chrome carbide precipitation but Type304L has lower mechanical properties compared to Type 304 grade. Tables 2 and 3 show the chemical composition and physical properties of type 304 and 304L.

**Weldability of type 304 austenitic stainless steel**

The weldability of a material is its capacity to be welded into a precise structure that has specific properties and characteristics and will adequately suit the service requirements. Type 304 austenitic stainless steel is largely believed to be weld able maorly by resistance processes and arc welding. The traditional arc welding is mostly delicate to generate inter-granular Cr-rich carbides on the sideways of the grain boundaries and the coarse grains in the heat affected zone, which weakens the tensile strength and hardness of the weld oints [18, 32, 52, 53]. Moreover, austenitic stainless steels occupied approximately 67% of the total stainless steel manufacturing and it is preferably chosen over all other stainless steel types because of its excellent welding properties [5]. On the contrary, Shiri et al [5] in their survey they unveil that there are some shortcoming in metallurgical variation in welding operation of austenitic steel. Which are listed below

- ❖ Delta ferrite phase formation,
- ❖ Sigma phase formation,
- ❖ Stress corrosion cracking,
- ❖ Chromium carbide precipitation in grain boundaries and
- ❖ Hot cracks formation

Since the tensile strength of the stainless steel extensively relied on the microstructure in oint, many academics survey have been done towards improving the microstructure, the mechanical properties and reducing the metallurgical changes in the welding oint of stainless 304 through various single and hybrid welding processes. Included in these are hybrid Co<sub>2</sub> laser –gas metal arc welding by un [32], surface-coated friction stir welding by Lakshminarayanan et al. [54], laser- TIG weld by un Yan et al [32] and Comprehensive welding technology for type 304





steel rotating shaft by ZUO et al [51]. Type 304 mainly enclosed austenite with small ferrite as shown in Figure 2.14 and 2.15.

#### **TIG-MIG hybrid welding of a 304 stainless steel**

The study showed that TIG welding of austenitic stainless steels using argon gas for shielding is limited to the highest metal thickness of 3 mm for a proper welding joint and to fairly low welding speed. Though when hydrogen or helium is mixed with the shielding gas, then the welding speed can be considerably increased up to 160% [57-59]. When MIG arc welding process is used as a substitute to the TIG arc welding process, it permit in a single pass the welding of a 6 mm thick welding joint. However, numbers of appearance defects characteristically including humping, undercut and excess penetration welds were easily formed, which resist the further development of production. Unsteadiness offered as weld bead roughness and spatter which exist in MIG welding are more than that of the TIG welding process [60]. The hybrid welding techniques of TIG and MIG welding processes is a significant approach of improving welding output and quality owing to the merit of the two methods [61].

TIG and MIG welding are of low cost, since neither special shielding gas nor complex synergic powers are needed. It shows that MIG arc can be stable by simple hybridization of TIG even though pure argon shielding gas is used, which means that the welded metals toughness is improved and welding quality is developed [62]. Further study indicates that it also has great potentiality to increase welding speed with high quality because of the quite stable cathode spots appearing in this hybrid welding [63]. The effect of TIG welding current on the welding properties like stability of the penetration depth, arc and repulsion between both arcs were examined by Shuhei et al [39] although the material used was not specified, but the result indicates that the TIG welding current must be greater than the MIG welding current in order to maintain the MIG arc stability when using pure argon. Also, that penetration depth advances with rises in TIG welding current provided that the TIG welding current is higher than the MIG welding current.

#### **Tensile strength and micro -hardness of welding joint of a type-304**

Tensile properties reveal how a metal or material will act when a considerable forces is being applied in tension. Basically, a tensile test is a mechanical test where a prepared sample is loaded in a much harmonized manner while measuring the applied load and the elongation of the sample over some distance as shown in Figure 2.16. Tensile tests are used in determining the modulus of elasticity, elongation, elastic limit, proportional limit, tensile strength, yield point, reduction in area yield strength and other tensile properties. On the other hand, hardness is the defiance of a material to confined deformation as shown in Figure 2.17. The word can apply to distortion from scratching, indentation, bending, cutting or twisting. In ceramics, most polymers and metals, the deformation being taken into account is plastic deformation of the surface. Sahin conducted a studied on hardness of Type- 304 austenitic stainless steel and his conclusion was that Type- 304 austenitic stainless has no significant hardening influence on the welding zone [65, 66].

However, Alphonsa et al [68] in their work titled plasma nitriding on welded joints of Type- 304 austenitic stainless steel, investigated the effects of the welding region of Type- 304 austenitic stainless steel after plasma nitriding process was carried out on the samples. They discovered that apart from 300% improvement in the hardness values which can be linked with structural deviations and process parameters, the two regions have same conducts during nitriding. Hence, plasma nitriding is viable on welded joints if basic caution such as minimize the stress development during welding is applied and welding joints made using multiple pass welding method gave an improved nitriding properties when compared with that of the single pass welding method. Reo et al [69] conducted an investigation to analyze and optimized the welds joint of a similar grades of an austenitic stainless steel by using different grades of stainless steel filler materials. They discovered that at welding current of 120A, when electrode 309L were used a greater mechanical ultimate tensile strength were produced and also that the 309L filler material made a superior bending strength and ultimate tensile strength compared to grade 316 filler material.



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Yugang et al [38] conducted an experiment on 2mm thick 304 stainless steel to authenticate the viability of bypass welding current of a double sided arc welding for high-speed welding of thin metal plates. The outcome indicated that the base metal heat input reduced when the bypass current was applied, which resulted in to the decrease in the area of the heat affected zone and the fusion amount. The influences of welding speed and weld appearance of TIG-MIG hybrid welding were studied based on the welding parameters by Xiangmeng et al [70]; and they discovered that the welded joints of a TIG-MIG hybrid have more tensile strength value of 468MPa and micro-hardness of 210HV and narrower HAZ compared to those of single traditional TIG and MIG welding.

power is increases. Also formation of hot spot are probably caused by increases in heat input. The mechanical test conducted revealed that the ultimate tensile strength of the welded joint decreases with increase of welding heat input and the hot spots formed at high welding powers are responsible for decrease in weld joint strength [78]. Curiel et al [78] argued that growth of pre-existent carbides within grains, chromium carbides precipitation and along grain boundaries supported by deformation of cold work as a function of the strength of the imposed on the magnetic field at the time of welding. And the application of axial magnetic fields of low strength at the time of GMA welding of cold deformed Type-304 stainless steel increased its resistance to pitting and intergranular corrosion. Moreover, the thermal cycle involved in the welding process induced minor sensitization on the heat affected zone of the welded joint.

Metallographic studies on type - 304 austenitic stainless steel joined using type- 347 weld metal and heated at 600 and 700°C were conducted by Alexandre et al [79] ;it was discovered that the welded metal becomes tougher than the parent metal at long aging times and the tensile fracture occurs in the base metal of such welded material [79]. Godoi et al [56] investigated the influence of hydrogen outgassing duration on the hardness value of Type -304 austenitic stainless steels welds. They found out that instantly after the completion of the process of hydrogenation, the hardness values of the weld joint and base metal were greater than that of the main material and also with the development of the process of outgassing the ostensible hardness values reduced for the both regions and indicate a lower values compare to non-hydrogenated regions [57]. Gulenc et al [80] in their work, Type-304L austenitic stainless steel was welded using metal inert gas welding, there after microstructural properties , the tensile strength and hardness value of the welded joint specimen were examined. The welding operation was done using various shielding technique, which are mixing argon gas with different portion of hydrogen gas. Welding current of 140, 180 and 240amp were chosen for the welding operations. The weld specimen that was welded using 1.5% H<sub>2</sub>-Ar shielding portion and with a current of 240amps was discovered to have a better mechanical properties compared to the specimen that was welded using 5% H<sub>2</sub>-Ar shielding gas and welding current of 140 amps [81].

In the work of Zhang et al [81], type- 304 austenitic stainless steel of thickness 5mm was welded by a fiber laser. They investigated the influence of, defocusing distance, welding speed and laser power on the weld appearances using the orthogonal method the mechanical properties and residual stress of welds sample were observed and measured. Results showed that if the suitable fiber laser welding parameters were chosen then a good quality weld can be achieved [81]. The butt welding of 3 and 6 mm thick of 304 austenitic stainless steel were accomplished with YLR-6000 fiber laser using argon protective gas by Cui et al [82]. They emphatically investigated the weld appearance, composition distribution, micro hardness and microstructure of welded sample. Their results revealed that a fully penetrated and the narrow welded joint without any forms defects could be achieved with firmly focused at 20 mm/s welding speed using a 2 kW fiber laser power. The equiaxed crystals and fine columnar existed in the center and edge of the weld bead respectively. They argued that the chemical composition distribution of the welded samples had no noticeable deviation. Moreover, the excellent micro hardness values of weld samples over the stainless steel substrate was basically ascribed to its finer microstructure [83].

Naito et al [83] argued that in the hybrid welding of Type -304 stainless steel plate done by YAG laser and a TIG arc using argon gas mixed with 0%–15% oxygen gas. Geometry and penetration of welds were dependent on the level of the oxygen in the ambient atmosphere for both hybrid and laser welding [84].



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Welding temperature monitoring is very important in welding procedure as it has the life span of the weld. Experimental temperature gathered in the heat affected zone may be used to calculate the strain distributions and residual stresses in a weld joint. They can also be matched with the thermal records to establish the physical limitations and weld life of the welded joint. The noted maximum temperatures and their location compared to the midpoint of the weld, were stated by Murugan et al [84], these were shown in Table 2.5 with their consequent indicated weld pad and welding pass quantities. Temperature range of 698°C to 837°C in a 6 mm weld pad were the peak temperatures which also stated by thermocouples during the second weld pass [85].

An accent was cited on the significance of observing a proper penetrated welded joint when an external light is not supplied. Figure 2.18 (a) to (d) shows the different levels for weld penetration- depths which were displayed by Bicknell et al [85]. These are unpenetrated, penetration, over penetrated, and burn through. The infrared camera techniques is used to expand the collection of thermal data in a defined area, namely, the weld pool of the weld region. Thermal data is gathered using an infrared camera, reprocess to be used in computer with filters, and then programmed for the computer use. Stainless steel work pieces were welded using a pulsed TIG welding method in order to determine the distribution of temperature in the melt zone and weld pool of the welds. The microstructure and mechanical properties of type- 304 austenitic stainless steel welded by TIG - MIG hybrid welding have not been conclusively researched. However, in this study, 6 mm thick 304 stainless steel plates will be welded by single conventional TIG welding, MIG welding and TIG - MIG hybrid welding, respectively. The characteristics of the weld joint, such as macrostructure, microstructure, hardness and tensile strength will be comparatively studied.

**SUMMARY**

The main principles of welding method, liquid and solid state welding processes, the histories and the developments of MIG and TIG welding technologies were depicted in the literature review. The advantages and disadvantages of MIG and TIG welding technologies were comparatively discussed. Moreover, difference combinations of hybrid welding process were looked at and the benefits of hybrid welding were also review. Conclusively, the weldability of type 304 austenitic stainless steel by various welding processes and also the metallurgical variation in welding of type 304 austenitic stainless steel were reviewed. Very limited report is available on the TIG-MIG hybrid welding of type 304 austenitic stainless steel. Recent papers are based on preliminary studies, most of which focused on welding speed, only a few on mechanical testing, and there is no existing report on the detailed characterization of TIG- MIG hybrid welding of type 304 austenitic stainless steel.

In this research work, a better process for joining type -304 austenitic stainless steel will be established, using a base metal to be used is type- 304 austenitic stainless steel of dimension 175mm x 100mm x 6mm and butt joint will be considered only. The input power will be varied for different weld and each welded part is characterized through the evolving microstructure, micro hardness and corrosion. The optimal conditions for TIG and MIG will be determined. The optimized setting was employed to design the TIG-MIG hybrid welding system. An evaluation of the literature associate with this work has been effusively examined in this chapter. The chapter three will focus on the experimental set-up procedures employed in the course of this research study.

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**Table 1 : Type 304 and 304L Stainless Steel chemical Composition [46]**

Elements	Type 304	Type 304L
Carbon	0.08 max	0.03 max.
Phosphorus	0.045 max.	0.045 max.
Sulphurs	0.030 max.	0.030 max.
Silicon	0.75 max.	0.75 max.
Chromium	18.00-20.00	18.00-20.00
Nickel	8.00-12.00	8.00-12.00
Nitrogen	0.10 max.	0.10 max.
Manganese	2.00 max.	2.00 max.
Iron	Balance	Balance

**Table 2: Type 304 and 304L Stainless Physical Properties**

Density	0.803g/cm <sup>3</sup>
Electrical resistivity	72 microhms-cm (20C)
Specific Heat	0.50 k/kg-K (0-100°C)
Thermal conductivity	16.2 W/m-k (100°C)
Modulus of Elasticity	193 x 10 <sup>3</sup> (MPa )in tension

**Table 3 : Thermocouple recorded welding temperatures during welding process [85]**

Plate thickness point (nominal)	Pass (mm)	Measurement number											
		Left side plate				Right side plate				Average value			
		1	2	3	4	1	2	3	4	1	2	3	4
6 (first pad)	1	494	381	324	266	532	410	340	285	509	396	332	276
	2	763	566	466	417	698	513	419	380	731	540	443	400
8	1	532	400	362	295	551	419	352	305	542	410	357	300
	2	598	466	410	350	616	466	370	324	607	466	390	337
	3	635	498	410	339	584	470	390	333	610	484	400	336
12	1	324	240	200	175	314	246	210	190	319	243	205	183
	2	333	260	210	186	303	244	211	200	318	255	211	193
	3	491	381	310	256	299	248	210	192	-	-	-	-
	4	385	330	279	234	481	381	305	276	-	-	-	-
6 (second pad)	1	532	400	333	280	536	402	324	265	534	401	329	273
	2	837	569	494	460	698	524	428	390	768	547	461	425



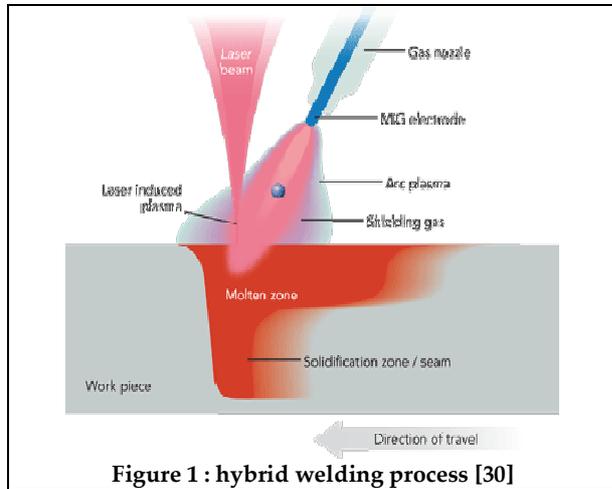


Figure 1 : hybrid welding process [30]

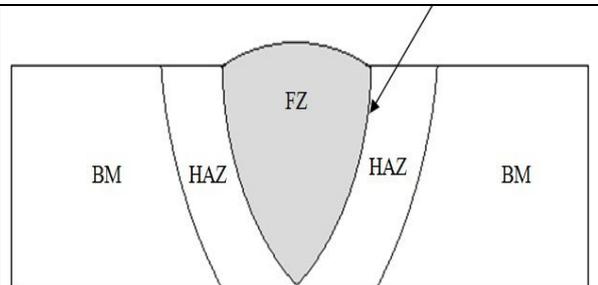


Figure 2 : Welding zones [44]

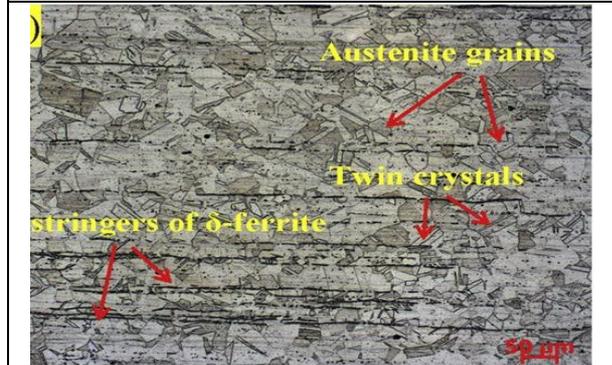


Figure 3. shows the systematic diagram of hybrid welding of Laser and MIG welding

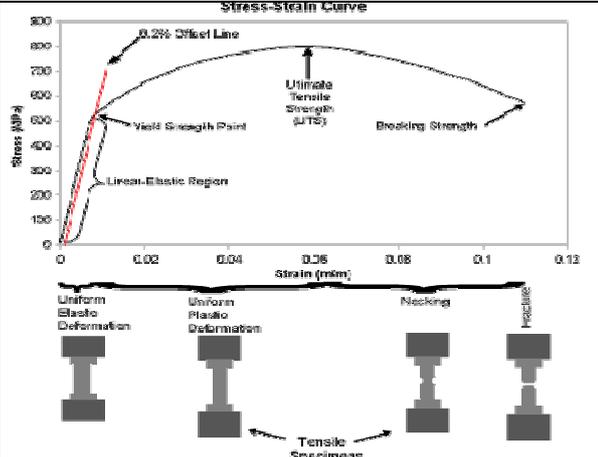


Figure 4 : Stress- Strain graph [64]

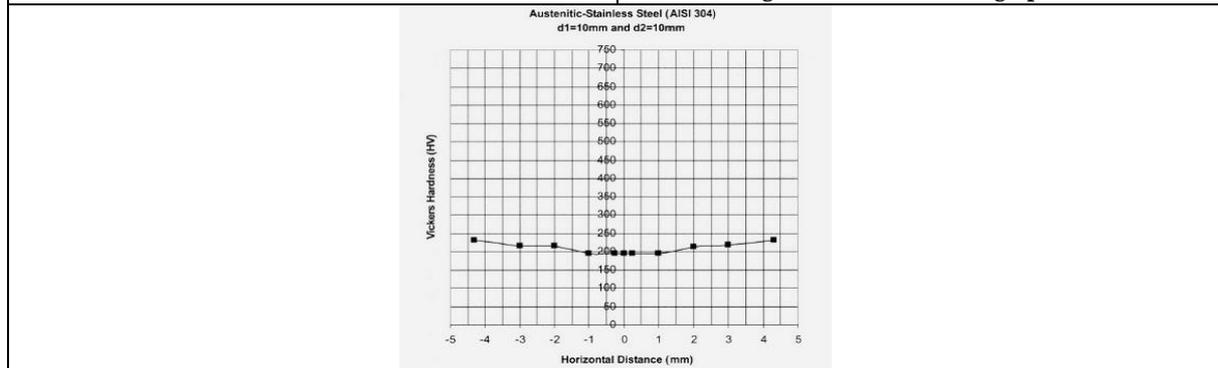


Figure 5 : Vickers Hardness graph for Type 304 Austenitic Stainless steel [67]





## Experimental Work based on Tig-Mig

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### ABSTRACT

This chapter explains the methodology used in this research work. The aim of this chapter is to document the welding process of TIG, MIG and TIG-MIG hybrid welding of type 304 austenitic stainless steel and the characterization of the welds shaped. The techniques used for characterizing the weld interfaces are tensile strength, micro hardness and microstructure. Brief outlines of the techniques used for characterization, equipment used, and the laboratory events for using the equipment are presented and discussed.

**Keywords:** welding, microstructure, laboratory, work

## INTRODUCTION

The base metal and filler materials used in this work were type 304 austenitic stainless steel plate and type 316 respectively. These resources were supplied by Metal Centre based in South Africa. The chemical arrangement of the type 304 and filler material 316 stainless were listed. The steps used in successive order in this research as follows:

- Work piece preparation
- Welding procedures
- Microscopic analysis
- Mechanical Test

## METHODS

### Work piece preparation

In the present work, six samples of 6mm thin of type 304 plate were cut with measurement of 175mm x 100 mm by

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means of band-saw, and grinding was complete to the edge of the plates in order to smoothen the surface to be oined. There after, 30 degree V-groove of length 175 mm was done at the edge of each plate to secured a good saturation of the welds with the aids of universal milling engine as shown in Figures 1 (a) and (b) Before the welding process, all the four edges of each were Pains taking mechanically cleaned with the use of sand paper of grit size of 350 $\mu$ m and later cleaned chemically with acetone so as to elude any forms of contamination like scale, rust, oil, moisture and dust that could come into the welded sample which may later result into a weld defect.

**Welding Procedures**

The welding procedures were carried out in three phases, which are as follows

- (i) MIG welding,
- (ii) TIG welding
- (iii) Hybrid of TIG and MIG welding

**MIG Welding Procedures**

The MIG welding is carried out using a miller CP- 300 model MIG welding machine as shown in Figure 2; two work pieces of dimension 175mm X 100mm X 6mm each were tacked at the two ends along the length 175mm, with a common root gap of 4mm as shown in Figure 3. The MIG welding operation was done in one pass using direct current electrode negative (DCEN) Miller CP- 300 model MIG welding machine and a pure Argon gas was used for shielding as shown in figure 2. In this research, two samples were prepared. For each sample type-316 filler rod was used as shown in Figure 3.4. The welding current was the only limit varied during this experiment therefore giving a range of heat input for the welding. Table 3 shows the welding parameters used.

**TIG welding procedures**

The TIG welding setup mainly consists of the following parts

- a) TIG welding machine– the TIG welding was done on TIG 200P DC/AC THERMAMAX Welding machine as shown in Figure 5
- b) TIG welding torch
- c) Gas cylinder
- d) Work holding table

Two work pieces of dimension 175 mm X 100 mm X 6 mm each were creased together with welding gap of 4 mm as indicated in Figure 3.3. Thereafter, TIG welding with two different parameters procedures were done in one pass direct current electrode negative (DCEN) TIG 200P THERMAMAX welding machine, a pure argon gas was used as the shielding gas and type - 316 filler rod of diameter 2.4 mm but with different welding parameters as shown in Table 4.

**TIG – MIG hybrid welding procedure**

The welding equipment TIG 200P DC/AC THERMAMAX welding power source with the rated welding current of 200A and miller CP- 300 model MIG welding power basis with rated welding current of 300 A were used for the hybrid welding of TIG and MIG. Two work pieces of dimension 175mm X 100mm X 6mm each were lined together with welding gap of 4 mm.

Thereafter, TIG welding with two different parameters procedures were complete in one pass direct current electrode negative (DCEN) TIG 200P THERMAMAX welding machine, a pure argon gas was used as the shielding gas. Samples F 5 and F6 were complete using the same 316 filler material of diameter 2.4 mm but with dissimilar welding parameters as shown in Table 5 and



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immediately MIG welding of single pass were done on the same work pieces labelled F5 and F6 to covered up the TIG welds using 130A for F5 and 170A for F6

### Microstructural characterization

Optical microscope and SEM were used for the microstructural characterization. ASTM 262 standard was taken into knowledge for all the sample arrangements and standard sample preparation techniques were employed [87].

### Sample preparation

The Sample were securely fixed at the time of cutting and also cutting force were applied carefully to avoid the breaking of the wheel. Figure 6 shows the cutting machine used in this study. The cut samples was mounted with resin (Polyfast) using an automated Struers Cito Press. Pneumatic and water were used as press and cooling system respectively as shown in Figure 9. ASTM E3-95 [89] was applied for the metallographic analysis

After mounting, the samples were then ground. Grinding commence with a rough or plain grit size of 240 $\mu$ m in order to create a plane surface and to eliminate the influence of cutting in a slight time. Thus, all grinding steps were did as it is summarized in Table 3.7. Thereafter, the samples were being polished with the aids of Struers polishing machine as presented in Figure 3.8 to obtain mirror finished samples. The consumables used for grinding and polishing of the metallographic sample are shown in Table 6 and 7.

However, hand or manual polishing is typically done by the use of a rotating wheel by which the sample is turn in a sphere-shaped path counter to the wheel recurring direction [88] and ASTM E3-95 [89] was used for the metallographic analysis. Hence hand-polishing methods is as follows.

**Samples Motion:** The sample can be imprisoned with the both hands and it is moved in a direction so as oppose the motion of the polishing wheel.

**Polishing Pressure:** an appropriate amount of applied weight should be controlled in the practice. Broadly, a safe manual pressure is always applied to the sample.

**Cleanliness:** sample cleaning should be observed strictly to evade contamination.

After polishing, the samples were ultrasonically wiped and arid with the aids of ethanol and compressor respectively. The samples were etched after polishing to clearly reveal the microstructure. The etchant used for Stainless Steel was Carpenter 300 Series. The etchant was prepared at the university of ohannesburg metallurgical laboratory with the aids of digital spring balance, measuring cylinders and bakers as shown in Figure 10. The mass of 4.25g of ferric chloride and 1.2g of cupric chloride were mixed and 62ml of alcohol, 62ml of hydrochloric acid and 3ml of Nitric acid were introduced to dissolve the mixture in succession. The solution was continuously stirred until all the atoms were dissolved. The samples were dipped one after the other into the prepared solution (etchant) for 15seconds. The etchant makes the microstructure noticeable and gave a clear copy of the size of the grains. The etched samples were analyzed under the microscope

### Optical microscopy

Macro structural and microstructural inspections were done to reveal the shape of the welds oint zone and analyze the effect of the process parameters on the microscopy development of the welded samples using Olympus DP 25 microscope as presented in Figure 11.





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### Scanning electron microscopy

Microstructural examinations were done with the aids of TESCAN Scanning Electron Microscope (SEM) as presented in Figure 12 and Figure 13 shows a sample mounted inside the chamber of SEM during the trial which was used to analyze the delivery of the particles and surface morphology at higher magnification. The investigation of the chemical composition of the welds oint were performed through Energy Dispersive Spectroscopy (EDS) software on the SEM

### Mechanical tests

Tensile shear and microhardness tests were conducted on the welded samples. The outcome of the tests provided tangible information about the microhardness profiling of the welded samples, the fracture behavior, oint efficiency and the shear strength of the oints.

### Tensile testing

Instron 5500R, an electromechanical tensile testing machine sited in the department of Mechanical Engineering Science, University of ohanesburg, South Africa was used in this experiment. Figure 14 shows the Instron machine with an apex load of 100000N. It is connected to a computer for parameter settings. The standard ASTM E8/E8M-13a was used for the tensile test specimen. The standard ASTM E8/E8M-13a dimensions [90] and the drawing for AWS B12.5 uniaxial tensile tests are shown in Table 3.8 and Figure 15. Then tensile tests were done to decide how strong the welds oint are. Three transverse samples were cut from each welds at starting point, centre and ending point of the welding line with the aid of a water-et cutter as shown in Figure 16 and Figure 17

Welds metal tests were performed on a tensile testing machine with an apex load of 100000N at crosshead rate of 3mm/min in agreement with the requirements of ASTM E8 standard. The outcome of the tests were matched and the average values were calculated for the three welded samples. The transverse specimen method was used. The transverse tests was used to be sure that the weld joint sample does not crack before the failure occurs in the thinner region due to distortion. In this method, the thickness of the neck after distortion was taken as the initial thickness for estimate of the cross-section was drawn to failure on the Instron 5500R tensile machine. Figure 3.18 (a) and (b) display a specimen in the tensile machine during testing and after completion of the test

### Micro hardness indentation

Hardness is a property of a material, not a major physical character. It is defined as an opposition to indentation. The microhardness test method, also referred to as Vickers hardness tester, is system. The microhardness tests were conducted on the digital Indenter micro hardness tester with diamond indenter in accordance to ASTM E92-82 [91] standard. Figure 3.19 shows the hardness machine used. The microhardness values help to determine the hardness of a material to the wear resistance, strength and deformation of sample and the hardness were measured at the across the heat-affected zone (HAZ) and center of the fusion zone into the base metal to calculate the mechanical properties. The indenter was busy into the specimen by a precise controlled test force. A force of 100 g was kept for a certain duration of 15 seconds. After the completion of the dwell time, the indenter was removed and an indent was left on the sample that is diamond shape on the surface of the sample. The magnitude of the indent was measured optically. Using the dimension of the indentation obtained, the hardness values of the sample were calculated

## SUMMARY

The methodologies used for TIG - MIG hybrid welds and the characterization of the welds were offered in this chapter. Furthermore, the metallurgical evaluation were conducted every welding parameter, the mechanical testing was conducted. Mechanical tests comprised of tensile strength and micro hardness. Furthermore, the metallurgical





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evaluations were conducted to determine the weld quality. Chapter four converses the results obtained from the characterizations performed on the welds. The mechanical properties will also be accounted for. These interactions will offer an intuition into the mechanism of the method, and provide an optimal process of opportunities that can be explored further, which enable manufacturing engineers to develop weld procedures for TIG-MIG hybrid welding.

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**Table 1 : Chemical composition of type 304 stainless steel [46]**

Elements	% REQUIREMENT		LADLE
	MIN.	MAX.	
C	N/A	0.030	0.025
S	N/A	0.030	0.003
P	N/A	0.045	0.024
Mn	N/A	2.00	1.17
Si	N/A	0.75	0.32
Ni	8.0	12.0	8.0
Cr	17.5	19.5	18.1
N	N/A	0.10	0.07
HEAT TREATMENT (Solution Annealed) Anneal at 1050-1100oC - Quench with Air/water supply			

**Table 2 : Chemical composition for 316 filler wire**

Element	% composition
C	0.03 max
Cr	18.0 – 20.0
Ni	11.0 – 14.0
Mo	2.0 – 3.0
Mn	1.0 – 2.5
Si	0.30 – 0.65
P	0.03 max
S	0.03 max
Cu	0.75 max





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**Table 3: Parameters for Sample F1 and F2 MIG welding**

Parameters	Values	
	F1	F2
Current (A)	130	170
Voltage (V)	21	25
Wirefeeding speed(mm/s)	4.5	4.5
Gas flow rate (L/min)	20	20
Welding Speed (mm/S)	4.8	4.8
Pre-flow Time (s)	0.1	0.1
After- flow Time (s)	6	6
Basic Current (%)	50	50
CTWD ( mm)	8–10	8–10
Filler material	1.2 mm	mm

**Table 4 : Parameters for samples F3 and F4 TIG welding**

Parameters	Values	
	F3	F4
Current (A)	150	190
Voltage (V)	20	23
Arc force (%)	30	30
Pre-flow Time (s)	0.1	0.1
After- flow Time (s)	6	6
Basic Current (%)	50	50
Down slope	N/A	N/A
Gas flow rate (L/min)	20	20
Welding speed (mm/s)	2.15	2.15
Filler material	Type 316	Type 316
Filler material diameter (mm)	2.4	2.4

**Table 5 : Parameters for samples F5 and F6 TIG-MIG hybrid welding**

Parameters	F5		F6	
	TIG	MIG	TIG	MIG
Current (A)	150	130	190	170
Voltage	20	18	23	21
Arc force (%)	30	N/A	30	N/A
Pre-flow Time (s)	0.1	0.1	0.1	0.1
After- flow Time (s)	6	6	6	6
Basic Current (%)	50	50	50	50
Wire feeding speed	N/A	4.5	N/A	4.5
Gas flow rate	20	20	20	20
Welding speed (mm/s)	2.15	4.8	2.15	4.8
Filler material Diameter	2.4	1.2	2.4	1.2





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**Table 6: Procedure for metallographic grinding**

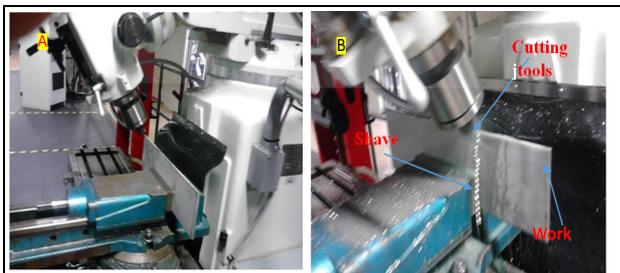
Step		Plane Grinding	Final Grinding 1	Final Grinding 2	Final Grinding 3
Surface		SiC Paper	SiC Paper	SiC Paper	MD-Largo
Abrasive	Type	SiC	SiC	SiC	Diamond
	Size	240	320	600	9µm
Suspension / Lubricant		Water	Water	Water	Dia pro-Allegro
RPM		320	320	320	140
Force (N)		140	140	140	140
Time (Min)		Until plane	2	2	5

**Table 7 : Procedure for metallographic polishing**

Step		Initial Polishing	Final polishing
Surface		MD-Dac	MD-Chem
Abrasive	Types	Diamond	Sillica/Alumina
	Size	3µm	0.04/0.02µm
Suspension / Lubricant		DiaPro Dac 3	OP-S NonDry OP-A
RPM		150	150
Force (N)		20	15

**Table 8 : Standard ASTM E8/E8M-13a [90]**

Standard ASTM E8/E8M-13a	Dimension (mm)
Gauge length (G)	50
Width (w)	12.5
Radius of fillet (R)	12.5
Overall length (L)	200
Length of reduced section (A)	57
Length of grip section (B)	50
Width of grip section (c)	20



**Figure 1: V-groove setup on Universal Milling Machine (a) setup (b) during the cutting**



**Figure 2 : Miller CP- 300 model MIG welding machine setup**





Figure 3 : Work piece positioned for Welding

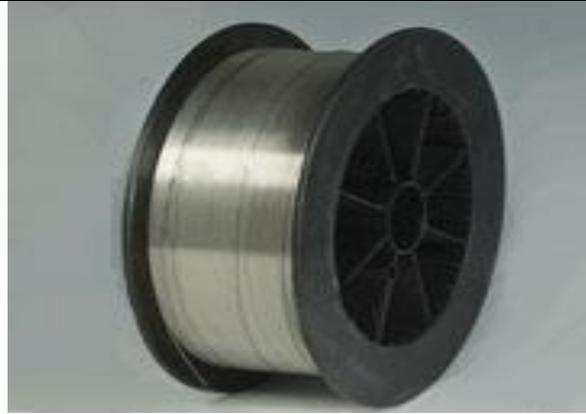


Figure 4 : Type 316 filler material used for the MIG welding



Figure 6 : T300 cutting machine



Figure 7 : Mounted samples



Figure 8 : Grinding and polishing machine



Figure 9 : Digital spring balance





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Figure 10 : DP 25 Olympus Optical Microscope

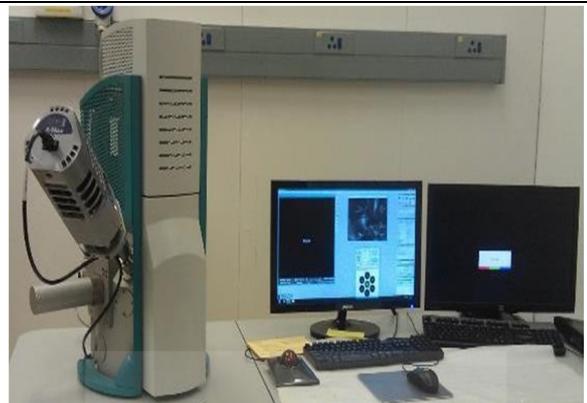


Figure 11 : TESCAN Scanning Electron Microscope



Figure 12 : Mounted sample in TESCAN Scanning Electron Microscope (SEM) Chamber



Figure 13 : Instron 5500R electromechanical tensile testing machine used

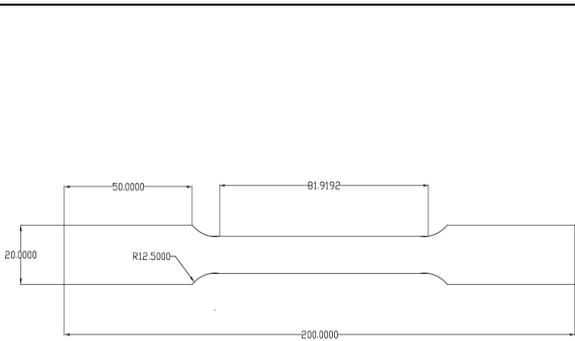


Figure 14 : Drawing of tensile sample according to standard ASTM E8/E8M-13a

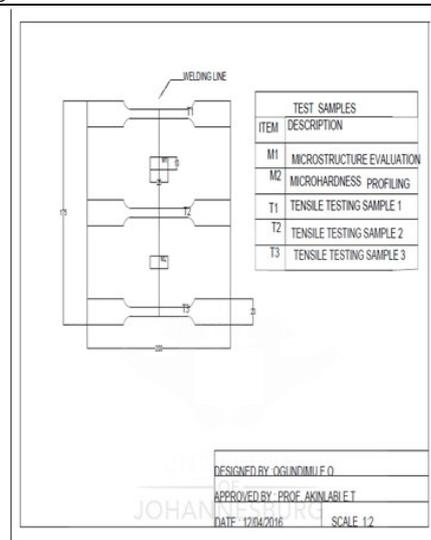


Figure 15 : Layout





Figure 16 : Samples prepared for tensile test

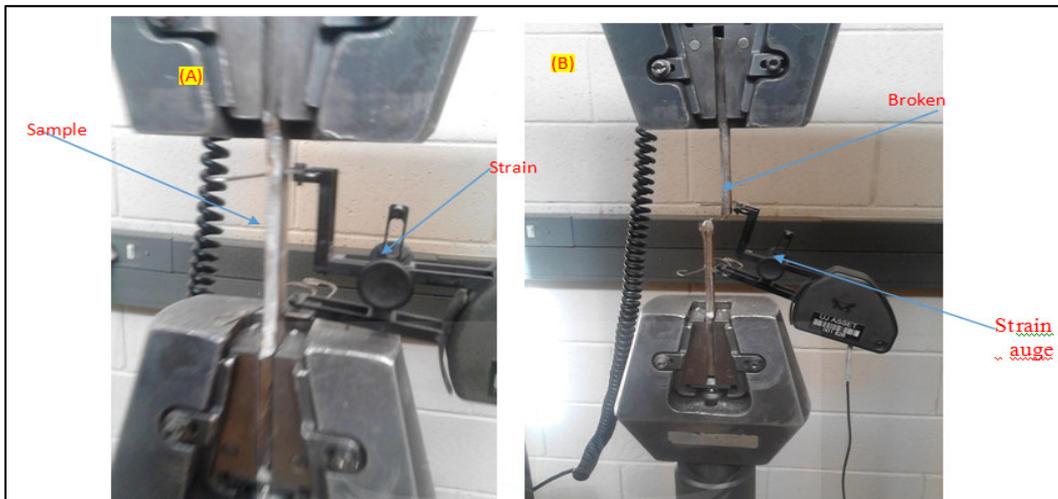


Figure 17 : Specimen in the tensile machine (a) during testing (b) after completion



Figure 18 : Indenter hardness testing machine





## Design of the Pulsed Wire Plasma Arc Process

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### ABSTRACT

This paper discusses the design of the pulsed wire process. The pulsed wire process is discussed in context of a specific embodiment of the process that is used to create ultra-fine copper and copper oxide particles. The manual and drill EDM experiments showed that current pulses rather than a constant current create a more stable process. Also the pulsed EDM like processes have the advantage of near zero cathode electrode growth or erosion. Near zero cathode growth provides the possibility of needing only one consumable electrode. The twin wire experiments showed that if two identical diameter wire electrodes are used, the alignment of the wires must be very good to have a stable process. If the wire alignment is not good, then only a portion of the wire cross section is eroded wasting that portion of the electrode. The wire misalignment also creates a condition where the electrodes will touch while passing by each other creating a shorted condition.

**Keywords:** EDM, diameter, electrodes, cathode, copper

### INTRODUCTION

It was clear that a process with a pulsed power supply would be more likely to perform well with wire electrodes than with a constant current power supply of the wire anode electrode is aligned to the cathode electrode poorly. Because the cathode electrode is large in comparison to the anode electrode the cross section of the anode will still be totally eroded. The pulsed wire process uses a closed loop anode electrode motion control system. Stable, closed loop motion control is required to maximize the rate of erosion in the process. Both EDM process, and the rod processes show that the stability of the motion controller is key to maximizing the rate of erosion. Typically, the average electrode gap voltage drop is measured to estimate the electrode gap distance and close the motion control loop.





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The pulsed wire process is defined as a process that uses a pulsed DC power supply creating current pulses between a flat plate electrode and a wire electrode whose position is controlled using a closed loop motion control system where the average arc gap voltage is used as the feedback signal.

### **Mechanical Design of the Pulsed Wire Process**

The mechanical design of the machine in terms of particle production can be split into two parts; the design of the reactor, and the design of the wire feed system. The design of these parts of the mechanical design has changed significantly as a result of the information gained during the development of the process.

#### **Some of the key requirements the mechanical design must accomplish are the following:**

- The new machine must use an anode in wire form
- The machine must be able to run continuously for long periods of time
- The machine should limit the need for frequent operator adjustment
- Seals in the reactor must be eliminated

The development of the mechanical portion of the process was completed at the same time that the idea of using a single wire electrode with a flat plate cathode electrode rather than two wires was developed. As a result, the reactor and the wire feed system can use two wires, or a wire anode electrode and a larger cathode electrode.

### **Reactor Design**

One of the most time consuming maintenance requirements for the rod process is the re-placement of the seals in the reactor. Because the rods are constantly rotating and translating, the seals and the bearings used in the reactor frequently need to be changed. Even when new seals were installed in the reactor the dielectric fluid still leaked out due to variations in the diameter of the rods and misalignment of the rods. One of the major goals of the pulse wire machine was to eliminate the need for seals or bearings in the reactor. Wire is compliant and can be bent to turn a corner in the reactor unlike the rod electrodes. An open top basin was used so that the wires could enter from the top without a need for seals. The wire electrodes enter the top of the reactor guided by a Teflon tube. The Teflon tube is formed into a curve by a slot in the wire feed plate. As the wire is fed through the Teflon tube, it is bent into a circular arc until the wire is horizontal and perpendicular to the flat plate electrode.

Because the electrodes enter from the top of the reactor and then are bent inside the reactor, no seals are required. The Teflon tubes will wear over time and will need to be replaced, but the replacement of the tubes is easy and will only be required one or twice a year rather than daily. The design shown was developed prior to the decision to use a flat plate cathode electrode of .0625 inches. A second wire electrode with a diameter of .25 inches was used as the cathode electrode. The diameter of the cathode electrode is 4 times the diameter of the anode electrode; this makes the cathode electrode effectively a flat plate in comparison to the anode electrode. The cathode electrode is stationary, and the anode wire is fed using the wire feed system. The dielectric fluid enters the reactor through a tube that flushes the dielectric gap and fills the reactor. The fluid exits the reactor through an overflow pipe (black pipe). The fluid that exits through the overflow pipe is drained into a 10 gallon storage tank. The fluid entering the reactor through the fill tube is pumped out of the same storage tank. The water in this closed loop system is recirculated till the concentration of particles in the fluid is high enough. After the concentration of the particles is high enough, a low flow rate peristaltic pump starts to remove fluid from the storage tank. A float valve in the storage tank keeps the fluid at the same level by adding clean deionized water. At steady-state conditions the concentration of the particles in the fluid is nearly constant and the fluid leaving the system leaves at the same concentration.





### Wire Feed System

The ideal feed mechanism for wire feedstock in a continuous process is friction drive roller like those used in wire feed welders. The drive roller is ideal because it can feed an infinitely long wire without any pauses or interruptions. A set of U-Groove drive wheels from a Miller wire feed welder were used in the machine so that the rollers would be off-the-shelf components. The diameter of these drive rollers is about 1.6 inches. Because the electrode gap in the process is very small, on the order of a few ten thousandths of an inch to a few thousandths of an inch, high resolution positioning of the electrodes is required. Also, the backlash of the positioning system must be low to prevent a large delay when the direction of motion is changed. To provide the fine resolution motion required a micro-stepping stepper motor along with a 10:1 gearbox was used to drive the roller.

The stepper motor was driven with a 256 micro stepping controller that results in a theoretical 102,400 steps per revolution. With the 10:1 low backlash gear box there are approximately 200,000 steps per inch, or 0.000 005 inches per step. The drive roller needs to be electrically isolated from the stepper motor because the electrical current is transmitted into the wire through the drive roller. To isolate the motor from the drive roller, a timing belt with Kevlar bands is used to transmit the torque from the gearbox to the drive roller. The timing belt electrically isolates the motor and the roller but introduces some torsional flexibility into the system. Because the system has friction, stiction, torsional flexibility, and other effects the expected resolution of the wire positioning system is expected to be somewhat less accurate than 5 millionths of an inch per step of the motor. The resolution is expected, however, to be smaller than the electrode gap. It has been confirmed by experimentation that the resolution of the system is well under one ten-thousandth of an inch (.0001 inches).

### Power Supply

Pulsing the current across the electrode gap limits the length of the discharge time in the process. When the length of the discharge time is limited, the maximum particle size is also limited. Limiting the maximum particle size has a significant impact on the distribution of particle size. The design chosen for the pulsed wire process power supply is a simple current limiting pulsed DC power supply. This design is very similar to the design used in the drill EDM described in section 3.3. Figure 4.4 shows the basic concept for this type of power supply. The power supply design uses a resistor to limit the current across the electrode gap. The resistor is a passive element so no active feedback loop is needed to provide a constant current. Ohm's Law is used to determine what resistance is needed for a given voltage and current. There are three states that should be considered during the design of this type of power supply. The first state is the short circuited state where the electrodes are touching. Ideally the machine will never be in this state, but it is nearly impossible to completely prevent the electrodes from shorting out. Using Ohm's Law the current can easily be determined and is shown in Equation (1). This is the maximum current that can be expected in the system. Equation (2) shows the power dissipated by the resistor in this shorted state. The power dissipated by the resistor is very significant and is the largest loss in the power supply. This is because the resistor limits the current in the circuit by converting electrical power to heat. All the components in the current loop should be selected to handle the shorted current for an indefinite period. Failure to select components that will indefinitely handle the shorted current could result in failure of the power supply, or worse an electrical fire.

$$I = \frac{V_{\text{source}}}{R} \quad (1)$$

$$P_{\text{resistor}} = I^2 R \quad (2)$$

The second state that needs to be analyzed is the current during a discharge. Typically, once the discharge has started the voltage across the electrodes will be between 18 and 26 volts depending on the electrode gap distance. For the design of this power supply the electrode voltage drop,  $V_{\text{gap}}$ , will be assumed to have a value of 22 volts. Equations (3), (4), and (5) show the current, power dissipated by the resistor, and the power delivered to the





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electrode gap, respectively. The current and power dissipated by the resistor is less in this discharge state compared to the shorted state. The rate of wire erosion is roughly proportional to the average power delivered to the electrode gap. Because the current in the gap is constantly being switched on and off, the duty cycle of the process must be considered. The duty cycle is the ratio of  $t_{on}=t_{off}$ , or in other words the percent of the time that the current is flowing through the gap. The average power delivered to the electrode gap. The power supply design requires an electronic switch to handle the high frequency switching of the load. A set of N-channel MOSFET transistors were selected for the supply. N-channel

MOSFET transistors were used in the power supply due to their low cost, high switching speed, and low on resistance. A MOSFET gate driver was also selected to improve the switching characteristics and reduced the switching losses of the transistors. The power supply design requires a constant voltage source of 80 VDC. A custom made toroidal transformer was used to convert three phase 208 VAC power to three phase 55 VAC power. A three phase full bridge rectifier was then used to rectify the power into a DC voltage. An LC input filter was used to filter the rectified DC voltage to a nearly constant voltage of 80 VDC. The LC filter acts as a buffer between the erosion process and the three phase AC input.

### Design of the Control System

The control system for the pulsed wire process is very important. The control system uses measurements from the process to make corrective actions to the wire position, stabilizing the process. One important note is that overshoot (when the controller feeds the electrode too close together) should be avoided to prevent shorting the two electrodes. In addition, the rise time, or the time it takes to reach the set point, should be minimal to quickly react to disturbances in the system. The electrode gap discharge is difficult to model accurately. The electrode is constantly changing in length, and the relationship between the electrode gap distance and the electrode gap voltage drop is quite non-linear. However, to roughly determine what kind of controller should be used, and what the optimal parameters are expected to be, a simplified model is sufficient. Two PCI interface cards were used to connect the PC to the pulse wire machine. An FPGA (Field Programmable Gate Array) based signal control card was used to provide digital I/O and to output the step direction signals to a stepper motor controller. The second interface card provides several analog to digital converters. The voltage and current signals are acquired using the analog to digital PCI card, processed by the controller on the PC. This manager calculates a new position for the motor. The EMC software produces a smooth motion path to the new position with limits on velocity and acceleration. The FPGA card then produces the step direction signals for the stepper motor controller to change the position of the stepper motor. The stepper motor changes the position of the electrodes to correct the electrode gap distance.

### Voltage and Current Sensing

Great care was taken to electrically isolate the discharge power supply from all the control systems in the machine. This isolation is to provide safety to the operator and to reduce noise and offset in the voltage and current signals. In the original design of the pulsed wire process, the electrode gap voltage was measured, converted to a digital signal, transmitted through optical isolation, converted back to an analog signal, and finally converted into a digital signal by the analog to digital PCI card in the PC.

Unfortunately, several filtering and aliasing problems were produced with this configuration due to the signal being converted from analog to digital two times at two different rates. The signal was required to be converted from analog to digital twice because the analog to digital converter in the computer was not electrically isolated from the discharge power supply. The way the current across the arc is sensed is fundamentally different from the way that the voltage was sensed. The current transducer used in the machine uses the hall effect principle to indirectly measure the current in a wire by measuring the magnetic field induced into a metallic ring in the current transducer. Because the transducer only measures the magnetic field produced by the current in the wire the signal it produces is already electrically isolated from the discharge power supply.





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Because the power supply uses passive resistance to limit the current in the circuit if the current across the resistor is known, then the voltage across the resistor is also known. Also, if the voltage across the resistor is known, then the voltage across the electrode gap is also known. This means that only one of the two parameters of voltage and current really need to be measured. Using Ohm's law for the resistor the voltage drop across the resistor at any given instant of time is given in Equation (1) as a function of the instantaneous current  $i$ . The only other element in the circuit is the electrode gap, so the remaining voltage must be across the electrode gap as shown in Equation (2), where the open circuit voltage of the power supply is  $V_d$ . The current transducer measures the average current,  $\bar{i}$  over several discharges so the remaining terms must also be expressed as an average value. The average open circuit voltage  $\bar{V}_d$  is shown in Equation (3), and the resulting average gap voltage, is shown in Equation (4).

$$V_r = i R \quad (3)$$

$$V_{\text{gap}} = V_d - V_r \quad (4)$$

$$\bar{V}_d = V_d (t_{\text{on}} = t_{\text{off}}) \quad (5)$$

$$\bar{V}_{\text{gap}} = V_d - R \bar{i} \quad (6)$$

The rod process produced a large amount of energy from the arc that was converted directly into heat increasing the temperature of the dielectric fluid in the system. The change in dielectric fluid temperature was enough to require a chiller to be installed in the system to keep the fluid at a reasonable temperature. This same effect was expected with the wire process, but the pulsed discharges in the pulsing wire process do not add a significant amount of energy to the fluid, unlike the rod process. Most of the energy in the pulsing wire process is used to create particles, and very little is used to heat the dielectric fluid. Because the temperature of the water does not change significantly when the pulsing wire process is used, all the designed experiments were performed with the water at room temperature. This eliminated the dielectric temperature as a design variable.

#### Impact of Motion Control Parameters

The PID motion control parameters will clearly have an impact on the response variables. The PID parameters affect the stability of the process. If the PID parameters are poorly tuned then the rate of erosion will be reduced, and the size of the particles will vary more due to the variation in electrode gap distance. It is possible to tune the PID parameters for every experiment performed on the machine. However, if the PID parameters were tuned for each setting, then the effects from the design variables and the PID parameters would be confounded. It would be unclear if the change in the output at a given setting is a function of the PID parameters, the design variables or any combination of the two.

To prevent the confounding of the PID parameters and the design variables in the experiment, the PID parameters are held constant for all experiments performed on the machine. A set of PID parameters was found that allowed the process to be reasonably stable in the range of the design variables used in the experiment. After the designed experiment have been finished and the optimal settings for peak current, pulse frequency, and pulse duty cycle are determined, the PID parameters for that setting can be fine-tuned to increase the performance at the optimal settings.

#### Expected Form of the Model

The three remaining design variables are peak current, frequency, and duty cycle. These are the design variables used in the experiments to create predictive models of the process. From a theoretical standpoint these three parameters are expected to have the largest effect on the process. The rate of erosion is largely a function of the amount of power delivered to the electrode gap [1]. As more current is delivered to the gap, the rate of erosion is





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increased. Peak current, pulse frequency, and pulse duty cycle all will have a large effect on the average power delivered to the electrode gap. The average power delivered to the gap,  $\bar{P}_{gap}$ , is shown in Equation (5) and is  $\bar{P}_{gap}$  clearly linear with respect to the average gap current  $\bar{i}_{gap}$ . Equation (6) shows the average gap current as a function of the peak current, the function  $q(w)$ , and the Duty Cycle.

$$\bar{P}_{gap} = \bar{v}_{gap} \bar{i}_{gap} \quad (7)$$

$$\bar{i}_{gap} = i_{peak} q(w) \text{DutyCycle} \quad (8)$$

The duty cycle and the peak current of the pulses clearly have a linear effect on the average power delivered to the gap. So it would be expected that the peak current and duty cycle would have a nearly linear effect on the rate of erosion. The model of the power supply shows that the resistors and conductors in series with the electrode gap are purely resistive elements. In reality the resistors and conductors used in the power supply have some parasitic inductance and capacitance. So the resistor bank used in the power supply really should be treated as a complex impedance,  $Z$ , having both resistance and reactance. As the pulse frequency increases the effective resistance of the resistor bank increases decreasing the current delivered to the gap. This means that as the pulse frequency increases the rate of erosion will likely decrease. The average size of particle produced in the process is expected to correlate with the surface finish of the workpiece in EDM processes. Parameters in an EDM process that result in fine surface finishes would be expected to produce small particles. Surface finishes in EDM machining are generally smoother when the current is decreased and the frequency is increased. This effectively creates more frequent, lower energy sparks in comparison to a higher current lower frequency setting. The lower current and higher frequency pulses will erode less material for each discharge reducing the probability of creating larger particles.

Little is known about what might affect the variance in the size of particles produced in the process. It would be expected that a lower variance in particle size would be expected when the process is more stable. That is to say when the electrode gap is well regulated and all the discharges produced are the same. It is difficult to guess at how the design variables might affect the variance of particle size.

### Selection of a Designed Experiment

The objective of performing the designed experiment is to determine the optimal setting for the process to operate at. Because of this a RSM, or response surface methodology, design should be used. One constraint in the design is that the power supply can only be set to four equally spaced current settings of 16, 32, 48 and 64 amps. This eliminates the possibility of using a full central composite design that requires 5 parameter setting. The remaining two factors of pulse frequency and duty cycle can be set to any setting in a reasonable range. There are two RSM designs that would be possible to use with three factors and the con-straints on the current settings. The first is a faced centered central composite design. This design uses three factor levels in each factor. This design has high variance on the edges of the design space, but has nearly flat variance in the middle of the design space where the optimal parameters are expected.

The second possible experimental design would be an I-optimal design. This design is a computer generated design that selects treatments from a subset of the full factorial design space. The treatments are selected on the basis of D-optimality, or the determinate of the information matrix composed from the treatments selected. An I-optimal design was created for the experiment and was compared to the face centered central composite design. Both designs have the ability to create a quadratic predictive model from the data. The face centered central composite design was favored over the I-optimal design because the variance of the design is lower and more constant though the center of the design space. The face centered central composite design is more commonly used so more tools are available to analyze it. Because of this the face centered central composite design was chosen over the I-optimal design.





### Factor Levels

The factor levels in the face centered central composite design are linearly coded variables from -1 to 1. For each of the design variables, a maximum and minimum value must be selected to map to the coded factor levels. For the current design variable only four settings are possible and the higher settings are expected to be favorable so the higher three settings were selected. The maximum and minimum settings for the pulse frequency and duty cycle were selected to give extreme values that still result in a stable process. The process was run at each of the extreme setting to make sure that the process could operate stably at these settings. The resulting designed experiment is shown in Table 4.4. The design has 6 center points shown in the table as treatments 7-14. These six center point are used to estimate the variation in the system.

### Experimental Procedure

Great care was made in the experiment to make sure than the operating conditions were the same for every run in the design. The order of the treatment was randomized to prevent background noise from being interpreted as a real parameter effects. Before each treatment was run the ends of the electrodes were flattened with a file and cleaned. The reactor was cleaned and filled with 4 liters of clean deionized water. Next, a marker was attached to the wire electrode next to a 5 cm scale. The maker was positioned so that the it points at the 5 cm mark on the scale. The reaction is started and the wire was eroded until the marker reaches the 0 cm mark on the scale. A stopwatch was used to measure the time required to erode the 5cm of wire. Care was taken to make sure that the particles in the fluid were well mixed and then one liter of fluid was collected in a vial for particle size analysis. The reactor was then cleaned and prepared for the next treatment. For each treatment in the experiment the rate of erosion was calculated based on the mass of a 5cm long wire and the time required to erode that length of wire.

The two remaining response variables, particle size and particle size variance, were mea-sured using a Beckmann Coulter LS230 particle analyzer. Based on scanning electron microscopy the expected particle size range is from about 50 nm on the low end to about 50-100  $\mu\text{m}$  on the high end. The LS230 instrument is a laser diffraction particle analyzer. Laser diffraction particle analyzers typically have a measurement range between 400 nm and 2000  $\mu\text{m}$ . Laser diffraction methods will easily measure the larger particles but will be useless for measuring the smaller particles produced in the process. The LS230 has an addition PIDS (Polarization Intensity Differential Scattering) module for measuring particles from 40 nm to 800 nm.

The LS230 used was fitted with a small volume fluid module that requires only a 200 ml fluid sample. 200 ml of RODI(Reverse Osmosis Deionized) water was placed in the LS230 sample module and the machine was then calibrated and prepared to measure the sample. Then the container with the sample to be measured was shaken to disperse the large particles in the sample. A syringe was used to introduce fluid from the sample container into the LS230 sample module until the appropriate PIDS concentration was reached. A debubbling cycle was then run on the instrument to remove any air bubbles introduced in the sample chamber when the particles were introduced. The sample was then analyzed in three 90 second runs. The three runs were then averaged to produce single particle size histograms (see Appendix A).

After the first designed experiment has been performed and the data analyzed, it became apparent that a second experiment would be required to properly characterize the rate of erosion in the process. This second experiment was required due to a lack of fit between the data and the predictive model created from the data. It was clear from the first experiment that the pulse current was a very significant factor. Additionally, it was clear that current has a positive effect on the rate of erosion. Because current is now known to have a positive effect on the rate of erosion, and the objective is to find settings that will maximize the rate of erosion, the current was set at the maximum value for the second designed experiment. The two remaining parameters of frequency and duty cycle can be set at any reasonable value unlike the current setting that could only be set at 16, 32, 48, or 64 amps. With this greater flexibility a new design was selected for the second experiment. A full central composite design with alpha points was selected





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for the second design. This design has 5 levels for each factor. In addition to changing the design for the second experiment the new design was centered around the expected maximum predicted from the first experiment.

## RESULTS

As was explained, two designed experiments were performed to create a predictive model of the rate of erosion, mean particle diameter, and particle diameter variance for the proposed pulsed wire process. The raw data from the first experiment (current included as a factor) is found in Table 3. This data is shown in the randomized order that the runs were performed. For each of the three response variables (erosion rate, mean particle diameter, particle size variance) a predictive model was created using statistical tools commonly used in designed experiments. The factor effects were calculated using least squares regression and a t-test was used to determine the significance of each of the effects. The designed experiments used are capable of creating, at most, a quadratic predictive model. Two designed experiments were performed for this research. The first designed experiment was created to create models for the erosion rate, mean particle diameter, and particle diameter variance. A second experiment was required to properly model the rate of erosion. These two experiments will be referred to as the first and second designed experiments, respectively.

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**Table 1: Required Resistance Values and Related Power Dissipation**

Peak Current (Amps)	Resistance (W)	Power Dissipated (Watts)
16	3.5	896
32	1.75	1792
48	1.17	2688
64	0.875	3584

**Table 2: Mapping to the Coded Factor Levels**

Coded Value	Current (Amps)	Pulse Frequency (kHz)	Pulse Duty Cycle (%)
-1	32	5	30
0	48	12.5	50
1	64	20	70

**Table 3: Face Centered Central Composite Design**

Treatment	Current (Amps)	Pulse Frequency (kHz)	Pulse Duty Cycle (%)
1	32	5	30
2	32	5	30
3	32	5	30
4	32	5	30
5	32	5	30
6	32	5	30
7	48	12.5	30
8	48	12.5	50
9	48	12.5	50
10	48	12.5	50
11	48	12.5	50
12	48	12.5	50





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13	48	12.5	50
14	48	12.5	50
15	48	20	50
16	64	5	30
17	64	5	70
18	64	12.5	50
19	64	20	30
20	64	20	70

**Table 4: Second Composite Design (with Alpha points)**

Treatment	Pulse Frequency	Pulse Duty Cycle
	(kHz)	(%)
1	3.2	32.9
2	6.8	32.9
3	3.2	47.1
4	6.8	47.1
5	5.0	40.0
6	5.0	40.0
7	2.5	40.0
8	7.5	40.0
9	5.0	30.0
10	5.0	50.0
11	5.0	40.0
12	5.0	40.0
13	5.0	40.0





## Development of a Plasma Arc Manufacturing Process and Machine

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### ABSTRACT

Ultra-fine metal oxide elements are useful in several areas. Ultra-fine elements can be used as abrasives, coat and adhesive additives, and as feedstock for plasma spray arc coatings. Aluminum oxide particles could be used as an abrasive material in place of garnet in water-jet cutting applications. The same aluminum oxide particles could be used as an additive in paints to make them more wear resistant. Because some metal oxides are electrically conductive they could be used in paints and adhesives to make them electrically conductive. Iron oxide particles could be applied to a surface with the plasma spray arc process to create magnetic films [1, 2]. Undoubtedly, more submissions for these particles will be discovered as more ways are developed to create ultra-fine elements.

**Keywords:** Aluminum, elements, plasma, oxide, areas

### INTRODUCTION

Many of the applications previously mentioned require very small particles. For example, if particles are used as an additive in a paint, the particles would need to be small enough to not produce any significant texture in the applied painted surface. These particles would need to be 70 nm or smaller. Particles with a size under 70 nm are considered ultra-fine elements. In many applications the performance of the particles are superior if the particles are smaller. For example, some particles are transparent to some light ranges as they are lesser than the wavelength of light [3]. The first variation of the plasma arc process is a completely physical method where a human operator panels the process. This method has serious drawbacks in terms of produce quality or constancy, production charges, and high labor costs. The manual process is very flexible in terms of size and shape of the electrodes used in the process because the human operator can easily regulate to these changes. This manual method has many difficulties because it is controlled by a human. The degree of production and the excellence of the particles produced is incomplete by





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the slow response time of the operator. The variation introduced into the system by a human operator could be greatly reduced if the operator was replaced by a feedback control system.

The second variation of the plasma arc process, the rod process, was established in previous research at BYU by Chris Lewis. [4] The rod process uses metallic rod electrodes that are fed toward each other as the rods are eroded. The rod process greatly improved the state-of-the-art by replacing the human operator with a digital control system to close the feedback loop. In this way the production rate and product quality were both increased. The production rate was improved by several times over the manual process. Additionally, the rod process requires frequent operator adjustments to maintain consistent control of the process. These adjustments are required due to the way that the electrodes wear. The operator must frequently stop the process to remove and dress the ends of the electrodes. These maintenance issues are time consuming and labor intensive and also seriously limit the utilization of the process. The objective of this research is to improve upon previous variations of the process and develop a new plasma arc process that increases production rate, improves the particle quality, and requires limited operator interference and maintenance.

### Plasma Arc Process

The plasma arc process used for the production of ultra-fine particles has many similarities to other plasma arc processes such as plasma arc welding. Two electrodes are placed in close nearness to each other in a dielectric fluid. In all the experiments deliberated in this research deionized water was used as the dielectric. A voltage change is placed between the two electrodes causing the two faces of the electrodes and the dielectric amid them to act as a capacitor. This gap between the electrodes will last to act as a capacitor until the electric field is strong enough to dazed the strength or resistance of the dielectric fluid. Equation (1) shows the breakdown voltage of a capacitor where  $V_{bd}$  is the breakdown voltage,  $E_{ds}$  is the strength of the dielectric material and  $d_{gap}$  is the distance between the plates.

$$V_{bd} = E_{ds} d_{gap} \quad (1)$$

This relationship shows that the breakdown voltage is proportional to the distance between the capacitor plates. This means that as the electrodes get closer together the voltage required for the dielectric to breakdown is abridged. The dielectric strength of the material is an intrinsic property of a material. The dielectric power of a material decreases with an increase in temperature and frequency. The dielectric strength of deionized water is on the order of 20kV/mm [5]. Given that the power supplies used in this research have an open circuit voltage of 80V, the electrode gap distance for dielectric breakdown is on the order of 4 microns or 0.00015 inches.

The plasma arc can be divided into five stages: pre-breakdown, breakdown, discharge, end of discharge and post-discharge. Chris Lewis' research focused on understanding the discharge stage of the process. During pre-breakdown, shown in Figure 1.1(a), a voltage difference is placed between the electrodes. The process will continue in the pre-breakdown stage until the asset of the electric field overcomes the dielectric strength of the gap. When the dielectric begins to breakdown it ionizes, the result is a conductive path between the electrodes. Current begins to flow, creating a plasma arc between the electrodes through the conductive ion column. The creation of the arc starts the discharge stage of the process. While the arc is sustained, the heat of the arc originates material from both the cathode and the anode to melt and vaporize, then combines with the other material in the plasma channel

### Process Design Challenges

In addition to the control problems noted above the use of rod electrodes in the previous processes had led to many problems in terms of process down time, production rates, raw material cost and maintenance costs. Most of these



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issues are related to the fact that the previous processes have required bearings and seals where the rods enter the dielectric filled reaction chamber. If the need for these bearings and seals could be eliminated, then the process down time and maintenance cost would be dramatically reduced.

Seals were required in the rod process because the electrodes entered the reactor from the side below the water line. The seals were required to prevent the dielectric fluid from leaking out of the reactor. Bearings were required in the process to align the electrode with the seals. If the electrodes are not concentric with the seal, the seals will leak. Rods with fine surface finishes, high straightness and high tolerance diameters are required for the seals to function and to increase the life of the bearings. Rods with these properties are difficult to machine and therefore are expensive to purchase. If the need for the seals and bearings were eliminated then the cost of the electrodes, as well as maintenance of the process, would be greatly reduced. The downtime required for replacement of the seals and bearings would also be eliminated increasing the productivity of the process.

The rod process also requires that the electrodes rotate to maintain a stable process. The rotation of the electrodes is what keeps the discharge from staying in one place on the electrode faces. If the process can be stabilized without using rotation, then many additional problems would be eliminated. The proposed new pulsed process would use wire as the consumable electrode. Most of the metal materials that might be used in the process are most readily available in wire form. A large volume of metal can be wound on a spool providing enough feedstock for days or weeks without need for maintenance. If the tip of the wire electrode has buildup or any other problems the tip can simply be cut off. No high cost or time consuming maintenance will be needed for a consumable wire electrode.

## PRELIMINARY EXPERIMENTATION

Several preliminary experiments were performed to better understand how the pulsed wire process should be designed. Originally the goal of the research was simply to create a new variation of the rod process that used wire feedstock rather than rods. While attempting to create this new wire feed process, it was discovered that using a pulsing current across the electrode rather than a constant current had several advantages. This chapter briefly describes these preliminary experiments and the results from these experiments. The first experiment involved an attempt to create a twin wire process prototype. A prototype was created to determine if a welding power supply could be used with two wire electrodes rather than rod electrodes. The prototype demonstrated that a welding power supply is not the optimal power supply for use with wire electrodes. The second set of experiments used an RC EDM type power supply along with manual control to test the feasibility of pulsed EDM like power supplies. This experiment was created to determine if the EDM like pulsed power supply would create ultra-fine particles. The results of the experiment show that ultra-fine particles were produced, and that the process could be controlled to provide consistent results.

In addition to answering the above three questions, the drill EDM experiments also showed that the settings on the power supply could be set so that the cathode electrode has a near zero erosion rate. This near zero wear rate can be used in solving the electrode alignment problem. Rather than using two wires, a single wire could be used as the anode and a larger electrode, like a flat plate, could be used as the cathode. Because the cathode is large in comparison with the wire anode, there is no need for close alignment of the electrodes. The advantages of this configuration will be discussed later. The remaining sections of this chapter will discuss these three preliminary experiments as well as the results of the experiments. The results of these experiments provide a foundation for the development of the pulsed wire process.

## Twin Wire Process Prototype

Inspired by the twin wire spray arc process discussed, a set of experiments was performed to test the feasibility of using two wires as electrodes. A Constant current welding power supply was used in the twin wire prototype. Up to



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this point EDM type power supplies had not been used in the process. In fact, the twin wire prototype provided major motivation to move away from the use of a welding power supply toward pulsed DC power supplies like those used in EDM processes.

### **Twin Wire Experimental Setup**

Each of the wire feed assemblies shown feeds a wire through a copper tube. The copper tube guides and conducts electricity to the wire. The copper tubes are partially flexible and can be bent to align the wires at different angles with respect to each other. The wire feed assemblies are mounted above a glass tank filled with deionized water. The copper wire guide tubes were positioned so that the electrode gap is under water

### **Twin Wire Control System**

The position of the wires was controlled by two DC servo motors. The servo motors drive the wires with drive rolls through a planetary gearbox with a 40:1 reduction ratio. The positioning resolution of the drive mechanism is just under one ten thousandth of an inch (.0001 inches). A micro controller was used to control the position of the servo motors with a PID feedback loop based on the electrode gap voltage.

### **Twin Wire Results**

The twin wire prototype was used to experiment with several current settings from 5 to 60 amps. For each current setting and wire orientation the PID control parameters were tuned to attempt to create a stable arc between the wires. Unfortunately, a stable reaction was not realized for any power setting. The welding power supply could be used in two modes, a TIG mode for currents from 5 to 30 amps, and a stick welding mode for current from 30 to 250 amps. At low currents in the TIG mode, an arc was only created when the wires separated after touching. When the wires separated, a very brief spark would be created, but an arc could not be sustained.

After there was no success using the power supply TIG mode, the stick welding mode was used. In this mode when the wires would touch, the power supply would provide a very large surge current causing about one quarter to one half inch of metal from each electrode to nearly instantly melt and fall to the bottom of the tank. When the controller was optimally tuned this behavior would be repeated several times a second. The wires would touch, a high current arc would melt the wires, and then the motors would advance the wires causing them to touch and the process to repeat. The large surge current that causes the wires to melt is a result of the design of the welding power supply. It became apparent that it would be difficult to use this type of power supply in a process that uses wires as electrodes. It is believed that the welding type power supply works well with the rod process because the mass of the rods is much higher than the wires allowing them to adsorb the energy of the high current surge when an arc is struck.

### **Manual EDM Experiments**

Because the results using a welding power supply with wire were poor it became apparent that if wire electrodes were to be used successfully, a different kind of power supply would be needed. EDM pulsed type power supplies are a natural replacement in this situation. EDM applications often use very small electrodes with good results. A prime example of this is the wire EDM process. The wire EDM process uses very small diameter wires in the range of 0.005 inches to 0.015 inches to machine conductive materials at relatively high current. Even though the wire is very small, it can endure the high energy pulses used to erode the workpiece. The key is that pulses are used rather than a constant current. A simple low power, RC-type, power supply was proto-typed to examine the feasibility of pulsed EDM power supplies as a power source in the process. The prototype power supply uses a set of DC power supplies in series to produce a constant voltage supply adjustable between 40 and 120 VDC. A power resistor with a resistance of 50 ohms and several capacitors with capacitance values ranging from 2 to 50 mF were used in the prototype power supply.





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The electrode gap distance was controlled manually. The cathode electrode was attached to a fixed base and the anode was mounted on the carriage of a linear slide. The electrode gap was controlled by moving the carriage of the linear slide toward or away from the cathode electrode. The electrodes were submerged in deionized water as usual. It is difficult to align two wire electrodes in this kind of manual test, so a wire electrode, the anode, and a plate electrode, the cathode, were used. Wire electrodes of various diameters ranging from 0.125 inches to 0.01 inches were tested with the RC type power supply. Creating a sustained set of pulses between the electrodes that would last several seconds before the electrode gap grew too large was easily achievable with all the wire diameters used in the test. The capacitor could be switched to a different value and the change in spark frequency could be heard. Also, as higher capacitance values were used, the erosion rate of the electrodes was increased. The higher capacitance value effectively increased the power in each pulse, increasing the rate of erosion.

In addition to stability of the arc, it was clear that small particles were being generated because a visible dark cloud of particles was seen being dispersed from the electrode gap while the sparking was stable. These particles were small enough to remain suspended in the water. When the capacitor is removed from the circuit the power supply becomes a simple current limiting power supply similar to the welding power supply previously used. This simple current limiting power supply does not have any energy storage elements to create a high current surge like the welding power supply produced. In general, it was difficult to create sustained discharges without the capacitor in the circuit. There was one special case where a stable set of discharges could still be easily maintained. If a thin flexible foil electrode was used in combination with a wire as the other electrode, an interesting thing happened. The pressure wave created by the arc is enough to cause the foil electrode to deflect away from the wire electrode acting like a switch interrupting the flow of current.

Thicker foils cause the frequency of this reaction to increase because the higher stiffness results in a higher spring back force. In the case of this configuration the power supply in combination with the electrodes are acting like a resistive switching power supply. There are no energy storage elements in the circuit, unlike with the welding power supply, so there is no surge of current at the start of a discharge. The resistor simply limits the current preventing the thin electrodes from instantly being melted. The success of these experiments prompted further development with a power supply of the EDM type.

### **EDM Drill Experiment**

Because the first experiments with the RC type EDM power supply were performed manually it was difficult to produce consistent particles for analysis. Analysis of the particles is important to determine particle size and distribution. In addition to particle analysis, the EDM Drill experiments were performed to estimate what power supply setting would produce an optimal erosion rate. A drill EDM machine was used to generate particles for analysis. A drill EDM was chosen rather than a sinker EDM because the drill EDM already has a system to align and guide small diameter round electrodes. In addition, the control system and power supply used in drill EDM processes are generally simpler.

In these experiments two wires are used as electrodes. The anode wire is clamped in a collet fixture and connected to the power supply. The cathode wire, from here on called the tool, is clamped into the tool chuck on the upper end of the machine. This tool chuck is connected to the negative side of the power supply. The tool is then lowered through the tool guide. The tool guide is used to keep the tool electrode centered in the hole during the process. To prevent contamination with other particles and to easily collect particles, a test reactor is used to hold a small amount of deionized water. The anode electrode enters this reactor through a rubber stopper on the bottom end. The tool electrode simply enters the reactor through the open top. The tool electrode is positioned directly above the anode electrode. Because the tool electrode is not tubular, deionized water cannot be pumped through it to flush the electrode gap. Non-optimal performance of the process can be expected due to the poor flushing conditions.





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### Power Supply and Control System

This specific EDM drill uses a fuzzy logic controller to maintain the electrode gap distance. The fuzzy controller is useful in this application because the electrode cuts a deep hole into the workpiece. dramatically changing electrode gap conditions. The exposed area between the electrode and the workpiece increases changing the electrode gap resistance. As the hole gets deeper it also becomes much more difficult to flush out the eroded particles from the hole. These two changes in the process will require the controller to provide different motion dynamics to match the changing conditions. A fuzzy logic controller can sense changes in the process like poor flushing conditions and temporarily increase the electrode gap distance to flush the gap. Once the flushing conditions are better, the controller is returned to normal operation.

### Experimental Process

A statistical screening experimental design was used to determine the what settings and parameters effect wire erosion rate using the EDM machine. The design used is a screening design for up to 8 variables. The design can be used to estimate what factors will have a significant effect on the rate of wire erosion. The design variables in the design are the Peak Current, Tool electrode, rotation rate, electrode diameter,  $t_{on}$ , and  $t_{off}$ . The order of the experiment was randomized to reduce the influence of uncontrolled variables. Prior to each run the wire electrodes were massed and the tips were ground flat. The reactor was drained, cleaned and filled with 500 mL of clean deionized water between each run. For each run the electrodes were mounted and aligned in the machine and the machine was run at the given settings for 4 minutes. Then the electrodes were removed from the machine and massed again to determine the erosion rate of each electrode.

## EXPERIMENT RESULTS

The results of the experiment show that the peak current, electrode diameter and the electrode material are all significant factors that effect the rate of erosion. The rate of erosion increases as current and diameter increase. It is very likely that the  $t_{on}$  and  $t_{off}$  parameters have a significant effect on the rate of erosion, but the values were not changed enough to see a change in the rate of erosion.

One important note to make at this point is the rate of erosion of the cathode electrode. During the experiments with the EDM machine, the cathode has a near zero wear rate. In some high setting where the  $t_{off}$  time is short the cathode electrode actually grows over time. The twinwire experiment showed that it would be difficult to align two wire electrodes and create a stable reaction. If the cathode electrode experiences near zero wear rates, then only one consumable electrode is needed. If the anode wire electrode is fed toward an electrode that is significantly larger than the diameter of the wire then fine wire alignment is no longer needed. The cathode electrode only needs to be large enough to prevent the wire electrode from missing it. From the data it was concluded that a pulsed DC EDM type power supply is well suited for the particle generation process. Particles in an acceptable size range were generated at a reasonable rate.

The particles generated at the optimal erosion rate were analyzed using a scanning electron microscope, SEM, to determine particles size and distribution. Figure 3.7 shows a micrograph of the particles generated using 0.0625 inch diameter wire at 57 peak amps of current. The particles generated are smaller than those generated using the rod process with an average size of 200 nm with a range of plus or minus 70 nm. Also the distribution of particles size is very tight in comparison to that of the rod process

## CONCLUSION

These results show that using a pulsed DC power supply like those used in EDM processes will produce particles with a smaller average size and a much tighter distribution of particle size than those created with the rod process.





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Even though the EDM drill is successful in producing ultra-fine particles there are some reasons not to use an EDM machine for the production of particles.

EDM machines are optimized to maximize the rate of workpiece erosion and to produce fine surface finishes. Similarly, a machine designed to produce ultra-fine particles should be optimized to maximize the rate of erosion, or in other words the rate of particle production. In contrast, when generating particles there is no concern for the surface finish of the electrodes, only the quality of the particles being produced. EDM power supply settings that result in fine surface finishes usually have low material removal rates. When producing particles if there is no concern for the surface finish of the electrodes, it may be possible to produce small particles at a high rate using different power supply settings and control strategies than those of EDM. If an EDM machine were used to produce particles it would be difficult to modify the controller and power supply to determine if this is possible. By designing a machine specifically for the production of particles, both the controller and the power supply can be designed to produce high quality particles at a high rate.

EDM machines also are quite costly due to the additional features that would not be used in particle production. EDM machines usually include dielectric filtration systems and dielectric chillers. A particle production machine may also require a chiller and a dielectric filtration system, but the chiller and filter system in the EDM machine could not be used because they include metallic components that are incompatible with the particles being produced. EDM machines also have CNC controllers, additional axes of motion controls, and other subsystems. These subsystems only add to the cost of the EDM machine without any added benefit with respect to particle production.

Because wire will be used as the electrodes in the pulsed wire process, a wire feed mechanism would also have to be integrated into an EDM machine to replace the linear actuator used to control the electrode gap distance. The base cost of the EDM machine, plus the replacement of all the metal components in the fluid system, modification to the controller and new wire feed system will result in a higher cost machine than a machine designed specifically to produce particles.

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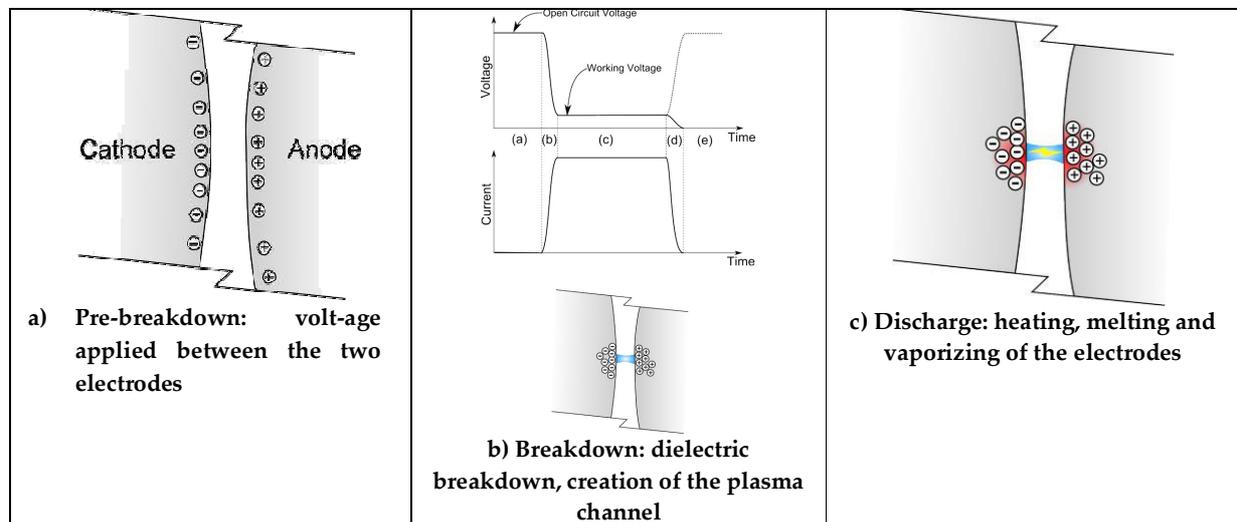
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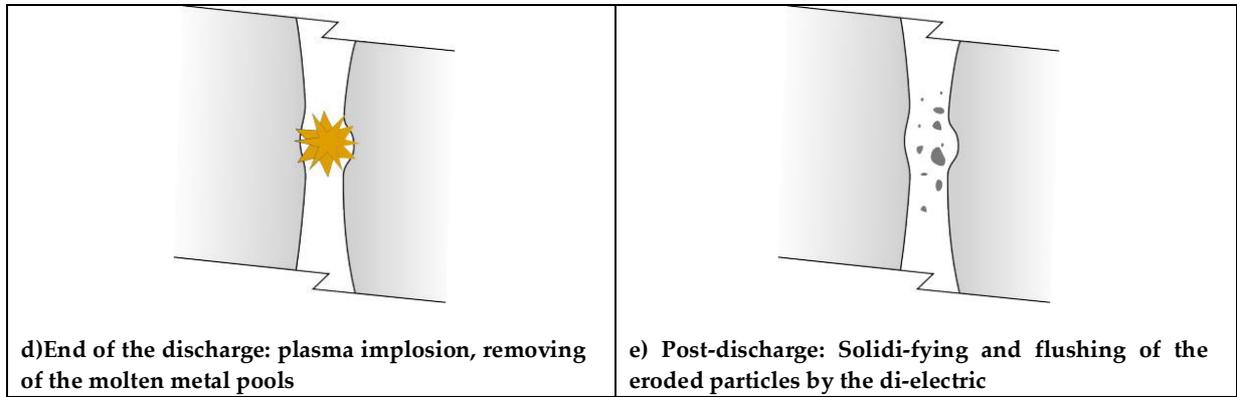


Figure 1: Plasma Arc Process Steps [6]

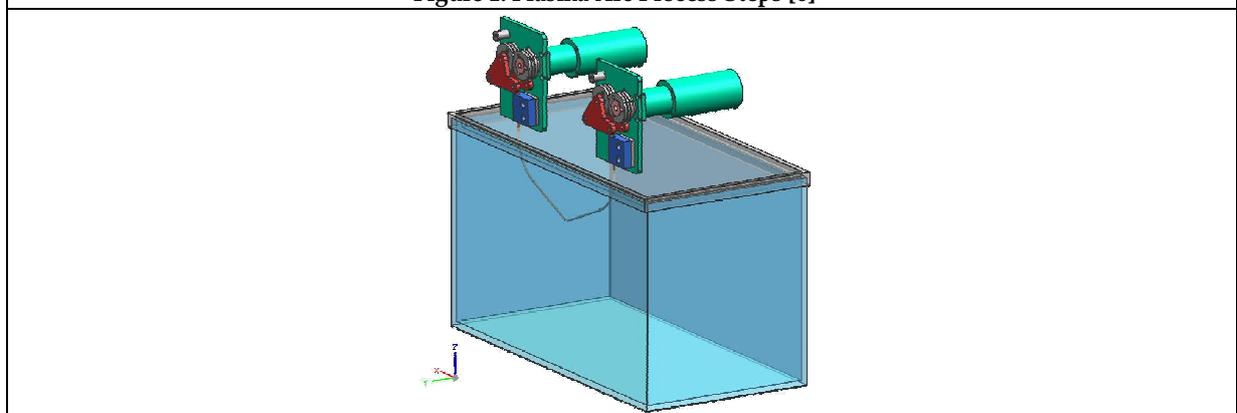


Figure 2: Twin Wire Prototype

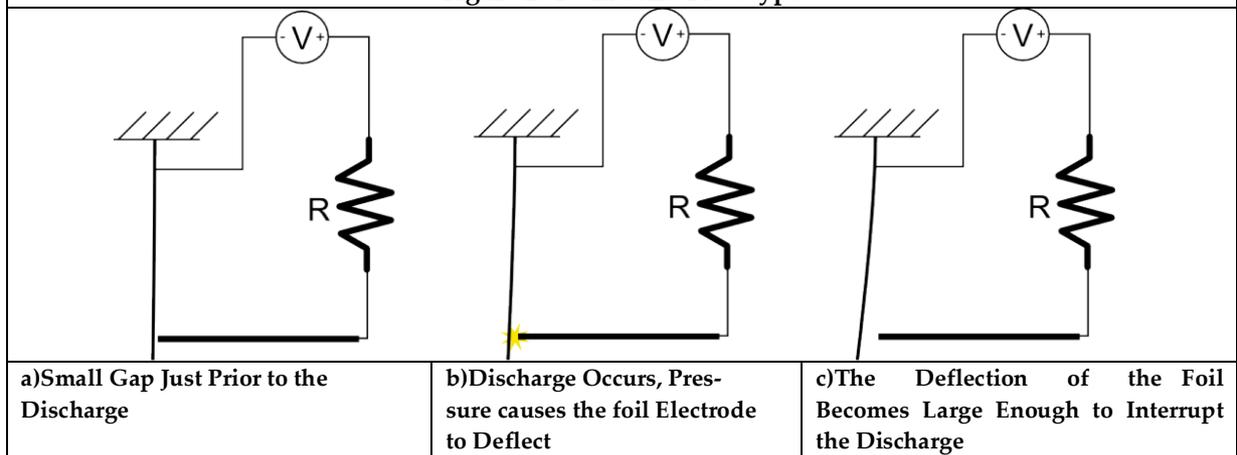
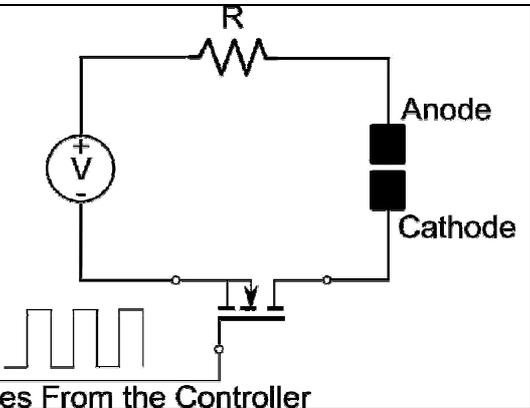


Figure 3: Pressure Wave Actuated Switching System





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 <p>Pulses From the Controller</p>	
<p>Figure 4: Drill EDM Experiment Reactor and Electrodes</p>	<p>Figure 5: Micrograph of Particles Produced with the Drill EDM</p>





## E-Governance and the Influence of Common Service Centers on Rural Citizens: A Study in Rayagada District

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### ABSTRACT

The “Government of India” in the year 2006 has initiated the step of establishing rural tele-centers in the name of “Common Service Centers (CSC)” under “National e-Governance Plan (NeGP)” to provide “various government services” electronically to citizens. The idea behind establishing such tele-centers in public private partnership (PPP) was to provide quick, effective and hassle free government services in affordable price within the village or panchayat, so that the citizens should not go to various offices physically. When the researchers were reviewing the available literatures in the area of e-governance and CSCs found various studies. But as far as Odisha state is concerned there were absolutely very few studies were available on this area. Further “Rayagada” being a tribal dominating district far from the state capital attracts the “researchers to focus and conduct the study”. The main focus of the study is to find out how influential are the CSCs to cater the need of the citizens for various government services electronically. This paper addresses and evaluates the influence of CSCs on rural citizens in rendering e-governance services with a focus on Rayagada district of Odisha state.

**Keywords:** E-Governance, Common Service Centers, Rayagada District, Odisha, PPP, Citizens, VLE

## INTRODUCTION

### E-Governance in India

The CSC initiatives have started way back in 2006 by “Department of electronics and information technology (DeitY) now known as MeitY” and “Department of administrative reforms and public grievances (DARPG)” under NeGP.

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The mode of operation has decided that the CSCs will be operated in “PPP” mode, where the stake holders are Central Government, State Governments, “Service center agencies (SCA)” as the operational partner, “State designated authorities (SDA)” as the technical partners and the “Village level entrepreneurs (VLE)” as the service delivery partners [1]. Citizens in general are service takers. There was a clear vision of the Government while setting up this CSCs as “to deliver and make accessible all Government, social and private sector services in the area of agriculture, health, education, utility payments, banking, financial services and many more to the citizens at affordable cost” [2]. The “former president of India Dr. APJ Abdul Kalam” has quoted in the context of providing all government services to the citizens as “Delivery of services to citizens is considered a primary function of the government. In a democratic nation of over one billion people like India, e-Governance should enable seamless access to information and seamless flow of information across the state and central government in the federal set up. No country has to so far implement an e-Governance system for one billion people. It is a big challenge for us” [3]

### E-Governance in Odisha

The “Common Service Center”, is popularly known as “Jana Seva Kendra” in Odisha. The government of Odisha has taken “various initiatives to implement the e-Governance projects in the state in association with Odisha Computer Application Center (OCAC) as the SDA for technical support, “Tata Consultancy Services (TCS)” as technical support partner, “National Informatics Center (NIC)” as another technical partner to provide the back end data support, and Odisha e-Governance Services Limited (OeSL)”. The “e-Governance roadmap of Odisha was released on 14<sup>th</sup> June 2006 by the Hon’ble Chief Minister of Odisha with good governance vision, governance strategy and the blue print for capacity building” [4][5].

The “Information and Communication Technology (ICT)” is used extensively to support the e-Governance projects in Odisha. Odisha State Wide Area Network (OSWAN) has established which connects to “State Head Quarter (SHQ)”, 30 district head quarters, 284 blocks of the state and 60 horizontal offices of the state [6]. Odisha State Data Center (OSDC) is “fully functional since October 2011 with an objective to provide shared, secured and managed infrastructure for consolidating and securely hosting state level data and applications”. Applications like e-districts, e-registrations and e-municipality are some of the main focuses of OSDC [6]. State Service Delivery Gateway (SSDG) is established to provide seamless interoperability and exchange of data across multiple government departments [6]. Tata Consultancy Services (TCS) is the service provider for SSDG.

### E-Governance in Rayagada

Odisha Government has started the e-District project under NeGP and the Rayagada district has its own portal to provide all the services to its citizen designed and maintained by “National Informatics Center (NIC)”. The district was initially under the undivided Koraput district and became one independent district on 2<sup>nd</sup> October 1992. The district with 7,073 square kilometer area, 11 blocks, 182 gram panchayats and 2667 villages has a total population 9,67,911 (source census 2011). The literacy rate is 42.13% [7]. Out of 445 sanctioned CSCs only 197 CSCs are rolled out in Rayagada District till 2019 [8]. Some of the major services provided to the citizens through CSCs are caste certificates, legal heir certificates, residence certificates, employment exchange registrations, land record registrations as state government services along with all central government services. The Service Center Agency (SCA) for Rayagada district is BASIX [10][11] and the same organization is in charge of 4 districts of Odisha including Rayagada and they have their operations in 19 states of India including Odisha [11]. The role of SCA is to provide digital network support to VLEs.

### Objective of the study

The main objective of this study is to find out the influence of Common Service Centers in rural India with a special reference to Rayagada district of Odisha State. Further the study will reveal the influence of CSCs on two major stakeholders of e-Governance initiatives i.e. the Village Level Entrepreneurs (VLEs) as the service providers and the citizens at large as the service takers.





## METHODOLOGY

This study has been carried out by conducting a survey in the district of Rayagada to collect primary data. The secondary data is also collected by referring various web portals. The researchers have used two sets of structured questionnaires to collect the primary data from the VLEs and the Citizens separately. Five VLEs from each block (11 blocks of Rayagada) were participated in the survey except Chandrapur block.[11]. Under each VLE 10 citizens were contacted randomly as respondents. The data were compiled and refined in MS-Excel sheets and then data analysis tool "Pivot Table" and graphical tool like "Pivot Graphs" were used to analyze the data and the findings represented.

### VLE Data Analysis

#### VLE Respondent Details

The respondents in each stakeholder are chosen carefully, which is a mix of all category users to get some quality data for this study. As per the data in Figure-1 out of 55 VLEs Bisamcuttack, Gunupur and Rayagada have 6 VLEs each and Chandrapur block has 2 VLEs and all other blocks have 5 VLEs each. There are 6 female (10.90%) VLEs and 49 male (89.10%) VLEs. The age of the VLEs ranges from 26 to 56, out of which 31 VLEs (63.26%) are male of the age group of 26 to 35. Then 13 male are from the age range of 36 to 45 which is 26.53% of total male VLEs. As per the data available in Table-1, out of total VLEs 40 (72.72%) VLEs are graduates, 9 (16.36%) VLEs are intermediate and 6 (10.90%) VLEs are post graduates.

#### Citizen Respondent Details

Based on the data available in Table-2, there are 185 (33.6%) citizens from the age group 29 to 38. From the age group 39 to 48 there are 166 (30.2%) citizens, 126 (22.90%) are from the age group 19 to 28. Next age group is 49 to 58 where 11.3% citizens were participated in the survey. The age group 59 to 68 has 10 citizens which is only 1.82% of the total respondents. And finally only one respondent (0.18%) is from the age group 69 to 78.

#### Influence of Common Service Centers on VLEs

##### Prior Computer Knowledge of VLEs

As per the data in Figure-2, which shows there are 35% of the VLEs were not having any prior computer knowledge, but after starting of CSCs they have been provided training on how to operate computers for performing day to day business activities, which is a positive influence of having CSC to render e-Governance services.

##### Profession of VLEs before setting of CSCs

As we can see the data in the Figure-3, that 20 VLEs (36.36%) were in temporary or contractual job, 5 VLEs (9.09%) were unemployed and 4 VLEs (7.27%) were house wives but now each of them are earnings by opening CSCs as a business option, which is a positive influence of CSC.

##### The VLEs income before CSC and after CSC

Now let us compare the data shown in the Figure-4 which shows the income of the VLEs before they have CSCs and after the CSCs. We can see there are 12 members who were having the earnings up to 5000 now having the income of 15000 to 20000. Similarly 10 VLEs were having the income up to 7000 and now have 15000 to 20000. Similarly there were 10 VLEs who were getting up to 7000 and 6 VLEs who were getting up to 5000 now getting 20000 to 25000 per month. Those who were earning 10000 or more than 10000, are now earning 25000 to 30000, per month. One VLE was earning 5000 per month, now earning more than 30000 per month. So the impact and influence of CSC is very impressive on the financial and hence the social growth of the VLEs.





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### **Influence of Common Service Centers on Citizens**

#### **Whether to use CSCs or the office physically for e-Governance services**

After referring the data set in Figure-5, we can conclude that most of the citizens prefer to get the services at CSCs rather than visiting the office physically. The graph shows a very clear picture that almost in all the blocks people preferred to visit CSCs. 79.81% of Citizens given their choice to use CSCs where as only 20.18% of Citizens said they prefer to visit the respective offices to get their work done. The result analysis shows that the Citizens behavior of getting the e-governance services is quite influenced by CSCs.

### **Computer Literate Citizens**

As per the data available in Figure-6, which says, 436 citizens (79.27%) out of 550 are not computer literate that they can't operate computer of their own. The remaining (20.72%) of citizens can operate computers of their own. When a citizen can do his/her own work at CSCs, efficiency of the work will increase and that will be inspiration to others who don't know to operate computers.

### **CSCs Provides better e-Governance Services**

The data in Figure-7 shows almost every block's citizens admitted that the CSCs are providing better e-governance services, so which is very influential reason to use services rendered at CSCs.

### **Findings of the study**

After a thorough study on the Common Service Centers at Rayagada district with 55 active VLEs and 550 Citizens of all categories, it is observed that the CSCs have enough positive influence on the rural citizens. Some of the findings of the study are as follows.

- A. The VLEs having prior computer knowledge are providing better e-governance services and hence those VLEs did not know computer operations earlier are trained by the service center agencies (SCA).
- B. Those VLEs were unemployed or house wives are also earning more than they have expected through CSCs.
- C. It is also observed that CSC owners or VLEs are earning more than they were earning before setting up CSCs.
- D. Majority of the citizens of Rayagada are preferred to use CSCs for their e-governance services rather than visiting the offices physically.
- E. The citizens who are computer literate are using the services at CSCs efficiently and effectively.
- F. Citizens agreed that CSCs provides better e-Governance services.

## **CONCLUSION**

The researchers have concluded from this study that, the Common Service Centers are having a very influential role on citizens and Village Level Entrepreneurs. The various e-Governance services rendered at CSCs of Rayagada district are widely acceptable by the citizens, but bit more awareness is needed among the citizens. Both the stakeholders (VLEs and Citizens) are benefitted out of the services provided at CSCs. The VLEs are getting earnings, name and fame at the same time the citizens are getting the services within their locality.

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**Table-1. Block wise Qualifications of all VLEs as respondents**

Block Names	Highest Qualification			Grand Total
	Intermediate	Graduate	Post Graduate	
BISAMCUTTACK	1	3	2	6
CHANDRAPUR	0	2	0	2
GUDARI	2	3	0	5
GUNUPUR	1	4	1	6
KALYANSINGPUR	1	3	1	5
KASHIPUR	0	5	0	5
KOLNARA	0	5	0	5
MUNIGUDA	2	2	1	5
PADMAPUR	0	5	0	5
RAMNAGUDA	2	2	1	5
RAYAGADA	0	6	0	6
<b>Grand Total</b>	<b>9</b>	<b>40</b>	<b>6</b>	<b>55</b>

**Table-2. Block wise Age group wise Citizen details as respondents**

BLOCK NAMES	AGE GROUP						Grand Total
	19-28	29-38	39-48	49-58	59-68	69-78	
BISAMCUTTACK	14	18	22	5	1	0	60
CHANDRAPUR	3	6	4	7	0	0	20





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GUDARI	8	14	19	7	2	0	50
GUNUPUR	18	26	11	4	1	0	60
KALYANSINGHPUR	6	21	16	7	0	0	50
KASHIPUR	17	14	17	2	0	0	50
KOLNARA	9	23	15	2	1	0	50
MUNIGUDA	17	15	13	5	0	0	50
PADMAPUR	13	10	15	10	2	0	50
RAMNAGUDA	7	23	14	4	2	0	50
RAYAGADA	14	15	20	9	1	1	60
Grand Total	126	185	166	62	10	1	550

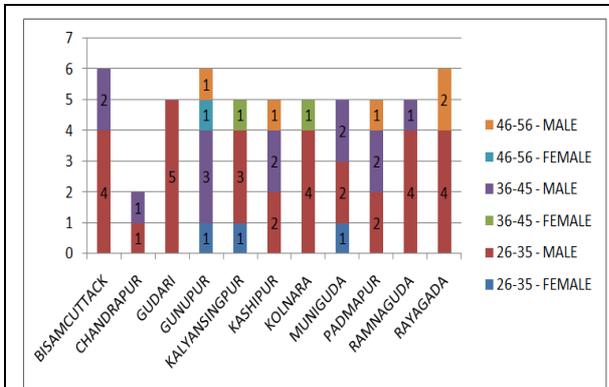


Figure-1. Block wise Age wise Gender wise VLEs as respondents

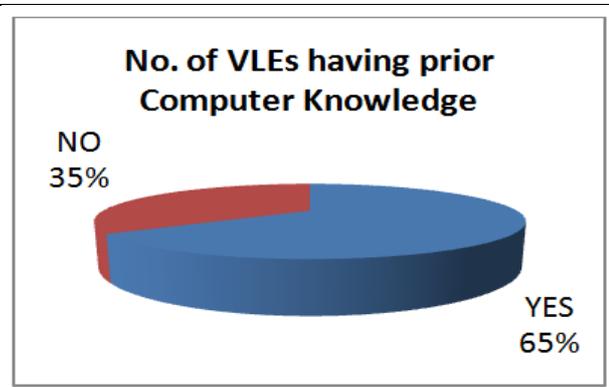


Figure – 2. Prior Computer Knowledge of VLEs

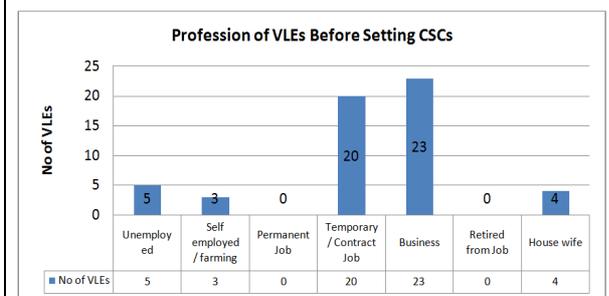


Figure-3. Profession of VLEs before Setting of CSCs.

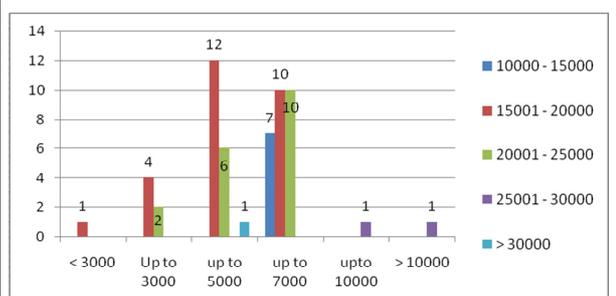
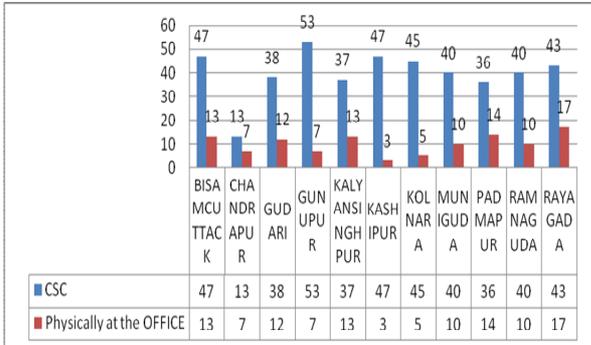


Figure-4. Income Comparison of VLEs before and after the CSC business

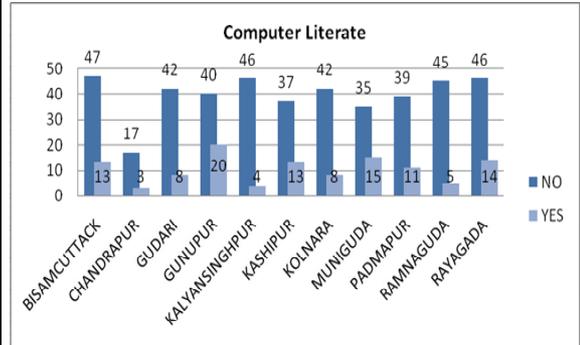




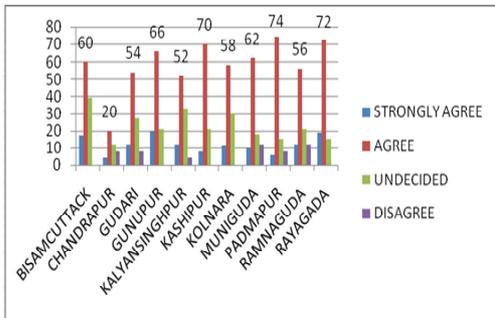
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**Figure-5. Use of CSC or Office for e-Governance services**



**Figure-6. Computer literacy**



**Figure-7. CSCs provide better e-Governance services**





## Farmers' Suicides in India

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### ABSTRACT

Agriculture plays a pivotal role in the growth of an economy and is considered as the backbone of a nation. About 58% of India's population relies mainly on agriculture as a primary source of their livelihood and approximately 70% are small and marginal farmers. Despite having a large section of people involved in agriculture, it has been facing a downfall in India, thus it has become an unproductive venture that has a direct impact on the socio-economic status of the farmers in a negative manner resulting in multiple suicides among the farmers on a large scale. This review deals with the crucial factors that resulted in massive suicides among the farmers as a form of passive protest toward the unconcerned behaviour or apathy exhibited to them.

**Keywords:** Agriculture, farmers, population, growth, scale

### INTRODUCTION

Agriculture plays a pivotal role in the growth of an economy and is considered as the backbone of a nation. For decades, agriculture has been closely associated with the cultivation of the soil, production of economically important crops and raising livestock which in turn contributes to national income. About 58% of India's population relies mainly on agriculture as a primary source of their livelihood and approximately 70% are small and marginal farmers (Srvanath and Sundaram, 2019). Despite having a large section of people involved in agriculture, it has been facing a downfall in India, thus it has become an unproductive venture that has a direct impact on the socio-economic status of the farmers in a negative manner (Mishra, 2014). Due to their occupation, farmers are failing to satisfy their basic needs and are given a lower status in society.

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Studies suggest agriculture as an occupation is a high risk affair (Milner *et al.*, 2013 and Agerbo, 2007) as compared to other occupations. The cultivation of a crop does not rely solely upon agricultural practices but also on the culmination of several factors *viz.*, crop failure due to unforeseeable weather conditions during the crop season, easy availability of financial assistance and support from private bank with high interest rates, non-repayment of loans and indebtedness due to crop failures, unable to procure good returns for farm produce, etc (Kumar and Hashim, 2017). In addition to the factors related to farming, a few personal factors *viz.*, expenses towards education, unexpected health issues, marriage and other family functions also contributes to their expenditure. Altogether, these factors have manifested to a large number of suicides among the farmers in the country and many have opted out of farming to pursue a different career as a part of insecurity.

Farmers' suicides cannot be regarded as an event that occurs by itself, but an utmost exemplification of the associated crisis prevailing in the agrarian sector from the past decades in the country (Mukherjee, 2012). On the contrary, this disaster is also regarded to be associated with the economic and financial crisis faced by the farmers. The report of the National Crime Records Bureau, 2015 revealed that indebtedness or bankruptcy contributed to 35%, agricultural issues contributed to 19.5%, family problems and illness contributed to 11.7 and 10.5%, marriage problems and disputes related to property contributed to 2 and 1.15% of the suicides. Furthermore, approximately 45.2% small farmers and 27.4% marginal farmers were reported to commit suicide during 2015 (National Crime Records Bureau, 2015). In India, farmers' suicide has turned into an epidemic (Mukherjee, 2012) and it has been recorded that in every 30 minutes, a farmer end his life and everyday more than 2,000 farmers quit farming. About 3,00,000 farmers have already taken their own lives in a period of 20 years and in comparison to the national average, the suicide rate has been recorded to be 47% higher (Ahmed, 2015). Thus, an attempt has been made to review the crucial factors that resulted in massive suicides among the farmers as a form of passive protest toward the unconcerned behaviour or apathy exhibited to them.

**High Farmers' Suicide Rates**

The former Prime Minister of India, Dr. Manmohan Singh in 2007 stated that the growth rate in agriculture was very poor, thus considered it as a primary reason for rural distress. The combination of drought and debt causes a serious threat to the farmers and constant financial pressure prevails on the farmers due to the farm crisis. The condition that prevails due to ongoing drought and flood also adds to the problems related to the economy (Padalia, 2015). Furthermore, issues like government policies, damages due to pests and diseases, unpredictable weather conditions are not within the control of the farmers, but despite facing all these problems they are bound to pay their personal debts. All these factors give rise to a repeated sense of hopelessness due to loss of crops, crop failure, financial obligation, loss of land, income, community, family farm, and a way of life.

Farming has become increasingly an unviable activity. The 15 years of economic reforms have given farmers access to expensive and promising biotechnology. However, issues like crop insurance, land irrigation, or enough bank loans remained untouched by the reforms (Kumar, 2015). Reforms opened Indian farmers to global competition, such as with the United States and the UK who receive over \$18 billion a year in subsidies. These subsidies negatively influenced the price of the crops e.g., cotton in the global market. The global competition and poor yield of the crop caused the real threat to the cotton growers and this had resulted in multiple suicides among the farmers on a very large scale in the cotton belt, thus given the name as suicide belt of India. Vidarbha, the north-eastern region of the State Maharashtra alone has 3.2 million cotton farmers and it was estimated that over 200 farmers have committed suicide in a period from July 2005 to February 2006. According to a study by the government of Maharashtra, almost 6 in 10 of those who kill themselves had debts between \$110 and \$550.



**Nanda S.P. and Reddy M. Devender****The Global Perspective**

The phenomenon of suicides is not limited to India. Farmers around the world have turned to the suicide amid crop failures and livestock diseases. In countries like France, a farmer commit suicide in every two days (Nilsson, 2016) and in China, farmers die as a passive protest against seizing of their land by the government for urbanization (Wormer and Link, 2015). In Britain, farmers commit suicides at a rate of one a week. During the outbreak of foot-and-mouth disease when the government instructed the farmers to slaughter their animals, the suicide rate of the farmers was found to be increased by 10 times in the UK in 2001. The rate of suicides increased in Ireland, as result of unusual wet winter that led to trouble in growing hay for feeding animals during 2012 (Ahmed, 2015). In Australia, consecutive droughts for two years have forced the farmers to commit suicide. In the United States, the rate of committing suicides by the male farmers is twice as compared to the general population. In developing country like India, the record shows in every 32 minutes a farmers committed suicide during 1997-2005 (Kumar, 2017). In agriculturally rich states like Punjab and Haryana, this disaster occurs due to crashing prices of commodities and rising debts. The impact of an industrial approach all over the globe in boosting yield of crops has thrown many small farmers into despair.

**Indian Agrarian Crisis**

In comparison to other industries, agriculture has emerged to be a peaceful and healthy way of livelihood. However, with the increasing mortality rate in agriculture due to suicide among farmers, farming has become a fatal industry. Studies show that farming has grown to be one of the dangerous industries in recent times. Even though farming practices, production systems, and types of farms are diverse, the commonalities across the farms are also important to health. Most of the farms are family-owned and operated businesses. The volatility of commodity markets, the variability of weather patterns, and the influence of respective government regulations have a great impact on the farms. Due to this, the farmers face a high rate of stress.

An amalgamation of physical aggravation and risks from the farm environment is caused by the regulatory framework and economic dynamics of managing farm business. Financial crisis and government bureaucracy have been considered as major causes of stress which lead to suicide. Farmers tend to work till very old age as there is no customary or mandatory retirement age for them all over the world. This leads to dependence of the younger generation on their parents and causes rift between the two generations. In Britain, the farmers are more concerned about family problems while in India, the concerns are mostly monetary and debt related which leads to suicides.

**How to Stop Indian Farmer's Suicides**

Almost 70% of the Indian household is dependent on agriculture but the agriculture and allied sector has been growing at the compound annual growth rate of 3.3%. The share in GDP of Indian agriculture has declined at a faster rate and came down to around 13.9 per cent but the principal livelihood source still remains the same for rural households. According to the National Crime Records Bureau from 1995 to 2013, an average of 16,469 suicides occurs per year, i.e. 296,438 farmers have already committed suicide. Farmers are committing suicide because farming has become a capital intensive operation. Money lenders and banks lend money to the farmers at a very high interest rate. National Crop Insurance Scheme Programme was introduced by the Government in 2013 according to which crop insurance was made compulsory for all the loaned farmers. However the scheme is unable to provide the farmers with sufficient funds during crop damage. In agriculture business, there is no hedge fund available for farmers to protect their investment or income. All the risks are taken by the farmers themselves and maximum profit goes to the middlemen and whole sellers. On December 19, 2014 the National Sample Survey Office released Situation Assessment Survey of Agriculture Households according to which only 58 percent of rural household in India are engaged in farming activity and it contributes less than 60% to their average monthly incomes.

In order to protect the farmer's income, necessary measures should be taken by developing policies framework. Loan as well as the total crop which farmer would get should be covered under insurance (Pastor, 2015). Hedge fund



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should be created in all the states through imposing tax on purchasing agricultural commodity beyond stipulated limit. Local government should be authorized to implement the scheme which will ensure maximum participation from the farmers. Weather based crop issuance scheme should be developed and instead of Tahsil or Patwari area boundary, the unit of calculation should be each field. The damage of the crop should be calculated *via* satellite imaging system (Pastor, 2015).

**Short term measures**

The major reason behind the increasing rate of suicides among the farmers is the inability of farmers to manage their distress and depression properly. The farmers have to be sensitized of the fact that suicide is not the right way out of problems they face. Another factor is the guilt which they feel when they find themselves unable to feed their family. In order to overcome these issues, major steps to be taken are launching relief measures like providing compensation to the farmers, increasing amount of food to be made available to each household, providing insurance benefits for the crops that are insured, opening of a helpline and grievance contact number which will be working 24 hours, etc. It gives immediate psychological relief and helps the farmers to drop the idea of committing suicides. Farmers can also approach the established counseling centers in person to share their problems. The farmers are to be assured not to lose hope. The leaders and officials have to visit those areas on regular basis to meet the families in distress. Contact program of government with the farmers in which various government officials will meet the farmers personally and will assure them and will listen to their problems.

With the government support mechanism in the event of a failed monsoon and drought, to start a campaign with a view to help those affected by the failed rains, so that they are aware of the various mechanisms available for their help and do not feel alienated. It must be conveyed to such farmers that a failed monsoon is not their fault, and they shall not blame themselves for the same. Temporary moratorium on loans would relieve the finance burden and microfinance mechanisms to be utilized for the benefits of farmers to proceed farming further and announcing loan waivers or moratorium to dues on agriculture loans in case of credit issued by banks. In case of non-institutionalized credits, gram sabhas will be asked to convene and mediations on this respect at best interests of farmers. Generate and instill confidence in people through resource pool and at mean time necessary provisions for uninterrupted supplies will be ensured through public distribution system in most affected wards. Spreading awareness among the farmers about the various alternatives available, carry out discussions to reach to possible solutions. Educating the family members so that they can act appropriately when they see signs of distress in the farmer.

**Long-term measures**

Scaling up crop insurance compliance, irrigation systems, procurement machinery, fair prices, increasing share of institutionalize agriculture loans working close with lead bank and spreading awareness campaigns in these directions, strict implementation of anti dowry laws, provision of education and health care to the rural people, encouraging better farm practices like mixed dry land farming to cushion eventualities are some long term measures that will mitigate the distress of farmers.

Encouraging farmers to adopt mixed crop farming, multiple cropping, crop rotation, other agricultural practices such as dairy farming, back yard poultry, sheep and goat rearing and others. Minimizing dependency on external farm inputs - own seed, own fertilizing, own plant protection etc, raising cereals, vegetables, fruits, strengthening water sheds, harvesting rain water in-situ, proper regulation of ground water withdrawal, promotion of millets instead of rice will help in increasing farmers income. Further, to make it mandatory to save and conserve rain water, safe use of water. Encouraging farmers to shift to less water-intensive crops and drip irrigation, and providing incentives for this will serve as a practical cure. Make it understandable to them the relationship between the rain and preserving the forests and biodiversity, planting more trees. Loan waiver has been ineffective in the past, and also may not be considered as an out-of-the-box solution. Because small farmers often are the ones who commit suicide, and they often avail private money lenders' loans, not institutional credit. So they get no benefit from institutional loan



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waivers. Asking money lenders to suspend debt collecting for sometime as heavily debt ridden farmers upon failure of crop tend to commit suicide. It is good to ask panchayats, to organise motivational talk about life.

Create better scientific assistance for crop diversification, higher productivity, markets without middlemen and mandi taxes to market produce at competitive prices, periodic review of all-farmer related programmes like irrigation schemes, compensation to farmers. Use of technology has to be central to any endeavor to help farmers get rid of mental agony they face on account of crop failures. Assure, increasing irrigation potential, proper insurance mechanism to insulate against rainfall vagaries. Setting up a team of professional counselors including some psychologists, bankers, bureaucrats and social workers to function as a help centre where the farmers can approach them personally or through a helpline number. To prevent unemployment, some alternative employment must be ensured. Unskilled workforce can be diverted towards skill enhancing programs conducted. Identify areas of high suicidal tendency and immediate organize panchayats more aware about social and economic conditions of the village to identify the farmers facing grave problems of repayment or crop failure.

Self Reliance Education and Employment - Free vocational training to groups of women from impoverished agricultural families and the women are given the necessary start-up capital after completion of their training to begin small, home-based businesses. Financial counseling is provided to prepare these women to qualify for proper bank loans and also provide full scholarships to the children of farmers living below the poverty line. Social support helps can curb stress. That is why huge support from friends, family, local communities, national policies and society as a whole will lower the impact of stress level on individuals and families. Need to get in touch with farmers which are in distress through panchayats. By connecting through panchayats to get data of the families where there is a problem and it has reached to a level where it cannot be sustain anymore (Kaur, 2013).

Suicide is the most extreme step a person can take. Farmer suicides are very disheartening phenomena, in contemporary times. Promote the small social businesses and enterprises among the people so that they can earn to meet their expenditures. Arrange periodical meetings and sessions for farmers with regional government officials and experts which, along with reinstating trust on the government, will help a great deal to find out pragmatic solutions. The Supreme Court of India on 21 August, 2015 instructed the Union Government that no farmer should commit suicide. A Public Interest Litigation filed by a Punjab-based NGO indicating the increasing number of suicide cases in the country. The SC showed its discontent with the Government as they were unable to lower the cases of suicides quoting the efforts was not sufficient. The National Policy for Farmers 2007 could not address the agrarian crisis which forced the farmers to commit suicide (Department of Agriculture and Cooperation, 2007). The Swaminathan Commission and many other agricultural experts have given other solutions in the recent years and some these have been described above. The current situation requires political will and for that the government will have to begin by changing its current line of argument saying more suicides are happening outside agriculture than in it.

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## Caspase Dependent Rapid Cell Death in *Bacillus subtilis*

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### ABSTRACT

*Bacillus subtilis* is a small, Gram-positive, rod-shaped bacterium commonly found in soil and also gastrointestinal tract of ruminants and humans. Results of the present study showed that *Bacillus* was found to exhibit a nutrition stress-related postexponential rapid cell death (RCD). The RCD in this bacterium is accompanied by typical markers of eukaryotic apoptosis such as loss of cell viability in the post-exponential phase, enhanced biosynthesis of caspase-3 like protein. The affinity purified fraction cross reacted with human caspase-3 polyclonal antibody.

**Keywords:** Gram-positive, nutrition, cell, biosynthesis

### INTRODUCTION

In eukaryotes, programmed cell death (PCD) is a genetically regulated self destruction process for the elimination of damaged or unwanted cells. It plays an important role in the development and maintenance of the integrity of organisms. Cells undergoing PCD exhibit a number of biochemical, physiological, and morphological features [1, 2]. Similarly to eukaryotes, PCD in bacteria is a complex and regulated process that is essential for bacterial communities' survival, differentiation, and spreading. The similarities observed between cell death systems of animals, plants, and bacteria suggests endosymbiotic acquisition of bacteria by eukaryotes [3, 4, 5]. PCD in a cell is induced by a certain signal(s). The end point of the signaling activity is the induction and activation of caspases (cysteiny aspartate-specific proteases), the proteases that finally execute PCD [1, 2]. Several investigators have reported the occurrence of PCD in bacteria regulated by chromosomal and extrachromosomal toxin-antitoxin pairs of molecules. In *Escherichia coli*, such chromosomal toxin-antitoxin systems include *mazEF*, *chpBIK*, *relBE*, *yefM-yoeB*, and *dinJ-yafQ* [3, 4, 5, 6]. Earlier studies in *Xanthomonas campestris* pv. *glycines* (Xcg), a plant pathogen and the etiological agent of bacterial pustule disease of soybean (*Glycine max*), was found to exhibit a nutritional stress-related



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postexponential rapid cell death (RCD). The RCD in *Xanthomonas campestris* pv. *glycines* was found to display certain molecular features similar to those of the programmed cell death (PCD) of eukaryotes such as increased cellular reactive oxygen species levels, externalization of phosphatidyl serine, Biosynthesis of catalytically active caspase-like protein in the mid-log phase cultures. . The amino acids glycine and L-alanine as well as the D isomers of valine, methionine, and threonine were found to induce the synthesis of an active caspase-3-like protein that was associated with the onset of RCD. Addition of pyruvate and citrate to the culture medium induced both the synthesis of active caspase-3-like protein and RCD [7]. Computational analysis of the already sequenced genomes revealed that the apoptosis-related domains in bacteria typically form complex multi-domain architectures. These multi-domain proteins contain fusions between apoptosis-related domains, such as apoptotic ATPases fused with a metacaspase or a tollinterleukin-receptor (TIR) domain [8, 9]. Consistent with this bacterial caspase was found to interact functionally and physically with poly(ADP-ribose) like protein (PARP) like protein in the observed modulation of genetically programmed RCD [10]. Purification and further characterization of caspases to electrophoretic homogeneity from *xanthomonas* is challenging due to exopolysaccharide Xanthan that promotes protein aggregation in cell free systems. The present study was undertaken to search for a new bacterial species that undergo post exponential RCD akin to Xcg and eventual purification and characterization of this novel and uncharacterized cell death protein called caspase. *Bacillus subtilis* is a small, Gram-positive, rod-shaped bacterium commonly found in soil, vegetation and gastrointestinal tract of ruminants and humans. *Bacillus* promotes crop productivity by improving soil health and also improves gut health by acting as probiotics [11, 12]. Genome serach of *Bacillus* has not revealed caspase-like domain, but found to exhibit post exponential RCD similar to Xcg with the synthesis of catalytically active caspase-3 like protein that cross reacted with human caspase-3 antibody. This 82± 2 kDa *in vivo* affinity purified protein lost a majority of its activity.

**MATERIALS AND METHODS****Media and culture conditions:**

Inoculation was carried out by the addition of a single isolated colony of *Bacillus* to the Luria-Bertani (LB) medium and was incubated for 24 h on a rotary shaker (150 rpm) at ambient temperature (26±2°C). The 24 h grown culture was incubated further under static conditions at the ambient temperature, in order to observe PCD. For viable cell counts aliquots of the culture broth were withdrawn and serially diluted using sterile saline (0.85%) and transferred to LB-agar using spread plate technique. Plates were incubated at ambient temperature for 72 h. Viable cell counts were obtained at the end of the incubation period by counting colonies. To induce RCD, metabolites such as alanine (Ala), pyruvate (Pyr) and citrate (Cit) were added to the LB medium at the start of incubation in 100mM, 100 mm and 50 mM respectively

**Caspase-3 assay**

A single colony of *Bacillus* was transferred to 10 ml of medium and incubated overnight (~18 h) on a rotary shaker (150 rpm) at ambient temperature. A one ml (~10<sup>8</sup> cfu/ml) aliquot of the culture was centrifuged at 10,000 g for 10 min. The pellet was washed once with phosphate buffered saline (PBS, 10 mM, pH 7.4), suspended in 500 µl of caspase assay buffer [HEPES (20 mM, pH 7.6), NaCl (100 mM), CHAPS (0.1%), DTT (10 mM), EDTA (100 µM), and glycerol (10%)] [7, 10], and the cells lysed by freeze-thaw (freezing under liquid nitrogen and thawed at 37°C) followed by sonication on ice for 15 s. Protein equivalent to 25 µg was mixed with 200 µM of synthetic colorimetric substrate, Ac-DEVD-pNA [N-acetyl-Asp-Glu-Val-Asp-pNitroanilide], prepared in dimethyl sulfoxide (DMSO) as 10 mM stock and incubated at 37°C for 30 min in 1 ml caspase assay buffer. After incubation the absorbance at 405 nm was measured using a spectrophotometer. The protein concentration was determined by the standard Bradford method [13].



**Kalidindi Krishnam Raju****SDS-PAGE**

Overnight grown *Bacillus* cells were harvested by centrifuging at 10,000 g for 10 min, the pellet washed twice with phosphate buffered saline (PBS, 10 mM, pH 7.5) and suspended in sterile milli-Q water. The cell suspension was mixed with an equal volume of 2X gel loading buffer [Tris (100 mM pH 6.8), SDS (4%), glycerol (20%), bromophenol blue (0.002%), and  $\beta$ -mercaptoethanol (200 mM)]. The mixture was heated at 95°C for 10 min, immediately chilled on ice for 5 min, and centrifuged at 12,000 g for 10 min. A 50  $\mu$ l aliquot of the supernatant was loaded on 10% (w/v) SDS-polyacrylamide slab gel, which was run vertically at 35 mA constant current on a PAGE system (Techno Source, India).

**Silver staining of SDS PAGE**

The gel was left overnight in the fixative solution, removed and washed thrice in 100 ml of 50% ethanol, each washing for 15 min. The gel was then treated with sodium thiosulphate (20 mg/100 ml) for 1 min. After treatment with sodium thiosulphate, the gel was rinsed 4X with distilled water, each for 30 s. The gel was immersed in a solution containing 200 mg / 100 ml of AgNO<sub>3</sub> and 1  $\mu$ l formaldehyde / ml and left for 30 min with gentle shaking. It was then rinsed 4X with distilled water; each for 30 s. Silver stain was developed by adding developer on the gel. When proper contrast was visible, the over development of gel was stopped by adding 100 ml of stopping solution on the gel. Finally, the gel was stored in 50% methanol.

**Western blotting**

After completion of the SDS-PAGE run, electro-blotting was performed using a hybond-P membrane in a transfer buffer [25 mM Tris, 192 mM glycine (pH 8.3); 20 % methanol] employing 50 mA constant current overnight at 4°C. The blotted membrane was air dried for 1 h, suspended in methanol for 5 min and equilibrated in TBS buffer (20 mM Tris pH 7.6, 0.5 M NaCl) for 30 min. The equilibrated membrane was subjected to blocking with 3% gelatin (3g of gelatin in 100 ml TBS), washed twice with TTBS (TBS containing 0.05% Tween-20) and hybridized with 10  $\mu$ l (0.5 mg/ml) of the affinity purified biotin-conjugated polyclonal rabbit anti-active human caspase-3 antibody for 18 h at ambient temperature as described previously [7, 10]. After primary antibody hybridization the blot was washed twice with TTBS and later subjected to secondary hybridization with 50  $\mu$ l of streptavidin-horseradish peroxidase conjugate for 1.5 h. Both the primary and secondary antibody reactions were performed in TTBS buffer having 1% gelatin. After secondary hybridization the blot was washed once with TBS-Tween-20 (0.05%) and once with TBS for 5 min, respectively and the band detection was performed by using enhanced chemiluminescence method [Tris pH 8.5 / 4-chloro-1-naphthol / H<sub>2</sub>O<sub>2</sub> / p-coumaric acid].

**Affinity chromatography and immunoprecipitation**

Overnight alanine fortified LB grown culture (1000 ml) was harvested by centrifugation (10,000 g for 10 min.), washed once with PBS and the cells lysed by freeze-thaw and sonication on ice for 5 min in a caspase assay buffer containing protease inhibitors PMSF 1mM, 10  $\mu$ g each of pepstatin, leupeptin and aprotinin. The cell debris was removed by centrifugation (10,000 g for 20 min), and the supernatant was subjected to sequential ammonium sulfate precipitation. The caspase active fraction (15-40 % ammonium sulfate precipitate) was dialyzed overnight in the caspase assay buffer and incubated with commercially available biotinylated form of single specific potent inhibitor of caspase-3 (1  $\mu$ M biotinylated DEVD-CHO) for 30 min [14]. The incubated protein was captured onto a streptavidin-agarose gel. The column material was washed with 20 volumes of the caspase assay buffer containing 0.5M NaCl. The protein was eluted with 200  $\mu$ M free caspase inhibitor (Ac-DEVD-CHO). After blotting the partially purified fractions onto a polyvinylidene difluoride (PVDF) membrane, the caspase protein bands were visualized by means of ponceau-S stain and the blots were probed separately with caspase antibody.

For immunoprecipitation the caspase active fractions after ammonium sulphate precipitation were incubated overnight at 4°C with biotin conjugated caspase-3 antibody in the incubation buffer (TBS buffer containing 1mM EDTA, 1mM PMSF, 10  $\mu$ g each of protease inhibitors pepstatin, leupeptin and aprotinin) and the protein was captured onto a streptavidin-agarose column (1.5 ml). Later the column was washed with 50 ml of the incubation



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buffer. The protein was eluted with 100 µl SDS-gel loading buffer and the eluted protein was analyzed by silver staining and Western blotting.

**RESULTS AND DISCUSSION****Survival of *Bacillus* in LB fortified media**

Viable cell counts in stationary-phase cultures of *Bacillus* grown for 24 and 96 h in different culture media are shown in Table 1. In media such as LB fortified with alanine, pyruvate and citrate, rapid declines in the viable cell numbers were observed between 24 and 96 h of incubation. The cell count was reduced from 8 log<sub>10</sub> CFU/ml at the onset of the stationary phase (24 h after the start of incubation) to 5 log<sub>10</sub> CFU/ml at the end of stationary phase (96 hrs from the start of incubation) in LB media fortified with metabolites. While in LB untreated control (without addition of metabolites) the cell count remained stable at the onset of the stationary phase (24 h after the start of incubation) to the end stationary phase (8 log<sub>10</sub> CFU/ml). RCD in the presence of previous reported inducer(s) suggested occurrence of a conserved RCD mechanism in *Bacillus* similar to Xcg.

***In vivo* caspase activation during RCD**

In order to confirm expression of active caspase in the presence of RCD inducers such as alanine, pyruvate and citrate, the protein lysate fraction was subjected to caspase activity. Nearly 3-fold higher caspase activities were observed when compared to LB grown control cultures (Table 2). All the three metabolites (alanine, pyruvate and citrate) showed increased expression of caspase-3 like protein over the untreated LB controls (Figure 1). This clearly indicated that the genetic regulation of PCD in *Bacillus* correlated positively with the caspase-3 like activity.

**Affinity purification and immunoprecipitation**

An affinity purification strategy followed for caspase purification was also employed to purify the caspase-3 like protein from *Bacillus* [14]. The partially purified caspase protein after affinity elution gave a strong hybridization signal with the caspase antibody (Fig. 2A & 2B). After elution of this protein from streptavidin agarose column, the 80± 2 kDa protein lost a majority of its activity. Previously reported that intracellular accumulation of metabolites such as pyruvate and citrate in *Xanthomonas campestris* pv. *glycines* was found to result in a caspase dependent stationary phase rapid cell death (RCD) [7,10]. Pfam domain architecture analysis combined with operon identification revealed wide and scattered distribution of bacterial metacaspase sequences, and with a potentially intriguing evolutionary role. These metacaspases imply roles in programmed cell death, cellular signaling, various enzymatic activities and protein modification [15]. At the moment, neither the nature of the caspase protein nor the putative gene is clear in *Bacillus*. Western analysis of the cellular lysate revealed that it cross-reacted with the caspase, a feature that needs to be understood. Understanding RCD features in bacteria will help future characterizations of death pathways in prokaryotes.

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**Table 1. Viable cell counts of *Bacillus subtilis* at 24 and 96 h of stationary-phase incubation in different growth conditions. Results are given  $\pm$  standard deviation.**

Medium	Viable cell count (CFU/ml)	
	24 hr	96 hr
LB	$6 \times 10^8 \pm 2 \times 10^8$	$3 \times 10^8 \pm 1 \times 10^8$
LB+Ala	$3 \times 10^8 \pm 2 \times 10^8$	$2 \times 10^5 \pm 1 \times 10^5$
LB+Pyr	$3 \times 10^8 \pm 2 \times 10^8$	$4 \times 10^5 \pm 2 \times 10^5$
LB+Cit	$4 \times 10^8 \pm 1 \times 10^8$	$3 \times 10^5 \pm 2 \times 10^5$

**Table 2. Caspase activity of *Bacillus* when grown in LB medium alone and also fortified with Alanine, Pyruvate and Citrate.** Approx. 20  $\mu$ g of the total protein was used for each assay with a specific colorimetric caspase-3 substrate (Ac-DEVD-pNA) and the absorbance ( $A_{405}$ ) was recorded after 30 min.

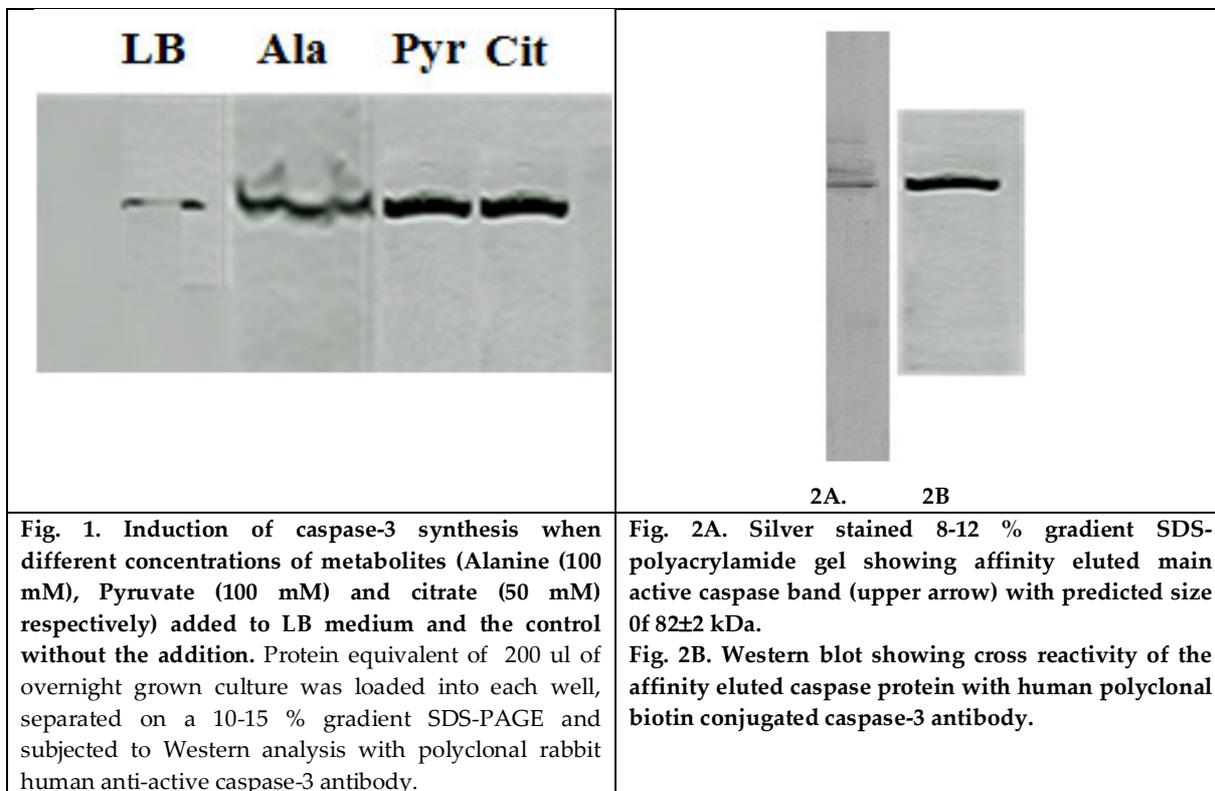
Treatments	Caspase activity
LB	0.039 $\pm$ 0.003
LB+Alanine	0.129 $\pm$ 0.003
LB+Pyruvate	0.136 $\pm$ 0.005
LB+Citrate	0.134 $\pm$ 0.002

Numbers after ( $\pm$ ) symbol denoted SD from three replicates





**Kalidindi Krishnam Raju**





## Emergence of Leaf Blight of Taro Caused by *Phytophthora colocasiae* in Odisha, India

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### ABSTRACT

Taro (*Colocasia esculenta*) is one of the major tuber crops grown in Odisha. It is mainly cultivated by the poor tribal farmers as an alternative food source. Taro has multidimensional nutraceutical effectivity with the enrichment of carbohydrates, amylose and amylopectin, protein, dietary fiber and antioxidants. It contains substantial amount of vitamins i.e.  $\beta$ -carotenes, cryptoxanthin, vitamin A, and B-complex, folates, riboflavin, pyridoxine (vitamin B-6), pantothenic acid, and thiamin. Leaf blight of taro caused by *Phytophthora colocasiae* is one of the devastating biotic stresses for taro production with an average yield losses upto 75%, though it depends on prevailing weather conditions. Applied treatments (T1-T7) were selected to evaluate efficacy of different ecofriendly techniques for controlling the *Phytophthora* blight during 2016-2019. Results revealed that, in control plot disease incidence was maximum PDI [SD ( $\pm$ ) 1.899] with the tuber yield of Y [SD ( $\pm$ )0.525]. When the same susceptible check cv. Telia was applied with six different treatments, the results shows that treatment T<sub>5</sub> recorded maximum yield [SD ( $\pm$ )2.993] and minimum leaf blight incidence of PDI [SD ( $\pm$ )0.624]. Whereas in resistant check cv. Muktakeshi (T<sub>3</sub>) leaf blight incidence of PDI [SD( $\pm$ ) 1.328] with yield [SD ( $\pm$ ) 0.712] of was recorded. Traditional agricultural practices if we incorporate into our modern farming system, then it turned to more beneficial and profitable in terms of low cost, ecofriendly, non-consumable chemicals for different class of tribal communities and sustainable agricultural system.

**Keywords:** Leaf blight, taro, emergence, severity, sustainable





## INTRODUCTION

Taro [*Colocasia esculenta* (L.) Schott] is one of the major tuber crops in Odisha, India. Area/production ratio throughout the country was estimated as 80,000 ha / 0.8 million tones. According to Mishra and Chowdhury (1997), its rich with high nutritive value, each 100 g fresh tuber contains, protein (3g), mineral (1.7g), carbohydrate (21.10g), energy (97.0 Kcal), vitamin A (24 IU), and different amounts of inorganic components (Table-1). Consumption of natural foods rich in flavonoids helps protect from lung and oral cavity cancers. Further, the corms provide healthy amounts of some of important minerals like zinc, magnesium, copper, iron, and manganese. In addition, the root has very good amounts of potassium which is an important component of cell and body fluids that help regulate heart rate and blood pressure. Not only for urban areas and villages, it is widely used as a major vegetable in all over the strata of the society of modern civilization. The crop is mostly grown (throughout the season) as an intercrop with maize, cassava and plantain and is cultivated on a wide range of soils. From rural market to modern city, market demand related to production, is all time high. Leaf blight of taro caused by *Phytophthora colocasiae* [hemi-biotrophic oomyceteae (Raciborski,1900)], is one of major biotic stresses and limiting factor for taro cultivation, in the present agro-climatic scenario of Odisha. The symptoms appears as small, water soaked spots that increase in circumference and also spread to healthy plants. The entire leaf area is destroyed within 3-5 days after the initial symptoms develop, depending on weather conditions. Under humid weather conditions, coupling with 28-30° C temperature and 85-90% humidity helps in the disease spreads at tremendous speed and the entire field gives a blighted appearance (Mishra et al.2008). Different management strategies like, use of tolerant cultivars, use of bio-control agents, using of chemical fungicides, traditional cultural practices like shifting of planting time etc are practices by the farmers, but they are somehow costly to the farmers. For management of this destructive disease, we are following the two main key objectives i.e. one is “Low cost” and another is “Eco-friendly”, on the basis of Odisha’s present agro-economic condition. To measure the comparative efficacy of low cost eco-friendly management (among different management strategies) we are conducting one field experiment with the combination of seven different treatments.

## MATERIAL AND METHODS

### Survey and Surveillance

From 2016-2019, regular interval basis survey and surveillance data, reveals the disease severity range in different location

### Isolation of the Pathogen

Diseased taro leaves were collected from different location of Odisha. Leaves were washed with 0.1 % HgCl<sub>2</sub> and 100 % alcohol to remove surface debris and contaminants. Small pieces (ca. 5 × 10 mm) were cut from each leaf, surface sterilized in 0.6% sodium hypochlorite for 2 min, blotted on a sterile paper towel, and placed on 1.5% water agar. Plates were incubated at 24 °C under continuous fluorescent light. Mycelia of *P. colocasiae* were visible after 1 to 3 d. From each diseased leaf, 2 single hyphal tips were transferred to V8 agar (10% V8 juice, 0.025% CaCO<sub>3</sub>, 1.8% Bacto agar) (V8 juice,) and incubated at 24 °C under continuous fluorescent light. To induce sporulation, an agar plug from a 5-d-old culture was submerged in 10 ml sterile distilled water, incubated at 24 °C under continuous fluorescent light for 16 to 24 h, and then transferred to 16 °C for 30 min. A small amount of the zoospore suspension was then spread on 2% V8 agar (2% V8 juice, 0.005% CaCO<sub>3</sub>, 1.8% Bacto agar) using a sterile loop. After incubation at 24 °C under light for 6 h, individual germinated zoospores were transferred to V8 agar plates. These single-zoospore cultures were used for subsequent study. Sporangia were also produced on the agar surface on V8 agar at 24 °C in 4-6 d.



**Siddhartha Das and Sudeepta Pattanayak****Morphological Characterization of the Pathogen**

The mycelium is hyaline, coenocytic and inter- or intra-cellular. The haustoria are slender, long and unbranched. The growth of the fungus is optimum at pH 6.5 and 28°C (Sahu *et al.* 2000). The sporangiophores are very slender, unbranched and extremely narrow at the tip approximately 50 µm in length. The sporangia are elongated pear or lemon shaped which approximately 38-60 × 18-26 µm in length and breadth. They germinate directly or indirectly depending on the weather conditions. When indirect (20-21°C) as many as 12 reniform, biflagellate zoospores are released, which convert to cysts and germinate after 30 min (Trujillo 1965; Misra 1996). Indirect germination of zoosporangia occurred in water in less than 2 h at optimum temperature (20-21°C) and zoospores germinated in less than half an hour after release. Direct germination occurred in 5-6 h at 20-28°C. Thick-walled, round, hyaline chlamydospores are also produced, especially in old cultures (Thankappan 1985; Misra 1999). The zoosporangiophores are slender, unblemished and extremely narrow at the tip and measure up to 50 µm. Misra (1996) observed that zoosporangial length was over 100 µm and the width was over 50 µm. Depending on the weather conditions, the zoosporangium is capable of producing another zoosporangium. It may germinate directly or by producing one or more germ tubes or by producing zoospores. Zoosporogenesis (indirect zoosporangial germination), like in most other species of *Phytophthora*, starts with the fusion of cleavage vesicles, which occurs almost spontaneously with the release of zoospores. Chilling the zoosporangia at 4°C for 10 min induce zoospore cleavage. Immediately after cleavage, the apical exit pore plug material balloons outwards to form a discharge vesicle that varies in size. The zoospores get expelled from the discharge vesicle and break through the thin plastic wall to escape. Within 20 min of the release, the zoospores encyst having a rather thick cell wall. The cysts germinate within 30 min of their encystment. The cysts are more damaging from a disease point of view as they are produced in large numbers, are small in size and light in weight compared to zoosporangia. The abundant production of zoosporangia, zoospores and cysts make *P. colocasiae* a devastating pathogen. The oogonium is spherical and yellowish and the amphigynous antheridium persists at the Base of the oogonium for a considerable period after the oospores are formed. The oospores are spherical having a 20-28 µm diameter and lie freely in the oogonium. *P. colocasiae* produces pectolytic enzymes like polygalacturonase, pectin methyl transeliminase and poly methyl galacturonase and these enzymes may play a major role in the pathogenesis on *C. esculenta* (Agarwal and Mehrotra 1986).

**Study of Lifecycle and Epidemiology**

The main factors which triggers the life cycle of the disease are rainfall, humidity, and temperature. Sporangia act as a primary reproductive unit. Putter (1976) and Trujillo (1965), reported that the sporangia require free water to germinate and germination can be reported in two ways viz indirect and direct germination depending on the temperature. Cool condition (20-22°C) prefers cyto-differentiation of sporangium which produces approximately 20 zoospores. The top pore of the sporangia dissolves and all the zoospores comes out and swim into the film of water. Zoospore development occurred within 15-20 minutes at 20°C and then anchored on the surface of the leaf, lose their flagella and form a round cyst. Later within 5-10 minutes cyst germinate to form germ tube. At 28-30°C direct germination occurred, the sporangia germinate directly by a germ tube and anchored the leaf. In both the cases at the time of, direct or indirect germination, dispersal of the sporangia or zoospore happened by rain splash or wind blown moisture.

**Isolation and Mass Production of Biocontrol Agent**

Soil samples were collected from different locations of Odisha for the isolation of *Trichoderma*. Samples were collected and stored at 4°C. Five fold serial dilution of each soil samples were prepared in sterilized distilled water and 0.5 ml diluted sample was poured on the surface of *Trichoderma* specific medium. Plates were maintained at 28 ± 2°C. Sub-cultured plates were maintained in PDA medium. Mass culture of the isolates was done by moist paddy straw cultivation method. In this method dry paddy straw was firstly weighted in the amount of 500 gms per polypropylene bag. Moist it with sterile distill water and autoclaved. Moist straw was inoculated with isolated sample, with single mycelia disc inoculation technique. Inoculated paddy straw kept in growth chamber for 48-72 h.





### Field Trials

Field experiments were conducted on the basis of seven treatments. An experiment was conducted using seven low cost ecofriendly treatments [T<sub>1</sub>: cv. Telia covering with black polythene, T<sub>2</sub>: cv Telia mulching (15 cm thickness) with dry leaves, T<sub>3</sub>: cv Muktakeshi resistant variety, T<sub>4</sub>: cv Telia seed tuber treatment with *Trichoderma viride* followed by soil application of *T. viride* enriched compost, T<sub>5</sub>: cv Telia two foliar spray with bio-formulation at 60 and 90 days after planting, T<sub>6</sub>: fungicidal check with 3 mostly used fungicides [copper, Mancozeb, carbendazim + mancozeb], T<sub>7</sub>: control cv Telia without any treatment) to evaluate efficacy of different ecofriendly techniques for controlling the *Phytophthora* blight during 2016-2019. Bio formulation (T<sub>5</sub>) was prepared using water (8 litre), cow urine (3 litre), neem cake (1.5 kg), 80 gm leaves each of neem, bel, kalmegh, custard apple, aswagandha, eucalyptus, agave and castor.

### RESULTS

From 2016-2019, our research reveals the following data with seven different treatments (T<sub>1</sub>: cv. Telia covering with black polythene, T<sub>2</sub>: cv Telia mulching (15 cm thickness) with dry leaves, T<sub>3</sub>: cv Muktakeshi resistant variety, T<sub>4</sub>: cv Telia seed tuber treatment with *Trichoderma viride* followed by soil application of *T. viride* enriched compost, T<sub>5</sub>: cv Telia two foliar spray with bio-formulation at 60 and 90 days after planting, T<sub>6</sub>: fungicidal check with 3 mostly used fungicides (copper, Mancozeb, carbendazim + mancozeb), T<sub>7</sub>: control cv Telia without any treatment), including 3 major parameters- disease severity [DS], percent disease index [PDI], and yield[Y]. (Table-2, Table-3, Table-4). Peak disease infestation was recorded from July to November.

### DISCUSSION

Taro leaf blight is one of the most severe diseases in Odisha. Different epidemiological components directly or indirectly take part in disease establishment and spreading, causes severe yield loss. Favorable temperature (28±2° C) with moisture (70-90 %) condition enhances the leaf blight disease incidence in taro cultivation. Due to *Phytophthora colocasiae* infection every year crop production suffers a havoc loss up to 75%. Available cultivation strategies are sometimes costly for the farmers and also not eco-friendly. From the analysis seven treatments, it was observed, control plot disease incidence was maximum PDI [SD (±) 1.899] with the tuber yield of Y [SD (±) 0.525]. When the same susceptible check cv. Telia was applied with six different treatments, the results shows that treatment T<sub>5</sub> recorded maximum yield [SD (±)2.993] and minimum leaf blight incidence of PDI [SD (±) 0.624]. Whereas in resistant check cv. Muktakeshi (T<sub>3</sub>) leaf blight incidence is PDI [SD (±) 1.328] with the yield [SD (±) 0.712] was recorded. Pathogenic emergence may come due to change in climatic condition (naturally) or inductive way (through mutation). Like as reemergence of *Choanephora* was reported by Das *et al.* in various crops like aubergine (2017), hyacinth bean (2017), teale gourd (2017), green pea (2017), papaya (2017), ban tulsii (2017), *Amaranthus* (2018) etc. Though, this pathogen was considered to be a minor pathogen at nineteenth century. Complex adaptability with preferential epidemiological factors makes the minor pathogen to a severe one. Pattanayak and Das (2020) reported severity of rice blast pathogen *Magnaporthe grisea* from the south eastern India which partially supports results of this investigation. In the current scenario, leaf blight of taro is considered to be a spontaneous emerging pathogen, which needs to control in an eco-friendly management strategy. Traditional agricultural practices if we incorporate into our modern farming system, then it turned to more beneficial and profitable in terms of low cost, ecofriendly, non-consumable chemicals for different class of tribal communities and sustainable agricultural system.





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Table-1. Different amounts of inorganic components

Constituent (par 100 gm fresh tuber )	Taro ( <i>Colocasia esculenta</i> )	Potato ( <i>Solanum tuberosum</i> )	Cassava ( <i>Manihot esculenta</i> )	Sweet potato ( <i>Ipomoea batatas</i> )	Elephant foot yam ( <i>Amorphophallus paenifolius</i> )	Yams ( <i>Dioscorea alata.</i> )	Coleus ( <i>Solenostemon rotundifolius</i> )
Moisture (g)	73.1	74.7	59.4	68.5	78.7	79.6	87.4
Protein (g)	3	1.6	0.7	1.2	1.2	1.3	0.3
Fat (g)	0.1	0.1	0.2	0.3	0.1	0.1	0.2
Minerals (g)	1.7	0.6	1	1	0.8	0.8	0.7
Fibre (g)	1	0.4	0.6	0.8	0.8	0.1	-
Carbohydrate (g)	21.1	22.6	38.1	28.2	18.4	18.1	11.4
Energy Kcal	97	97	157	120	79	79	49
Calcium (mg)	40	10	50	46	50	16	153
Phosphorus (mg)	140	40	40	50	34	31	13
Iron (mg)	1.7	0.7	0.9	0.8	0.6	0.5	0.6
Vitamin A (IU)	24	24	-	6	260	-	93
Thiamine (mg)	0.09	0.1	0.05	0.08	0.06	-	0.04
Niacin (mg)	0.4	1.2	0.3	0.7	0.7	-	0.4
Vitamin C (mg)	-	17	23	24	-	-	-
Riboflavin (mg)	0.03	0.01	0.01	0.4	0.07	-	0.05

Table 2. 2016-2017

MONTH	T-1			T-2			T-3			T-4			T-5			T-6			T-7		
	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y
APRIL	20	11.2	13.9	30	29.4	14.6	30	10.5	12.7	45	28.5	8.2	30	10.3	10.2	25	25	10.2	24	20.5	8.2
MAY	25	12.5	13.7	46	26.3	15.9	36	10.1	14.1	53	30.1	12.4	42	12	12.7	37	29	14.1	31	12	10.7
JUNE	30	16.2	15.5	50	26.6	18	35	10.7	20.1	58	32.5	15	53	19	16	48	31	15	35	13.5	16
JULY	33	15	17.6	58	22.2	16.8	40	13	19.7	68	27.7	16	59	15.1	13	54	26	17	40	16.5	13
AUGUST	38	18.9	16.5	60	23.9	15.6	58	20.3	19.9	76	25.5	21.9	65	20.3	15.6	61	25	16.3	43	20.3	15.6
SEPTEMBER	42	13.8	18.9	65	27.1	16.1	66	11.7	15.9	86	30.4	14	72	15.9	16.1	69	29	19.1	45	11.7	19
OCTOBER	45	16.5	13.9	71	26.9	15.8	80	20.3	17.8	92	29	14.3	88	18.3	15.8	75	21	18.7	50	20.3	17.6
NOVEMBER	31	18.8	18.5	64	31.6	15	75	16.1	18.9	78	31.5	12.7	70	10.3	15	68	31	16.4	41	16.1	19.8
DECEMBER	22	13.9	16.5	35	29.3	14.2	52	10.3	23.5	61	28.8	21.9	45	11.9	14.2	40	25	18.2	30	10.3	23.2
Average	31.8	15.2	16.1	53.2	27	15.8	52.4	13.7	18.1	68.6	29.3	15.2	58.2	14.8	14.3	53	27	16.1	38	15.7	15.9





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Table.3 2017-2018

MONTH	T-1			T-2			T-3			T-4			T-5			T-6			T-7		
	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y
APRIL	22	13.5	18.7	28	27.8	14.1	34	15.6	14.8	48	29.8	10.7	32	13.4	12.6	23	27	15	26	22.8	8.5
MAY	29	14.8	18.1	48	30.8	15.1	37	14.2	12.5	54	30.5	15.9	38	13	14.8	35	28.5	16.1	33	14	11.7
JUNE	35	17.2	17.3	52	32.7	15.8	36	13.4	24.9	60	31.1	14	50	18.7	19	45	28.2	16.8	38	16.4	18.3
JULY	31	17	17.8	60	28.9	16.9	42	14	19.7	71	28.6	18	55	16.1	16	54	22.2	19.6	45	18.9	14
AUGUST	40	19.4	16.3	64	29.1	18.3	60	22.8	19.9	77	26.5	20.6	60	21.3	18.7	64	23.9	18.8	45	25.6	19.4
SEPTEMBER	46	16.3	18.3	66	30.5	18.1	64	14.3	18.6	90	35.6	18	70	16.2	18.1	72	28.6	18	48	13.8	16
OCTOBER	46	17.3	17.8	74	22.8	19.7	85	21.8	19.6	92	30	18.9	85	18.9	16.8	70	28.4	14.2	55	26.3	18.6
NOVEMBER	34	19.3	16.2	68	32.8	17.4	79	18	15.5	80	32.5	15	75	11.1	16	70	30.4	19.8	45	19.1	18.5
DECEMBER	24	16.7	15.3	37	29.5	19.2	54	12.9	25.8	64	29.1	28.3	42	13.9	16.5	38	27.4	18.3	35	12.3	22.7
Average	34.1	16.8	17.3	55.2	29.4	17.2	54.6	16.3	19	70.7	30.4	17.7	56.3	15.8	16.5	52.3	27.2	17.4	41.1	18.8	16.4

Table 4 : 2018-2019

MONTH	T-1			T-2			T-3			T-4			T-5			T-6			T-7		
	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y
APRIL	24	13.9	11.3	35	20.7	13.2	33	11.9	15.1	48	29.5	17	31	11.3	16.1	27	25.8	12.5	26	27.8	7.2
MAY	29	15.8	13.1	51	29.1	15.1	38	11.3	14.1	55	33.6	16	38	12.9	15.1	39	27.6	14.9	36	14.7	15.8
JUNE	35	17.4	18.1	53	33.9	17.7	37	19.3	22	62	34.6	19	49	19.8	22	43	29.6	13.8	33	18.2	17
JULY	38	17.8	12	61	23.1	19.1	42	14	20.4	70	28.9	16	56	17.8	20.4	58	27	18.2	46	18.3	15
AUGUST	39	23.7	21.2	62	24.9	17.5	60	25.4	21.6	78	28.7	16	59	22.6	21.6	63	25.3	15.5	48	22.8	17.8
SEPTEMBER	46	17.9	17	65	25.9	17.5	67	13.7	17.8	88	32.5	16	70	16.8	17.8	74	29.6	17.7	49	11.7	18.7
OCTOBER	49	17.3	17.7	73	25.3	19.3	81	24.3	19.6	94	26.9	18	85	17.6	19.6	76	28.3	15.5	54	25.8	18.3
NOVEMBER	33	24.5	11.1	66	37.3	17.3	76	16.5	19.2	80	32.6	18	76	12.5	19.2	71	33.2	16.9	49	19.5	18.8
DECEMBER	21	18.2	27.5	38	29.7	17.8	53	10.1	25.7	64	29.1	16	41	14.7	25.7	41	33.2	15.9	36	13.6	24.8
Average	34.9	18.5	16.6	56	27.8	17.2	54.1	16.3	19.5	71	30.7	17	56.1	16.2	19.7	54.7	28.8	15.7	41.9	19.2	17





Table 5. 2016-2019 SD ( $\pm$ )

YEAR	T-1			T-2			T-3			T-4			T-5			T-6			T-7		
	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y	DS	PDI	Y
2016-2017	32	15.2	16	53.2	26.7	16	52.4	14	18.1	69	29	15.2	58	15	14	53	27	16.1	38	15.7	16
2017-2018	34.1	16.8	17.3	55.2	29.4	17.2	54.6	16.3	19	70.7	30.4	17.7	56.3	15.8	16.5	52	27.2	17.4	41	18.8	16.4
2018-2019	34.9	18.5	16.5	56	27.8	17.2	54.1	16.3	19.5	71	30.7	16.6	56.1	16.2	20	55	28.8	15.7	42	19.2	17
SD( $\pm$ )	1.49	1.65	0.66	1.45	1.38	0.67	1.14	1.33	0.71	1.07	0.91	1.26	1.03	0.62	2.99	1.2	1.02	0.91	2.2	1.9	0.52

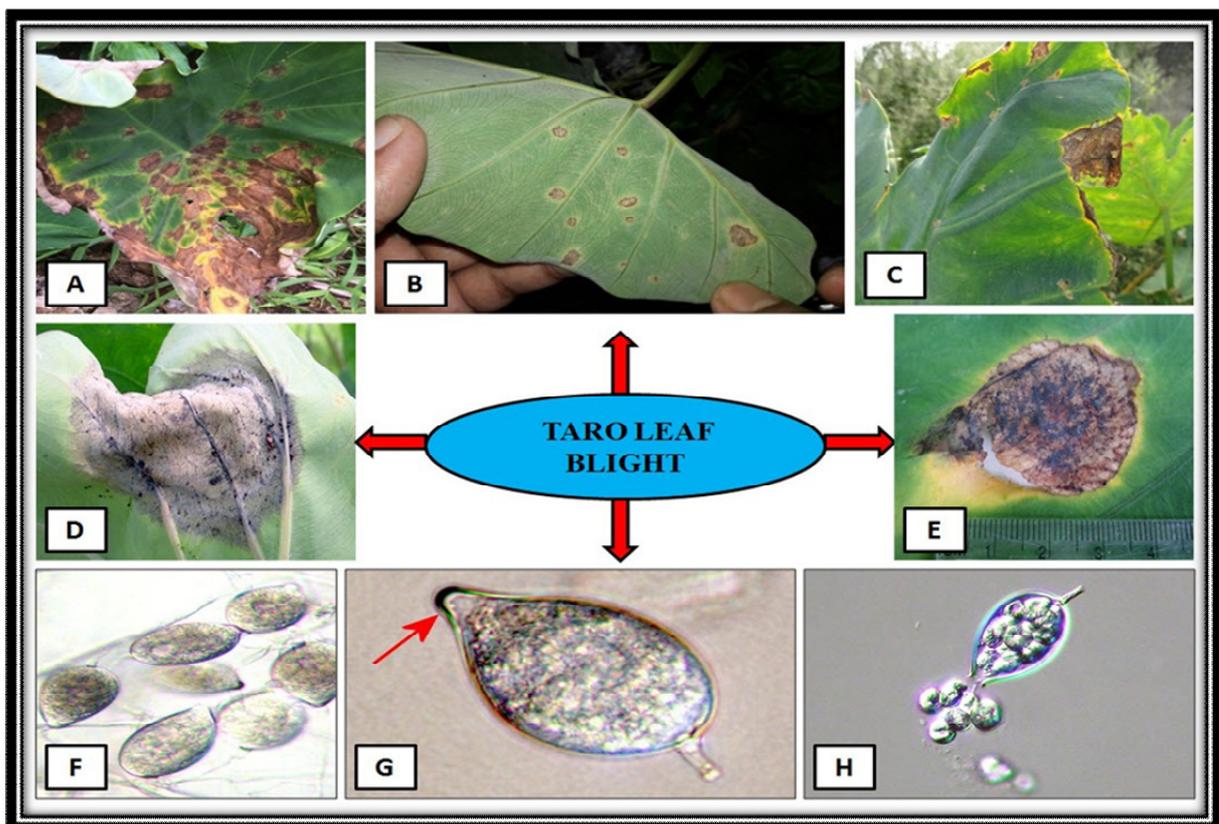


Fig. 1 - A] 80-90 % Disease severity level. B] 10-30% disease severity level. C] Leaf apical portion and tip blight. D] Ventral side of the symptoms (Brooks, F.E. 2005).E] Scaling (4-5 cm) of infection zone.F] Clusture of sporangium (Brooks, F.E. 2005).G] Single sporangium with apical papillae (Brooks, F.E. 2005). H] Sporangial germination producing zoospores (Brooks, F.E. 2005).





Siddhartha Das and Sudeepta Pattanayak

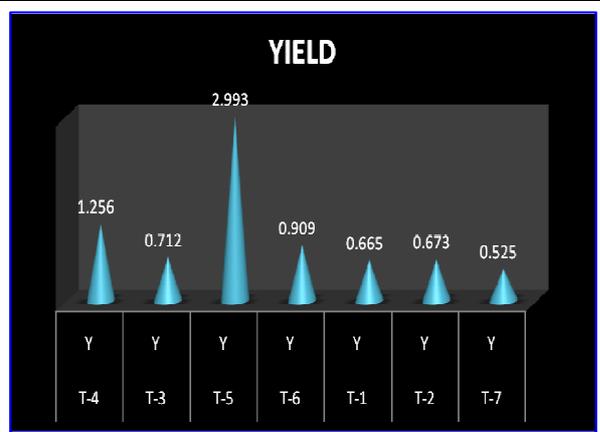


Fig 2 :- Graphical representation of Yield ( 2016- 2019)

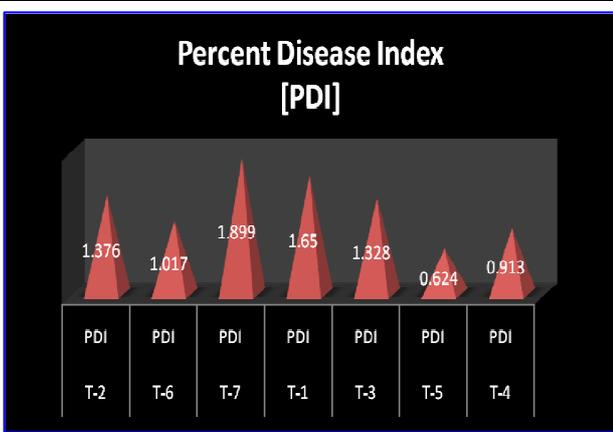


Fig 3 :- Graphical representation of PDI ( 2016- 2019)

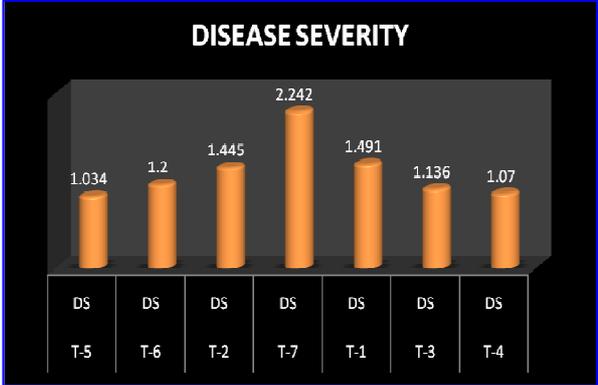


Fig 3 :- Graphical representation of Disease severity ( 2016- 2019)





## Behavioral Responses of Agriculture Students towards Covid 19 Pandemic

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### ABSTRACT

An online survey was conducted with the agriculture students of Centurion University, Odisha, India to find the behavioral response towards ongoing Pandemic and its impact on their studies. Dependent variables like social distancing, impact on studies, gaining quality timing with family, reading habits, social media involvement, their insecurity about future aspects and preference of online class over offline class and related aspects were taken into account. After noting the responses it was found that the students were showing favorable responses towards factors like social distancing, impact on studies, involvement with social media, change in study patterns etc. while online classes, reading habits, loss of studies etc. got unfavorable attitude. After the ranking social distancing got highest favorable response (Score: 421) while preference of online classes (Score: 239) got lowest rank.

**Keywords:** COVID 19, response, social impact, education, e-learning

### INTRODUCTION

The world has been encroached by the Covid 19 Pandemic since quite long now. It has impacted the whole society badly. The impact has been profound amongst students regarding the suspension of classes, online classes and online exams. The pandemic has impacted the higher education also which is an important aspect of the country's future. Social distancing has become the new normal lifestyle amongst corona virus pandemic. Now people are losing face-to-face contact with friends therefore they may begin feel different, may be depressed and anxious to some extent. These type of trends being very new to the mass it is somewhat pertinent to record the responses as it is

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expected that the education system is leaning towards some soft technologies and machine learning in near future. Further agriculture students being more equipped with traditional technologies and class room and field level learning it's very important to note their reaction. Whether they are able to cope with this change and can carry forward the same for the stakeholders or they are not interested to follow the trend. Therefore a study was conducted amongst students of Centurion University regarding the impact of covid19 and their behavioral responses were recorded.

**OBJECTIVES**

1. To find the socio-psychological status of the respondents.
2. To find the psychological behavioral response of students towards the covid 19 impact.
3. To find the most favorable and least favorable factor after ranking them according to their scores.

**METHODOLOGY**

The method of data collection was through online questionnaire method and also by telephonic social interaction afterwards. Google form by one-to-one student was the method of data collection in this lock down period. It has been tried for taking into account the responses of an exploratory kind of study through a relatively new and technology driven methodology. Therefore only ten factors have been considered as dependent variable here to minimize the probability of errors. The response were retrieved and collected through google mail and tabulated later on by using of MS Excel. Only simple method like percentage, ranking and frequency calculation has been implemented to get into the clarity of results rather than any statistical analysis.

**Sample Selection**

Samples were purposively selected from the 6<sup>th</sup> semester agriculture graduates who have almost completed the agriculture course just before joining their internship of the result. The sample size is one hundred and four students from agriculture background including 64 male students and 40 female students.

**Variables / Factors**

Ten most common parameters have been selected like extent of liking about the social distancing, its impact on studies, whether enjoying lockdown days, good impact of lockdown day enjoying lockdown days, impact on reading habits, involvement with social media, hampering level of studies, insecurity about future prospects and comparison between online and offline classes. For the measurement of behavior Likert's summated rating scale with five point continuum was used in this study. Final score was calculated by multiplying the rating effect with frequency and then ranked amongst themselves

**Likert's Method of Summated Rating**

The scale consists of a set of items (statements) to which the subject is asked to react. Items that seem to be definitely favorable or definitely unfavorable to the attitude under study are used. Neutral or slightly favorable or unfavorable items are also included in the continuum. The respondents indicate their agreement or disagreement with each item. Each response is given a numerical score. (As in this experiment scores being given like Very great extent:5, Great extent:4, Moderate:3, Little extent:2, Not at all:1) Since a subject's response to each item may be considered as his/her rating of attitude on a 5-point scale and the total score is obtained after summing all these weights being summated, therefore the method is known as summated rating.





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Here after summing all the scores from the responses towards each factor, the factors are being ranked from highest to lowest indicating the most favorable behavioral response or most unfavorable behavioral response of students after Covid 19 impact on education.

## RESULTS AND DISCUSSION

The result has been discussed with respect to each factor along with ranking of the scores.

### Socio-psychological Status of Respondents

According to the study all the respondents belong to students category studying B.Sc.(Agriculture) in 6<sup>th</sup> semester selected purposively for sampling. Amongst them 64 i.e. 61.53% students are male and 40 i.e. 38.46% students are female students which means there is not much gender gap in the selected sample. All of them belong to the age group between 19 to 22 i.e. quite young and most of them were new to these kind of survey. It is believed that they have provided their genuine responses. Amongst them due to lock down and Covid 19 impact 28 i.e. 26.92% felt that they got affected mentally while only 9 (8.65%) students physically affected in some way. Forty-six (44.23%) students had impact both at physical and mental state while 21 students i.e. 20.19% students had no impact any way according to their perception.

### Factors

#### Social Distancing

Amongst the students 46 students responded that they are liking the social distance to very great extent which comes out to be 44% of the population. 29 students i.e. 28% say that to great extent. While 19% are almost neutral, the rest 7% are in unfavorable attitude towards social distancing.

#### Impact on Studies

Amongst students 47% perceived that the concerned situation has definitely impacted their studies in some way. 21% of the sample population thought it had an impact to great extent towards studies. Seventeen (16%) students moderately reacted while only rest 8% thought the impact was little while 8% were not at all affected in studies.

#### Lockdown Days as Qualitative Family Holidays

When they were asked whether they considered the lock down days as quality family time and enjoyed throughout only 14% of them reacted to very great extent, while 20% to great extent and the majority 35-36% being neutral the rests (11% and 22%) perceived as enjoying the days to little extent and not at all .

#### Positive Aspects of Lockdown Day

In response to the positive aspect of the lock down 22% and 15% had positive response like to very great extent and great extent while 17% were neutral. Only 12% thought it had little extent positive aspects, the majority i.e. around 35% found that it had not any positive aspects at all.

#### Change in Study Pattern

Whether these days have changed your study pattern was responded as to very great extent by around 28% and again 28% responded as to great extent. 24% i.e. around one fourth of the population being very neutral, the rest 16-17% did not perceive much change in their study pattern due to lock down and Covid-19 impact.

#### Enhancement of Reading Habits

Amongst the population 20% opined that they had enhanced their reading habits to very great extent and 18% enhanced it to great extent .Around 35% were moderate about the issue while around 13% had very little / limited



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enhancement of the skill. Again 14-15% of the population did not have any change at all in this regard as per their views.

**Involvement with Social Media**

Forty-six students i.e. majority are in opinion that they had very great extent involvement with social media. Around 18% had involvement to great extent only. 23% being moderate about the issue the rest 15% being little to not at all involvement with social media.(7% and 8% respectively)

**Loss of Studies**

According to the students, 19% of the sample felt that loss of their studies occurred to very great extent. Great extent loss was incurred by 21% population. 26% sample viewed it as moderate loss, while 19% thought it as little extent and 14% did not at all found any loss.

**Insecurity about Future Prospects**

The students being on the verge of internship and placement options, it is very obvious to feel insecure about the same (33% to very great extent and 25% to great extent i.e. the majority). 17% reacted moderately to the fact. Around 13% had little insecurity while only 11% had not at all any insecurity.

**Preference of Online Class Over Offline Class**

In response to the stimulus whether they prefer more online classes more to the regular offline class room coaching, only 13% reacted as to very great extent. Again only 7% liked it to great extent. 17% reacted moderately on this issue while 16% reacted to little extent. Majority of the population i.e. around 47% opined that they did not prefer the online classes at all over offline classes.

**Ranking of the Scores**

After obtaining all the scores summative score for each factor was calculated by multiplying the frequency with numerics associated with the rating effect of continuum.

E.g. for Factor 1 Summative Score:

$46 \times 5 + 29 \times 4 + 20 \times 3 + 6 \times 2 + 3 \times 1 = 421$ , Maximum scores could be highest frequency  $\times$  highest rating i.e.  $104 \times 5 = 520$

Here after obtaining the final summative scores those 10 factors were rearranged according their highest to lowest score values in range of highest to lowest favorable attitude/ factor/behavioral response of the students in this phase from the selected ones. According to the result, students showed highest favorable response (Score: 421) towards Factor1 (Social distancing) and lowest liking ness or least favorable attitude (Score:239) towards Factor 10 (Preference of online classes). Factor2(Impact on studies), Factor7(Involvement with social media), Factor 5 (Change in study pattern) got relevant favorable scores while the low scores of Factor 6(Enhancement of reading habits), Factor 8(Loss of studies), Factor 3(Lockdown days as qualitative family holidays), Factor 4(Positive aspects of lockdown day) indicates that most of them disagreeing the statement / factors.

**CONCLUSION**

As it is noticeable that students are comfortable with social distancing and maintaining the rules and regulations, but it may be estimated that due to impact of social media the unfavorability of perception towards some of the factors have been ameliorated here. From the result it is too evident that some of the factors like, preference to online classes change in reading habits and change study patterns have gained more unfavorable responses. Therefore multi-pronged strategy is necessary to manage the crisis and build a resilient education system in the long term. Immediate measures though have been started but vision is essential to ensure the continuity of learning in schools and





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universities. Proper implementation is required to prepare the higher education sector for the evolving demand–supply trends across the globe through time. Inclusive learning solutions must be provided, keeping in mind the vulnerability aspects of the situation and the respondents need to be developed. Increase in the integrity and effectiveness of learning and teaching, giving both the students and teachers multiple options and platforms to choose from is extremely necessary. Though innovative, mobile-based learning models have already been initiated but the adoption and learning rate etc. must be measured if we consider it a long-term strategy for modernization of education.

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N=104	Very great extent (5)		Great extent (4)		Moderate (3)		Little extent (2)		Not at all (1)	
	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%
	Factor 1	46	44	29	28	20	19	6	5	3
Factor 2	49	47	22	21	17	16	8	7	8	7
Factor 3	15	14	20	19	36	34.5	11	10.5	22	21
Factor 4	23	22	16	15	17	16	12	11.5	34	32
Factor 5	29	27.8	30	28	25	24	13	12.5	7	6
Factor 6	21	20	19	18	36	34.5	13	12.5	15	14.
Factor 7	46	44	19	18	24	23	7	5	8	7
Factor 8	20	19	22	21	27	26	20	19	15	14
Factor 9	35	33	26	25	17	16	14	13.5	12	11.5
Factor 10	14	13	8	7	18	17	17	16	49	47

Sl no.	Factors	Sl no.	Factors
1	Social distancing	6	Enhancement of reading habits
2	Impact on studies	7	Involvement with social media
3	Lockdown days as qualitative family holidays	8	Loss of studies
4	Positive aspects of lockdown day	9	Insecurity about future prospects
5	Change in study pattern	10	Preference of online classes





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Factors	Score (Score Max =520)	Factors	Score (Score Max =500)
Factor 1	421	Factor 6	330
Factor 2	408	Factor 7	400
Factor 3	307	Factor 8	324
Factor 4	288	Factor 9	370
Factor 5	373	Factor 10	239

Rank	1	2	3	4	5	6	7	8	9	10
Scores	421	408	400	373	370	330	324	307	288	239
Factors	Factor 1	Factor 2	Factor 7	Factor 5	Factor 9	Factor 6	Factor 8	Factor 3	Factor 4	Factor 10

Age	Male	Female	Education
19-23	64(61.53%)	40(38.46%)	Continuing graduation in agriculture
<b>Highest impact of Covid -19 pandemic</b>			
Mentally	Physically	Both	None
28(26.92%)	9(8.65%)	46(44.23%)	21(20.19%)





## Comparative Studies on Antimicrobial Activity of Silver and Chitosan Nanoparticle - A Review

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### ABSTRACT

Agriculture production and productivity is constantly suffering from of threats created by various classes of plant pathogens leading to huge economic losses. To control the plant disease a huge amount of pesticide used for many year lead to the warning to environment and at the same time it is contribute the development of resistant pathogen races. So to maintain sustainability nano technology (Nanopesticide, Nanofertilizer etc.) introduced in modern agriculture. Among all the nano formulation tested for antimicrobial activity against plant pathogen silver and chitosan nano particle show significant effect.

**Keywords:** Nano-particle, Chitosan, Silver, Pesticide

### INTRODUCTION

Agriculture is the primary source of livelihood for about 58 per cent of India's population. The production and productivity is constantly suffering from of threats created by various classes of plant pathogens leading to huge economic losses. Among the total crop losses caused by different sources, 14.1 % are lost due to plant diseases alone and the total annual worldwide crop loss from plant diseases is about \$220 billion. (Agrios ,2005). To minimize loss caused due to the pathogen pesticides are used in huge amount for many years since mid-1950s. Due to the potential use of pesticide it start damage the environment and food as they are spread over the crop plant several times each year, at the same time it has contributed to the development of resistant pathogens (Lamsal *et al.*, 2011).

So for the maintain equilibrium between environment and food production innovative technologies are being introduced in modern agriculture to minimise such losses. Among such technological innovations, nanotechnology



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(nanopesticide, nanofertilizer etc.) is gathering noteworthy considerations due to its robust applications in agriculture (R nair 2010) (Ghormade V *et al.*, 2011). In general, nanoparticles have attracted considerable attention in the fields of medicine, pharmaceuticals, cosmetics and electronics due to unique physical, chemical and biological properties (Bakshi M *et al.*, 2014). In present day, the development and application of biosynthesized nanoparticles has opened new avenues in agricultural research oriented to developing ecofriendly and effective means of controlling plant diseases. Most importantly, biological synthesis of silver nanoparticles (AgNPs), Chitosan has offered a consistent, non toxic and ecofriendly approach for plant disease management due to their strong antimicrobial properties (Navrotsky A, 2000) .This review evaluates the current literature on the effect of nanoformulation to inhibit the growth of plant pathogenic microorganism in *in-vitro* condition.

**Antimicrobial Efficacy of Chitosan**

Chitosan is a naturally-occurring, linear polysaccharide produced from chitin by deacetylation in the solid state under alkaline conditions, or by enzymatic hydrolysis of chitin deacetylase. It is considered to be the second largest renewable biomaterial after cellulose in terms of utilization and distribution (Elgadir *et al.*, 2015). Now a days chitosan and its derivative biomaterials have a significant attention in the biomedical field, owing to their unique biological properties. Some of the most noted properties of chitosan are its non-toxicity, biodegradability, biocompatibility, and immunoenhancing, antibacterial and antimicrobial activity. Sudarshan *et al.* ( 1992) suggested that chitosan could penetrate fungal cell wall and bind to its DNA and inhibit the synthesis of mRNA and, in turn, affect the production of essential proteins and enzymes required for the infection. Rabea *et al.* (2003) explained chitosan chelates with metal ions, which has been implicated as a possible mode of antimicrobial action.

Phaechamud and Ritthidej (2008) reported chitosan nanoparticles have got various applications in biology due to its biodegradable and nontoxic properties. In acidic condition the free amino groups of chitosan protonates and contributes to its positive charge the inhibition mode of chitosan against fungi. García-Rincón *et al.* (2010) explained that positive charge of chitosan interacts with negatively charged phospholipid components of fungi membrane, which in turn alter the cell permeability of plasma membrane and causes the leakage of cellular contents, which consequently leads to death of the cell . Soleimani *et al.*(2011) reported that host resistance was an efficient and effective component in integrated management of plant diseases. The aim of this study was to test whether Acibenzolar-S-methyl (ASM), Chitosan, Heads-up and Acetyl Salicylic Acid (ASA), known to induce resistance against various diseases, can help protect potato crop against brown leaf spot. The effect of these inducers, on two potato cultivars, Goldrush and FL1879 against *Alternaria alternata*, causal agent of brown leaf spot at two different field sites were evaluated.

To determine the effects of the application of inducers on disease resistance, the foliage of the potato cultivars was sprayed with appropriate concentrations of ASA, chitosan, and ASM. Heads-up was also applied as a pre-plant treatment on potato tubers. The results obtained from the both field experiments indicated the highest yield performance was achieved in plots treated with ASM, followed by Heads-up and chitosan treatments. However, no significant difference in terms of tuber yield production has been noted between ASA treated potato foliage, and the untreated control plants. Results of experiments with detached leaves showed that there was a significant difference regarding disease index reduction between plots which been treated with defense inducers and untreated, inoculated plots. It was clear that on both potato cultivars, application of chitosan and ASM encouraged enhancement of the disease resistance compared to the ASA and Heads-up treatments. In the laboratory experiment, disease progress was recorded on leaves from three different heights of the crop canopy. The results indicated that disease severity was low in the apex, moderate in the middle and high in the lower parts of the crop, in both potato cultivars. These results suggest that chitosan and ASM may offer alternative methods for controlling brown leaf spot of potato. M. Sathiyabama *et.al* (2015) found that chitosan at the concentration of 1mg/ml inhibit the radial growth of *Alternaria solani* and protect the tomato plant from blight pathogen by enhancing the chitinase activity. Yadi Suryadi *et al* (2017) explained that nano chitosan had an inhibitory activity to *Colletotrichum gloeosporioides in vitro* up to 85.7%.



**Abhinandita sahoo and Ria Mukhopadhyay****Antimicrobial Efficacy of Silver Nanoparticle**

Silver was known as one kind of efficient disinfectors in the early 19th century. From then on, it was widely applied in the fields of bacteria inhibition, wound dressing, mildew preservation, etc. In the recent year, it was found that silver nanoparticle (AgNPs) were checked the growth of fungi, bacteria and virus. Becker *et al.* (1999) showed a nanosilver particle may or may not be charged on its surface or generate silver ions. Like ionic silver, nano silver is a very potent killer of bacteria and has been shown to kill fungi, algae, and some viruses, including HIV. Park *et al.* (2006) explained that Silver in ionic or nanoparticle forms had a high antimicrobial activity and was therefore widely used for various sterilization purposes including materials of medical devices and water sanitization. Relatively few studies were reported on the applicability of silver in controlling various plant pathogens in a relatively safer way compared to synthetic fungicides. Min *et al.* (2009) observed in microscope that hyphae exposed to silver nanoparticles showed severe damage and resulted in the separation of layers of hyphal wall and collapse of fungal hyphae. Wei *et al.* (2009) reported that Silver has been used as an antimicrobial agent since ancient civilizations; it has been used extensively due to its broad spectrum and multiple modes of antimicrobial activity. Young-ki Jo *et al.* (2009) examined the antifungal activity of silver ions and nanoparticles against two plant-pathogenic fungi, *Bipolaris sorokiniana* and *Magnaporthe grisea*.

*In vitro* petridish assays indicated that silver ions and nanoparticles had a significant effect on the colony formation of these two pathogens. Effective concentrations of the silver compounds inhibiting colony formation by 50% (EC50) were higher for *B. Sorokiniana* than for *M. grisea*. The inhibitory effect on colony formation significantly diminished after silver cations were neutralized with chloride ions. Growth chamber inoculation assays further confirmed that both ionic and nanoparticle silver significantly reduced these two fungal diseases on perennial rye grass (*Lolium perenne*). Particularly, silver ions and nanoparticles effectively reduced disease severity with an application at 3 h before spore inoculation, but their efficacy significantly diminished when applied at 24 h after inoculation. The *in vitro* and *in planta* evaluations of silver indicated that both silver ions and nanoparticles influence colony formation of spores and disease progress of plant-pathogenic fungi. *In planta* efficacy of silver ions and nanoparticles is much greater with preventative application, which may promote the direct contact of silver with spores and germ tubes, and inhibit their viability. Kumar *et al.* (2010) described that Metallic nanoparticles possess unique chemical and physical properties, small size, huge surface to volume ratio, structural stability and strong affinity to their targets. Lamsal *et al.* (2011a) showed the effective usage of silver nanoparticles instead of commercial fungicides. They evaluated the effect of silver nanoparticles against six *Colletotrichum sp.* associated with pepper anthracnose under different culture conditions and found that, application of 100 ppm concentration of silver nanoparticles inhibited the growth of fungal hyphae as well as conidial germination *in vitro* when compared to the control.

Silver nanoparticles showed significantly high inhibition of fungi in field conditions when applied on the plants before disease outbreak. Lamsal *et al.* (2011b) studied on *in vitro* and *in vivo* efficacy of silver nanoparticles against powdery mildew before and after disease outbreak in plants under different cultivation conditions, showed maximum inhibition of fungal hyphae and conidial germination with less concentration of nanoparticle on cucumbers and pumpkins. Hameed *et al.* (2012) studied that the secondary metabolites in plants have been used in the formulation of nanoparticles through increase the effectiveness of therapeutic compounds used to reduce the spread of plant diseases, while minimizing side effects for being: rich source of bioactive chemicals, biodegradable in nature and non-polluting (eco-friendly). Particulate systems like Nanoparticles have been used a physical approach to alter and improve the effective to properties of some types of synthetic chemical pesticides or in the production of bio-pesticides directly. Ing *et al.* (2012) explained that chitosan therefore could be formulated and applied as a natural antifungal agent in nanoparticles form to enhance its antifungal activity. Kim *et al.* (2012) reported the inhibitory effect of three different silver nanoparticles (WA-CV-WA13B, WA-AT-WB13R, and WA-PR-WB13R) against eighteen different commercially important plant pathogenic fungi on potato dextrose agar (PDA), malt extract agar, and corn meal agar. They found that inhibition of fungal pathogens with silver nanoparticles was concentration dependent and also on type of silver nanoparticles used. Most fungi showed a good inhibitory effect at 100 ppm concentration of silver nanoparticles on PDA, compared with others. WA-CV-WA13B showed the highest inhibition effect





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compared to other silver nanoparticles. Effect of silver nano particles on the growth of sclerotium-forming species *Rhizoctonia solani* and *Sclerotinia sclerotiorum* revealed that silver nano particles effectively inhibit the hyphal growth in a dose-dependent manner.

## CONCLUSION

In the review cited above it observed that silver and chitosan nanoparticle is significant properties like its non-toxicity, biodegradability, biocompatibility, and immune enhancing, antibacterial and antimicrobial activity. It potentially inhibits the mycelial growth, spore germination.

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## Effect of Different Levels of Fertilizers on Nutrient Uptake of Indian Mustard (*Brassica juncea* L.)

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### ABSTRACT

The present study was carried out with the objectives to study the growth the effect of different levels of fertilisers on yield, nutrient uptake and economics of the Indian mustard variety NRCHB-101 under graded doses of fertilizer. The field experiment was conducted during 2016-17 at the Agronomy Main Research Station, OUAT, Bhubaneswar laid out in a Factorial Randomized Block Design with three replications and twelve treatments. The total N uptake by Indian mustard var. NRCHB-101 was highest at N<sub>3</sub> (120 Kg ha<sup>-1</sup>) and lowest at P<sub>1</sub> (20 kg ha<sup>-1</sup>) i.e., 64.08 kg ha<sup>-1</sup> and 60.95 kg ha<sup>-1</sup>, respectively. The total P uptake was highest at N<sub>3</sub> (120 Kg ha<sup>-1</sup>) and lowest at N<sub>1</sub> (80 kg ha<sup>-1</sup>) i.e., 27.32 kg ha<sup>-1</sup> and 21.51 kg ha<sup>-1</sup>, respectively. The total K uptake by Indian mustard var. NRCHB-101 was highest at N<sub>3</sub> (120 Kg ha<sup>-1</sup>) and lowest at N<sub>1</sub> (80 kg ha<sup>-1</sup>) i.e., 51.79 kg ha<sup>-1</sup> and 45.60 kg ha<sup>-1</sup>, respectively.

**Keywords:** Indian mustard, Nutrient interaction, nutrient uptake

### INTRODUCTION

Role of oilseeds in Indian agriculture needs hardly any emphasis. Oilseeds constitute an important group of crops next to cereals. India is a premier oilseed growing country. India is the fourth largest oilseed economy in the world. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6 per cent of the total area. Presently, rapeseed-mustard is the third most important oilseed crop in India after groundnut and soybean. India is one of the largest producer, consumer and importer of oilseeds in the world. Out of nine major oilseeds grown in India, Indian mustard (*Brassica juncea*) is an important winter season *Rabi* crop. The gap between production and demand of rapeseed-mustard is progressively widening and therefore, the production is to be increased for self sufficiency. Indian mustard requires relatively larger amount of nutrients for realization of higher yield potential.



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Moreover, with increase in irrigated area and introduction of high yielding varieties, it becomes imperative to work out the response of Indian mustard to nitrogen, phosphorus and potassium in Odisha condition. The mustard growing areas in India are experiencing the vast diversity in the agro climatic conditions and different species of rapeseed-mustard are grown in some or other part of the country. Under marginal resource situation, cultivation of rapeseed-mustard becomes less remunerative to the farmers. This results in a big gap between requirement and production of mustard in India.

Therefore site-specific nutrient management through soil-test recommendation based should be adopted to improve upon the existing yield levels obtained at farmers field. Effective management of natural resources, integrated approach to plant-water, nutrient and pest management and extension of rapeseed-mustard cultivation to newer areas under different cropping systems will play a key role in further increasing and stabilizing the productivity and production of rapeseed-mustard. With this backdrop, the present paper on Indian mustard high yielding variety NRCHB-101 entitled "Effect of different levels of fertilisers on nutrient uptake of Indian mustard (*Brassica juncea*L.)" has been presented with the objectives to study the interaction effect of nutrients on the variety under different fertility levels.

## MATERIALS AND METHODS

The field experiment was conducted during *Rabi* 2016-17 at the Agronomy Main Research Station, Odisha University of Agriculture and Technology, Bhubaneswar (20026'N, 85081'E, 25.9m above MSL), Odisha. The soil of the experimental sandy loam acidic (pH-5.4) medium in organic carbon (0.628%) and available nitrogen (1673.3kg/ha), phosphorus (64.5kg/ha) and potassium (123.4 kg/ha). The experiment was laid out in a factorial randomized block design with three replications. Twelve treatment combinations comprising 3 nitrogen levels (80, 100, 120 kg N/ha), two (20, 40 kg P<sub>2</sub>O<sub>5</sub>/ha) and two potassium levels (0, 30 kg K<sub>2</sub>O/ha) were tested in the experiment. Indian mustard variety 'NRCHB-101' was sown 30 cm row distance. Thinning was done as 15 DAS to maintain plant to plant distance of 10 cm. All the recommended agronomic practices are done throughout the crop season. The crop was sown on 20th November and harvesting was done manually during last week of February. The N,P and K uptake in seed and stover was estimated by following standard procedure described by Jackson(1973) and all the data were analysed as per standard statistical procedures.( Gomez and Gomez,1984)

## RESULT AND DISCUSSION

The N uptake was significant for different levels of N, P and K. The N uptake increases as the doses of N, P and K increases. The seed uptake was highest at K<sub>2</sub> (30 Kg ha<sup>-1</sup>) and lowest at N<sub>2</sub> (100 kg ha<sup>-1</sup>) i.e., 52.12 kg ha<sup>-1</sup> and 49.33 kg ha<sup>-1</sup>, respectively. The stover N uptake was highest at N<sub>3</sub> (120 Kg ha<sup>-1</sup>) and lowest at N<sub>1</sub> (80 kg ha<sup>-1</sup>) i.e., 12.64 kg ha<sup>-1</sup> and 10.90 kg ha<sup>-1</sup>, respectively. The total N uptake in seed by Indian mustard var. NRCHB-101 is highest at N<sub>3</sub> (120 Kg ha<sup>-1</sup>) and lowest at P<sub>1</sub> (20 kg ha<sup>-1</sup>) i.e., 64.08 kg ha<sup>-1</sup> and 60.95 kg ha<sup>-1</sup>, respectively. The N uptake by both, seed and stover, was significant for all the interactions. The higher uptake at the increased doses of N was due to higher efficiency of the crop to make use of the increased levels of N because of increased growth and vigour. Similar results of N uptake with increasing levels of N have been reported by Kumawat et al. (2014) and Dabiet al. (2015).

Table 2 represents the interaction effect of NP, PK and NK levels on total uptake of N by seed and stover of Indian mustard var. NRCHB-101. As evident from the table, the highest N uptake by seed was at N<sub>3</sub>K<sub>2</sub>i.e., 51.73 kg ha<sup>-1</sup> and the lowest was at N<sub>1</sub>K<sub>1</sub>i.e., 49.58 kg ha<sup>-1</sup>. The table revealed that the highest N uptake by stover was at N<sub>3</sub>P<sub>2</sub>i.e., 12.90 kg ha<sup>-1</sup> and the lowest was at N<sub>1</sub>P<sub>1</sub>i.e., 10.30 kg ha<sup>-1</sup>. The N uptake by both, seed and stover, was significant for all the interactions. The N-P-K interaction effect on total N uptake by seed and stover has been shown in Table 3. As





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depicted in the table, the total N uptake by both, seed and stover, is highest at  $N_3 P_2 K_2$  i.e., 52.10 kg ha<sup>-1</sup> and 13.10 kg ha<sup>-1</sup>, respectively. The N uptake by both, seed and stover, was significant for all the interactions

The seed uptake was highest at  $P_2$  (40 Kg ha<sup>-1</sup>) and lowest at  $N_1$  (80 kg ha<sup>-1</sup>). The stover P uptake was highest at  $N_3$  (120 Kg ha<sup>-1</sup>) i.e., 8.32 kg ha<sup>-1</sup>. The lowest stover P uptake was observed at  $N_1$  (80 kg ha<sup>-1</sup>) and  $P_1$  (20 kg ha<sup>-1</sup>) i.e., 5.71 kg ha<sup>-1</sup>. The total P uptake in seed by Indian mustard var. NRCHB-101 is highest at  $N_3$  (120 Kg ha<sup>-1</sup>) and lowest at  $N_1$  (80 kg ha<sup>-1</sup>) i.e., 27.32 kg ha<sup>-1</sup> and 21.51 kg ha<sup>-1</sup>, respectively. The P uptake was significant for different levels of N, P and K. The P uptake increases as the doses of N, P and K increases. The total P uptake by both, seed and stover, is highest at  $N_3 P_2 K_2$  i.e., 19.82 kg ha<sup>-1</sup> and 8.83 kg ha<sup>-1</sup>, respectively. The P uptake by both, seed and stover, was significant for all the interactions. These results for P uptake corroborated with the findings of Ghimire and Bana (2011). The higher removal of N and P might be due to synergistic effect chlorophyll content, cell division, photosynthetic rate and root activities of plants which has been reported.

Table 5 represents the interaction effect of NP, PK and NK levels on total uptake of P by seed and stover of Indian mustard var. NRCHB-101. As evident from the table, the highest N uptake by seed was at  $N_3 P_2$  i.e., 19.47 kg ha<sup>-1</sup> and the lowest was at  $N_1 P_1$  i.e., 15.45 kg ha<sup>-1</sup>. The table revealed that the highest P uptake by stover was at  $N_3 P_2$  i.e., 8.59 kg ha<sup>-1</sup> and the lowest was at 5.33 i.e., 10.30 kg ha<sup>-1</sup>. The P uptake by both, seed and stover, was significant for all the interactions. The N-P-K interaction effect on total P uptake by seed and stover has been shown in Table 6. As depicted in the table, the total P uptake by both, seed and stover, was the highest at the interaction level of  $N_3 P_2 K_2$  i.e., 19.82 kg ha<sup>-1</sup> and 8.83 kg ha<sup>-1</sup>, respectively. The P uptake by both seed and stover was significant for all the interactions.

The seed uptake was highest at  $N_3$  (120 Kg ha<sup>-1</sup>) and lowest at  $N_1$  (80 kg ha<sup>-1</sup>) i.e., 13.42 kg ha<sup>-1</sup> and 10.24 kg ha<sup>-1</sup>, respectively. The stover K uptake was highest at  $P_2$  (40 Kg ha<sup>-1</sup>) and lowest at  $K_1$  (0 kg ha<sup>-1</sup>) i.e., 38.75 kg ha<sup>-1</sup> and 35.26 kg ha<sup>-1</sup>, respectively. The total K uptake in seed by Indian mustard var. NRCHB-101 is highest at  $N_3$  (120 Kg ha<sup>-1</sup>) and lowest at  $N_1$  (80 kg ha<sup>-1</sup>). The K uptake was significant for different levels of N, P and K. The K uptake increases as the doses of N, P and K increases. Similar results have been reported by Grewal *et al.* (2009). The highest K uptake by seed was at  $N_3 P_2$  i.e., 13.35 kg ha<sup>-1</sup>. The highest K uptake by stover was at  $N_3 P_2$  i.e., 38.87 kg ha<sup>-1</sup>. The total K uptake by both, seed and stover, is highest at  $N_3 P_2 K_2$  followed by  $N_3 P_2 K_1$  in seed and stover, respectively. The K uptake by both, seed and stover, was significant for all the interactions. The stover yields of Indian mustard were significantly obtained under application of higher levels of N and P could be ascribed to better transformation of growth and yield attributes into yield which corroborated with findings of Dabiet *et al.* (2015).

Table 8 represents the interaction effect of NP, PK and NK on total uptake of K by seed and stover of Indian mustard var. NRCHB-101. As evident from the table, the highest K uptake by seed was at  $N_3 P_2$  i.e., 13.35 kg ha<sup>-1</sup> and the lowest was at  $N_1 P_1$  i.e., 9.89 kg ha<sup>-1</sup>. The table also showed that the highest K uptake by stover was at  $N_3 P_2$  i.e., 38.87 kg ha<sup>-1</sup> and the lowest was at  $N_1 P_1$  i.e., 33.86 kg ha<sup>-1</sup>. The N uptake by both, seed and stover, was significant for all the interactions. The N-P-K interaction effect on total K uptake by seed and stover has been shown in Table 9. As depicted in the table, the total K uptake by both, seed and stover, was highest at  $N_3 P_2 K_2$  i.e., 13.57 kg ha<sup>-1</sup> and 39.12 kg ha<sup>-1</sup>, respectively followed by  $N_3 P_2 K_1$  i.e., 13.14 kg ha<sup>-1</sup> and 38.63 kg ha<sup>-1</sup> in seed and stover, respectively. The K uptake by both, seed and stover, was significant for all the interactions.

## CONCLUSION

The total N uptake by Indian mustard var. NRCHB-101 was highest at  $N_3$  (120 Kg ha<sup>-1</sup>) and lowest at  $P_1$  (20 kg ha<sup>-1</sup>) i.e., 64.08 kg ha<sup>-1</sup> and 60.95 kg ha<sup>-1</sup>, respectively. The total P uptake was highest at  $N_3$  (120 Kg ha<sup>-1</sup>) and lowest at  $N_1$  (80 kg ha<sup>-1</sup>) i.e., 27.32 kg ha<sup>-1</sup> and 21.51 kg ha<sup>-1</sup>, respectively. The total K uptake by Indian mustard var. NRCHB-101 was highest at  $N_3$  (120 Kg ha<sup>-1</sup>) and lowest at  $N_1$  (80 kg ha<sup>-1</sup>) i.e., 51.79 kg ha<sup>-1</sup> and 45.60 kg ha<sup>-1</sup>, respectively. The total





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N, P and K uptake by both, seed and stover, was highest at interaction N<sub>3</sub> P<sub>2</sub> K<sub>2</sub>. The N, P and K uptake increased as the doses of N, P and K increased.

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**Table 1. Nitrogen uptake by Indian mustard as influenced by nitrogen, phosphorus and potassium levels**

Nitrogen Uptake			
Treatment	Seed Yield (kg ha <sup>-1</sup> )	Stover Yield (kg ha <sup>-1</sup> )	Total (kg ha <sup>-1</sup> )
<b>N-levels (kg ha<sup>-1</sup>)</b>			
80	50.17	10.90	61.07
100	49.33	12.05	61.38
120	51.44	12.64	64.08
SE(m)±	2.26	0.56	2.82
CD(P=0.05)	NS	1.36	NS
<b>P<sub>2</sub>O<sub>5</sub> levels (kg ha<sup>-1</sup>)</b>			
20	49.51	11.44	60.95
40	51.11	12.28	63.39
SE(m)±	1.84	0.46	2.30
CD(P=0.05)	NS	NS	NS
<b>K<sub>2</sub>O levels (kg ha<sup>-1</sup>)</b>			
0	49.82	11.62	61.44
30	52.12	11.80	63.92
SE(m)±	1.84	0.46	2.30
CD((P=0.05)	NS	NS	NS

**Table 2. Interaction effect of NP, PK and NK on total uptake of N by Indian mustard**

N-levels (kg ha <sup>-1</sup> )	Seed (kg ha <sup>-1</sup> )		Stover (kg ha <sup>-1</sup> )	
	P-levels (kg ha <sup>-1</sup> )		P-levels (kg ha <sup>-1</sup> )	
	20	40	20	40
80	50.17	50.17	10.30	11.50
100	49.33	49.33	11.65	12.45
120	51.44	51.44	12.38	12.90





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SE(m)±	3.19		0.79	
CD(P=0.05)	NS		1.92	
P <sub>2</sub> O <sub>5</sub> levels (kg ha <sup>-1</sup> )	K-levels (kg ha <sup>-1</sup> )		K-levels (kg ha <sup>-1</sup> )	
	0	30	0	30
20	48.94	50.08	11.23	11.66
40	50.70	51.52	12.01	12.56
SE(m)±	2.60		0.64	
CD(P=0.05)	NS		NS	
N-levels (kg ha <sup>-1</sup> )	K-levels (kg ha <sup>-1</sup> )		K-levels (kg ha <sup>-1</sup> )	
	0	30	0	30
80	49.58	50.75	10.53	11.27
100	48.73	49.92	11.87	12.23
120	51.15	51.73	12.47	12.82
SE(m)±	3.19		0.79	
CD(P=0.05)	NS		1.92	

**Table 3. Interaction effect of nitrogen, phosphorus and potassium on total uptake of N by mustard seed and stover**

Total uptake of N by mustard seed				
Levels of N	Levels of P & K			
	P <sub>1</sub>		P <sub>2</sub>	
	K <sub>1</sub>	K <sub>2</sub>	K <sub>1</sub>	K <sub>2</sub>
N <sub>1</sub>	48.23	50.30	50.93	51.20
N <sub>2</sub>	47.93	48.57	49.53	51.27
N <sub>3</sub>	50.67	51.37	51.63	52.10
	N×P	P×K	N×K	N×P×K
SE(m)±	3.19	2.60	3.19	4.51
CD(P=0.05)	NS	NS	NS	NS
Total uptake of N by mustard stover				
Levels of N	Levels of P & K			
	P <sub>1</sub>		P <sub>2</sub>	
	K <sub>1</sub>	K <sub>2</sub>	K <sub>1</sub>	K <sub>2</sub>
N <sub>1</sub>	9.93	10.67	11.13	11.87
N <sub>2</sub>	11.53	11.77	12.20	12.70
N <sub>3</sub>	12.23	12.53	12.70	13.10
	N×P	P×K	N×K	N×P×K
SE(m)±	0.79	0.64	0.79	1.12
CD(P=0.05)	1.92	1.56	NS	NS

**Table 4. Phosphorus uptake by Indian mustard as influenced by nitrogen, phosphorus and potassium levels**

Phosphorus Uptake			
Treatment	Seed (kg ha <sup>-1</sup> )	Stover (kg ha <sup>-1</sup> )	Total (kg ha <sup>-1</sup> )
N-levels (kg ha <sup>-1</sup> )			
80	15.80	5.71	21.51
100	17.13	7.13	24.26
120	19.00	8.32	27.32
SE(m)±	0.49	0.35	0.84





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CD(P=0.05)	1.19	0.86	2.05
<b>P<sub>2</sub>O<sub>5</sub> levels (kg ha<sup>-1</sup>)</b>			
20	17.19	5.71	22.9
40	19.26	7.13	26.39
SE(m)±	0.40	0.29	0.69
CD(P=0.05)	0.97	0.70	1.67
<b>K<sub>2</sub>O levels (kg ha<sup>-1</sup>)</b>			
0	16.92	6.73	23.65
30	17.69	7.38	25.07
SE(m)±	0.40	0.29	0.69
CD(P=0.05)	NS	NS	NS

Table 5. Interaction effect of NP, PK and NK on total uptake of P by mustard seed and stover

N-levels (kg ha <sup>-1</sup> )	Seed (kg ha <sup>-1</sup> )		Stover (kg ha <sup>-1</sup> )	
	P-levels (kg ha <sup>-1</sup> )		P-levels (kg ha <sup>-1</sup> )	
	20	40	20	40
80	15.45	16.15	5.33	6.10
100	16.79	17.47	6.79	7.47
120	18.54	19.47	8.06	8.59
SE(m)±	0.69		0.50	
CD(P=0.05)	1.68		1.21	
P <sub>2</sub> O <sub>5</sub> levels (kg ha <sup>-1</sup> )	K-levels (kg ha <sup>-1</sup> )		K-levels (kg ha <sup>-1</sup> )	
	0	30	0	30
	20	16.75	17.10	6.60
40	17.40	17.98	7.11	7.65
SE(m)±	0.57		0.41	
CD(P=0.05)	NS		0.99	
N-levels (kg ha <sup>-1</sup> )	K-levels (kg ha <sup>-1</sup> )		K-levels (kg ha <sup>-1</sup> )	
	0	30	0	30
	80	15.66	15.94	5.56
100	16.86	17.39	6.86	7.39
120	18.71	19.30	8.14	8.50
SE(m)±	0.69		0.50	
CD(P=0.05)	1.68		1.21	

Table 6. Interaction effect of N, P and K on total uptake of P by mustard seed and stover

Total uptake of P by mustard seed				
Levels of N	Levels of P & K			
	P <sub>1</sub>		P <sub>2</sub>	
	K <sub>1</sub>	K <sub>2</sub>	K <sub>1</sub>	K <sub>2</sub>
N <sub>1</sub>	15.25	15.64	16.08	16.23
N <sub>2</sub>	16.70	16.88	17.02	17.91
N <sub>3</sub>	18.30	18.77	19.11	19.82
	N×P	P×K	N×K	N×P×K
SE(m)±	0.69	0.57	0.69	0.98
CD(P=0.05)	1.68	1.37	1.68	2.38





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Total uptake of P by mustard stover				
Levels of N	Levels of P & K			
	P <sub>1</sub>		P <sub>2</sub>	
	K <sub>1</sub>	K <sub>2</sub>	K <sub>1</sub>	K <sub>2</sub>
N <sub>1</sub>	5.15	5.51	5.97	6.23
N <sub>2</sub>	6.70	6.88	7.02	7.91
N <sub>3</sub>	7.94	8.18	8.34	8.83
	N×P	P×K	N×K	N×P×K
SE(m)±	0.50	0.41	0.50	0.71
CD(P=0.05)	1.21	0.99	1.21	1.72

Table 7. Potassium uptake by Indian mustard as influenced by nitrogen, phosphorus and potassium levels

Potassium Uptake			
Treatment	Seed (kg ha <sup>-1</sup> )	Stover (kg ha <sup>-1</sup> )	Total (kg ha <sup>-1</sup> )
<b>N-levels (kg ha<sup>-1</sup>)</b>			
80	10.24	35.26	45.60
100	11.51	36.13	47.64
120	13.42	38.37	51.79
SE(m)±	0.35	0.83	1.18
CD(P=0.05)	0.85	2.02	2.87
<b>P<sub>2</sub>O<sub>5</sub> levels (kg ha<sup>-1</sup>)</b>			
20	11.11	36.22	47.33
40	13.02	38.75	51.77
SE(m)±	0.22	0.68	0.9
CD(P=0.05)	0.70	1.65	2.35
<b>K<sub>2</sub>O levels (kg ha<sup>-1</sup>)</b>			
0	11.25	35.78	47.03
30	11.93	37.45	49.38
SE(m)±	0.29	0.68	0.97
CD(P=0.05)	0.69	1.65	2.45

Table 8. Interaction effect of NP, PK and NK on total uptake of P by mustard seed and stover

N-levels (kg ha <sup>-1</sup> )	Seed (kg ha <sup>-1</sup> )		Stover (kg ha <sup>-1</sup> )	
	P-levels (kg ha <sup>-1</sup> )		P-levels (kg ha <sup>-1</sup> )	
	20	40	20	40
80	9.89	10.59	33.86	36.66
100	11.17	11.85	35.62	36.83
120	12.68	13.35	37.86	38.87
SE(m)±	0.50		1.18	
CD(P=0.05)	1.21		2.86	
P <sub>2</sub> O <sub>5</sub> levels (kg ha <sup>-1</sup> )	K-levels (kg ha <sup>-1</sup> )		K-levels (kg ha <sup>-1</sup> )	
	0	30	0	30
	20	11.10	11.40	35.47
40	11.75	12.12	37.20	37.71





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SE(m)±	0.41		0.96	
CD(P=0.05)	0.98		2.32	
N-levels (kg ha <sup>-1</sup> )	K-levels (kg ha <sup>-1</sup> )		K-levels (kg ha <sup>-1</sup> )	
	0	30	0	30
80	10.08	10.40	34.83	35.69
100	11.38	11.64	36.05	36.39
120	12.81	13.22	38.13	38.60
SE(m)±	0.50		1.18	
CD(P=0.05)	1.21		2.86	

Table 9. Interaction effect of nitrogen, phosphorus and potassium on total uptake of K by mustard seed and stover

Uptake of K by mustard seed				
Levels of N	Levels of P & K			
	P <sub>1</sub>		P <sub>2</sub>	
	K <sub>1</sub>	K <sub>2</sub>	K <sub>1</sub>	K <sub>2</sub>
N <sub>1</sub>	9.72	10.06	10.44	10.75
N <sub>2</sub>	11.09	11.26	11.67	12.03
N <sub>3</sub>	12.48	12.88	13.14	13.57
	N×P	P×K	N×K	N×P×K
SE(m)±	0.50	0.41	0.50	0.70
CD(P=0.05)	1.21	0.98	1.21	1.71
Uptake of K by mustard stover				
Levels of N	Levels of P & K			
	P <sub>1</sub>		P <sub>2</sub>	
	K <sub>1</sub>	K <sub>2</sub>	K <sub>1</sub>	K <sub>2</sub>
N <sub>1</sub>	33.27	34.45	36.39	36.93
N <sub>2</sub>	35.51	35.72	36.59	37.07
N <sub>3</sub>	37.64	38.08	38.63	39.12
	N×P	P×K	N×K	N×P×K
SE(m)±	1.18	0.96	1.18	1.66
CD(P=0.05)	2.86	2.32	NS	NS





## A Review on Integrated Nutrient Management (INM) in Rice for Improving Productivity

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### ABSTRACT

Rice is the second most important cereal crop in the world after wheat and it is the most important staple food of south-west Asia including India. Due to the increasing population demand of rice is increasing, so the production must be increased accordingly. The improvement in the productivity is the only way to increase the total production because the cultivated land area is fixed and can't be increased but the use of natural resources must be judicious and the quality of environment shouldn't be sacrificed. The productivity enhancement requires proper management practices and nutrient management is one of the most important among that. Therefore, there should be a sustainable way of nutrient management for optimum production of rice. Integrated Nutrient Management (INM) is one of the appropriate option in present situation to improve productivity for fulfilment of the demand with less effect on the environment. In this chapter the INM of rice and its related aspects are critically reviewed.

**Keywords:** Rice, population, productivity, nutrient management, INM

### INTRODUCTION

Rice is an important food grain to many of the world population especially in the Asian countries. Not only in rice, but also in every crop nutrient management is having an important role in improving productivity as well as total production of the crop. The natural resources are shrinking day by day and the increasing use of synthetic fertilizers and pesticides is causing threat towards sustainability of the system, therefore the production system must be set



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accordingly. Among all the management practices nutrient management is one of the most important and it is also causing harm to the environment as it requires increasing use of synthetic fertilizers to maintain the productivity. So, the practices of nutrient management must be sustainability oriented for survival of the production system and INM is one of the best solution to optimise the productivity through use of both organic manures and inorganic fertilizers. INM provides a balanced fertilization to crop, which helps in the yield optimisation and system sustainability. Optimum nutrient application through appropriate method in right proportion at right time suitable for a specific crop and agro-climatic condition is called balanced fertilization. Balanced fertilization helps in 'soil health building', while imbalanced fertilization leads to 'soil mining', causing sickness of soil and an uneconomic waste of scarce resources. Only 'soil health building' leads to a sustainable land use system where most food grain production continues to come from existing agricultural land (Mahajan & Gupta, 2009). INM aims to improve the soil health and productivity by maintaining the sustainability (Prasad et al., 1995). Singh and Kumar (2014) observed increased yield and nutrient use efficiency in rice with the use of organics. Organic supply of nutrients also provide micro nutrients and change the soil-physical condition as well as increase the efficiency of applied nutrients (Pandey et al., 2007). The mixed use of organic and inorganic fertilizers has been observed not only to meet the nutrients requirement of the crop but also has been found to obtain large scale productivity goals (Yadav and Meena 2014)

### Effects of INM on different growth parameters

#### Plant Height

The plant height of paddy increased progressively with increase in the fertility levels of NPK (Deshmuk et al., 1988). The effect of application of duck weed @ 2t ha<sup>-1</sup> was found equally effective to 18 kg N ha<sup>-1</sup> application in terms of plant height (Ahmad et al., 1990). Incorporation of farm wastes like FYM, biogas slurry and poultry manure @ 5t ha<sup>-1</sup> and sunhemp, neem leaf, Calotropis and Pongamia @ 12.5t ha<sup>-1</sup> as green manure has significantly increased the plant height (Budhar et al., 1991).

#### Dry Matter Accumulation

The total dry matter yield of rice was higher when FYM and urea are applied together than only application of urea (Khan et al., 1986). The pattern of dry matter accumulation in rice was higher with increase in the level of nitrogen application (Balasubramanian & Palaniappan, 1991). Dry matter production of rice increased with the supply of N either from inorganic sources (50 kg N ha<sup>-1</sup>) or from combination of organic (10 t FYM ha<sup>-1</sup>) and inorganic sources (25 kg N ha<sup>-1</sup>) as compared with the application of organic source alone @ 20 t FYM ha<sup>-1</sup> on sandy clay loam soil of Kharagpur (Ghosh et al., 1994). Increase in the dose of nitrogen application even by 150% of the recommended dose increase dry matter (Mandal et al., 1994).

#### Number of Tillers per Unit Area

With increase in the level of Nitrogen application number of effective tillers increases (Deshmuk et al., 1988), (Singh et al., 1991). Relatively more number of effective tillers per hill were recorded with the application of poultry manure @ 15 t ha<sup>-1</sup> compared to FYM application @ 5t ha<sup>-1</sup> (Budhar et al., 1991). Number of Productive tillers recorded were higher, when Calotropis was incorporated @ 12.5t ha<sup>-1</sup> and it was followed by poultry manure application @ 5t ha<sup>-1</sup> to rice (Budhar et al., 1991). Highest number of productive tillers was recorded with 120 kg ha<sup>-1</sup> of inorganic nitrogen which was compatible with substituting the same nutrients through Glyricidia @ 30 kg N and 60 kg N ha<sup>-1</sup> as urea (HARI PRASAD, 1993).

### Effects of INM on Different Yield Attributes

#### Number of Panicles per Square Meter

An increase in the number of panicles per square meter was found when FYM and urea both were applied (G. D. Sharma & Sharma, 1994). In clay loam soils of Coimbatore similar results were also found with application of FYM



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and urea, when urea super granules were applied @ 58 kg ha<sup>-1</sup> along with Azolla or paddy straw to supplement 29 kg N ha<sup>-1</sup> (Thangamuthu and Balasubramaniyan, 1987).

**Panicle Length**

With Increasing levels of N, there is significant increase the length of panicle (Karuna Sagar & Rama Subba Reddy, 1992). Higher panicle length was obtained with incorporation of organic manures like leucaena tender loppings in combination with 75 kg ha<sup>-1</sup> inorganic N (Jeyaraman & Purushothaman, 1988). The length of rice panicle was increased by using 120 kg N ha<sup>-1</sup> through urea alone when compared with either organics alone or complementary use of organic and inorganic manures on equivalent nutrient basis (HARI PRASAD, 1993).

**Number of Grains per Panicle**

With addition of nitrogen the number of grains per panicle increase in rice (Reddy et al., 1987) (Rai et al., 1991). In rice basal application of farm waste like FYM @ 5t ha<sup>-1</sup> and green manures like sesbania, calotropis etc. @ 12.5t ha<sup>-1</sup> gives similar result in production of filled grains per panicle (Budhar et al., 1991). Number of filled grain per tiller was more when the nitrogen was applied through inorganic fertilizer by 75% and glyricidia or rice straw by 25% (Setty et al., 1990). Number of grains per panicle was significantly increased with application of 120 kg N ha<sup>-1</sup> through urea on sandy clay soil of Bapatla when compared with other organic and inorganic nutrient combinations (HARI PRASAD, 1993). Nitrogen application of 30 kg N ha<sup>-1</sup> through FYM along with 90 kg N ha<sup>-1</sup> as urea was found to produce more number of spikelets as compared to other combinations (G. D. Sharma & Sharma, 1994). With increase in the application of Nitrogen up to 90 kg ha<sup>-1</sup> was found to increase the number of grains per panicle significantly (Tripathi et al., 1998).

**Test Weight**

An increase in the test weight of rice grain with the combined use of organic and inorganic sources of nitrogen was observed (Setty et al., 1990); (Jeyaraman & Purushothaman, 1988). On the other hand, the basal application of FYM, poultry manure @ 5t ha<sup>-1</sup> or sunnhemp, calotropis, pongamia, soobabul, sesbania and neem leaf @ 12.5 t ha<sup>-1</sup> in the rice field don't have any impact on the test weight (Budhar et al., 1991)

**Grain Yield**

In many research, it is found that with incorporation of organic manures like wheat straw or, FYM (Maskina & others, 1987), FYM @ 12t ha<sup>-1</sup> (Purushotham et al., 1988), Prosopis or, Withania or, Abutilon or, neem leaf @ 6t ha<sup>-1</sup> (Alam et al., 1990), wheat straw or, FYM or, water hyacinth @ 5t ha<sup>-1</sup> (A. R. Sharma et al., 1990), FYM or, biogas slurry or, poultry manure @ 5t ha<sup>-1</sup> or green leaf manure @ 12.5t ha<sup>-1</sup> (Budhar et al., 1991) and FYM @ 20 t ha<sup>-1</sup> (Tandon, 1991) increases the grain yield of rice significantly. Incorporation of rice straw and chaff along with 60-90 kg N ha<sup>-1</sup> from inorganic sources (Subbaiah et al., 1983), a combined of FYM along with urea (Khan et al., 1986) and application of 30 kg N ha<sup>-1</sup> as FYM and 90kg N t ha<sup>-1</sup> as urea (G. D. Sharma & Sharma, 1994), gave maximum yield of rice as compared to the individual applications.

Combined use of 12t FYM ha<sup>-1</sup> and 60 kg N ha<sup>-1</sup> (Kulkarni et al., 1978) and 12t FYM ha<sup>-1</sup> along with 80 kg N ha<sup>-1</sup> (Maskina et al., 1988) produced similar rice yields with the application of 120 kg N ha<sup>-1</sup>. Application of 75% NPK through fertilizers + 25% through Glyricidia or rice straw (Setty et al., 1990), application of 50 % of the recommended NPK through FYM and compost and 50% through fertilizer (Jayakrishnakumar et al., 1994) found similar rice grain yield with full dose of recommended NPK. Application of N in rice through two organic sources such as FYM and wheat straw proved better than individual application of them and affected economy of 50 kg N ha<sup>-1</sup> for rice grain yield (Rajput and Warsi, 1991). Application of full recommended dose of N on soil test lab recommendation through fertilizer was found to be at par with 75% N combined with FYM @ 5t ha<sup>-1</sup> and Azospirillum @ 5kg ha<sup>-1</sup> and there is possibility of saving of 25% of fertilizer N through INM (Arumugam et al., 1992). Application of FYM, compost or biogas slurry along with 30 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> gave higher rice yields than with



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60kg  $P_2O_5$  ha<sup>-1</sup> as super phosphate on a calcareous soil in Bihar (Prasad & Prasad, 1994). A significant increase in rice grain yield was found with application of 120kg N ha<sup>-1</sup> on FYM amended plots as compared to 180kg N ha<sup>-1</sup> on unamended plots (Agrawal et al. 1995). The grain yield of rice was recorded maximum through application of inorganic P along with poultry manure (Gupta et al., 1995). Application of organic manure (FYM @ 5 t ha<sup>-1</sup>) along with the recommended dose of fertilizers produced significantly higher grain yields in rice (Rabeya Khanam et al., 1997).

**Straw Yield**

Application of duck weed to rice @ 2 t ha<sup>-1</sup> produced equivalent straw yield to that of 18 kg inorganic N ha<sup>-1</sup> (Ahmad et al., 1990). Combinations of different inorganic and organic treatment application of organics (FYM @ 12.5 t ha<sup>-1</sup>, Azadiracta leaves @ 6.25 t ha<sup>-1</sup>, cowdung slurry @ 5 t ha<sup>-1</sup>) and Azolla recorded highest rice straw yield on farmers fields in Coimbatore (Subramanian and Rangarajan, 1990). Rice straw yield was highest with the application of poultry manure @ 5 t ha<sup>-1</sup> and it performed better than FYM @ 5 t ha<sup>-1</sup> (Budhar et al., 1991). Increase in application of FYM level from 10 to 30 t ha<sup>-1</sup> straw yield increased from 5.08 to 5.39 t ha<sup>-1</sup> respectively (Kumar et al., 1991). The application of inorganic N in combination with FYM or straw to rice has been found to increase the straw yield (Rajput & Warsi, 1991). Application of poultry manure @ 5 t ha<sup>-1</sup> in rice was highly effective in increasing straw yield (Datta & Banik, 1994). Where as, with application of 120 kg N ha<sup>-1</sup> through FYM resulted in reduced straw yield (Radha Madhav, 1995). In addition to the recommended dose of fertilizers, incorporation of organic manure (FYM @ 5 t ha<sup>-1</sup>) in resulted significantly higher straw yield in rice crop (Khanam et al., 1997).

**Harvest Index**

Harvest index of rice was found to be increased with application of FYM @ 30kg N ha<sup>-1</sup> along with 60kg N ha<sup>-1</sup> as urea (HARI PRASAD, 1993). The harvest index of rice was relatively higher when the 120kg N ha<sup>-1</sup> was applied through FYM (Radha Madhav, 1995).

**CONCLUSION**

From this review, it is clear that INM in rice improves almost all growth and yield attributes of rice, increases both the grain and straw yield and also improves the harvest index. Therefore, INM in rice fulfils the increasing demand of rice by improving the yield and maintain the sustainability of the system by maintaining the soil health and reducing environmental pollution through reduced application of synthetic fertilizers.

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## Does Faculty Development Programmes have any Impact on Fostering the Teaching, Learning Skills and Professional Competency in Faculty?

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### ABSTRACT

The higher education system aims at achieving sustainable development and a significant increase in the growth rate through the dissemination of proper education in terms of knowledge and skills which has become possible only through the establishment of educational institutes in different parts of the country. However, the success of an institution hinges substantially on the vitality of faculty that intensifies the proficiency and competence in the professional education system. Enrichment of vitality of the faculty members is of utmost importance in key domains related to teaching, research and administration to provide effective assistance to the students by improving the educational system significantly which can be achieved through faculty development programmes (FDPs). FDPs are need based, and are efficiently designed to eliminate the gap that exists in quality teaching and research. This review covers the impact of faculty development programmes in grooming the faculty and teachers in order to enhance the quality of the education system.

**Keywords:** faculty, teachers, programmes, system, institution

### INTRODUCTION

The Indian system of higher education is considered as the second largest system in the globe in terms of enrollment. The higher education system aims at achieving sustainable development and a significant increase in the rate of

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growth through the dissemination of proper education in terms of knowledge and skills which has become possible only through the establishment of educational institutes in almost every pocket of the country. However, the success of an institution hinges substantially on the vitality of faculty that intensifies the proficiency and competence in the professional education system (Bilal *et al.*, 2019). Faculty and teachers are the assets of an institution as the quality of the teachers reflect the quality of the students. The core responsibility of faculty members is how best they can impart knowledge and skills to their pupil (Hrnciar and Madzík, 2013) which will help in shaping their lives. However, mere increasing the number of faculty in an institution will not serve the purpose if the quality will not be taken into consideration. Many times it has been observed that despite fulfilling all the pre-requisites, a faculty underperforms which not only affects the professional and personal lives of the individual but also the learners.

This situation prevails mainly due to multiple factors like lack of understating of the subject, lack of theoretical and practical knowledge, lack of confidence to face the class, nervousness, etc. Enrichment of vitality of the faculty members is of utmost importance in key domains related to teaching, research and administration to provide effective assistance to the students by improving the educational system significantly (Bilal *et al.*, 2019), and also to get the better of the hurdles faced by an underperforming individual. Superior quality professional pedagogy is the need of the hour for the faculty members not only to improve their teaching, research and administrative competencies but also to keep pace with the ever-changing scenario in the educational system which can be achieved through a dynamic faculty development programme. Faculty development programmes (FDPs) include a wide array of activities aimed at assisting the academicians or faculty members to work on their professional expertise necessary for teaching, research, curriculum support, mentoring and administration (Kwan *et al.*, 2009 and Guraya *et al.*, 2016). FDPs are recommended by professional experts as well as organizations for creating awareness among the learners to achieve knowledge in the line of teaching in a better way (Ghazvini *et al.*, 2014 and Jones *et al.*, 2015). Many researchers have proposed faculty development programmes are often required to circumvent monotony and one-way lecturing (Fink, 2013). However, a perusal of literature has shown sustained availability of information in a scattered way. Thus the researchers have attempted to provide a systematic review on the impacts of FDPs in fostering the teaching, learning skills and professional competency in faculty.

### Genesis and expansion of Faculty Development Programmes

For the enhancement of instructional cum teaching skills, different faculty development programmes are being developed in the past. These FDPs mainly aimed to initiate and impart sustain changes in targeted learners (Sullivan, 1983). Previous studies were reviewed by Hitchcock and his co-worker in 1992 who proposed the gradual development and expansion of the concept (McLeod, 2010; Sheets and Schwenk, 1990; Stritter, 1983) whereas Hubbard and Atkins (1995), suggested the strategies related to faculty development as valuable means that enhances not only the capabilities of the faculty but also the institution which in turn upgrade the teaching-learning environment, creates awareness on the emerging technologies among the learners and enables to understand the expansion of higher education. In recent times, contemporary perspectives of FDPs critically addresses the awareness on the vitality and improvement of teaching skills, reinforce the bond between the faculty including the sustenance of faculty members as well as the institutions (Kamel, 2016).

Faculty development programmes are being classified in various ways by different researchers. The researchers Bergquist and Phillips (1975) had described FDP based on three vital components *viz.*, instructional development, personal or individual development and organizational or institutional development. Instructional development solely includes activities like development of curricula, diagnosis of teaching and pedagogy; individual or personal development includes activities that provide interpersonal skills and counseling on career advancement that encourages growth and development of the faculty and organizational or institutional development involves activities that enhance the administrative capabilities of the faculty members and administrative staffs including development of managerial skills and healthy team work. Another classification was proposed by the researchers Ullian and Stritter (1994) in which they included fellowships, seminars, workshops in addition to organizational





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strategies and personal activities. Wilkerson and Irby (1998) also suggested a classification, in which they involved orientation programmes for the new faculty in the initial stage prior to instructional, administrative and institutional developmental programmes.

### Importance of Faculty Development Programmes

There are evidences showing the ineffectiveness of the traditional method of teaching due to the ever-changing scenario of the present education system (Fink, 2013). Incorporation of improved technologies is also one of the major factors contributing to the need of FDPs in recent times to cope up with the technologies. The importance of FDPs lies upon various factors *viz.*, increasing diversity among the students in respect to age, learning needs, cultural and academic background; opportunities and challenges related to technological aspects that enhances learning processes and changes in recruitment process and faculty characteristics (Kamel, 2016). FDPs ensure effectiveness of faculty members by enhancing their efficiency to support the learning of students which have diversified learning needs though development of appropriate teaching aids, strategies and curricula for a whole new environment. FDPs also provide opportunities to exploit and take advantage of the newer techniques by integrating them with teaching and research to make the subject more attractive to the students and also to exploit them in curricula planning. FDPs also help in identifying ways to involve new faculty members in institutional activities by ensuring the quality of their capabilities (Kamel, 2016).

### Impact of Faculty Development Programmes on faculty and students

The faculty development programmes aim at enriching the academic as well as intellectual competencies of the learners as well as the organizations. These are focused series of workshops or pedagogy that enhances the teaching quality, educational techniques and experiential learning. The results pertaining to various studies revealed that FDPs have number of purposes that includes improvement in attitudes, identification and recognition of various lacunae in teaching, opportunities to pursue research work, opportunities to improve pedagogical skills, opportunities to develop course curricula and administrative acumen in an efficient manner.

Many researchers have analyzed the results of FDPs through questionnaires, video recordings, feedbacks collected from students and faculty reports (Steinert *et al.*, 2006). Several publications were reviewed by Reid *et al.*, 1997 during 1980-1996 and they concluded that FDPs involving fellowships, seminars and workshops gave positive results. Results of many studies revealed a significant positive correlation between ratings of videotapes and knowledge tests. While reviewing the impact of FDPs on students, feedbacks collected from the students were evaluated and it was observed that ratings of the students were focused mainly on to increase in active learning process and clarity in lectures including delivery in immediate feedbacks. In case of faculty members, increase in confidence and competence was observed (Finelli *et al.*, 2008)

Thus FDPs were found to have beneficial effects both on faculty as well as on students in general when results of the students' evaluation reports and surveys were taken into consideration. However, the above mentioned measures involves more cost and time consuming, henceforth, more reliable and valid measures are needed to analyze the impact of FDPs in a more accurate way (Steiner *et al.*, 2006). For psychometric properties, most of the studies have used questionnaires and developers and researchers involved with the assessment of changes need to use questionnaires that are valid and reliable or work in a serious manner to establish these measures, e.g. development of a number of measures and scores can be seen in education that measures the performance of the faculty (Gibbs and Coffey, 2004). Different assessment tools and measures must be utilized to get more consistent and reliable results whenever possible (Gibbs and Coffey, 2004). Glowacki-Dudka and Brown, 2007 suggested the advantages and beneficial effects of FDPs provided in medical via self-evaluation of teaching skills, creating awareness on efficient teaching and research methodologies, and also feedbacks from the students. Improvements in ratings of the students and changes in teaching methods and practices were demonstrated by the researchers Finelli *et al.*, 2008 through focused instructional consultations.





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### Development and Future Vision

The efforts of faculty developments were mainly apprehensive with the advancement of the teaching or disciplinary skills of the individuals initially (Hubbard and Atkins, 1995). However, over the last few decades, it was realized that this perspective is conventional and has narrower sense that would be unable to keep track of the developments taking place in the new generation's technologies and society which is connected globally (Millis, 1994). Thus, this realization had given birth to philosophy of faculty development in a broader sense involving short series of pedagogy to professional development including teaching, reaching and administrative activities and cooperation between the members. The concept of professional learning in a continuous mode rather than single training as proposed by different educators involved in higher education system (Clarke and Hollingsworth, 2002; Knight, 2002). It was observed that intended learners usually get to know from a series of training activities which involves interactions with fellow learners and experienced professionals, learning from formal programmes as well as form job related activities (Bergquist, 2010).

The future vision is focused on three key themes (Sorcinelli, 2005) – a) emphasizing in the field of development of organization by enhancing the leadership qualities among the faculty and to work under the supervision of academic leaders *viz.*, administrators (chairs and deans) with an objective to create encouraging and supportive environments to carry out quality teaching and research by enhancing their aptitude and skills (Sorcinelli, 2005; Bergquist, 2010; Wilkerson and Irby, 1998); b) emphasizing to link up the capacity of the professionals with research work to enhance learning of the students, systematically working on a research base in teaching and learning and c) developing new analytical views to bring about absolute structures for the development of faculty by lessening the organizational operations in centralized ways (Austin and Sorcinelli, 2013).

### CONCLUSION

Faculty development programmes are being considered to be successful in enhancing the quality of teaching and research through enrichment in the competency of the faculty members. Superior quality professional FDPs provide promising results in higher education that helps in developing teaching, research and administrative skills in an efficient manner. FDPs not only help in the development of an individual but also contribute towards the institution building in a way that ensures quality, excellence, advancement and readiness to bring about effective changes in a positive manner as a response to ever-growing demands of education and students to keep pace with the new generation and newer technologies.

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## An Overview of Q Methodology: Process, Application and Challenges

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### ABSTRACT

Q methodology or Q sort technique is a research tool used to study people's own perspectives, meanings and opinions developed by physicist William Stephenson in the 1930s. This is a research method used in psychology and in social sciences for understanding subjectivity. This review paper tries to introduce briefly about this methodology which integrates quantitative, qualitative and mixed methods and its application procedure. Applying Q method involves five consecutive steps those are like identifying discourse to concourse, developing a Q sample or Q statement set, ordering from the piles and ranking etc. This review has also included the challenges of the technique as have found some loopholes in Q methodology like non-linearity and absence of value neutrality. This study also included information regarding difference between Q method and other social science survey and its applications along with important features.

**Keywords:** Q Methodology, discourse, concourse, statements, research, investigation

### INTRODUCTION

Q methodology was developed by psychologist and physicist William Stephenson in the 1930s, and documented in his book, *The Study of Behaviour: Q technique and its Methodology* (1953). Its aim is to study people's own perspectives, meanings and opinions. For some scholars, considerable emphasis is given to the fact that Q methodology is a 'scientific' study of these phenomena. For example, Goldman (1999) categorises Q methodology as the 'science of subjectivity' while McKeown and Thomas (1988) consider it to be 'a method for the scientific study of

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human subjectivity'. This emphasis on the 'scientific' credentials of the method is equivalent to the Stephenson's own disciplinary and positivist background, and the values and beliefs of people who have traditionally tried to apply Q methodology.

### Steps of Q Methodology

Q methodology can be explained having five key stages.

#### 1<sup>st</sup> key stage

The first stage involves identifying the 'discourse' which is under investigation. In Q methodology a discourse is referred to as a set of shared beliefs, opinions, understandings or meanings that is held by a population. For example, the discourse under investigation by (Fieldhouse 1986) was attitudes towards food and nutrition while (Brown 1993) investigated this as a discourse on animal experimentation. The discourse in a Q study is, of course, directly connected to one's research questions. The quantitative researchers typically develop a set of hypotheses at the commencement of a study, while the Q researchers develop research questions because the Q methodology is a research technique which neither tests its participants nor imposes the meaning a priori. (Stainton Rogers 1995). Rather, meaning and significance of generated profiles in Q methodology are 'attributed a posterior through interpretation' (Brown 1980).

#### 2<sup>nd</sup> key stage

The second stage in the Q process is moving from the broader discourse to identifying a 'concourse'. This refers to the range of issues that exist on a particular discourse (topic). For developing a concourse researchers may use either naturalistic or ready-made type texts (McKeown and Thomas 1988). Dell and Korotana 2000 used interviews to obtain a sense of the discourse about domestic violence, but turned as well to the literature and media reports to develop their concourse. In earlier Q methodological work (Stepheonson 1936) used with more unusual stimuli including hedonic values of different odours. However, this methodologists have employed a Q set of statements. During concourse development researchers build up a statement set which identifies different, though recognizable assertions about the social phenomena being studied for 'broadly representative of the opinion domain at issue' (Watts and Stenner, 2005).

#### 3<sup>rd</sup> key stage

The third stage in the Q methodology is the process of developing a Q sample or Q statement set from the concourse. Developing the Q set helps researchers in refining and setting the research question, which, in Q method, must be clearly defined before data collection starts. (Watts and Stenner 2005) recommend for developing straightforward questions, containing a single proposition for each. A clearly defined statement in the research question is required as it dictates the nature and the structure of the Q set and acts as a 'condition of instruction' for participants during the actual sorting process of it. Therefore, a Q set reflects the complexity of the issue given, as well as enables each participant to respond based on their experience.

Often the concourse may be 'around three times the size of the aimed-for Q set, say 200 for an aimed-for Q set of 65' so this is much an arduous process. (Stainton Rogers 1995) The size of the statement set may vary, but typically it is between 30 and 60 statements (Thomas and Watson 2002 ). Time and practical constraints should be considered while determining the size of the sample. Piloting is consequently recommended for this. Above all the researchers should ensure that they have covered the breadth of opinions or themes that may circulate about a discourse, and also ensure that they have avoided unnecessary duplication as well as under/over sampling here. There is a variety of suggested Q sample techniques in the literature for moving from the concourse to Q sample including coding statements and matching them to matrix according to different dimensions of a discourse to create a structured sample. This is a technique engaged in their study of sustainability of discourses. (Barry and Proops 1999)





#### 4<sup>th</sup> key stage

The fourth stage after the development of the Q sample is to ask participants to order the statements in a process which is called a Q sort. This is a ranking procedure which (Brown 1980) calls 'the technical means whereby data are obtained for factoring'. In practice, the statements are typically written on small cards and sorted into different piles in a quasi-normal distribution according to the 'conditions of instruction' described by the researchers. For example, participants will be asked to respond according to whether they will strongly agree (+6) or will strongly disagree (-6) with an individual item in the Q set. In Q sorting it is identified as a 'forced-free' distribution, because it takes the form of a quasi-normal distribution that is symmetrical about the middle. Both the range and the distribution shape are arbitrarily designed to accommodate the number of statements chosen for the study (Addams 2000).

#### 5<sup>th</sup> key stage

Typical Q studies use an 11 or 13 point scale, with the possible ranking values from +6 or +5 for items that are 'more agreeable' in view of the participants, through '0' to -6 or -5 for items considered 'more disagreeable'. The key point in this procedural step is to ensure that Q sorters discard statements that are irrelevant and retain those that best describe their opinions and experiences of the social phenomena being studied. Brown 1980 explained that a participant completing a Q sort is usually more emotive about statements scored '-6' than those scored '0' because statements placed by participants towards the 'middle' lack some significance as compared to those statements placed at the extremes. Practically Q sorting is an interactive process and the factors that emerge are 'operational definitions' of opinions, experiences and preferences of each individual (Brown 1980).

#### Important Features

This is a research method used in psychology and in social sciences to study people's "subjectivity"—i.e., their own viewpoint. It has been used both in clinical settings and for assessing a patient's progress over time (intra-rater comparison), as well as in research settings to examine how people think about a topic (inter-rater comparisons). The name "Q" has been derived from the form of factor analysis which is used to analyze the data. Normal factor analysis, called "R method," involves finding correlations between two or more variables (e.g. height /age) in a sample of subjects. Q, on the other hand, looks for correlations between subjects across a sample of variables. Q factor analysis reduces many individual viewpoints of the subjects down to few "factors," those are claimed to represent the shared ways of thinking. It is sometimes said that Q factor analysis is R factor analysis with the data table turned sideways i.e. helpful as a heuristic for understanding Q, this explanation may be misleading, as most Q methodologists argue that for mathematical reasons any data matrix would not be suitable for analysis with both Q and R.

The data for Q factor analysis extracted from a series of "Q sorts" from one or more subjects. A Q sort is a ranking of variables which is presented as statements printed on small cards—according to some "condition of instruction." For example, in a Q study of people's views of a celebrity, a subject might be given statements like "He is a deeply religious man" along with "He is a liar," and asked to sort them from "most like how I think about this celebrity" to "least like how I think about this celebrity." The use of the ranking, rather than asking subjects to rate their own agreement with statements individually, which is meant to capture the idea that people think about the ideas in relation to other ideas, rather than in isolation.

#### Difference between Q and other social science survey

One salient difference between Q and other social science research methodologies, such as surveys, is that -Q Method typically uses many fewer subjects. This can be a also its strength, as Q is sometimes used with a single subject, and it makes research far less expensive. Here a person will rank the same set of statements in different conditions of instruction. e.g., someone might be given a set of statements about personality traits and then asked to rank them according to how well they describe herself, her ideal self, her father, her mother, etc. Working with a single individual is particularly relevant in the study of how an individual's rankings change over time and this was





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the first use of Q-methodology. As Q-methodology works with a small non-representative sample, conclusions are limited to those who participated in the study.

### Application

Q-methodology is used as a research tool in a wide variety of disciplines including nursing, veterinary medicine, public health, education, transportation, rural sociology, hydrology, and even robotics. The methodology is mostly useful when researchers wish to understand and/or describe the variety of subjective viewpoints on an issue relating some aspects. The "Q sort" data collection procedure was used to be done using a paper template and the sample of statements or other stimuli printed on the individual cards. Now-a-days, there are also computer software applications for conducting online Q sorts. E.g., UC Riverside's Riverside Situational Q-sort (RSQ), which claims to measure the psychological properties of situations. Their International Situations Project is using the tool to explore the psychological aspects of situations and how those aspects may differ across cultures with this university-developed web-based application. Till date there has been no study of differences in sorts produced by use of computer based vs. physical sorting.

One Q-sort application should produce two sets of data. The first is the physical distribution of sorted objects and the second is either an ongoing 'think-out-loud' or narrative type or a discussion that immediately follows the sorting exercise. The purpose of these narratives may be to elicit discussion of the reasons for particular placements. The relevance of this qualitative data is often suppressed in current uses of Q-methodology and the modes of reasoning behind placement of an item can be more analytically more relevant than the absolute placement of cards. This scale has some commonality with summated rating scale. In this scale the respondents are asked to sort a given set of statements (items) and classify them into a predetermined number of categories (piles) usually 11. The number of statements (items) to be included in each category is also selected in advance.

### Challenges

Though a good psychological measurement tool, still researchers have found some loopholes in Q methodology to be used as a good research technique. E.g. it is not a linear process (Onwuegbuzie, Collins, Leech, Dellinger, & Jiao, 2010). Therefore, it is very common for researchers to oscillate between their primary research study and the further information. This non-linearity enhances complexity. This is also not value neutral like any scale. (Dellinger, 2005; Onwuegbuzie & Frels, 2012). The study contains quantitative information regardless of whether the source of information represents a quantitative, qualitative, or mixed research study (Onwuegbuzie et al., 2010; Sandelowski, Voils, & Barroso, 2006). It represents quantitative, qualitative, or mixed research studies. Due to the array of quantitative and qualitative data those are potentially inherent in each work, it needs simultaneously to the analysis of quantitative and qualitative information. So it optimally involves using mixed research techniques (Onwuegbuzie et al., 2010; Onwuegbuzie & Frels, 2016).

Using both quantitative and qualitative information in the same literature review automatically renders the literature review process as a mixed research study (Onwuegbuzie et al., 2010). Truly, with respect to the analysis of information, the reviewer must be competent in conducting quantitative-based (e.g., meta-analysis; Glass, 1976) and qualitative-based (e.g., meta-synthesis; Sandelowski & Barroso, 2003) along with mixed research-based (e.g., meta-summary; Sandelowski & Barroso, 2003) analyses.

## CONCLUSION

The power of Q methodology does not lie in the findings that can be generalized to the population from where the participants were selected (i.e. external statistical generalizations). Rather, the power of Q methodology has its ability to lead to analytic findings, wherein the literature reviewer is "striving to generalize a particular set of results to some broader theory". (Yin, 2009, p. 43)





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It is the participants' view points which can be generalized according to the types of persons who share similar points of view on a topic, under the assumption that the statements that comprise the Q sample are representative of the universe of viewpoints on the chosen topic (Brown, 1980; McKeown & Thomas, 1988). More clearly, although the findings from a Q methodology of information extracted from the literature reviews generalize to those who participate in the study, as the Q sample reflects a representative sample of statements those are drawn from the concourse, which, evolves from the comprehensive literature review. Above all the whole methodology provides us a useful tool which helps both beginning researchers and also the experienced researchers through the mixed analysis process onto the literature review process for a rigorous study.

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34. Sample set of statements / Items for Q sort scale tabulation example: directly compiled from the book "Research Methodology" by Sagar Mondal

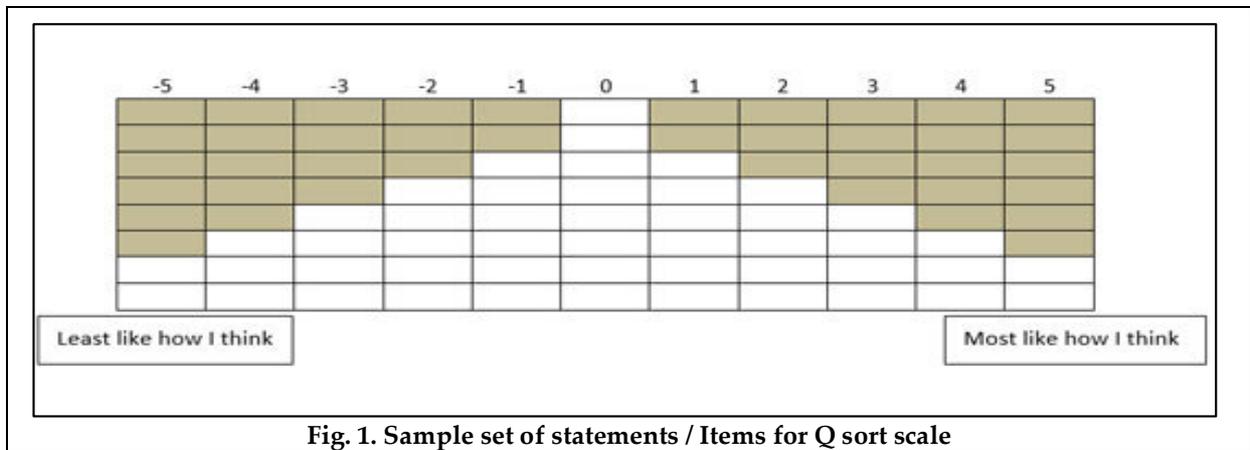
**Table 1. Sample set of statements / Items for Q sort scale**

Item no.	Statements
1	There is hectic competition among employment institution in providing employment opportunities
2	Some educational institutions are not bothered about employment issue of their graduates.
3	Since the average salaries in industries are very low, graduates of premier institutions are not willing to accept this low-paid jobs
4	In technical education educational institutions are not employing qualified and experienced faculty which affects employment opportunities diversely.
5	Because of higher pay in some industries educational institutions are finding this difficult to attract talented graduates/ experienced persons for faculty positions
6	Some educational institutions do not plough back their surplus which badly affects institutional infrastructure development.
7	There is a gap between job specifications in employment market and skill provided in educational institutions.
8	Some educational institutions do not plough back their surplus which badly affects the institutional infrastructure development
9	There is a difficulty in implementing most modern syllabus for all educational institutions because of autonomous status conferred to some col...
10	Insecurity of job in private colleges make faculty members to move frequently to other institution which affects quality of teaching frequently to other institutions which affect quality of teaching greatly.
11	There is no integrated effort like symbiotic marketing to employ graduates of different institutions in industries / service organisations.





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## Production Technology of Lemongrass (*Cymbopogon flexuosus*)

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### ABSTRACT

Lemongrass (*Cymbopogon flexuosus*) is tropical perennial grasses belongs to the family Graminae. Plants are grown under tropical and subtropical climatic conditions. It can be propagated through both sexually and asexually. In many regions, lemongrass is planted as an intercrop in fruit orchards or Plantation field. This plant is giving economically yield up to 5-6 years therefore this time coincides with the initial establishment of fruit orchards and plantation field. The plant is containing Citral about 75-80% which is responsible for its lemon-like smell. The essential oil is extracted through the steam distillation process and stored in a dark room to preserve the quality. Plants are dried and chopped into pieces before distillation as oil is highly evaporated. East Indian Lemongrass is largely exported from Cochin port; hence it is called Cochin oil [1]. India is the greater exporter of this oil. This oil is utilized for various purposes like Aromatherapy, Flavoring industry, confectionary, preparation of perfume etc. Besides, it has many medicinal values and use against digestive disorders, diabetes, nervous disorder, inflammation, fever [10] etc.

**Keywords:** Lemongrass, Uses, Essential oil.

### INTRODUCTION

Aromatic plants are an economically important group of plants which possessing Aroma and Flavour. Aromatic plants possess odoriferous compounds which synthesized as an essential oil or oleoresin and exudate as a gum from different plant parts including root, wood, bark, stem, foliage, flower, fruit and seed etc. The term essential oil corresponds with fragrance or perfumes, since such fragrances are oily and reflect the plants' essence or active constituents[1]. Several chemical constituents are responsible for characteristic aroma in plant. India is rich in



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biodiversity and comprise of numerous aromatic plants that are now being used as Aromatherapy for various ailments. Besides this, it can be utilized in many aromatic industries or confectionary or as a food and flavoring industry to adding delightful aroma. Two major scientific councils work on medicinal and aromatic plants in India. One is the Central Institute of Medicinal and Aromatic Plants under CSIR which looks at the point of view of the industry and another is Directorate of Medicinal and Aromatic Plants under ICAR which looks at the point of view of farmers. In the Aromatic plant, about 1500 species are known[1], but, only slightly more than 300 species were studied in some details. Of the 50 species that find use of essential oils and aroma-chemicals as commercial sources. Aromatic plants are classified into four broad groups for practical convenience. *i. e.*

1. Aromatic grasses: Lemongrass, palmarosa, citronella, vetiver etc.
2. Aromatic herbs and shrubs: Mints, Ocimum, patchouli, rosemary etc.
3. Aromatic trees: Sandalwood, eucalyptus, clove, camphor, cinnamon, nutmeg, linaloe etc.
4. Aromatic flowers: Rose, jasmine, tuberose, marigold, champak etc.

Aromatic grasses belong to the genus *Cymbopogon* and native to the tropics and subtropics of Asia, Africa and Australia. The name *Cymbopogon* derives from the Greek words 'kymbe' meaning boat and 'pogon' meaning beard that denotes the spike arrangement. Most oil grasses are perennials that are robust and densely tufted. It can prefer hot, humid tropics and can reach a height of 2 meters. They can bear long, flexible, narrow leaves. The genus *Cymbopogon* consists of approximately 50 to more than 100 numbers of species [2] under the Poaceae family. Aromatic grasses have traditionally been used in aromatherapy as an essential oil in Indian and Chinese medicine.

Lemongrass (*Cymbopogon flexuosus*) is tropical perennial grasses which possess a lemon-like odour. The name Lemongrass is justified by its lemon-like odour. It is belonging to the Graminae family[3] and native to many parts of tropical and subtropical South East Asia and Africa [4]. Aromatic oil is extracted from leaf and stalk of the plant. The main active principle is Citral (75-80%) which is extracted from leaves through the distillation process. East Indian lemongrass is largely exported from Cochin port; hence it is called Cochin oil[1]. Kerala shares the leading producer of this oil. India is the largest producer of lemongrass and about 80% of the produce is being exported. The essential oil is being traditionally exported to West Europe, U.S.A. and Japan. In India, the total cultivated area for lemongrass is estimated about 3000ha and largely grown in Kerala, Karnataka, Uttar Pradesh and Assam [5].

**Geographical Distribution**

Three types of lemon grasses are grown *i. e.* East Indian lemongrass or Cochin oil (*C. flexuosus*); West Indian lemongrass (*C. citratus*); and Jammu (*C. pendulus*) lemongrass. East Indian lemongrass is an Indian indigenous plant and commercially grown in Kerala, Assam, Maharashtra, Uttar Pradesh etc. West Indian lemongrass is native to Pakistan, India and Sri Lanka [6]. Then, it is widespread in many countries, such as West Indies, Guatemala, Brazil, Congo, Tanzania, Thailand, Bangladesh, Madagascar and China, etc. Jammu lemongrass is primarily restricted to the states of North India, including Jammu and Kashmir, Sikkim, Assam, Bengal and Madhya Pradesh. In India, lemongrass is commercially grown in the states of Kerala, Maharashtra, Karnataka and Tamil Nadu states [7].

**Uses of Lemongrass**

Lemongrass oil is being used as raw material for the preparation of important ionone such as  $\alpha$ -ionone for the preparation of perfumes, cosmetics as well as flavours, even as  $\beta$ -ionone is being used for the manufacture of synthetic vitamin A[8]. Lemongrasses are also used in many countries such as Java, Japan, China and India as flavouring in fruit, drink and tea or scented bathwater. The characteristic smell of oil makes use of soaps, detergents, insect repellent and formulations in the scenting process. From it is prepared a bio-pesticide with a nontoxic mode of action. It does have soil and water conservation properties. It can also be used as live mulch and cultivated along with the main crops. Spent gasses are also useful for the manufacture of cardboard and papers or as fuel. In India, it can be used as sedatives for the central nervous system [9]. Lemongrass oil is usually used in the preparation of



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many folk medicines for curing of digestive disorders, diabetes, nervous disorder, inflammation, fever [10] and also utilized as an antimicrobial agent for various pathogenic fungi [11].

**Morphology**

Lemongrass is tall, perennial grass that yields thick, glaucous, dense green leaves from a short rhizome. The culm is sturdy, upright, and grows up to 1.8 meters. It produces abundant flowering in South India. It is a short day plant and inflorescence is about a meter in length, with a long spike. Flowers are rarely produced from Panicle. Inflorescences are rosy in colour, growing up to 30 to 60 cm long.

**Species and Cultivars****Species**

Commonly lemongrass is categorized into three groups, such as

- East Indian lemongrass (*Cymbopogon flexuosus*): It is commonly termed Cochin grass or Malabar grass. It is a tall, perennial plant that grows up to 2 m tall and produces linear and lanceolate leaves. Plants consist of drooping panicles, as they are very long. Panicles are produced mainly in grayish colored leaves but are rarely shown in pinkish tinge. Two varieties are classified under this genus based on the colour of the stem. One of these is reddish or purple stem i. e. *C. flexuosus* var. *flexuosus*. It produces more Citral percentages (75-90 %) but poor yield. Another variety is the wild type, commonly referred to as white grass (*C. flexuosus* var. *albescens*) for its white stem colour. This grass produces less amount of Citral (60-75%) with a higher yield.
- West Indian lemongrass (*Cymbopogon citratus*): It is a smaller stem of perennial grass with numerous steep tillers arise from short rhizomatous rootstock. Leaf-blades are usually long, flat, glaucous and drooping. Inflorescences are reproduced very rarely.
- Jammu lemongrass (*Cymbopogon pendulus*): It is stemmed in white and has a small stature. The plant is frost resistant and suitable for northern India's Sub-Himalayan areas.

**Variety**

Some improved variety is developed for commercial cultivation like

**Sugandhi (OD-19):** This variety has originated from Research Station for Aromatic and Medicinal Plants, Odakkali. It can be cultivated in a wide variety of soil and climate conditions. Stem is typically reddish and expands 1 to 1.75 m long. It can yield approximately 80 to 100 kg/ha under rainfed conditions with a citral percentage varying from 85 to 88 percent.

**Pragati:** It is developed from CIMAP, Lucknow and suitable for Subtropical and tropical climatic conditions in the regions of North Indian Plains and Tarai Zone. It is a tall variety and produces dark purple colour leaf sheath. The Average oil content is 0.63 percent with a Citral content of 75-82 percent.

**Praman:** This variety was developed through clonal selection and belonging to species *C. pendulus*. It is a medium-sized variety with erect leaves and profuse tillering. The oil yield is high with 82 percent citral.

**Jama Rosa:** It is a hardy plant with vigorous growth that remains in the field for 16-18 months. This variety produces about 300kg oil in 4-5 cuts in peak growing period.

**RRL 16:** This variety was developed from RRL, Jammu. This variety's average annual herbage yield is 15 to 20 tonnes/hectare and yielding 100 to 110 kg of oil. The oil content varies from 0.6 to 0.8 percent on a fresh weight basis with a citral 80 percent.



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**CKP 25:** It is developed from a cross between *C.khasianum* X *C.pendulus* from RRL, Jammu. This variety is suitable for North Indian plains under irrigation conditions. It can produce 60 t/ha herbage and oil containing 82.85% citral. This variety can produce 50% and 140% more oil yield than RRL-16 and OD-19 respectively.

**Other Varieties**

**OD-408:** This variety has developed through selection from OD-19. It comprises a white stem and produces more oil and citral content.

**Kaveri:** This variety is suitable in the region with high soil moisture to produce luxuriant growth.

**SD-68:** This has been developed by CIMAP, Lucknow through selection.

**LS-48:** It is an improved variety developed at CIMAP, Lucknow are available for cultivation.

**Agro-climatic Requirements****Soil**

The plant is very hardy and it can be grown under a variety of soil conditions ranging from rich loam to poor laterite. However, it cannot tolerate Calcareous and water-logged conditions with poor drainage [12]. Lemongrass can be cultivated under well-drained sandy-loam soils with adequate incorporation of manure to obtain better yield and oil content. In the hilly region, it can be grown as a vegetative cover on an eroded land for its soil binding properties. It can prefer soil pH ranging from 5.5 to 7.5. In India, *C. flexuosus* is yielded more herb and oil under pH 7.5 [13]. It is also reported that electrical conductivity of 11.5, 10 and 5.5 mmhos/cm of soil was not affected the herb and oil yield of *C. flexuosus* in a pot trial where, Citral content was not decreased with increasing of Salinity level 15 mmhos/cm [14].

**Climate**

Lemongrass can be cultivated with ample sunlight in both tropical and subtropical conditions. It can grow up to the elevation of 900m above from MSL with uniformly distributed annual rainfall ranging from 250-280 cm. supplemental irrigation can be applied in the region where rainfall is poor. It is reported that *C. citratus* is more drought-tolerant [14] grass. In the hilly region, Citral production can be hampered with more rainfall per annum. It can prefer 20-30<sup>o</sup> C temperature with good sunshine throughout the year for better oil yield, but oil production can be reduced when the temperature goes to above 30°C.

**Field Preparation**

Lemongrass is a perennial crop and stands a minimum of 4 to 5 years in the field. So, initial land preparation is necessary for better growth and development. The land should be prepared by 2 to 3 ploughing and followed ridge and furrow beds. Land should be free from unwanted vegetation or Stones etc. Application of Phorate @ 10 kg neem @ 8-10 kg should be mixed on the soil at the time of last ploughing to control soil-borne disease.

**Propagation**

Lemongrass can be propagated through both sexually means seed and vegetative means Slips or root divisions. Seeds are most available but, vegetative propagation is preferable as seed causing a genetic heterogeneity resulting in degradation of oil yield and quality [15].

**Seed Production**

It is a perennial crop and produce flower during November-December. Seeds are collected from a healthy mother plant in the month of February-March. The healthy plant must be chosen by performance-based like average yield of about 100-200 g of seeds per plant. Seeds are collected from healthy plants by cutting off the whole inflorescence followed by dried under sunshine for 2-3 days. Again, seeds are threshed and re drying under Sunshine. After that,



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dried seeds are stored in gunny bags lined with polythene. But, it can lose viability under a long storage period line for more than one year.

**Rooted Slips**

Slips are also propagating materials for Lemongrass and it is more beneficial for commercial cultivation as compare to seed. Slips are separated from well-grown clumps and cut off at a height of 20-25cm. before planting; lower sheath should be removed for better exposure of roots.

**Nursery Preparation**

It is more advantageous to grow the plant through transplanting of seedlings rather than direct sowing as seeds lose their viability within a short storage period. In the case of broadcasting, about 25-30 kg/ha seeds are required for sowing, whereas, 3-4 kg/ha of seeds are required for transplanting. Nursery beds can be prepared by raised bed about 1m to 1.5m width. After bed preparation seeds are sown by hand on the month of April-May and covered with a thin layer of soil. The bed should be watered immediately after sowing and care should be taken to maintain adequate moisture in the soil. Seeds are germinated within 5-6 days after planting. Seedling is transplanting at 60 Days after planting when they are attaining a 6-7 leaf stage.

**Planting**

Planting is generally done at the beginning of monsoon maintain at a spacing of 40x40 cm, 40x30 cm, 40x60 cm [5] which is depends on soil fertility and Intercultural implements. Slips are planted on ridge and furrow beds at 15 cm deep. Generally, 2 -3 slips are recommended for one hole. Deep planting enhances root rot disease during the rainy season.

**Nutrient Management**

The fertilizers and nutrients should be applied in the field after knowing soil fertility status or soil testing. Generally, Farm Yard Manure can be mixed at the time of final land preparation at the rate of 8-10 MT/Ha. The recommended dose of fertilizer is 30 kg of each nitrogen, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O per ha as a basal dose and remaining 60-90 kg nitrogen [5] can be mixed as a top dressing in 3-4 split doses during the growing season has beneficial for proper growth and development. It is also recommended that spent lemongrass compost and Wood ash is obtained as a by-product of Grass distillation and applied at the time of final bed preparation [15]. Pest and disease do not generally occur on the lemongrass field but, some micronutrients like copper, iron, calcium and sulphur has been shown beneficial effect [5]. CIMAP, Lucknow was reported that a combination of Boron @ 2.5 ppm and Chloride Salts has been beneficial for lemongrass [12]. Citral production can be increased by the application of optimum fertilizer dose [16] and deduces with an excess dose of fertilizer [1].

**Water Management**

Irrigation is an important part of the cultivation of lemongrass. A supplementary application of irrigation is optimum for improved variety and frequent irrigation is requiring for newly bred grass. In the case of drought-prone areas, irrigation can be applied at an alternative day about a month. In general, 4 to 6 irrigations are required for optimum growth in February to June under North Indian conditions. In a rainfed condition, irrigation is supplied at 3 days intervals for the first month and 7-8 days interval on the subsequent month [17]. Irrigation can be supplied as a requirement by the plant depending on water holding capacity after establishment of plant

**Intercultural Operation**

Lemongrass is suitable as an intercropping crop in the orchards of fruit crops or plantation crops for utilization of land during the first 4 to 5 years before the establishment of main crops. Lemongrass cannot be suitable for shady areas as diffused light can reduce the oil yield [18]. Plants are suitable in the cinnamon plantation as compared to the coconut



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field as recommended by AMPRS, Odakkali. Distillation waste of the crop can be applied as an organic mulch @3 tonnes/ ha.

**Weed Management**

Weed management is an important operation for reducing crop-weed competition for the initial 3-4 months. After the establishment of a crop, it can able to compete with weed. Generally, 2-3 weeding are requiring in each after harvesting or 25 -30 days after planting. Hoeing is also done immediately after weeding. Weeding can be done with the help of tractor or hand weeding or by application of herbicides. Diuron @ 1.5 kg a.i. /ha and oxyfluorfen at 1.5 kg a.i./ha is effecting to control the weed in the field of lemongrass [15]. In rainfed condition, dried grasses are burnt on the field which is beneficial for controlling termites and also help to rejuvenation of old clumps.

**Pests and their Management**

This plant is not severely attracted by pests but, few pests are reported. Stem boring caterpillars are caused by *Chilotrea* sp. They are mainly feeds on a stem and causing drying up of leaf followed by whole plants. It can be controlled by spraying of Malathion @ 0.2%. Some plants are infected by nematode which is caused by *Tylenchorhynchus vulgaris*, *Rotylenchulus reniformis*, *Helicotylenchus* spp. and *Pratylenchus* spp.

**Diseases and their Management**

Red leaf Spot is one of the most important diseases which is caused by *Colletotrichum graminicola*. At first, a brown spot with concentric rings appear on the lower leaf surface. Then these spots are gradually increased and form big patches on leaf followed by drying of a leaf. This can be controlled by two spraying of Bavistin 0.1% at 20 days interval or spaying of Dithane M-45 (0.2%) at 10-12 days interval. Leaf bight also appears on the leaf margin or tip of the leaf. Older leaf is more susceptible than younger. Very small reddish-brown circular spots are appeared at the initial stage, later on, merge and causing premature drying of leaves. It can be controlled by spraying of Dithane Z-78 (0.2%) or 0.3% Copper oxychloride at an interval of 15 days. Little leaf or Grassy shoot is caused by *Balansia sclerotic*. The symptoms of this disease are stunting growth and little leaf formation instead of normal inflorescence. It can be controlled by foliar application of Dithane Z-78 (0.3%) just before the flowering stage at an interval of 10-12 days. It can also be controlled by planting healthy seedling and crop rotation.

**Harvesting**

Harvesting starts in May and continues to the end of January. Generally, lemongrass is cut by a sickle at a height of 10 cm above from the ground level and allowed to wilt in the field. Sunny days are preferable, as cloudy and misty conditions tend to deduce oil yield. Harvesting is also depending on some factors like temperature, rainfall, humidity and soil fertility level. Lemongrass is grown well under humid conditions [19]. First harvesting is done at 90 days after planting and subsequent harvest is done at 50-55 days interval up to consecutive 5-6 years [20]. Subramanyam and Gajanana (2001) [21] reported that three harvesting is done in the first year and 5-6 cuttings per year are recommended for the second year onward. On average, 25-30 tons of fresh herbage is obtained from 4-6 cuttings per year from one hectare of land, resulting in around 80 kg of oil. Under irrigated condition, improved variety can yield about 100-150 kg/ha of oil. Oil yields in the first year are lower but in the second year they increase and in the third year they reach a maximum; after this, yield declines. On average, the fresh herb contains 0.3-0.4 percent oil and thick stems are removed before distillation because these are oil-free.

**Postharvest Technology****Drying**

The essentials oils are found in different oil glands, oil sacks and glandular hairs of the plant. It can be lost through oxidation and resinification, therefore it must be store in a dry atmosphere before distillation. Plants are allowed to dry up to 30% moisture level for better oil yield. Plants are chopped into small pieces and immediately send to the distillation process to avoid oil loss. Small pieces of plants are dipped into 1 to 2 % sodium chloride solution for 24



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hours before distillation to maintaining the citral percentage. The recovery of oil from the grass ranges from 0.5 - 0.8 percent.

**Distillation**

Dried small pieces are inserted in the boiler made by stainless steel for steam distillation for around 3-4 hours at a vapor pressure of 18-32 kg / cm<sup>2</sup>. After completion of the process, it can produce yellow colour oil having 75-85% citral and other aroma compounds.

**Purification of Oil**

Other aroma compounds are removed by filtration methods. Oil is mixed with anhydrous sodium sulphate and kept in a dark room for 4-5 hours. Sometimes oil colour has changed due to rust then it should be overcome by the steam rectification process.

**Storage and Packing of Oil**

The better quality oil can be stored in a glass container in a dark condition. Sometimes, oil can also be stored in a stainless steel or aluminum or galvanized iron with a properly sealed and kept in a dark room.

**CONCLUSION**

Considering the above point it should be concluded that Lemongrass is utilized for various purposes like Aromatherapy, Flavoring industry, confectionary, preparation of perfume etc. Besides, it has many medicinal values and use against digestive disorders, diabetes, nervous disorder, inflammation, fever [10] etc. But, it is not so popularly cultivated in India as commercial. The purpose of this paper is to provide knowledge about Lemongrass cultivation and encourage cultivating this plant for more utilizing its phytochemicals in various treatments.

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## Sustainability of Cotton Farming Needs Attention

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### ABSTRACT

Cotton cultivation provides livelihood security to millions of marginal and small farmers. The cotton enterprise is knowledge based and market driven. It evolved through innovations to better yields for meeting present and future national needs and attaining global competitiveness. Cotton yields in India are low due to various reasons such as inadequate inputs, rainfed cultivation, untimely field operations, and inefficient crop production practices. In India, 65% of the cotton acreage is dependent on rain. The annual variation in monsoon rainfall has an important role in cotton production in any particular year. Cotton is one of the profitable non-food crops in the world. Cotton production provides income for more than 250 million people worldwide and employs nearly 7% of all labour in developing countries. Half of all textiles are made of cotton. Although the global reach of cotton is wide, the current cotton production methods are environmentally unstable. This undermines the industry's ability to maintain future production. Developing cotton production technologies with even minimally acceptable environmental standards is a challenging task.

**Keywords:** livelihood, global competitiveness, income. Environmental standards

### INTRODUCTION

About 30% of all fibre used in textiles is contributed by cotton. Throughout the world around 30 million hectares, which is more than 2% of total arable land, are planted with cotton and 25 million metric tons of cotton is produced

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annually. It is grown in over 80 countries. Cotton supports the livelihood of 350 million people including 50 to 100 million farmers[1]. Maintenance of soil moisture levels in cotton fields is very challenging. It could bring pest attacks and diseases. Drip irrigation to maintain adequate moisture level is the best solution. Cotton farming that is mainly dependent on flood irrigation faces challenges with flowering, ball development, and ball opening. For good crop establishment and growth, high seed germination percentage and balanced nutrition are essential. To ensure this in cotton cultivation, precise irrigation is required [2]. The most common problems of unsustainable cotton growing systems include water quantity and quality issues, inappropriate and excessive use of pesticides and fertilizers, low incomes of small holder farmers, forced labour and child labour, soil erosion, adapting to land use pressure of the future, price volatility of an uncertain commodity market [1]. Cotton cultivation needs to be knowledge based, market driven and should meet the present and future needs of nations by accomplishing global competitiveness, as it is providing livelihood security to millions of marginal and small farmers[3].

## Precision Irrigation Requirement for Cotton [2]

### (1) Lower humidity for improved quality

Water should be supplied to the cotton crop root and not to the canopy. This ensures that humidity levels are unaffected. The lint quality is better when the humidity is lower.

### (2) Cultivating the right cotton plant

The application of measured water dosage in precision irrigation helps to control and create flexibility to develop mild stress during specific growth periods. This help for cultivating an ideal plant with several bolls.

### (3) More yield with less water

Drip irrigation can result in a 20% increment in the cotton yield per cubic meter of water despite diverse agro-ecological conditions and without affecting the lint quality.

(4) Fusarium wilt and Verticillium wilt are the major soil borne diseases affecting cotton cultivation. Precise fertilizer application along with fungicides prevents these diseases.

### (5) Managing EC and pH of irrigation water

Cotton plants respond well to optimum EC and pH of irrigation water. These factors help for increasing the yield through precision irrigation.

## Climatic Factors Affecting Crop Production

Sustainability of cotton production requires more precise water, mineral nutrition, and plant growth management. Fruiting of cotton plant is influenced by cultivars, climatic conditions, management practices, and pests. The effects of evaporation, sunshine duration, humidity, surface soil temperature, and maximum air temperature affect flowering and boll production of cotton. Applying specific cultural practices that minimize the deleterious effects of these factors leads to an improvement in cotton yield [4]. There were negative correlations of flower and boll production with evaporation and sunshine duration while correlations with minimum humidity were positive [5]. Climate change is one of the most important issues in the world. Increased number and severity of days with very high temperatures during the cotton season would have negative effects on cotton growth and development. These kind of events will reduce yields by decreasing daily photosynthesis, raising respiration at night, consuming stored assimilates leading to increase in squares and boll shedding and reducing seed numbers per boll [6].

Temperature is one of the most important climatic factors that affect cotton yield. The primary impact of heat stress in cotton results in reduction in fruit retention which can reduce overall lint yield, delay crop maturity, and reduce



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lint quality [7]. Depending on cotton variety and environment, the effects of heat stress on cotton could be different [8]. At high temperatures, nutritional and water shortages were responsible for fruit loss [9] & [10]. Temperature played a role in fruit development. When the day and night temperatures were 30 C and 20 C respectively, maximum boll growth rates were observed [11]. Light duration is the key meteorological factor influencing the wheat cotton cropping pattern and position of the bolls, but temperature had an important function on upper node (7 to 9) and top (node 10) bolls, especially for double cropping patterns with early maturing varieties [12].

The farmers in India are unable to manage scientific transportation and storing facilities. Immediately after harvest they take cotton produce to the nearby market in open vehicles that leads to deterioration with dirt and dust. Manual picking leads to contamination of the cotton fiber with other trash materials. Cotton requires covered handling to protect from contamination. This is not available due to inadequate infrastructure at farms, markets, and ginning factories [13]. The enhanced production levels of cotton can only be maintained by the best package of practices and best management services. The main requirements are sustainable disease resistant, adverse weather tolerant, and high yielding varieties. At the picking time, transportation, storage, and handling cotton must be protected from contamination. By upgrading technology, it can be achieved. Due to small size on holdings in the country, the marketable surplus of the farmer is very less and it is uneconomical to use the required technology. Self help groups should be established with common mechanization processes to handle these activities in a scientific manner [13].

### **Risks of Cotton Farming [14].**

(1) In cotton cultivation, the prominent environmental impacts result from the use of agrochemicals mainly pesticides, consumption of water, and the change of habitat to agricultural use. The major impacts of diversion of water and its pollution are on major ecosystems such as the Aral Sea in Central Asia, the Indus Delta in Pakistan, and Murray Darling river in Australia.

(2) Due to cotton cultivation soil quality is degraded. Due to cotton production the soil is depleted in many areas although the global area is constant for the past 70 years. On well established fields cotton is grown, but due to exhaustion it leads to expansion into new areas and destruction of habitat.

(3) During conventional cultivation practices of cotton, the applications of substantial amounts of fertilizers and pesticides are involved. There is deterioration in the quality of soil and the health of biodiversity. Due to heavy use of pesticides, the health of farm workers and nearby populations is affected. The rivers, lakes, and underground aquifers are affected by runoff from the pesticides, fertilizers and minerals. So biodiversity is directly affected by immediate toxicity. These are affected indirectly through long term accumulation.

(4) Cotton uses more water compared to other agricultural commodities. Cotton production and processing requires large amounts of water. The surface and ground water are diverted many times to irrigate cotton fields. It leads to fresh water loss through evaporation and inefficient water management.

### **CONCLUSION**

Cotton yields are low in India due to inadequate input usage, rainfed cultivation, untimely operations on field and inefficient crop production technologies. Monsoon Rain plays an important role in India for production and yield in any particular year [15]. Cotton production provides income for more than 250 million people worldwide and employs nearly 7% of all labour in developing countries. Half of all textiles are made of cotton. Due to environmental instability in cotton production, it becomes a difficult task to achieve the target with minimum natural hazards [14]. Some quick primers on cotton are hard to pick, heavy use of pesticides and minerals, hard to control insect pests and diseases, hard to separate lint from seed, hard to control weeds, and difficult to grow





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without adequate water [16]. There is focus on the cropping systems approach in the Cotton Development Programme of the Department of Agriculture, Cooperation and Farmers Welfare in 15 major cotton growing states. The emphasis from 2014-15 was on increasing production and productivity. The thrust was on transfer of technology to cotton growers through front line demonstrations, The scheme is being implemented by State Department of Agriculture and Indian Council of Agricultural Research from 2015-16 [17].

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## Role of Communication for Improving the Mental Health of Farmers

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### ABSTRACT

In the present day society, farmers are facing multiple challenges, isolation, fatigue, and stress. They are experiencing serious mental health problems and are unable to confide in others and express their feelings. Some of the external factors are beyond the control of the farmers such as weather and commodity market prices. Prolonged droughts and extreme temperatures cause significant damage to crop yields. These add to the debt burden of farmers. Stress, mental health issues, and suicides are found more among people who work in agriculture than other occupations. Farmers are not able to manage stress due to uncertainty of economic and environmental conditions. Behavioral health is very much important for managing stress. Behavioral well being is important for increasing capacity building of the farmers. It can help for staying healthy and function efficiently. Social support systems can be helpful. Staying positive and communicating with trusted friends, relatives, fellow community members, and counselors is necessary and by these activities stress can be mitigated.

**Keywords:** Mental Health, Farmers, Stress, isolation.

### INTRODUCTION

Good communication skills are required for success in today's multiple generation farms. Communication breakdown is one of main reasons for farm families and that is the reason they have to seek help [1]. Farm life has its own set of challenges. Isolation, fatigue, and stress and there are some other factors that can lead to mental health

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problems [2]. Farm industry is now predominately male dominated. Mental health issues are not gender biased and traditionally men have been taught to put down their feelings and not to express their problems [3]. Destruction led by climate change is one of the world's leading health crises. Although it affects physical health, the effects on mental health are many times ignored. Extreme heat is directly associated with sleep loss, increased aggression and domestic violence. Heat strokes can lead to dementia, agitation, and confusion. These can be fatal. Changing weather patterns have impacted Agriculture by changing weather patterns.. Prolonged droughts and extreme heat cause significant damage to crop yields. In India more than 50% people are engaged in agriculture. Farmers face consecutive years of crop losses and worsening debt burden [4].

**Challenges Faced by Farmers**

Farmers want to get information from their innermost circle directly as per a recent research.. Limited mental health care facilities are available in rural areas. So it is difficult for farmers to manage stress arising from uncertainties of economic and environmental conditions [5]. External factors are responsible like weather and commodity market prices and are beyond the farmers' control. Financial difficulties and decreased market prices result in stress experienced by farm families. Open communication is required in farm operations in case of difficulties. Increased tension and worries may occur when information is not shared among family members and employees. Farm employees may be worried by losing the job. They can come through the difficult times if they maintain open communication and seeking social support [6]. Communication gives emphasis on agriculture related details among agricultural partners and between agricultural and non-agricultural partners. Agriculture includes farming, rural issues and natural resources [7]. Canadian Mental Health Association (CMHA), Ontario Division, and local CMHA branches say that mental health in agriculture industry is a rising concern. As compared to the general population, suicides due to stress and mental health issues are much higher among people who work in agriculture industry than in other occupations. Due to pressure and time constraints farmers put their work ahead of their well being [8].

Farmers face many challenges such as deviant weather, long hours, low commodity prices, self doubt and physical labour. Johnson [9] stated that farming is one of the dangerous occupations. Injuries can prevent farmers from completing their work in time. These can lead to depression. Occupational injuries lead to a seven times greater risk of depression in agriculture [9]. She reported that farmers face obstacles like accessibility to professional treatment and acceptance in their community who have mental health issues. She also added that many rural areas face shortage of mental health providers. Mental health problems are stigmatized in some small towns. Farmers and ranchers are facing many stressors in their lives. Many Nebraskans have experienced weather challenges and disasters that led to crop and livestock production losses. This has led to increased debt loads, machinery breakdowns, unstable markets, sleep deprivation, and changed regulations of multiple generations farm holdings. Farmers know the importance of planning and talk about their financial health to bankers and spouses. They do not realize how important it is to spend time on their mental well being [10]. Mental health affects the overall well-being as reported by Johnson [9] in a webinar on farm stress and mental health that was sponsored by Farm Credit Knowledge Center. Johnson told that the most common mental health disorders are anxiety and depression. The farmers faced some of the common stressors in U.S. These are financial pressures, debt load, unpredictable weather, unstable markets, extreme outdoor work conditions, fatigue, lack of personal time and time to talk through difficult problems, inter-generational differences and views of work and business philosophy, and excessive workloads that prevent their ability to maintain valuable relationships, health disorders, and disabilities connected to years of physical labour [11].





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## **Remedial Measures**

Effective communication should be expected, maintained, routine, and rewarding. The communication barriers can be removed. Calmness in all situations should be maintained. By removing misconceptions about communication, the farm conditions can be improved [12]. Several tips are there on establishing effective operation meetings like establishing fundamental rules, including everyone connected, establishing regular meetings schedule, developing an agenda, alternating who leads the meetings, documenting minutes of the meetings, establishing decision making process, integrating fun into the meetings, providing a summaries of the meetings, and ending on a positive note [13].

With the abundance of multiple factors, farmers are getting limited platforms to connect with fellow farmers on a peer-to-peer level. Social outlets and local relationships are necessary for increasing the development of natural support systems. Natural support systems may come in different forms. It is necessary to connect with fellow farmers and the opportunity may come over coffee at a local elevator, weekly breakfast, and regular shop talk meetings. Staying connected with peers will develop local relationships. It can promote the development of natural support systems that create resiliency during difficult times [14]. The farming population experiences a high rate of anxiety and depression. So it is necessary to examine farm families' behavioral health, mainly during stressful times. A sociologist Michael R. Rosmann presented his professional knowledge on the matters of behavioral health. He said why suicide is unusually common among farmers in an AgriSafe webinar [15]. Key to healthy farming and ranching is behavioral well-being as studied by Rosmann. Behavioral health is extremely important for the farmers. To increase the capacity to function well and healthy, behavioral well being is important for agricultural producers. In the food chain, farmers are the most important asset. People can improve if farmers are healthier. The behavioral health of farmers has a positive correlation with their productiveness [15].

The active process of being aware of living a healthy and fulfilling life is well being. Well being is very essential in life. For being physically healthy, one can develop habits that can improve mental wellness. Mental well being and physical health are linked to each other. These kinds of skills should be developed and repeated in a balanced way. Rural communities and farmers are facing difficulty due to isolation or challenges in getting mental health providers and health care. The many uncertainties of farming can lead to added stress and financial difficulties. The five steps that help to become both physically and mentally healthy are doing regular exercises, good sleep, proper nutrition, community and relationships, and relaxation and recreation [16].

## **Positive Coping Strategies to Help Oneself or a Loved One Overcome a Traumatic Event [17].**

### **ACKNOWLEDGE FEELINGS**

Some emotional reactions and stress will happen around the anniversary of an event. One should acknowledge the feelings and allow oneself one to feel anger or sadness to relieve some of the stress.

### **Engaging in healthy ways to cope with stress**

Engaging in different activities can be different for every person. Some engage themselves in exercise such as running, taking a walk or doing yoga for coping with feelings, stress and emotions. Some people get involved in reading or writing a journal or being involved in a creative hobby that helps in relieving stress and provides a direction of healing.

### **Be gentle with Oneself**

Practicing sympathy is necessary. The same kindness and patience can be shown to oneself whatever one is showing to others. One should take time to celebrate his strength.



**Accepting kindness and help from others**

Allowing the people in one's life so that they can show their care and concern will help a lot. Inviting them for a cup of coffee or dinner for getting together will help for getting support and console. It is essential to get support from others for getting healing and recovery.

**Use social support system**

Depending on one's social support system can be useful. It is a positive way to talk with trusted friends, family or members of one's faith community. In the healing process expressing one's gratitude for support and assistance throughout the year is helpful.

**Help others**

A positive and healthy way to heal is volunteering. Finding time for helping the community by volunteering in some useful works. By donating one can provide a sense of satisfaction.

**CONCLUSION**

Indian agriculture is facing many problems. Farmers are greatly affected by these problems. Farmers consume lot of time and put efforts in farming practices and other activities of agriculture. People are storing grains and food throughout the year. They rarely think about the hard work and dedication of farmers. To contribute to the overall growth in the sector of agriculture, food crops are cultivated. The problems faced by farmers are unnoticed [18]. Depression in farmers and farming families is complex. It has its origin in stress. This includes economic, family, and traumatic stress. Agrichemical and pesticide stress contributes to higher than average level of depression [19]. Helping others, social support system, being connected with others, regular exercise, friendly and flexibility of approach can help coping with the farm stress.

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## Power Quality Fault Detection and Classification Using Moving Sum Average Filter and Relevance Vector Machine

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### ABSTRACT

A The signal processing transforms such as S-Transform, Wavelet Transform are utilized for time frequency localization and feature extraction from non-stationary signals such as power quality signals, Electro cardiogram signals etc. due to the complex calculations involved in the S-Transform, a novel moving sum average filter for the detection and localization of power signal disturbances is proposed. The proposed moving sum average filter averages the number of input samples on a recursive manner and detects variations in the power quality signals. The moving sun average filter has been utilized to detect the fault locations in the power signals and utilized for feature extraction from the power quality signals. Further, the extracted features are inputted to a relevance vector machine (RVM) classifier for the classification of power disturbance signals. RVM is a machine learning method which represents a Bayesian extension of the Support Vector Machine (SVM). The result analysis shows the effective classification of power quality events and comparison results utilizing SVM and RVM are presented.

**Keywords:** Relevance Vector Machine (RVM), Non Stationary Power signal, Sparse Bayesian Kernel, Support vector.





## INTRODUCTION

Power quality is accredited due to the voltage “sag, swell, impulsive, and oscillatory transients” etc. The improvement of the quality of electrical power, unfortunately rely on visual inspection by the engineers. The wavelet transform [1-7] is monitoring the physical appearance of non-stationary signals. The characteristics of wavelet transform afford detection, localization of power quality fault waveforms. The well-organized classification of power signal faults shown by NN (Neural network) based classifiers [8],[9]. Using the WT [10-12], the features are extracted and fed as input to ANN algorithms for training and achieved classification. Wang [13] presented seven categories of PQ events detection and the classification by using wavelets and probabilistic neural network. S-Transform (ST) [14-16] searches the opportunity to have good representation in terms of time-frequency illustration of a signal. The S-transform comprises extraordinary computational complexity which involves long calculation time.

To avoid the computational complexity in S-Transform, a computationally simpler MSA (“Moving Sum Average Filter”) technique has been proposed, which makes all similar samples to zero by moving sample to sample. The features have been extracted by utilizing the moving sum average filter. The Support Vector Machines (SVM) [17-20] utilized for classification of power quality patterns. Also numerous fruitful presentations of SVM have been described in the case of information retrieval, speech recognition, and face recognition, etc. However, this generalization cannot compensate for nonstationary data streams where the signal parameters may change at random. On the other hand Relevance vector machine (RVM) [21] is a well-organized classifier in the field of machine learning. The RVM is based on “Bayesian formulation” of a linear model with sparse illustration and “Gaussian distributions” [22]. RVM offers an excellent trade-off between accuracy and sparsity, and become less sensitivity in selecting the parameters. The benefits of the RVM over the SVM are established on probabilistic predictions and shown faster performance against SVM. RVM uses a “linear combination of kernel functions centered on a subset of the training data” to mark classification. The RVM produces a much sparser estimate of the Bayesian kernel than the SVM. Thus the features extracted from the Cumulative average sum filter are used with the RVM classifier to recognize the power quality event.

This paper has three subsections as follows: section-2 presents Moving sum average filter and its mathematical operation, section-3 presents RVM operation and section-4 presents binary tree, section -5 presents results and discussion and section-6 shows conclusion and reference.

## MATERIALS AND METHOD

### Proposed MSA Filter for Detection of Power Quality Fault

For the signal  $Q(k)$ , the moving average filter[18] is given by

$$q_{SUM}(l) = \sum_{i=l-n+1}^L q(i) \quad (1)$$

$$q_{sum}(L) = q_{sum}(L-1) + q(L) - q(L-n) \quad (2)$$

Where L represents the number of sample per cycle.

Taking Z-Transform of the above equation, the following equation is obtained:

$$Q_{sum}(z) = Q_{sum}(z)z^{-1} + Q(z) - Q(z)z^{-n} \quad (3)$$

Thus on simplification equation (4) is obtained as





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$$\frac{Q_{sum}(z)}{Q(z)} = \left[ \frac{1-z^{-n}}{1-z^{-1}} \right] \tag{4}$$

Considering  $z = e^{j\omega}$

$$H(e^{j\omega}) = \frac{1-e^{-j\omega n}}{1-e^{-j\omega}} = \frac{1-e^{-j\omega n/2} \cdot e^{-j\omega n/2}}{1-e^{-j\omega/2} \cdot e^{-j\omega/2}} = \frac{e^{-j\omega n/2} [e^{j\omega n/2} - e^{-j\omega n/2}]}{e^{-j\omega/2} [e^{j\omega/2} - e^{-j\omega/2}]} \tag{5}$$

Dividing numerator and denominator by  $2j$  we get the modified equation as

$$H(e^{j\omega}) = \frac{e^{-j\omega n/2} \left[ \frac{e^{j\omega n/2} - e^{-j\omega n/2}}{2j} \right]}{e^{-j\omega/2} \left[ \frac{e^{j\omega/2} - e^{-j\omega/2}}{2j} \right]} = ne^{-j\omega(N-1)/2} \cdot \left[ \frac{\sin(\omega n / 2)}{\omega n / 2} \cdot \frac{\sin(\omega / 2)}{\omega / 2} \right] \tag{6}$$

On further simplification the amplitude response is obtained as

$$H(e^{j\omega}) = ne^{-j\omega(n-1)/2} \left[ \frac{\sin c(\omega n / 2)}{\sin c(\omega / 2)} \right] = ne^{-j\omega(n-1)/2} \cdot a \sin c_n(\omega) \tag{7}$$

Where  $a \sin c_n(\omega) \equiv \left[ \frac{\sin(\omega n / 2)}{n \cdot \sin(\omega / 2)} \right]$

For  $N \geq 1$ , and  $\omega = 0$ ,  $H(e^{j\omega}) = 1$ , and the phase response is given by

$$\phi(\omega) = e^{-j\omega(n-1)/2} \tag{8}$$

The right hand side of the equation (7) is termed as linear phase term and its plot is shown in Fig. 1.

As it is a low pass filter the nulls occur at  $\omega = \frac{\pi}{64}, \frac{3\pi}{64}, \frac{5\pi}{64}, \dots$

The values of occurrences of nulls are 0.04908, 0.09818, 0.1467 etc, respectively. The transfer function shows the maximum at  $\omega = 0$ . The moving sum average filter averages a number of input samples and produces single output sample.

### Model Equations for Generating Power Signal

The 50 Hz signal with a rate of 64 samples per cycle having “sampling frequency”  $f_s = (50 \times 64) = 3.2$  kHz. In case of voltage reduction (sag), twenty values have been taken between 0.3 and 0.8 per unit (normal voltage signal peak values 1.0 per unit) with dissimilar locations showing 10 types of sag and Nine classes of disturbances are taken and over-all 1800 signals are generated. Table-1 describes the mathematical formulas for generating synthetic power signal disturbances needed for the evaluation of the new approach presented in this paper.





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**Feature Extraction**

From Figs. 1 to 9, it is evident that the MSA filter focusses the concerned power signal event which can be used to extract the relevant features. Statistical feature values for different types of power disturbance signals are shown in Table-2. All the features calculated are normalized between zero and one for better stability. Normalization is made by dividing the individual feature and maximum of that feature set.

$$Std = \sqrt{\frac{1}{K-1} \sum_{i=1}^K (v_{sum}(k) - \overline{v_{sum}}(k))^2} \tag{9}$$

$$Variance \ \sigma = \frac{1}{K-1} \sum_{i=1}^K (v_{sum}(k) - \overline{v_{sum}}(k))^2 \tag{10}$$

$$E_i = \sum_{k=0}^{K-1} (v_{sum}(K))^2 \tag{11}$$

$$S_i[f_1, f_2, \dots, f_k] = - \sum_{i=1}^K KP_i(f_n) \log_2(KP_i(f_n)) \tag{12}$$

**RVM (Relevance Vector Machines)**

In the case of SVM, the vectors  $R = \{r_n\}_{n=1}^N$  fed as input having the "target values  $T = \{t\}_{n=1}^N$ ." In SVM the parameter 'C' requires cross validation to estimate the prediction where 'C' is the parameter which is controlling the tradeoff between the margin size and amount of error  $\mathcal{E}$ . To overcome the disadvantages, we illustrate our approach with a particular algorithm the 'Relevance Vector Machine' (RVM), a model which is identical to the 'support vector machine' (SVM).

For the "training points  $X = \{x_1, x_2, \dots, x_N\}$  and target" " $t = \{t_1, t_2, \dots, t_N\}$  the RVM model" with the "sigmoid function" given by  $\sigma(u) = \frac{1}{1+e^{-u}}$

The "probability" is can be written as

$$p_b(t_i = 1, w) = [\sigma(u(r_i; w))] = \frac{1}{1+e^{-\gamma(r_i; w)}} \tag{13}$$

with "Bernoulli distribution, the likelihood" is expressed as :

$$P(t_i|w) = \prod_{i=1}^N [\sigma[u(r_i; w)]^{t_i} \{1 - \sigma[u(r_i; w)]\}^{1-t_i}] \tag{14}$$

The "zero mean Gaussian prior distribution" is given by

$$P_b(w|\alpha) = \prod_{i=0}^N N(\omega_i|0, \alpha_i^{-1}) , \text{ and}$$

$$P_b(w|\alpha) = \prod_{i=0}^N \frac{\alpha_i}{\sqrt{2\pi}} \exp(-\frac{\alpha_i \omega_i^2}{2}) \tag{15}$$





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Where  $\alpha = [\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_N]^T$ , and  $\alpha$  is a vector of "N+1 hyper parameter". With non-zero coefficients"  $\omega_i$  (relevance vectors)" will subsidize to the "decision function". The key feature of this learning method is responsible for its sparsity property.

(i) The probability  $P_b(t_i|w)$  is not a "normal distribution", and hence the approximation procedure based on Laplace's method is chosen.

Assuming  $\alpha$  the hyper parameters are known, the "probable weights"  $w_{MP}$  are found, and the data function  $p_b(w|t, \alpha) \propto P_b(t|w)p(w|\alpha)$ .

$$\begin{aligned} & \log \{P_b(t|w)p_b(w|\alpha)\} \\ &= \sum_i^N [t_i \log u_i + (1-t_i) \log(1-u_i)] - \frac{1}{2} w^T A w \end{aligned} \tag{16}$$

Where  $A = \text{diag}(\alpha_1, \alpha_2, \alpha_3, \dots, \alpha_N)$ ,  $u_i = \sigma[u(r_i; w)]$ , and equation (16) being a "regularized logistic log-likelihood function necessitates iterative maximization. Second order Newton methods is applied effectively" for this purpose as :

$$j = \nabla_w \log [P_b(t|w)p_b(w|\alpha)] = \psi^T (t - u) - A w \tag{17}$$

Where  $\psi$  is an "augmented kernel matrix" and is given by

$$\psi = \begin{bmatrix} 1 & \lambda(r_1, r_1) & \lambda(r_1, r_2) & \dots & \lambda(r_1, r_N) \\ 1 & \lambda(r_2, r_1) & \lambda(r_2, r_2) & \dots & \lambda(r_2, r_N) \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & \lambda(r_N, r_1) & \lambda(r_N, r_2) & \dots & \lambda(r_N, r_N) \end{bmatrix} \tag{18}$$

Where  $\lambda(r, r_i)$  is the RBF kernel function and 1 in the first column indicating the use of bias in the Hessian matrix.

The kernel function is given by

$$\lambda(r_i, r_j) = \exp \left( - \frac{\|r_i - r_j\|^2}{2\sigma_k^2} \right) \tag{19}$$

where  $\|r\|^2 = \frac{1}{N} \sum_{j=1}^N r_j^2$

$\Delta w = -H^{-1} j$ , and

$$w_{MP}^{new} = w_{MP} + \Delta w \tag{20}$$

Where  $H$  is the Hessian matrix.

The following quantities are defined as follows:

$u = [u_1, u_2, \dots, u_N]^T$

$$B = \text{diag}(\beta_1, \beta_2, \dots, \beta_N) \tag{21}$$





$$\beta_n = \sigma[u(r_n)]\{1 - \sigma[u(r_n)]\}$$

The algorithm progresses with repeated application of (20), updating the covariance matrix until the suitable convergence criteria have been satisfied, and after which the last prediction function is obtained as:

$$u_{\bullet}(r_{\bullet}; w_{mp}) = \psi(r_{\bullet})w_{mp} \quad (22)$$

The next section provides the method of constructing a decision tree based on the extracted features of the power signal disturbance waveforms.

### Binary Decision Tree

Decision tree is a data mining classification algorithm for pattern classification. The importance of decision tree is to represent rules [23, 24]. For the classification a decision tree shown in Fig.19. The features are extracted and grouped and the total is first divided into two sections as 2,3,4,5,6,7,8 and section-1 which refers as transient(event-1) and section-2 as (2,3,4,5,6,7,8,9) refers to the rest disturbances. Again the features (2,3,4,5,6,7,8,9) are also subdivided into another section-1 as (event-2) and section-2 as (3,4,5,6,7,8,9). Section -1 represents harmonic and (3, 4, 5, 6, 7, 8, 9) represents the rest of the signals and the procedure progresses till two groups having two types of disturbances. The power quality disturbances such as “Transient, Harmonic, Voltage Notch, Voltage Sag, Voltage Spike, Sag+ Harmonic, Voltage Swell, Swell+ Harmonic, Flicker” have been considered for classification utilizing the “decision tree” which is shown in Fig.19.

## RESULTS AND DISCUSSION

### Results from Cumulative Sum Average Filter

Figs. 1 to 9 present the output of the Cumulative sum filter for different types power signal disturbance problems like the voltage sag, swell, harmonics, transients, spikes, and notch, etc

### Classification Results Using SVM and RVM

From the feature analysis, the classification is made using different statistical features for different events. The Hessian matrix generated in RVM according to the model given by equation (14), in which the “kernel function” need not “satisfy ‘Mercer’s condition’”. During the computation it gives less numbers of relevance vectors and the decision speed is higher in comparison to SVM. The classification follows the decision tree adopted for the classifier and classifies the power quality events. It is found that the RVM uses less numbers of relevance vectors (RVS) with higher decision speed as compared to SVM. “For the classification of transient” as 1<sup>st</sup> event the statistical feature standard deviation is assigned to data set x1 and the statistical feature energy is assigned to data set x2. Now the kernel function is designed with x1 and x2 and assigned into the Hessian matrix for classification. The program for the decision boundary is defined for the input vectors to separate the power quality event transient from the total feature vector which is shown in the Fig .8, and it is found that transient has been identified with triangles below the decision boundary.

Fig -11 to Fig-18 shows “Classification” results by utilizing RVM. It is observed that for the “classification triangles are assigned to a particular class and for rest of the classes are marked with star”. Fig-10 shows the classification result of transient from the total power disturbance signals. Feature combination F1F7 is used for transient that is standard deviation and energy. Transient has been assigned with triangles and rest of the signal with star mark. From the Fig-10 it is seen that the triangles are between the amplitude 0.1 and 0.2 below the decision boundary and within the contour. For harmonic feature combination F1F4 is used and shown in Fig-11. For notch feature combination F4F7 is utilized and presented in Fig-12. Fig-13 “shows classification” of sag. Spike is shown in Fig-14. Fig-15 shows the event sag+ harmonic is within the range 0.5 and 1. The event swell is nearer to the “decision



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boundary” and in the range 0.55 and 0.65 shown in the Fig-16 with F2F6. Fig-17 shows the classification of flicker and swell+harmonic with feature combination F2F7.

## CONCLUSION

In this paper, the moving sum average filter avoids complex calculations as compared to “wavelet transform” and “S-transform filters”. The filter has been utilized for extraction of features and presented in the table-2. The extracted features are inputted to the kernel based RVM for the purpose of classification. Further the decision tree is utilized to improve the performance of classification results. RVM offers good performance in accuracy comparing to the SVM. For SVM the “support vectors” are formed near by the “borderline” and classification becomes difficult. Further, the relevance vectors are formed which is more demonstrative of the classification, and are positioned away from the decision boundary. RVM shows good decision speed and the “kernel function” does not satisfies “Mercer Condition”. The accuracy reported by RVM as 98.82 percent. This can even better in ELM (Extreme learning machine) which is our future research.

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**Table-1: Model equations used for synthetic signal generation**

PQ Disturbance	Equation
Harmonic	$Q(k) = a(\alpha_1 \cos(k\omega\Delta T) + \alpha_3 \cos(3\cos(k\omega\Delta T)) + \alpha_5 \cos(5\cos(k\omega\Delta T)))$ $0.05 \leq \alpha_1 \leq 0.15, 0.05 \leq \alpha_3 \leq 0.15, 0.05 \leq \alpha_5 \leq 0.15, \sum \alpha_i^2 = 1$
Sag and harmonic	$Q(k) = a(1 + \alpha(u(k - k_1) - u(k - k_2))) \left( \alpha_1 \cos(k\omega\Delta T) + \alpha_3 \cos(3\cos(k\omega\Delta T)) + \alpha_5 \cos(5\cos(k\omega\Delta T)) \right)$ $0.3 \leq \alpha \leq 0.8, 0.05 \leq \alpha_1 \leq 0.15, 0.05 \leq \alpha_3 \leq 0.15, 0.05 \leq \alpha_5 \leq 0.15,$ $\sum \alpha_i^2 = 1$
Swell and harmonic	$Q(k) = a(1 + \alpha(u(k - k_1) - u(k - k_2))) \left( \alpha_1 \cos(k\omega\Delta T) + \alpha_3 \cos(3\cos(k\omega\Delta T)) + \alpha_5 \cos(5\cos(k\omega\Delta T)) \right)$ $1.3 \leq \alpha \leq 1.8, 0.05 \leq \alpha_1 \leq 0.15, 0.05 \leq \alpha_3 \leq 0.15, 0.05 \leq \alpha_5 \leq 0.15,$ $\sum \alpha_i^2 = 1$



**Table-2: Feature values for different power line disturbance signals**

Features	"Flicker"	"Spie"	"Notch"	Transient	Harmonic	"Sag"	"Sag+Har"	"Swell"	"Swell+Har"
Std	0.4247	0.0518	0.0745	0.1104	0.1480	0.4414	0.5134	0.6587	0.6862
	0.4252	0.0524	0.0745	0.1156	0.1537	0.4448	0.5164	0.6626	0.6897
Variance	0.1804	0.0027	0.0055	0.0122	0.0219	0.1948	0.2636	0.4339	0.4672
	0.1808	0.0028	0.0056	0.0134	0.0236	0.1979	0.2667	0.4390	0.4723
Mean	0.0029	0.0064	-0.0054	-0.0034	-0.0053	0.0442	0.0465	0.0704	0.0823
	0.0020	0.0064	-0.0053	-0.0051	-0.0008	0.0445	0.0467	0.0707	0.0821
Max	0.8874	0.6891	0.1873	0.8850	0.9259	0.7859	0.6764	0.7802	0.7734
	0.8923	0.6975	0.1973	0.8850	0.9364	0.7899	0.6827	0.7848	0.7884
Entropy	0.9572	0.0369	0.0737	0.1833	0.6056	0.8494	0.7830	0.9184	0.7491
	0.8755	0.0219	0.0737	0.2037	0.7080	0.8494	0.7963	0.9184	0.7374
Energy	0.9857	0.6724	0.5654	0.8740	0.5449	0.6228	0.6671	0.7163	0.7408
	0.9873	0.6793	0.5689	0.8883	0.5528	0.6279	0.6715	0.7202	0.7348
Min	-0.4871	0.0000	-0.6316	-0.9867	-0.7387	-0.7047	-0.5443	-0.6850	-0.6706
	-0.4907	0.0000	-0.6380	-0.9897	-0.7500	-0.7084	-0.5505	-0.6895	-0.6749

**Table-3: Classifier performance using SVM and RVM**

Sl. No.	Powersignal	"Support vectors"	"Relevance Vectors"	Accuracyinpercentage (%)	
				"SVM"	"RVM"
1	Transient	8	2	94.56	100
2	Harmonic	19	2	91.55	97.35
3	Notch	22	2	89.32	98.4
4	Sag	12	2	86.43	99.37
5	Spike	5	2	94.89	98.47
6	Sag+Harmonic	12	2	91.05	99.44
7	Swell+Harmonic	10	2	89.98	98.46
8	Swell	20	2	92.36	99.12
	% Accuracy			<b>91.26</b>	<b>98.82</b>





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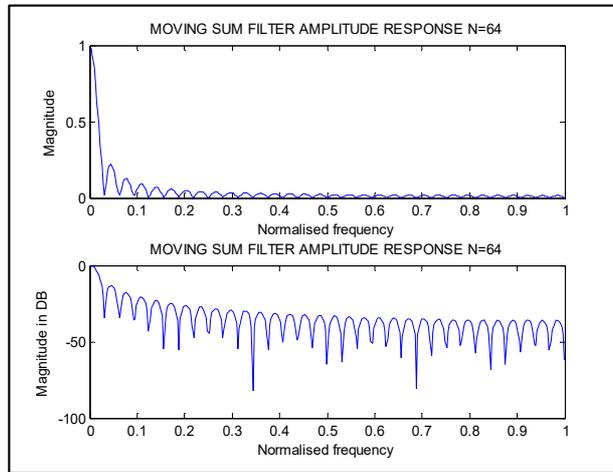


Fig. 1 MSA Filter Amplitude Response for 64 Samples.

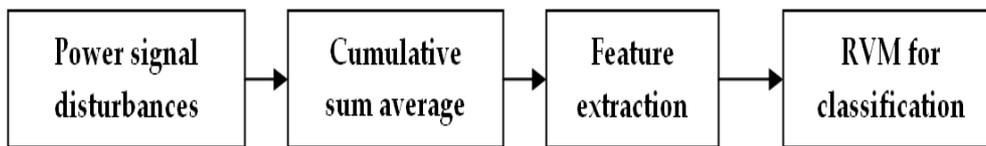


Fig.2 Block Diagram of the Research Work

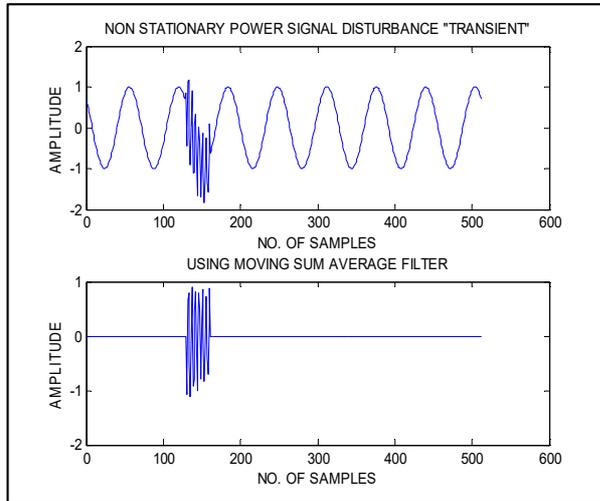


Fig. 3 Transient detection using MSA filter

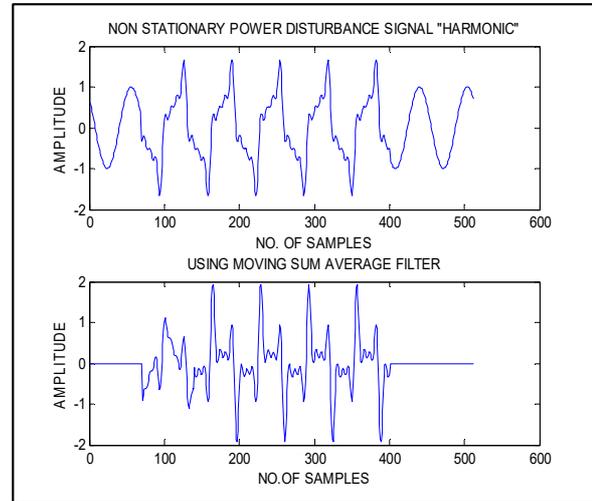


Fig. 4 Harmonic detection using MSA filter



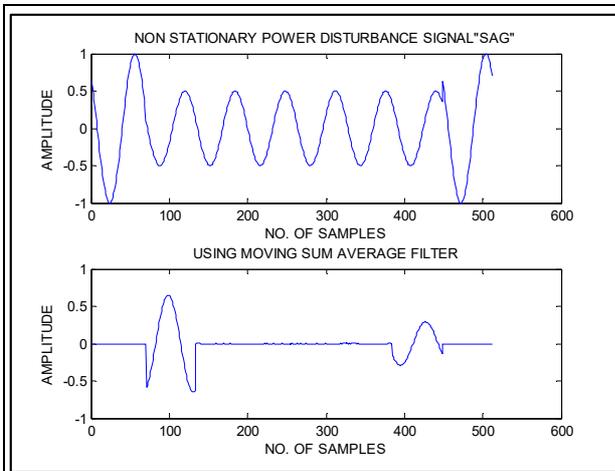


Fig. 5 Sag detection using MSA filter

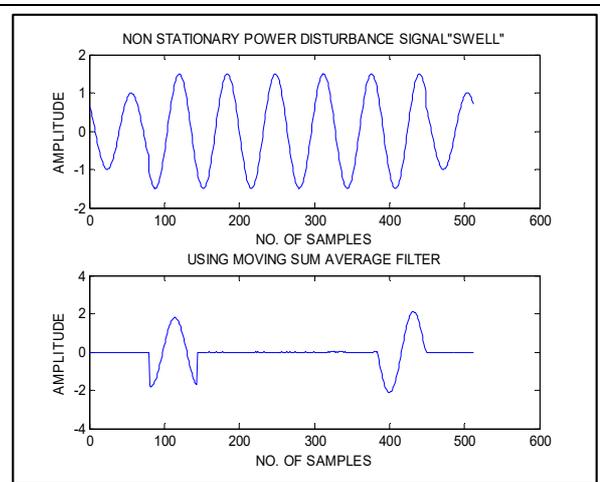


Fig. 6 Swell detection using MSA filter

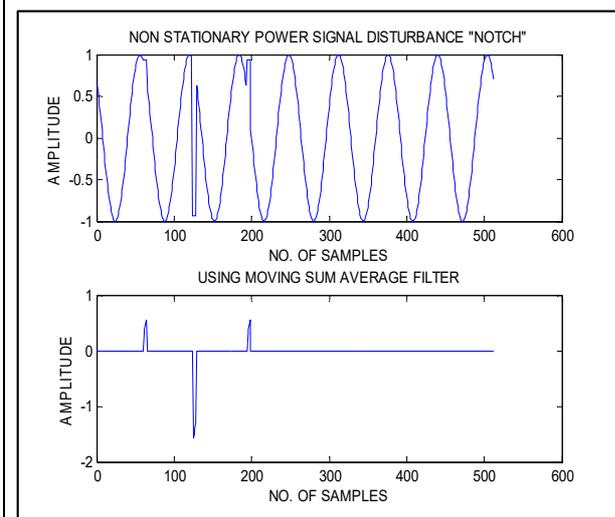


Fig. 7 Notch detection using MSA filter.

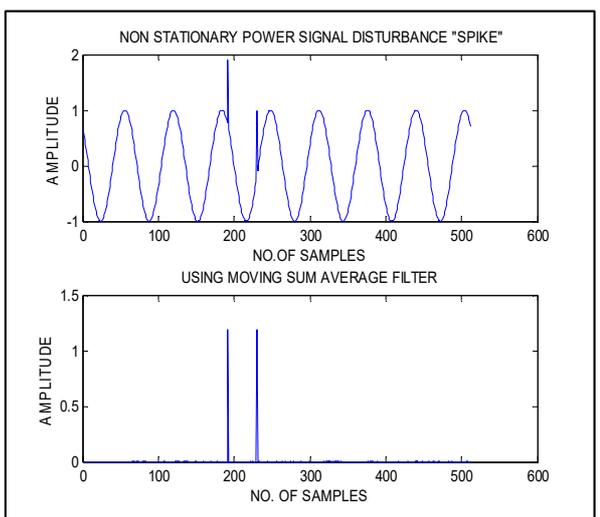


Fig. 8 Spike detection using MSA filter.





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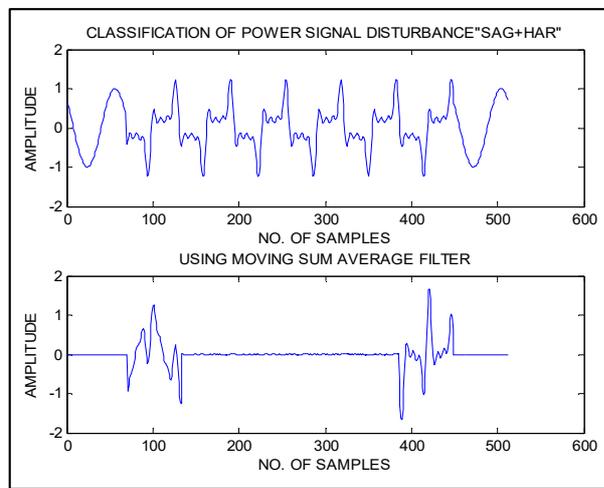


Fig. 9 Sag+ Harmonic detection using MSA filter.

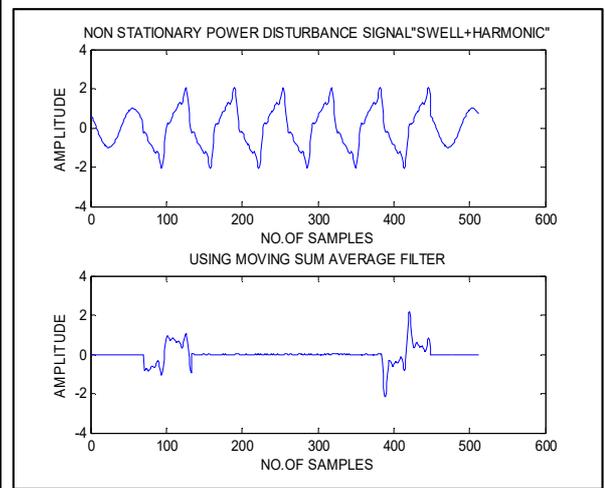


Fig. 10 Swell+ Harmonic detection using MSA filter.

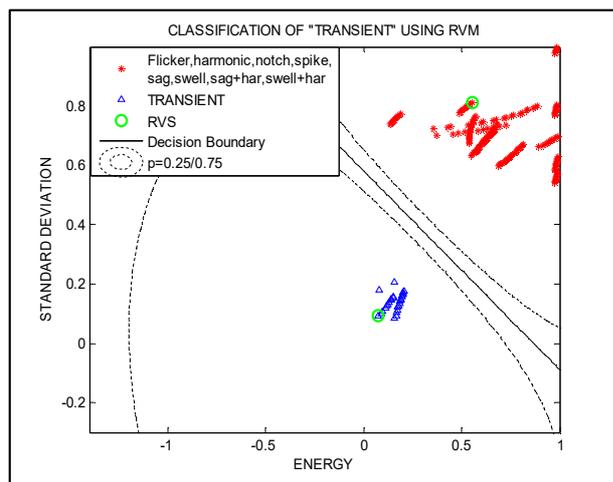


Fig. 11 Transient using RVM

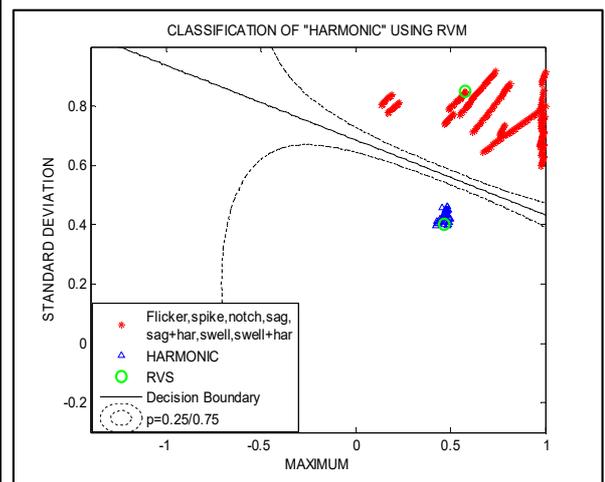


Fig. 12 Harmonics using RVM.





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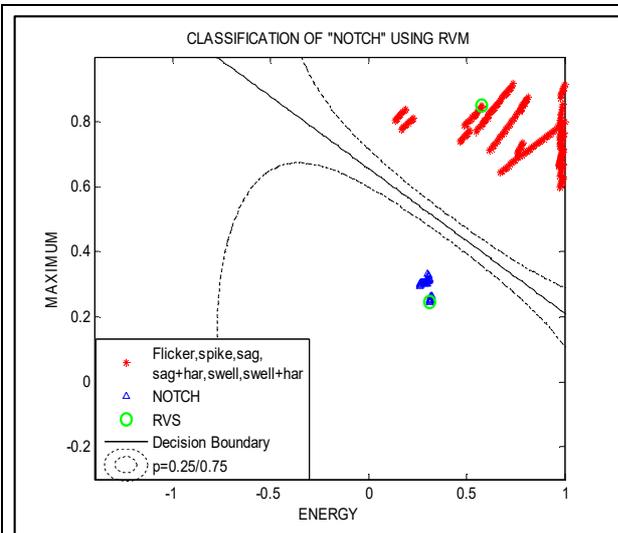


Fig.13Notch using RVM

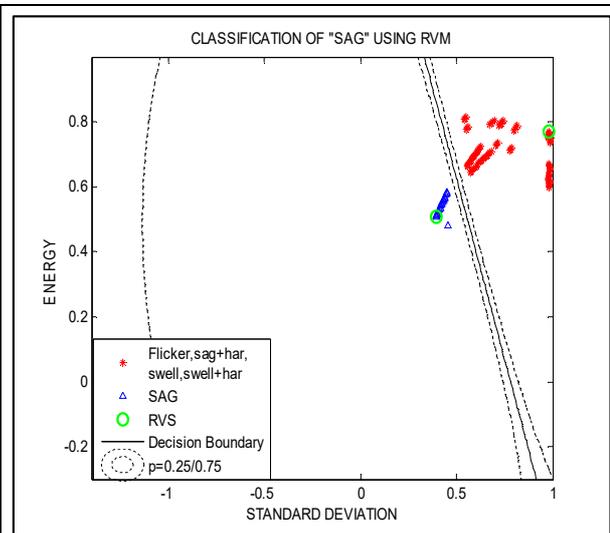


Fig.14Sag using RVM.

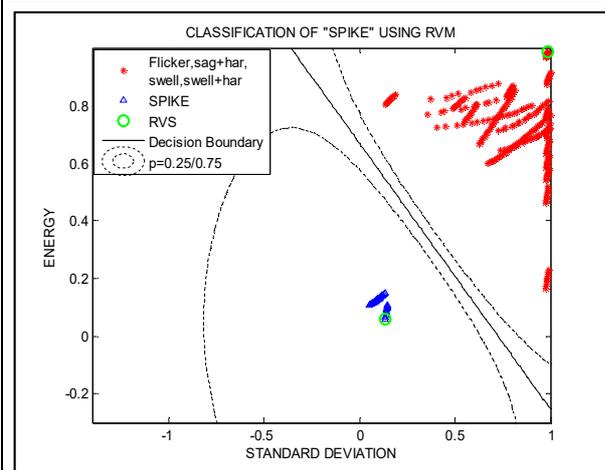


Fig.15Spike using RVM

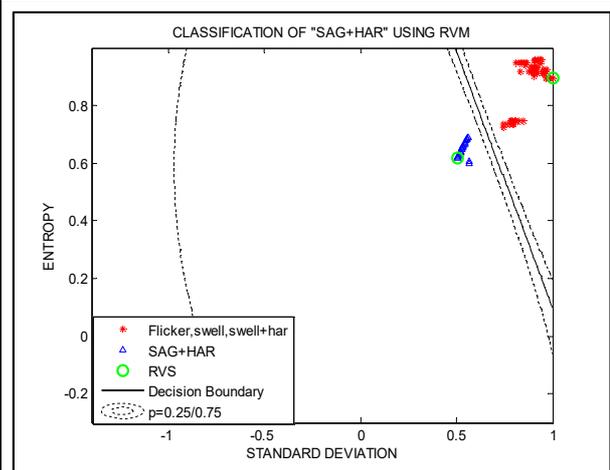


Fig.16 Sag+ Harmonic using RVM.





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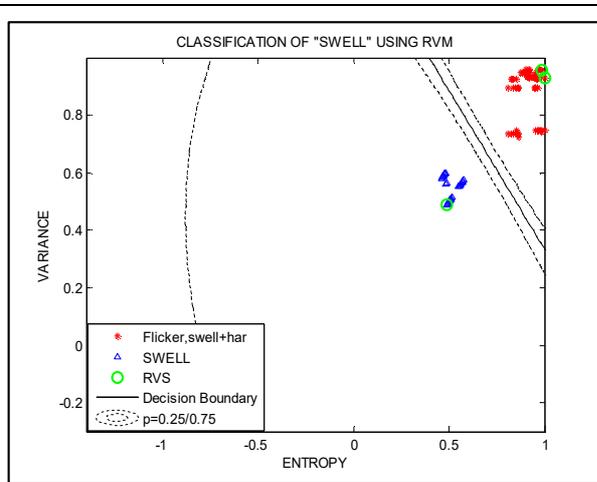


Fig.17 Swell using RVM.

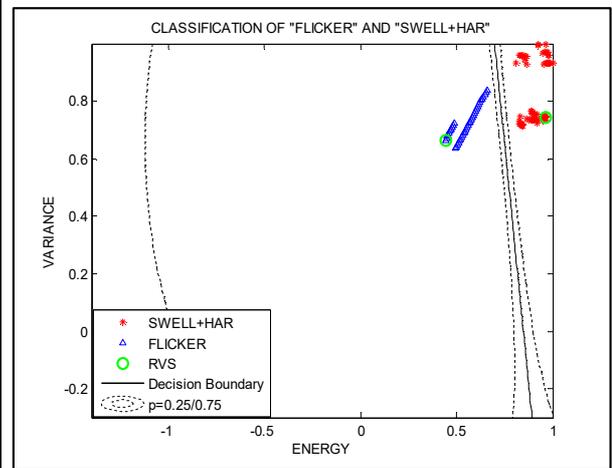


Fig.18 Flicker and Swell+ Harmonic using RVM.

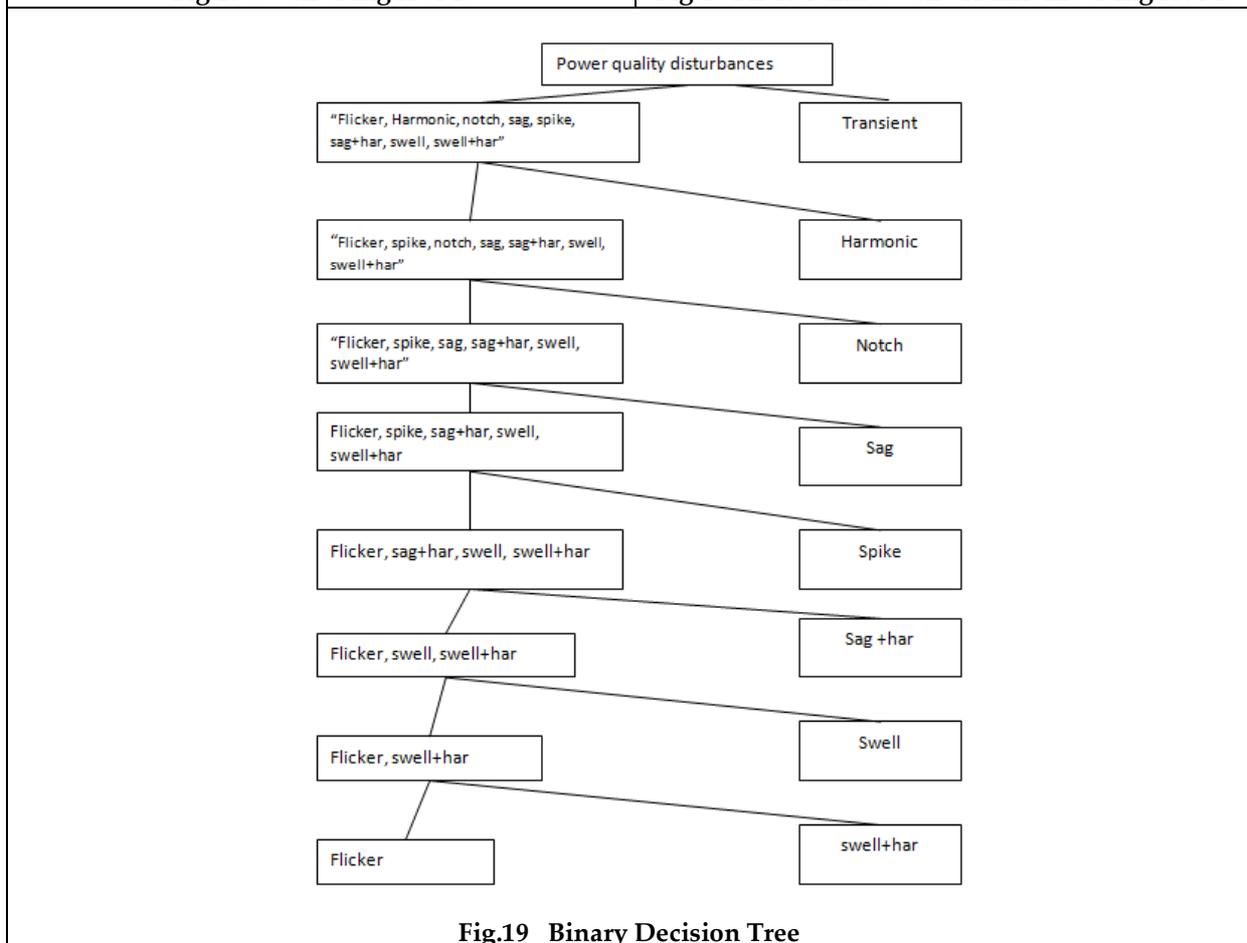


Fig.19 Binary Decision Tree





## Detection and Classification of Breast Cancer Using EnFCM based Segmentation Algorithms and LLRBFNN Machine Learning Model

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### ABSTRACT

According to the World Health Organization (WHO), breast cancer diagnosis is the main cause of cancer death among women in the world. Breast cancer occurs generally in world especially underdevelopment and developing countries. From the clinical point of view, mammography is still the most effective diagnostic technology, given the wide distribution of the use and analysis of these images. The main propose of this paper is to detect and classify mammographic injuries using the regions of attention of breast images. This research work proposes decomposing of each image using Enhanced fuzzy c means (FCM) based algorithm and classification by using local linear radial basis functional neural network (LLRBFNN). Further to enhance the performance of accuracy by controlling parameters of level set evaluation are considered from the results of fuzzy clustering. This approach will combine image and shape of surface features, which can be applied for detection and classification of breast cancer diseases. The result of this research will encourage, the best methods needed to detect different classes of breast cancer such as benign or malignant.

**Keywords:** Fuzzy c means, k-means, Radial basis function network, Multilayer neural network





## INTRODUCTION

Cancer is a leading cause of the unintentional death in the worldwide which is estimated 2.09 million deaths of people per year in 2018 G.C [1-2]. Breast cancer occurs almost entirely in women, had applied deferent technologies such as multilayer perceptron's (MLP), and probabilistic neural network [3] researched on "Wisconsin breast cancer" dataset. It is observed that the neural ensemble based detection (NED) are the most precise model for breast cancer classification [4]. "Radial basis functions (RBF)" represents substitute approach to "MLP's" in universal function approximation [5]. Early technologies use for detection of breast cancer images are: X-ray, Ultrasound, and Computer Aided Tomography (CT), magnetic resonance imaging (MRI) and mammogram that are seen one by one under background.

E. Mammography is one of the greatest current methods for finding of breast cancer. It has been recognized effectively to lessen mortality as much as by 30% [6]. Mammography has false negative rate of 10%-30%, false positive of 10%. Over 90% of breast cancer could be detected by mammography. The mammography machines is utilized to spot the cancerous tumor and eliminate it before the formation of metastases. Multiple factors affect accuracy of mammography are breast density, radiologist experience and body habitus. However, the primary signs for breast cancer challenging separated abnormalities scene due to contrast breast tissue [7]. Based on contrast breast tissue mammogram have been limited to below 40 aged women and pregnant women which can hide a tumor. There are several techniques available in the literature for the detection and classification breast cancer. However, clearly detection and classification of the breast cancer there are great challenge. Motivated by this, the development of new algorithms for local linear radial basis functional neural network method is very important for clear identification in to benign and malignant breast cancer detection. The aim of this paper is to proposed new efficient system for breast cancer classification. The remaining part of the paper is organized as follows section 2 presents related work and back ground of research work, section 3 presents the material and methods which includes the explanation of the FCM based algorithm, LLRBFNN model section 4 presents results and discussion and section -5 presents conclusion followed by reference.

### Related work

The initial pre-processing of mammogram leads to eliminate the noise, from the mammogram image [8, 9]. The filtering, segmentation, features extraction, features selection and classification are one type of transform based on shape features to increase the contrast of images into benign and malignant cases [10]. The regular features are also called as morphological shape features and provides a detail description of features in this category [11]. Accuracy scale rises the redundant data due to that the Computer-Aided-Diagnosis has been proposed for the medical diagnosis [12].

Segmenting mass regions computing texture features based on gray level co-occurrence matrix (GLCM) [13]. BPNN classifier has been trained to decrease the number of false positives executed the elimination of FP segments using shape analysis. Used LBP for on behalf of the textural properties of the masses [14]. The regions of cancer tissues are identified by filtering, DWT (enhancement), thresholding (feature extraction) and classification is done by SVM Classifier. MIAS db (75 images) is used for the purpose and achieved 88.75% accuracy [15]. The intensity features are extracted and computed to calculate volumetric values. Detection by using Gabor filter (feature extraction), histogram equalization (enhancement) by k-means clustering algorithm with MIAS db dataset provides 99% accuracy [16]. Using sequential floating forward (SFFS) as feature selection and PNN method the classification is also achieved [17]. Detection of tissues from mammographic images by utilizing wavelet neural network and classification by using particle swarm optimized neural network (PSO-WNN) with MIAS db achieved 93.67% accuracy [18-20]. The radial basis function neural network (RBFNN) [21], convolution neural network [22], "general regression neural network (GRNN)" [21], "probabilistic neural network (PNN)" [33], resilient back propagation neural network and hybrid with fuzzy logic [21]. According to [24] a supervised artificial neural





network and achieved accuracy of trained neural network to be 82.21%[25]. The accuracy of GLDM + SVM, Gabor Filter + KNN and PNN methods results 95.83%,71.83%and 92.5% respectively[25]. Szilagyi et al. [30] proposed enhanced FCM algorithm (EnFCM). The parameter  $\alpha$  (adjustable) in EnFCM improves segmentation results. This paper presents segmentation based on FCM and classification by machine learning model to show that greatness of the proposed LLRBFNN model.

## MATERIALS AND METHODS

### METHODOLOGY

Different methods were used to investigate detected and classified breast cancers. This paper proposed new method, as LLRBFNN model.

#### General Block Diagram Proposed Method

The attained system was designed based on general block-diagram of this method was followed. Breast cancer was detected and the exact point of scheme was showed by new fuzzy mean segmentation and classified as benign and malignant by local linear radial basis function neural network depending on the following steps of diagram.

#### Implementation of Research Work

The flow chart of research shown for detection and classification of breast cancer disease. In the first phase (i) the input image is segmented by EnFCM techniques, (ii) the statistical features are extracted from images (iv) The LLRBFNN has been trained by least mean square algorithm to differentiate the diseases from the healthy and non-healthy tumors. Mammogram input images identified potential abnormalities and segmented color image and regions of a contrast margin [29]. The systems use image processing correlation and de-correlation algorithms analyzed mammograms help of the histogram and scattering selected variables to plot.

#### Filtering Method

Image filtering used to translates an input image to its smoothed variety, where small intensity difference between neighboring pixels was minimizing by edge detection and removing noise. The goal edge detection and removing noise in filter techniques were smoothing image. The two filtering method linear filters and nonlinear filters are based on its scheme, in linear operations addition and constant multiplication, whereas nonlinear operations, minimum value selection used.

#### Removing Noise

Smoothing filter to minimize gray-level difference among neighboring pixels in which the resulting image becomes smooth and a median filter can remove salt-and-pepper noise. Gaussian filter used to reduce the amount of noise present in a signal at small value of the variance, wiener2 performs more smoothing value and a random, Gaussian distributed noise value, which is using Gaussian noise with a fixed variance. The adaptive mean filter used as preserved edges and other high-frequency parts of an image using a Weiner filter this noise can be reduced to very much extent.

#### Enhanced Fuzzy C Means Segmentation

Binary images are used for difference between dark regions and bright regions. Segmented colors in an automated fashion using the L\*a\*b\* color space.

The EnFCM algorithm achieved by adding up image  $\xi$  in FCM\_S [31] as:

$$\xi_k = \frac{1}{\alpha} \left( x_k + \frac{\alpha}{P_R} \sum_{j \in P_k} x_j \right) \quad (1)$$





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Where  $\xi_k$  indicate the gray value of the  $k^{\text{th}}$  pixel of the picture  $\xi$ , and the fast segmentation process is achieved with the objective function as:

$$J_p = \sum_{i=1}^c \sum_{l=1}^q \lambda_l u_{il}^m (\xi_l - v_i)^2 \tag{2}$$

where  $v_i$  represents the example of the  $i^{\text{th}}$  cluster,  $\lambda_l$  is the amount of the pixels carry the gray value equal to  $l$ , where  $l=1, \dots, q$ . obviously, we have

$$\sum_{i=1}^q \lambda_l = P \tag{3}$$

And below the constraint so as to  $\sum_{i=1}^c u_{il} = 1$  for any  $l$ , minimize  $J_s$ , correspondingly  $J_s$  to be at its limited extrema as follows

$$U_{il} = \frac{(\xi_l - v_i)^{-\frac{2}{m-1}}}{\sum_{j=1}^c (\xi_l - v_j)^{-\frac{2}{m-1}}} \tag{4}$$

EnFCM depends the factor  $\alpha$  and the filtering system. The value of  $\alpha$  has to be plays an important role in segmentation.

**Local Linear Radial Basis Function Neural Network Model**

In comparison of LLRBFN [27] considered for classification task.

Where " $x_1, x_2, \dots, x_n$ " are inputs (attributes) and " $Z_1, Z_2, \dots, Z_N$ " are the Gaussian activation function in the hidden elements.

The "Gaussian Kernel" is defined as

$$Z_n(x) = e^{\left( \frac{-\|x - v_i(n)\|^2}{2\sigma_n^2} \right)} \tag{5}$$

The "objective function is to minimize" the mean square error which can be written as

$$MSE(e) = \frac{1}{N} \sum_{n=1}^N (d_n - y_n)^2 \tag{6}$$

Where "d" is the required desired vector.

**RESULT AND DISCUSSION**

**Data Collection**

This breast cancer databases was obtained from the University Wisconsin Hospitals, Madison [27]. Dataset contained number of instances 400 (July /15/1992) ten plus the class attribute. Each instance has one of 2 possible classes: benign (245) or malignant. The arranging data were ID, nine variables measured and class attribute respectively coded. The Wisconsin breast cancer diagnose (WDBC) presents 9 variables descriptors related to the cell nucleus and modelled. Samples collected were 60 benign and 100 malignant masses from desire of mammographic image analysis Society (MIAS) database masses and calcifications [28]. The collection of dataset was not normalized for



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computer reading as binary image, color image and grayscale image. For this reason, we prepared suitable for design in required normalization dataset for recognized as essential images. Normalized dataset attributes between zero and one (0, 1) range by multiplying zero point one (0.1) by all instances of attribute except ID of patient. The last attribute class converted logical 0 or 1 to one if it's true or zero if it's false with the help of supervised learning with neural network. The classes is either benign or malignant when the output zero (0) and one (1) respectively.

**Simulation Results for Detection**

The simulation results for medical input image, filtering images, segmentation images extraction features were described separately. Output result for medical input image compared original image, true color image and grayscale image by histogram plot system. Figure 4.1 showed the original image was displayed with the RGB color values left as a subplot figure 4.1a and subplot of the same image was displayed the transformed intensity image as a heat map right figure 4.1b.

Grayscale and true color images analysis after de-correlation by histogram was observed as different shapes on the right hand histogram has greater contrast than the left histogram sides. The maximum value of the histogram count data 8000 was automatically reduced to 450, since outlier spikes do not dominate as its edge was easily detected.

**Noise Removal Results Using Filtering Method**

Output result for filtering evaluated mean filter, median filter and adaptive mean filter used grayscale image. Fig. 6 a, b showed edge detection and the rest two showed remove noise on the region of images. Figure 7 shows the removal of the noise by utilizing median filtering and adaptive filtering.

**Segmentation Results**

The segmentation results are presented in Fig. 8 to Fig. 9. It is found that the EnFCM algorithm shows good result than K-Means segmentation presented in table 2.

**Simulation Results for Classification**

The output simulation result for LLRBFNN provides reduced error was showed figure below. From figure 10 the Y axis of represents the simulation result error in number and the X axis showed the number of iteration of LLRBFNN. RMS performance of LLRBFNN is 0.0013 at iteration 500. The output results of overall designed for classification the combination of RBFNN, FFNN, and PRNN were obtained from MATLAB simulation showed figure 11 that observed LLRBFNN provides better classification performance among the others. The X axis of this graph represents the simulation number of iteration and the Y axis demonstrates the MSE in percent. The proposed LLRBFNN graph was the blue line, steadily approaching convergence at 300 iterations. Whereas graphs were the red, yellow and magenta lines, steadily approaching convergence at 350, 600 and 850 iterations respectively. The statistic of this parameters is given in the table 3.

**CONCLUSION**

The classification of breast cancer is a complex and difficult task. This research work proposes a novel LLRBFNN classification model for breast cancer classification. The images are decomposed using EnFCM segmentation. For detection of breast cancer areas, adaptive mean filter is employed to have better smooth image than median filter, as it is preserving edges and other parts of an image. In order to classify breast tumor clearly from mammogram image LLRBFNN has been applied. LLRBFNN has been proposed to increase the accuracy of breast cancer classification, as it is potential to take proper initiative in different levels of hidden layer and spread of radial basis functions implementation. Appropriate parameters selection in the neural network can be one of the ways to improve the accuracy of classification. The K-mean algorithm has also been considered for segmentation. It can support the cluster by minimizing distance of the centroids. So to overcome this barrier of other conventional algorithm,





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LLRBFNN can play an effective role by converting nonlinear to linear function. As experienced from the result, it can be seen that figure 6 and figure 7 detection of mammogram image can be seen by adaptive mean filter and mean filter to performs smoothest and segment exact tumor respectively. For classification design of LLRBFNN reduce error best among the others as observed figure 11. The future work may be done using hybrid models along with soft computing applications.

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**Table 1: Statistical features of Brain tumor image**

Parameters	Contrast	Correlation	Entropy	Homogeneity	Mean	STD
Results	0.3017	0.1718	3.01	0.9358	0.0035	0.0897
Parameters	Variance	Smoothness	Kurtosis	skewness	RMS	IDM
Results	0.008	0.9284	9.1671	0.7342	0.0898	1.2596





Table 2 Segmentation Accuracy and Computational time Evaluation

Algorithm	Accuracy in%	Computational time in sec	Accuracy in%	Computational time in sec
	Gaussian noise		Without noise	
En FCM	98.13	8.13	99.12	7.12
K-Means	97.22	9.55	98.89	8.71

Table 3: Comparison of accuracy in different methods

Previous Methods	Previous accuracy (%)	In this research work Methods	This research work of accuracy (%) consider only cross validation
K-Means clustering	99%	LLRBFNN	99.307
SVM	95.5	PRNN	99.048
KNN	71.83	FFNN	99.048
PNN	92.5	RBFNN	98.33

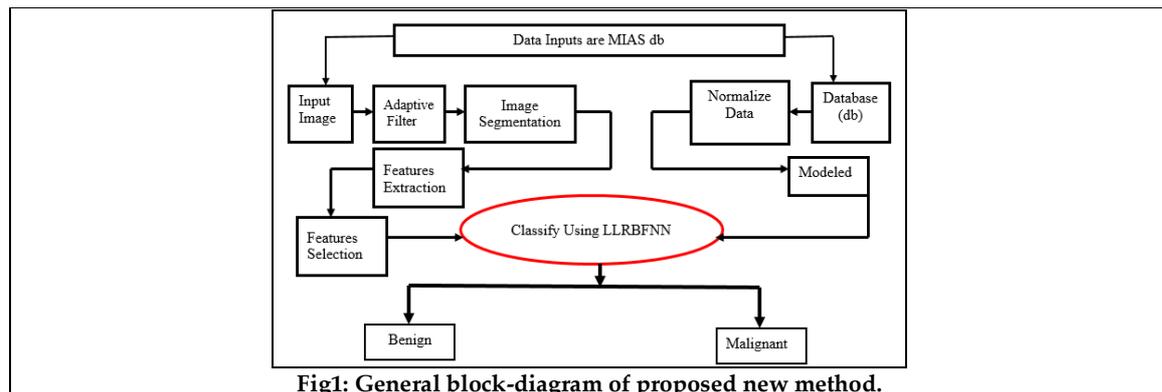


Fig1: General block-diagram of proposed new method.

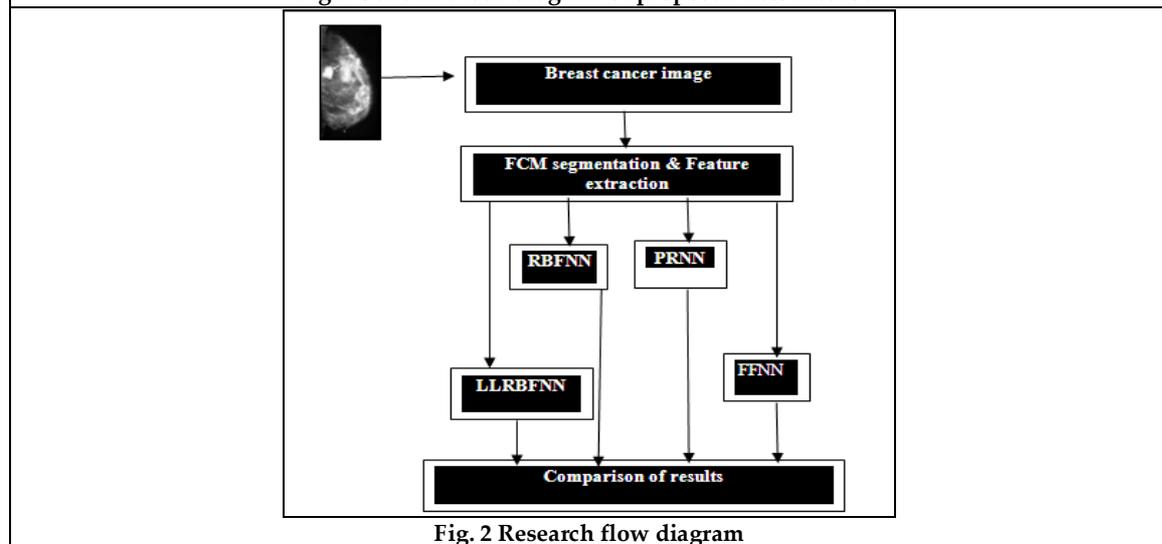


Fig. 2 Research flow diagram





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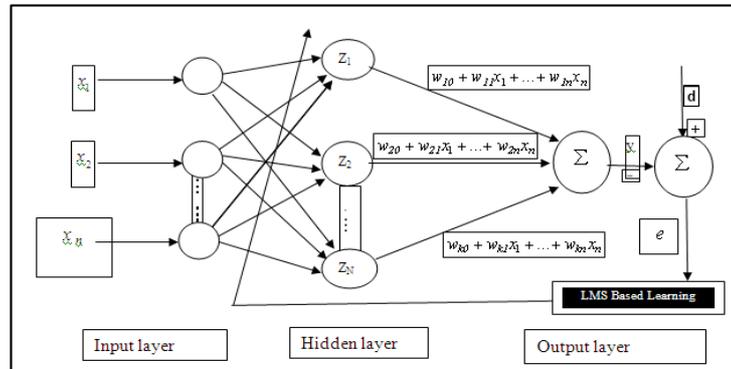


Fig. 3 LMS Based LLRFNN

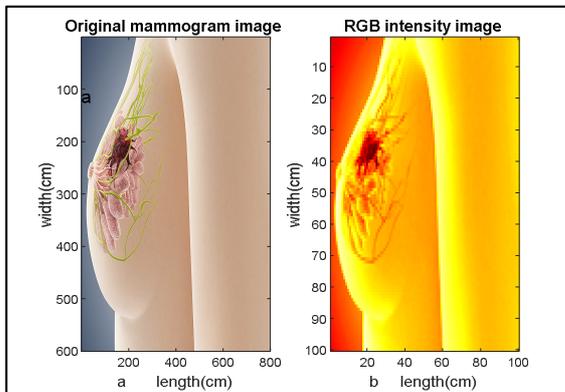


Fig.4 Comparison variation dimension true color with original images

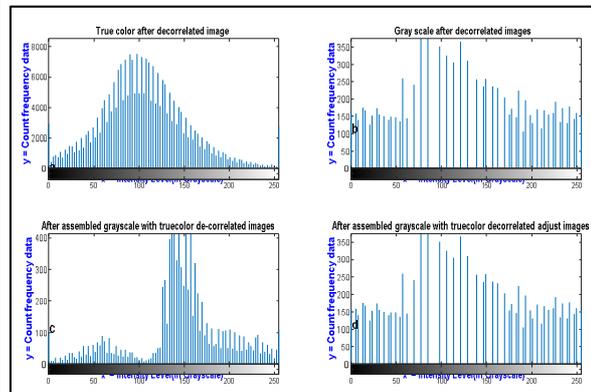


Fig 5. Comparison red color image with grayscale image analysis on histogram.

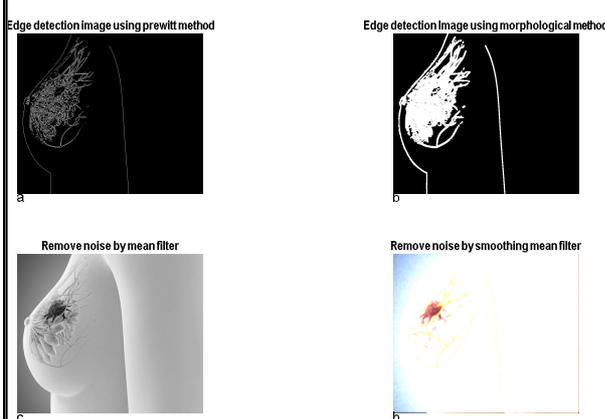


Fig. 6 Remove noise and edge detection of images by mean filter.

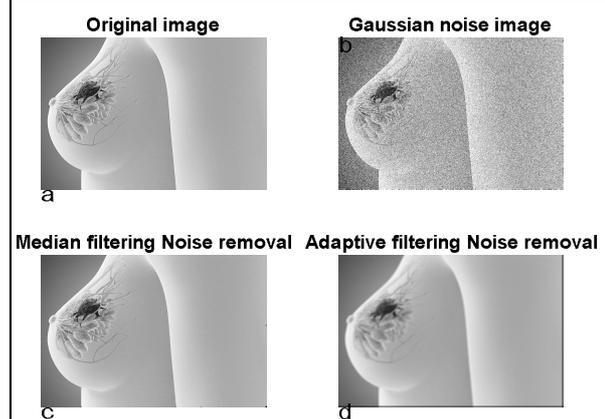


Fig. 7 Remove noise and edge detection of images



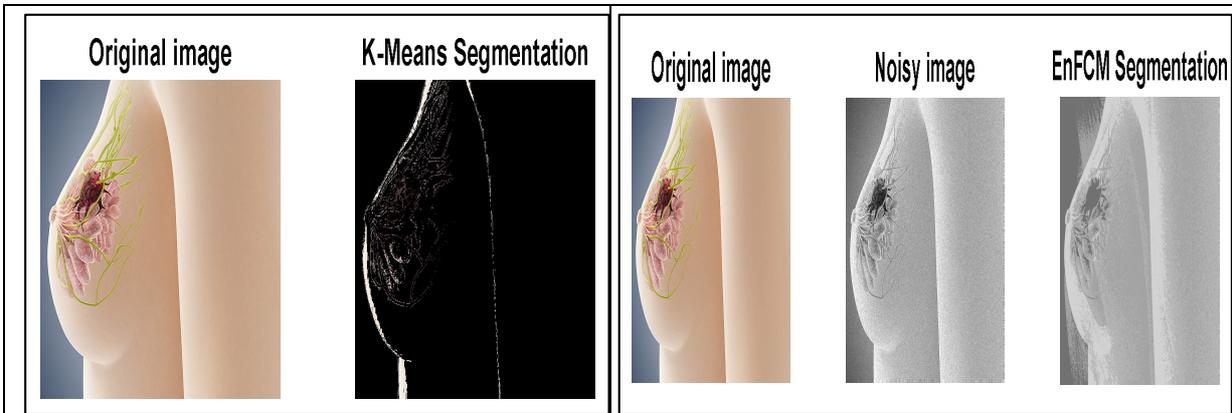


Fig. 8 Segmentation of images by K-Means algorithm

Fig. 9 Segmentation of images by En FCM algorithm

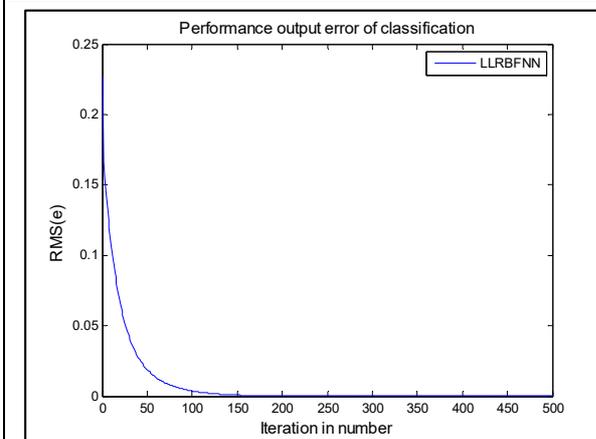


Fig. 10 LLRBFNN methods measured MSE for classification.

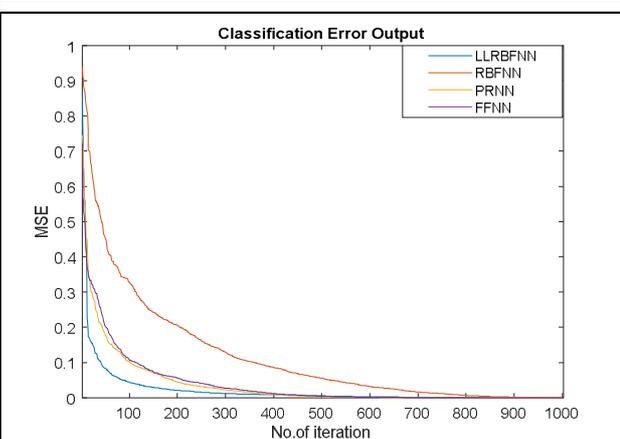


Fig. 11 Comparison of different methods measured MSE for classification

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## Digital Terrestrial Broadcasting over Smart Phone with ATSC 3.0 and 5G Network

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### ABSTRACT

A smart phone became essential part of our life and it is not limited to voice or text communication but for financial transactions, education, entertainment. The smart phone is a part of digital India programme and government is promoting more digital applications for the welfare of citizens. Today the smart phone is mostly used for entertainment, high quality content and video streaming. As per Omidyar Network serve the smart phone penetration rising 85-90 % by 2020 in India. The direct impact will be on mobile traffic, which is increasing from 10-100 time by 2030 and more than 80% global traffic will be internet video. This will demand more bandwidth and channel capacity. The study is given the brief of ATSC 3.0 architecture and different layers for implementation of Digital Terrestrial broadcast services and the scope and applications of 5G networks. The future scope of LDM for improvement the channel efficiency for better reception video quality in mobile and fixed services.

**Keywords:** Mobile Communication , 5G,, ATSC 3.0, 5G network, broadcasting, LDM, channel efficiency

### INTRODUCTION

Today the viewer's platform shifts from scheduled viewing on television to on demand viewing on smart phone. More than 70 percent viewers watch TV content and video on a smart phone. It is expected that by 2020 India will become second largest country on video viewing audience globally and digital subscription in India is estimated to cross Rs 2000 crore by 2020 from Rs 260 crore in 2016. The exponential growth in video content has given the best income opportunity to studios and content owners. In India more than 65 percent of viewers subscribe the channel

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and 7 out of 10 viewers watch ads with audio turned on, which directly impacts the advertising industry to generate revenue and 90 % of viewers like to watch video in local language. Future media services target Ultra High Definition (UHD), virtual and augmented reality contents with high resolution and with high reliability. But it is a great challenge to provide best media services with existing networks. This needs more bandwidth and spectrum efficiency. So, the time has come to switch from unicast to broadcast network. Broadcast video networks provide constant quality networks compared to the unicast mobile networks, especially for video delivery [1][2]. The Prasar Bharati introduced DVB-T2 technology for access the video streaming over the mobile phone with external antenna devices. But viewers need more user-friendly solution to access the TV over the phone without any external devices. Today, there are two different technologies moving parallel as ATSC 3.0 and 5G network.

The ATSC 3.0 is introduced as the upcoming generation broadcasting system on terrestrial network. The Advanced television system committee (ATSC) initiated the advanced upcoming generation system known as ATSC 3.0, the orthogonal FDM system along with LDPC for error correction[3][4]. The overall advantage of ATSC 3.0 is technical standard for broadcasting, which includes the management layer, physical layer and transport protocol layer. The Physical layer is the foundation for building of ATSC 3.0 standard for terrestrial network for TV broadcasting. The ATSC 3.0 standards increase the 30% capacity of A/53 SNR (signals to noise) for operating point [4][5]. The primary goal of ATSC 3.0 was to provide the platform for TV fixed and for mobile users with separate operational modes depends on the anticipated trade-off for user coverage (robustness) and capacity. ATSC 3.0 offers the different operating mode and toolbox for improving the signals for terrestrial TV broadcasting [4].

The 5G network is enhancing the “mobile phone broadband” (eMBB) application, which is “ultra-reliable at low latency” (URLLC) and “massive machine type communications” (mMTC) for mobile network [6][7]. The 5G network has a main objective of assuring the “Quality -Of-Experience” (QoE) for mobile users during dynamic and challenging network scenarios. The 5G network is also compatible with terrestrial digital communication for multicasting the video content at high efficiency, which improves the performance of network for content delivery at different geographical locations [7]. The improvement of services of ATSC 3.0 for broadcasting and 5G network targeted for employing a cut-off value for coding and modulation technique for video Streaming [8]. ATSC 3.0 and 5G network are more compatible for their capability approach performance with excluding complexity for comparable decoding hardware execution [6]. The study describes the basic architecture of ATSC 3.0 and 5G Network for broadcasting. In section 2, the architecture, and different layers of ATSC 3.0, Section-3 the 5G Technology and Applications and Section IV, Layered Division Multiplexing technology for broadcasting in ATSC 3.0 and 5G and finally, concluding remarks.

**ATSC 3.0 Architecture**

The ATSC 3.0 is introduced as the future generation broadcasting system on terrestrial network. ATSC 3.0 has been designed to deliver content to various categories of receivers, such as, fixed, portable, vehicular and handheld etc. It supports High efficiency video compression (HEVC/H.265). ATSC 3.0 includes upgraded transmission tools, like LDPC (“low-density parity-check”) codes, non-uniform QAM (nuQAM) modulation, advanced antenna technologies, and “layered-division-multiplexing” (LDM), a physical-layer “non-orthogonal multiplexing” (NOM) technology [3]. ATSC 3.0 is based on Internet Protocol (IP) and has a similar layer structure. Content can be broadcast in the same 6 MHz channels, but using OFDM modulation. ATSC 3.0 is designed with layered architecture as shown in Figure-1 due to future upgradability and extensibility [9].

As shown in Figure 1, the basic layered architecture of ATSC 3.0, each layer has its unique functionality. The First layer is System Discovery and signaling, this layer also refers to bootstrap. The bootstrap is starting the frame with necessary information to demodulate the preamble and preamble demodulates the remaining data in the frame and sub-frames. The second Layer is Transmission or physical layer, it is also foundation layer of ATSC 3.0. The framing process of physical layer in ATSC 3.0 takes coded, modulated and time interleaved PLP data, then it multiplexes with other transmission parameters such as pilot signal, control signal. Then the combined information



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transforms into a waveform, which can be transmitted [10][11]. The third layer is Protocol Layer, which uses TCP/IP protocol to manage all the services delivery and synchronization of ATSC 3.0. It is also allowing the integration with other systems. The Fourth layer is presentation layer for applications and this layer concentrates on the consumer experiences. The final layer is application layer, which is providing the interface for the users through web pages [10][11]. The main features of ATSC 3.0 are "Orthogonal Frequency Division Multiplexing" (OFDM) modulation, LDPC forward error correction codes and it supports "16200" and "64800" bits two code lengths. The ATSC 3.0 supports 12 code rates which varies from 2/15 to 13/15. ATSC 3.0 also supports three multiplexing modes such as "time division multiplexing" (TDM), "frequency division multiplexing" (FDM) and power. There are 12 guard interval (GI) lengths from ~27  $\mu$ s up to ~700  $\mu$ s. ATSC 3.0 has 3 FFT sizes such as 8K, 16K and 32K. By using channel bonding or cross-polarized MIMO technology data rate can be improved.

**ATSC 3.0 Physical Layer**

The Figure 2 shows a basic building block of physical layer in ATSC 3.0. It consists of four main blocks: first block is Input formatting, second block is BICM (Bit Interleaved and Coded Modulation), third block is Framing and interleaving and last block is Waveform generation. In Figure 3 shows the block diagram of multiple PLP system with LDM combining. ATSC 3.0 can decode 4 PLP parallel per services. The first and second block will differ for each PLP. The LDM injection block after input formatting and BICM block. All PLPs will combine before the third block i.e. framing and interleaving block.

The input formatting block consists of three different blocks, the first block is the encapsulation block also known as ALP ("ATSC Link layer protocol"), which interface between ATSC 3.0 physical layer and various input packets like internet protocol, MPEG-2 TS, link layer signaling etc. In ALP the different input packets processed into a one single packet format with variable length. The maximum length of a packet should not exceed 64KB and minimum length should be 4 bytes including header. The second block is scheduler block, which schedules the input data stream between ALP and physical layer with assistance of system management functions. The scheduler allocates the physical resources for the packets and directs baseband framing block for output packets. The third block is baseband formatting block, which output consists of baseband stream packets. The baseband packet has fixed length as per defined FEC Frame. One or more PLP can be created at baseband formatting block as directed by the scheduler. The Bit-Interleaved and code modulation (BICM) also has three different blocks, first block is Forward Error Correction block, the second block is Bit Interleaver (BIL) block and third block Constellation mapper Block. The Framing and Interleaving block has three blocks: time interleaving block, framing block and frequency interleaving block. The input to Time interleaving block is a stream of cells and output is a stream of "time interleaved" cells. One or more PLP can be the input of time interleaving but at output it can be only OFDM symbol. The waveform generation block consists of pilot insertion, MISO, IFFT, PAPR, guard interval (GI) and bootstrap blocks [12].

**The 5G Technology and Applications**

The 1st standard for enabling the internet access on mobile with 3rd generation (3G) is launched in 2002. Which is also known as UMTS and WCDMA network. For increasing the data rate over the mobile 4th generation (4G) LTE introduced in 2011. In 4G also data rate is unsaturable for video streaming and gaming apps having epidemic demand. The 5th Generation (5G) network also on the same path for improving the data rate access over mobile, IOT devices (Internet of things) and for low latency application such as vehicle to vehicle communication [13]. The 5G network in one step forward for smart technology implementation, with high data rate, low latency, improved network resilience and with very low power consumption. The 5G network implemented through millimetre wave's for transmitter share the information with high speed communication. Because of shorter wavelength, the antenna size reduced, which is providing the large-scale technical support [14].





For implementation of 5G network, the study is based on the basic theory of Shannon Formula as follow [2]

$$C = B \log_2 \left( 1 + \frac{S}{N} \right)$$

Here

C= Maximum transmission rate (bit/sec)

N= Noise power (watt)

S= Signal Power (watt)

B= Chanel Bandwidth (Hz)

For improving the transmission rate, in 5G network the more dense area with number of base station increasing w.r.t. area as shown in Figure-4. It is also implemented through new spectrum range and new frequency band, which improve the utilization rate of the spectrum with large scale antenna technology. The large-scale antenna technology is the key technology for improvement of communication network by hundreds of times in 5G network compare with previous single antenna. The beam forming technology is used in large scale antenna for small area. In Figure-4, the large scale antenna is shown with separate cities and basic data transmission between base station and micro & small terminals[14].The main advantage of large-scale antenna with beam forming technology, it has improved the efficiency and capacity of network at low cost of unit hardware. The large-scale antenna with ultra-dense network improve the spectrum access under 5G network. On other side the main challenges for implementation of large-scale antenna technology is channel estimation and modelling when mobile user terminal become more. The second challenges cost control for commercial layout as number of base stations are increasing [14].

### 5G technology for Broadcasting

The Application of 5G technology not only focus on the improvement of data rate on mobile devices for telecommunication services, it has the broad focus on different applications like autonomous vehicle driving, tracking devices, smart city applications, medical applications etc. The focus area of 5G technology is shown in Figure-5. As 5G technology improves the spectrum efficiency and reduces latency for mobile and smart devices.

It also supports the multimedia contents for broadcasting services with eMBMS (“Evolved Multimedia Broadcast Multicast Services”) technology for delivering the audio video contents. The major different between 4LTE network and broadcasting work is communication network or we can say point to point communication. The 5G technology has number of advantages for TV broadcasting network. It’s more reliable network for gathering the news with high performance of network. 5G improve the reliability and operation flexibility of broadcasting network with high efficiency. The broadcasting network covers the large area with 5G network. It has suitable business module at low cost implementation. It will add the value to the traditional TV broadcasting network with additional functionalities, features and applications. It contributes efficient distribution TV signal over the mobile network or mobile users. The 5G improves the remote content production for TV [15]. The 5G network will bring the revolution for TV broadcasting and remote content production with broad network signals over the mobiles.

### Layered Division Multiplexing in ATSC 3.0 And 5G Broadcasting

The LDM is a power based “non- orthogonal multiplexing” (P- NOM) technology. It delivers multiple services with different power level, channel coding and modulation. It provides high efficiency through spectrum utilization for broadcast services compared to Time/Frequency Division Multiplexing. In LDM system multiple PLPs are transmitting the signals using overlapped time and frequency of broadcasting resources. Each PLP have different and specific transmission power level and technology to deliver the services. In LDM multiple signal layers interface with each other and in receiver do the separation of signal layers to decode the different services based on power





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level and signal configuration. Initially LDM technology used in future digital Terrestrial transmitter but today LDM technology used in 5G broadcasting for simultaneously delivering multiple UHD quality for fixed services and HD quality to mobile services over a 20 MHz LTE band [3][16]. The scope of the research is implementation and comparison of channel efficiency for two and three-Layered Division Multiplexing in ATSC 3.0 and 5G technology for broadcast services.

## CONCLUSION

The study given the brief introduction of Digital Terrestrial broadcasting services over the smart phone and TV with better quality and reliability. The ATSC 3.0 is introducing as the next generation broadcasting system on digital terrestrial network. The study explains the layered Architecture of ATSC 3.0 along with physical layer functionality. As 5G network targeted for utilizing a cut-off value for modulation and coding scheme for broadcasting of video streaming. The study given the overview of 5G Technology and Applications for broadcasting services with ATSC 3.0. The future scope of research is implementation of two and three layered LDM for improvement of channel efficiency for Digital Terrestrial broadcasting services over the smart phone and TV.

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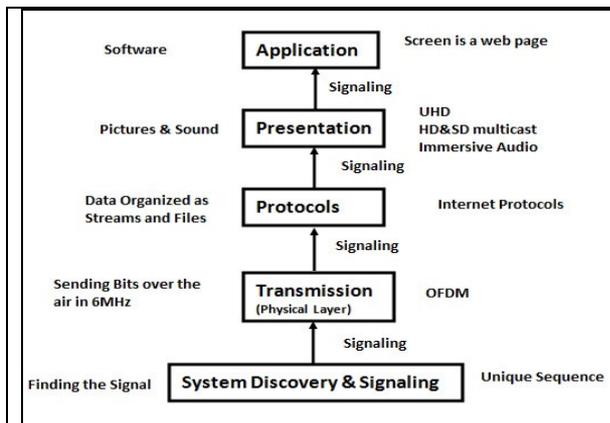


Figure 1: ATSC 3.0 Layered Architecture [9]

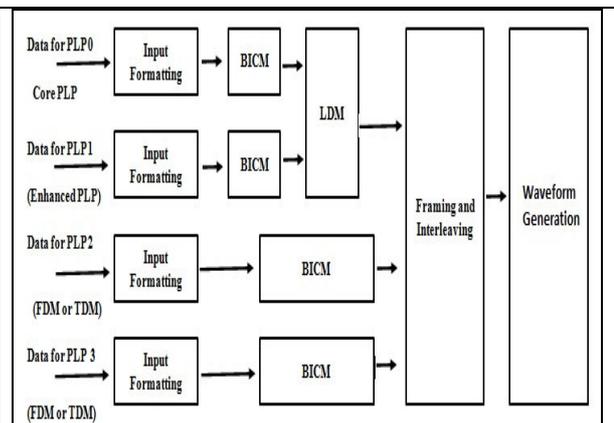


Figure 2 General block diagram of a single PLP system

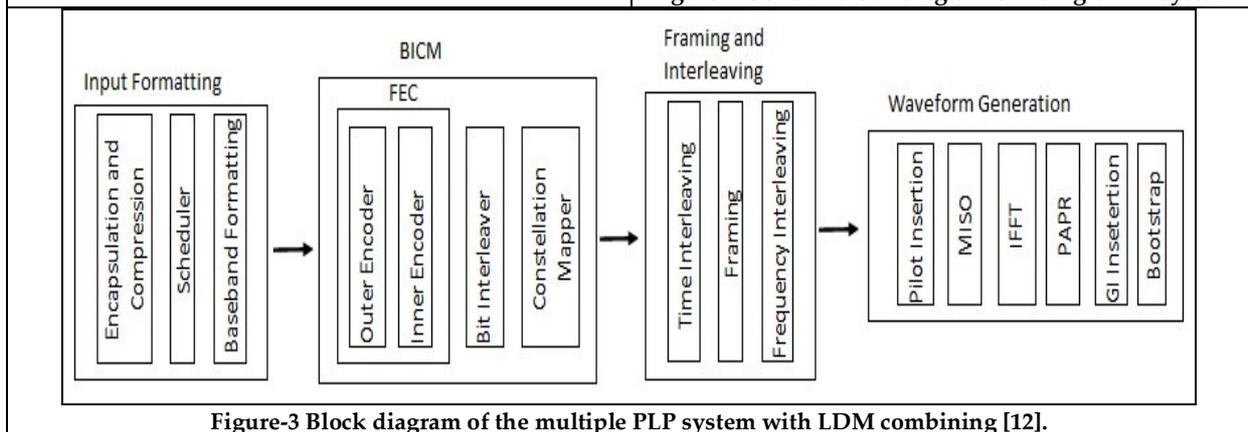


Figure-3 Block diagram of the multiple PLP system with LDM combining [12].





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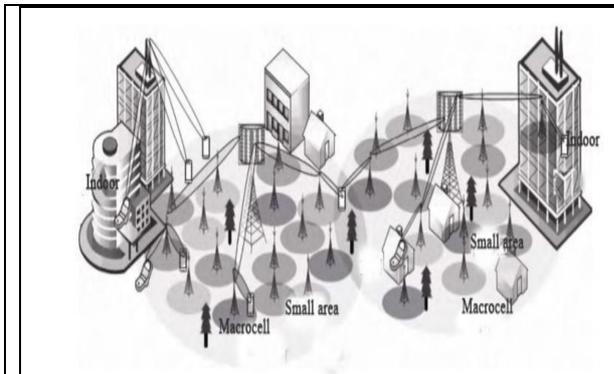


Figure-4 Large scale antenna technology for 5G Network [2]

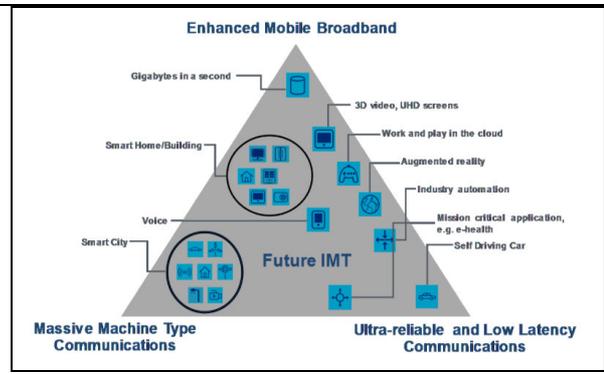


Figure-5 Applications of 5G Technology [15]

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## Recent Breeding Advancement and Divergent Species in Kokum: A Preliminary Study

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### ABSTRACT

Kokum, botanically *Garcinia indica* Choisy (Thouars), is a commercially under-utilized perennial tree species, found wide spread as a native species in Goa. It belongs to family Clusiaceae of order Theales and sub class Dilleniidae. The kokum is indigenous to the western coastal regions of southern India and is rarely seen beyond this area. It is popularly used either as an infusion, or as direct application, in skin ailments such as rashes caused by allergies. Kokum butter is an emollient beneficial in the treatment of burns, scalds and chaffed skin. The fruits are marinated in sugar syrup to make amrutkokum which is drunk to relieve sunstroke. Kokum is used for treatment of flatulence. The fruit is useful for curing of piles, dysentery, tumours, pains and heart complaints. Kokum juice is effective against allergies due to insect bites; sun exposure related symptoms as well as acidity. It also has shown anti-carcinogenic properties. Kokum possess excellent cooking quality in addition with the pharmaceutical value. But kokum cultivation and breeding advancement is yet to be exploiting in India.

**Keywords:** Kokum, *Garcinia sp.* Micro propagation

### INTRODUCTION

*Garcinia*, *Hypericum*, *Vismia*, *Cratoxylon*, *Triandenum*, *Pentadesma*, *Mammea*, *Allenblackia*, *Calophyllum*, *Mesua* etc. are the some major important genera under this family (Robson and Adams, 1968). The genus *Garcinia* comprised 200 species, among them 30 different species are reported to be found in India (Korikanthimath and Desai, 2005).



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However, Karnik (1978) mentioned that over 400 species of *Garcinia* have been identified and 40 edible species listed. Few economically important species distributed in tropical Asia are *G. mangostana*, *G. indica*, *G. gummigutta*, *G. xanthochymus*, *G. hombroniana*, *G. cowa*, *G. morella* etc. Around 30 species of *Garcinia* are available in India (Nadkarni et al., 2001). A feature of the genus is the presence of yellow or white latex plant parts. Out of thirty species, *G. indica* is confined to India and Sri Lanka only (Patilet al, 2005) It flower bud differentiation occur during the hot season and fruits ripen during the rains. The fruits are consumable, but too acid to be eaten raw. They are valued for their dried rind, which is used in Travancore - Cochin and Malabar as a condiment for flavouring curries in place of tamarind or lime. In Ceylon, the fruits are pickled under ripe, the thick pericarp cut into sections, dried in the sun and preserved for future use.

***Garcinia atroviridis***

Plants under this classification possess a moderate - sized, graceful tree, 30 - 50 feet high, found in the north - eastern districts of upper Assam. The fruit rind is too sour to be eaten raw, but tastes excellent when stewed with sugar. In Malaya, the rinds of under - ripe fruits are cut into slices, dried in the sun and sold in bazaars as a sour relish for use in curries in place of tamarind and for dressing fish. The fruit is used as fixative with alum in the dyeing of silk. A decoction from leaves and roots is used in the treatment of earaches.

***Garcinia cowa roxb***

A tall or medium - sized dioecious tree with short drooping branches often reaching the ground. The tree is found in the eastern parts of India (Orissa, Bihar, Bengal and Assam) and in Andaman Islands. The fruits are edible, though not very appetizing due to their acid taste. They can be made into jam or preserve. In Assam, sun-dried slices of the fruits are used in dysentery. In Burma, young leaves of the tree are cooked and eaten as vegetable. The bark is utilized as dyeing material (yellow). The tree produces a yellow gum - resin, which resembles gamboges.

***Garcinia dulcis***

30 - 40 feet high, found wild primarily in Malaysia. It has been introduced into India and cultivated in botanical gardens. The fruit contains citric acid and is suitable for jams and preserves. The seeds are medicinal and are used externally. The bark is used in Java for dyeing mats.

***Garcinia echinocarpa***

A robuste tree, 4-50 feet high, with sub-globose dark red fruits, containing 1-3 seeds, exist in the moist forests of southern Travancore and Tinnevely at altitudes of 3000 - 5000 feet and in Ceylon. The seeds yield a thick viscous oil (64.4% on the weight of kernels and 49.6% on the weight of seeds), which solidifies slowly at about 26°C to a soft brown fat.

***Garcinia hombroniana***

A small tree seems alike *Garcinia mangosfana*, rose red fruits, 1-2 inches in diameter, found in Nicobar Islands and further east in Malaya, chiefly on sandy and rocky coasts. The pulp surrounding the seeds is edible. It has a sour taste and a delicate peachy flavour. The fruit is reported to cause constipation. The root and leaves are used for itch in Malaya. The timber is used for house building and oars.

***Garcinia indica***

A slender evergreen tree having drooping branches, leaves ovate or oblong lanceolate, 2.5 - 3.5 inch long and 1 - 1.5 inch broad, dark green above and pale beneath, fruits globose or spherical 1 - 1.5 inch diameter, dark purple when ripe enclosing 5 - 8 large seeds. The tree is mostly available in tropical rain forests of Western Ghats, from Konkan southwards in Mysore, Coorg and Wynaad. The fruit has an agreeable flavour and a sweetish acid taste. It is used in Konkan preparation chiefly in the form of Kokam prepared by drying the outer rind, soaking it frequently in the juice of the pulp and sun-drying. Kokam contains approximately 10% malic acid and a little tartaric or citric acid. The fruit



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of the *GarciniaIndica* is anthelmintic and cardiotoxic and useful in piles, dysentery, tumours, pains and heart complaints. The fruit rind also contains Hydroxy citric acid (Krishnamurthy *et al.*, 1982). The seeds of the fruit yield (23 - 26% on the weight of seed, and 44% on the weight of kernels) a valuable palatable fat known in commerce as Kokam butter. Kokam butter, like other *Garcinia* fats, is affluent in combined stearic and oleic acids. It consists about 75% of mono-oleodisaturated glycerides and possesses a fairly low melting point. Kokam butter is considered to be nutritive, demulcent, astringent and emollient. It is suitable for ointments, suppositories and other pharmaceutical purposes. It is used as a local application for ulcerations and fissures of lips, hands etc.

***Garcinia lanceafolia***

It is a shrub or small tree up to 12 feet high, growing under the dense shade of other trees. The tree is common in the evergreen forests of Assam and Khasi hills up to 3000 feet and is often cultivated in villages for its fruits, which are acidic and eaten with relish. The leaves are sub-acid and are reported to be eaten by Mikirs after cooking.

***Garcinia livingstonei***

Plants are small tree with short branches and oblong elliptic leathery leaves introduced into India from tropical East Africa and grown in botanical gardens. It produces reddish or purple fruits, 2-2.5 inch long and 1-1.2 inch broad, which are consumable. The fleshy pericarp and the colored pulp are utilized in preparing a fermented beverage. The plant is a promising rootstock for mangosteen.

***Garcinia mangostana* Linn.**

A small or medium sized tree, 20 -45 feet high, with deep green, leathery leaves

**SURVEY AND COLLECTION**

Surveys were conducted in the forests of Western Ghats based on the floristic data and in the north eastern regions based on GIS predictions as well as floristic data. About 144 collections of *Garcinia* from Western Ghats region and 60 collections from north eastern region were made. The altitude of collection sites ranged from 50 to 1040 MSL. The species recognition was ascertained based on regional herbaria and with Floras of the region of Botanical Survey of India, Kolkata.

**GIS Predictions**

A systematic survey was conducted in the Western Ghats region of Kerala for collection of *Garcinia* species. Data on variables like altitude, rainfall and temperature were recorded during the collection surveys, along with longitude and latitude with the help of GPS. The records were arranged in the map with the help of DIVA GIS software along with collection sites of Kerala, Karnataka and Tamil Nadu. Bioclim model of DIVA GIS (Hijmans *et al.*, 2003) for altitude, and rainfall suitable for the *Garcinia* was created. Bioclim summarizes the bioclimatic parameters for an array of sites to produce a species profile, these points can be supplied either as a list of coordinates or as a regular grid. Surveys were conducted in the predicted suitable areas for *Garcinia* in the North Eastern states of Meghalaya, Assam (Kamrup District of lower Assam and Jorhat and Sibsagar Districts of upper Assam) and Nagaland.

**Micropropagation**

The seeds explants were cultured on MS medium (Murashige and Skoog, 1962) augmented with various concentrations of BAP (0, 1, 2, 2.5, 3, 4 mg/L). The media were supplemented with 30 g/L sucrose and solidified with 8 g/L agar after adjusting the pH to 5.7-5.8. After the shoot developed, the cultures were shifted to media containing BAP (1-4 mg/L) and NAA (1 and 2 mg/L). The cultures were first rest in dark for 72 hours. Culture were incubated at 22°C and were given a photoperiod of 16 hours with a light intensity of 2000 lux. Sub culturing was done in every 21 days.



**Datta Nilanjana and Sarkar Tapas****Molecular Characterization**

DNA was isolated from *Garcinia* leaves as well as dried fruit rinds using the modified protocol of Doyle and Doyle (1990). About 30 unspecified primers were screened and 12 random primers, which gave good polymorphism, were used in molecular profiling. NTSYS was used for diversity analysis.

**Biochemical Characterization****Estimation of HCA Content**

HCA content was estimated based on the methodology standardized at IISR using HPLC (Ashiset *al.*, 2008).

**Identification of Volatile compound and Fatty Acid from *Garcinia* spp. By the process of Gas Chromatography (GC)**

From four common *Garcinia* species Essential oil was extracted by hydro distillation. The oil was further subjected to GC-MS profiling and corresponding constituents were identified by matching the mass spectral data with those stored in NIST and Wiley libraries. Similarly, the free fatty acids exist in the seed kernel of *G. gummigutta* and *G. indica* were converted to fatty acid methyl esters (FAME) and were recognized by GC-FID using authentic standards.

**Extraction of Butter from the Seed Kernels**

Fresh fruits were cut into halves and separated seeds were dried for 15-20 days. The dried seeds were rubbed on a hard surface with a wooden plank to separate the kernels from the seed coat. About 100 g of kernel paste was boiled in 500 ml of water for 4-6 h in an open pan. Next step is continued by covering the pan with cloth and butter was separated by decantation and yield of butter was noted.

**Conversion of Free Fatty Acid to Fatty Acid Methyl Esters (FAME)**

About 500 mg of butter was incubated (70°C) with 5 ml of 3 N of NaOH and methanol in the ratio 1:9 for 2 h. It was segregated with 15 ml of hexane for removing steroids from free fatty acids. The lower fraction compiled from the separating funnel followed by acidifying with 0.8 ml of 6 N HCl. The acidified fraction was further splited with 15 ml of hexane and the upper fraction was taken for treatment. The separated upper fraction was treated with methanol and HCl in the ratio 5:1 and incubated at 70°C for 5 h. Again it was separated with 15 ml of hexane and again the upper fraction was taken for further analysis. Thus the conversion of FAME was used for recognition of free fatty acids by using GC-FID.

**Chromatographic Condition for Fatty Acid Standards and Samples**

The carrier gas used was Nitrogen. The injection port was maintained at 240°C; the detector temperature was 240°C; the oven was programmed as follows; 150° C for 3 min and then increased to 200°C at the rate of 5°C/min at which the column was maintained for 4 min. Perkin Elmer Gas chromatographic system identified constituents of the hexane extract with authentic standards of stearic, palmitic and arachidic acid methyl esters.

**Micropropagation**

Due to hindrance of the traditional method of propagation in *Garcinia* paved the way to innovate and using efficient method for micropropagation of 3 endemic species of *Garcinia* – *G. indica*, *G. tinctoria* and *G. gummigutta*. The detailed of the process is such; MS medium supplemented with 2.5 mg/L 6 benzyl amino purine (BAP) gave best response and induced multiple shoot initiation. Root initiation in MS medium ignited with or without  $\alpha$  Naphthalene Acetic Acid (NAA) but root elongation only get fastened in MS medium with supplementation of 2 mg/L of NAA. Species differences in in vitro response were observed. In vivo seed germination studies were also conducted to understand the seed germination pattern in the three species. This technology can be used for multiplication of elite genotypes and conservation of *Garcinia* species. Most of the earlier studies pertaining to in vitro culture of genus *Garcinia* have been conducted in *G. mangostana* using seed and leaf explants. Kulkarni and Deodhar (2002) experimented on immature seeds, young leaves, apical and axillary buds as explants for in vitro



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establishment of *G. indica*. Deshpande et al. (1999) and Mathew et al. (2001) carried out preliminary studies on in vitro establishment of kokum apical buds. Murthy and Patil (2010) had elaborated that in *G. tinctoria* with seed explants developed an average of around 11.1 multiple shoots on the MS medium supplemented with 3 mg BAP/L.

**Molecular Characterization**

RAPD profiling of *Garcinia* sp. Achieved for better accession of inter-specific genetic diversity. The markers could successfully distinguish different species of the genus. Rao et al. (2003) studied both intra- and inter-species relationship among six *Garcinia* species, namely *G. indica*, *G. cambogia*, *G. cowa*, *G. mangostana*, *G. xanthochymus* and *G. hombroniana*, using RAPD polymorphism. Also elaborated molecular diversity within *G. cambogia*. Utpal et al. (unpublished) studied RAPD polymorphism in 33 accessions of *Garcinia* species collected from different areas of Western Ghats. The dendrogram clearly recognized the identification of the 3 main species studied, *G. gummigutta*, *G. indica* and *G. xanthochymus* and suggested high amount of diversity within the collections of the same species. A like study was also conducted on *Garcinia* collections from North Eastern India using RAPD. High molecular diversity was noticed with the heterogeneity index within species of 0.81 to 0.82 in four species, *G. gummigutta*, *G. indica*, *G. cowa* and *G. xanthochymus*.

**Biochemical Characterization****Hydroxy Citric Acid (HCA)**

Variability of hydroxy citric acid and lycopene contents has been assessed in *Garcinia* species. Lycopene content did not show much variation. HCA content was higher in leaf, fresh and dry fruit samples of *G. gummigutta* followed by *G. indica* and low in *G. pedunculata*. In the Western Ghat collections as well as in N.E. samples HCA could not be perceived from leaf, fresh and dry fruit samples of *Garcinia xanthochymus*.

**Estimation and Identification Volatile Oil**

Constituents in *Garcinia* spp. volatile oil content was estimated by hydro distillation of dried leaves of *Garcinia* species. The volatile oils were further subjected to gas chromatography-mass spectrum (GC-MS) for the identification of various secondary metabolites. In the reports of GC-MS profiling of different *Garcinia* species indicates that *G. cowa* compose a total of 7 compounds, *G. indicacombined* 12 compounds, *G. tinctoria* has 9 compounds and *G. gummigutta* has 8 important volatile compounds. Trans-Caryophyllene and Gamma-Murolene are generally found in all. A recent study, trace of secondary metabolites such as beta-bourbonene, Alpha-humulene, Gamma-Gurjunene and Gamma-Cadinene were present in all the species except *G. cowa*. These secondary metabolites are mainly used in fragrance industry.

**Identification of Free Fatty Acids**

Seeds of *G. gummigutta* and *G. indicacombined* analyzed by the process of GC-FID. The main economic importance *G. indica* is the rich content of 'kokum butter' present in the seed kernel. Free fatty acids present in *G. gummigutta* and *G. indica* seed kernels were adapted to the purpose of producing fatty acid methyl esters (FAME) and were subjected to GC-FID. The free fatty acids in butter were identified by comparing their retention time with authentic standards. Here in both cases stearic acid was found as the more common (28-40%) fatty acid in *G. gummigutta* and *G. indica* samples. Jayanth et al. (2003) reported that scanning of fatty acids in *G. indica* at different developmental stages marked that stearic acid is the primer fatty acid and its concentration increases during maturation (40- 60%). According to the study of Reddy and Prabhakar (1994), presence of stearic (50 -60%) and palmitic (10-20%) acid in *G. indica* butter. Andrea and Scott (1988) reported plasma total cholesterol reduced by an average of 14% during consumption of the high stearic-acid diet. Obesity is correlated with insulin resistance and some reproductive abnormalities. Palmitic acid and stearic acid, markedly subdue these abnormalities (Ming et al., 2001). Thus *Garcinia* species are the noble sources of these useful fatty acid methyl esters.





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**Fig.1 *Garcinia echinocarpa* - Tree**



**Fig.2 *Garcinia echinocarpa* – Flower**



**Fig. 3 *Garcinia indica* - Fruit**



**Fi g.4 *Garcinia indica* – Fruit Rind**





## Evaluation of Advanced Breeding Lines of Rice (*Oryza sativa*. L) for Yield and Its Component Traits

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### ABSTRACT

An experiment was conducted in the field experimentation center of department of Genetics and Plant Breeding, SHUATS, Allahabad during *Kharif* 2015 in Randomized Block Design with 19 genotypes and 3 replications. The data were recorded for 13 quantitative characters to study genetic variability, heritability, and genetic advance analysis. Analysis of variance among 19 genotypes showed highly significant differences for all the characters indicated the presence of substantial amount of genetic variability. On the basis of mean performance the highest yield per plant observed in SHIATS DHAN-2. Highest Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV) observed for number of spikelets per panicle, biological yield per hill and biological yield per hill indicating that these characters could be used as selection for crop improvement. High estimate of heritability coupled with genetic advance was found in Number of spikelets/panicle and plant height. Biological yield, biological yield per hill, plant height and number of spikelets per panicle showed positive and significant correlation with grain yield per plant and direct effect on grain yield per plant hence direct selection for these traits could be helpful for the improvement of rice genotypes.

**Keywords:** Genetic variability, Heritability, Genetic advance, correlation coefficient and Path analysis.

### INTRODUCTION

Rice is one of the important food crops in the world and grown on 155 million hectares with annual production of around 596 million tonnes and average productivity of 3.9 tonnes per hectare. Correlation studies provide better understanding of yield components. Path coefficient analysis furnishes information about influence of each contributing trait to yield directly as well as indirectly and also enables breeders to rank the genetic attributes

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according to their contribution and thus, useful in indirect selection of elite genotypes from diverse genetic populations. (Wright, 1935 Fisher, 1981). Selection of high yielding varieties based only on grain yield will not be much effective unless adequate information on genetic parameters are available to formulate hybridisation and selection programme for further improvement because the estimate of the mean serves as a basis for eliminating the undesirable genotypes. Whereas genetic variability (GCV and PCV) help to choose the potential genotypes. Heritability along with genetic advance would be more useful tool in predicting the resultant effect from selection of the best genotypes for yield and some of its components in rice. It is very difficult to judge whether observed variability is highly heritable or not. Moreover, knowledge of heritability is essential for selection based improvement as it indicates the extent of transmissibility of a character into future generations. (Kumar, 2003) Genetic variability, character association and path coefficients are pre-requisites for improvement of any crop including rice for selection of superior genotypes and improvement of any trait (Krishnaveniet al., 2006). Realizing the importance of this crop, the present investigation was undertaken.

## MATERIALS AND METHODS

Experimental materials for the present study consist of 19 Advanced Breeding lines of Rice such as IR11A479, IR11A410, IR11A293, BP16732E-6, HHZ24DT11-LI1-LI1, IR11A106, NDR2026, NDR1045, V-PR-113, V-DM6600, MTU1001, BPT-2615, NLR-34449, SONAM LOCAL, DWARF MANSURI, AAIR-208, SHIATS DHAN-1, SHIATS DHAN-2 and SHIATS DHAN-3 received from the department of GPB, SHUATS during *Kharif*-2015. The experiment was laid down in a Randomized Block Design with 19 rice genotypes. The genotypes were replicated thrice; each genotype was grown in a plot of size 2.8m<sup>2</sup> (0.4 m X 7 m) square meter with a spacing of 20cm between rows and 15cm between plants. Recommended agronomic and plant protection package of practices were followed to raise healthy crop. The data were recorded on five randomly selected plants from each rice hybrids in each replication leaving the first one border rows from all the four sides, in order to avoid the sampling error. The observations such as days to 50% flowering, Plant height (cm), Flag leaf length (cm), Flag leaf width (cm), Panicles length (cm), Number of tillers per hill, Number of panicles per hill, Number of spikelets per panicle, Days to maturity, Biological yield per hill (g), Harvest index (%), Test weight (g) and Grain yield per hill (g) were recorded as per the following procedure. Readings from five plants were averaged replication wise and the mean data was used for statistical analysis for 13 characters.

## RESULT AND DISCUSSION

### ANOVA

Analysis of variance showed highest significant difference among 19 rice genotypes for all the characters studied, indicating that there is ample scope for selection of promising lines from present gene pool for yield and quality improvement.

### Mean Performance

On the basis of mean performance the genotypes Shiats Dhan-2 (43.40 g), Shiats Dhan-1 (41.80g), Sonam local (23.70g), NDR2026 (23.12g) Shiats Dhan-3 (22g) were regarded as the best genotypes for grain yield per hill.

### PCV and GCV

The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all the characters. The maximum phenotypic coefficient of variation (PCV) was observed for grain yield per plant (43.43) and maximum genotypic coefficient of variation (GCV) was observed for grain yield per plant (43.25). Similar findings were reported by (Chaubey and Singh (1994).



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### Heritability and Genetic Advance

Heritability estimates revealed that character like seed yield per plant (99.00), biological yield (99.00), spikelets per panicle (99.00) and plant height (99.00) exhibited highest heritability followed by harvest index (97.00), panicles length (95.00) and panicles per plant (94.00) panicle length (99.90). Estimates of genetic advance revealed that character Total spikelets per panicle (89.51) exhibited highest genetic advance followed by biological per hill (46.46) and plant height (32.56). Similar results were also reported by Rather *et al.* (1998). High heritability for grain yield per plant. Osman *et al.* (2012) recorded high heritability for plant height. However, Nayaket *et al.* (2002), Patel *et al.* (2013) Viveket *et al.* (2015) and Akhtaret *et al.* (2011) registered high estimated of heritability for grain yield per plant. Prasad *et al.* (2006) reported the genetic advance percentage of mean was highest for total number of spikelets per panicle, biological yield per hill.

### Correlation Coefficient

Grain yield per hill showed positive significant association with biological yield per hill (0.78\*\*), plant height (0.59\*\*), number of spikelets per panicle (0.44\*\*), tillers per plant (0.42\*\*), panicles per plant (0.38\*\*), days to 50% flowering (0.14\*\*), flag leaf length (0.12\*\*). It shows positive non-significant association with panicle length (0.04\*\*) and leaf width (0.01\*\*). It shows negative significant association with days to maturity (-0.25\*), harvest index (-0.15\*). It showed negative non-significant association with test weight (-0.04\*) at phenotypic level. Grain yield per hill showed positive significant association with biological yield per hill (0.79\*\*), plant height (0.60\*\*), tillers per plant (0.44\*\*), number of spikelets per panicle (0.44\*\*), panicle per plant (0.38\*\*), days to 50 per cent flowering (0.14\*\*) and flag leaf length (0.11\*\*). It showed positive non-significant association with panicle length (0.04\*\*). The correlation of grain yield per hill showed negative significant association with days to maturity (-0.26\*\*) and harvest index (-0.16\*\*). It showed negative non-significant association with test weight (-0.04\*\*), and flag leaf width (-0.02\*\*) at genotypic level. Similar results were also reported by Choudhary and Das (1998), Bala (2001), Nayaket *et al.* (2002), Shakthivel (2001) and Madhavilatha (2005).

### Path Analysis

The perusal of path analysis indicated that biological yield /hill (0.79), plant height (0.60), tillers /plant (0.44) spikelets per panicle (0.44), panicle / plant (0.38), flag leaf length (0.11) and days to 50% flowering (0.14) had positive direct effect on grain yield per hill at genotypic level, where as biological yield /hill (0.78), Plant height (0.59), spikelets / panicle (0.44), tillers /plant (0.42), panicle / plant (0.38), days to 50% flowering (0.14) and flag leaf length (0.12) had positive direct effect on grain yield per hill at phenotypic level. Thus, these characters may serve as effective selection parameters in direct breeding programmes for yield improvement in rice. Similar results were also reported by Nandan *et al.* (2010).

## CONCLUSION

It was concluded on the basis of mean performance the genotype SHIATS DHAN-2 (43.40gm) was recorded highest yield. The PCV was higher than GCV in all these characters. The high heritability coupled with genetic advance was observed for number of spikelets per panicle, Test weight, Biological yield per hill, Harvest index and Flag leaf length.

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**Table 1: Analysis of variance for 13 characters among 19 genotypes of rice**

S. NO.	Character	Mean Sum of Square		
		Replication (d.f=2)	Treatment (d.f=18)	Error (d.f=36)
1.	Days to 50% flowering	0.56	77.34**	3.16
2.	Plant height	6.90	758.83**	2.36
3.	Flag leaf length	0.35	158.90**	2.82
4.	Flag leaf width	0.01	0.14**	0.04
5.	No. of tillers per hill	1.37	23.15**	0.85
6.	No. of panicle per hill	0.06	19.65**	0.40
7.	Panicle length	0.23	14.70**	0.19
8.	Biological yield	0.98	1551.56**	6.51
9.	Harvest index (%)	0.23	153.99**	1.79
10.	Days to maturity	8.30	355.48**	15.27
11.	No. of spikelets / panicle	10.87	5704.31**	10.03
12.	Test weight	1.78	18.57**	1.68
13.	Seed yield per hill	0.05	234.72**	0.61

\*\*Significant at 5% level of significance respectively.





**Table 2: Mean Performance of 19 Rice Genotypes for 13 Quantitative Characters during Kharif- 2015**

Sl No	Character	Days to 50% Flowering	Plant Height (cm)	Flag Leaf Length	Flag Leaf Width	Tillers/ Plant	Panicle/ Plant	Panicles/ Length	Spiklets/ Panicle	Days to Maturity	Biological Yield	harvest Index	Test Weight	Seed Yield/ Plant
1	IR11A479	96.00	99.40	32.00	1.32	10.00	9.00	23.50	120.00	142.00	44.00	36.13	19.00	15.90
2	V-IR11A410	101.00	91.00	29.00	1.52	7.60	7.00	23.20	131.00	144.00	51.00	41.17	19.00	21.00
3	V-IR11A293	104.00	97.00	33.20	1.36	11.20	9.60	24.30	141.00	141.00	48.00	32.91	21.00	15.80
4	BP16732E-6	88.00	80.00	22.80	1.32	9.40	8.00	26.27	176.00	138.00	42.00	38.17	21.73	12.20
5	HHZ14-SAL10-DH1-DT1	92.00	87.60	29.40	1.36	9.20	7.80	22.80	195.00	147.00	38.70	32.88	22.88	18.30
6	V-IR11A106	99.00	95.20	32.00	1.47	10.60	10.00	28.00	168.00	151.00	45.60	38.66	23.12	15.00
7	NDR2026	98.00	83.80	48.30	1.59	7.40	6.20	29.48	174.00	126.50	50.93	45.39	22.10	23.12
8	NDR1045	91.00	96.00	48.86	2.00	9.13	7.80	29.60	210.00	111.26	49.10	46.72	24.66	22.94
9	V-PR-113	98.00	82.00	25.00	1.30	10.26	9.90	26.33	55.00	127.00	42.66	40.50	20.26	17.33
10	V-DM6600	97.66	88.00	28.00	1.40	10.00	8.50	25.81	145.00	131.00	43.77	36.88	21.38	19.28
11	MTU1001	90.00	84.00	23.00	1.40	12.50	11.36	25.70	106.00	121.00	39.86	36.65	20.33	14.60
12	BPT-2615	93.00	73.00	32.00	1.30	14.16	13.63	21.71	153.40	120.33	32.53	43.83	23.62	14.10
13	NLR-34449	94.33	82.00	25.00	1.40	13.52	11.60	24.17	134.00	123.33	52.96	17.18	15.16	7.76
14	Sonam local	87.00	68.00	34.00	1.50	8.00	6.40	25.70	126.00	120.00	47.20	38.67	23.50	23.70
15	Dwarf mansuri	92.00	56.00	29.00	1.00	14.00	11.00	23.33	143.00	130.00	43.77	33.06	19.50	21.80
16	AAIR-208	98.00	87.00	31.80	1.38	9.00	7.80	23.80	138.00	139.00	42.00	42.85	24.00	18.00
17	Shiats Dhan-1	105.00	126.20	29.40	1.50	17.00	14.00	25.30	267.00	128.00	100.58	30.51	16.50	41.80
18	Shiats Dhan-2	91.00	115.30	26.80	1.16	16.00	15.00	23.97	146.00	122.00	110.00	24.45	21.72	43.40
19	Shiats Dhan-3	93.00	102.80	22.20	1.00	12.00	11.00	22.70	152.00	123.00	100.76	34.42	21.00	22.00
	<b>Mean</b>	<b>95.16</b>	<b>89.17</b>	<b>30.62</b>	<b>1.38</b>	<b>11.10</b>	<b>9.77</b>	<b>25.04</b>	<b>151.60</b>	<b>130.81</b>	<b>53.97</b>	<b>36.37</b>	<b>21.08</b>	<b>20.42</b>
	Range Lowest	87.00	56.00	22.20	1.00	7.40	6.20	21.71	55.00	111.26	32.53	17.18	15.16	7.76
	Range Highest	105.00	126.20	48.86	2.00	17.00	15.00	29.60	267.00	151.00	110.00	46.72	24.66	43.40
	C.D. 5%	2.94	2.54	2.78	0.35	1.54	1.05	0.74	5.25	6.47	4.23	2.22	2.15	1.30
	C.V.	1.87	1.72	5.48	15.12	8.35	6.49	1.77	2.09	2.99	4.73	3.68	6.17	3.85

**Table 3: Estimates of components of variance and Genetic parameters for different characters in rice**

S.No.	Characters	VG	VP	GCV	PCV	h <sup>2</sup> (bs)%	GA	GA as % of mean
1.	Days to 50% flowering	24.73	27.89	5.23	5.55	89	9.65	10.14
2.	Plant height cm	<b>252.16</b>	254.52	17.81	17.89	99	32.56	36.51
3.	F.L Length	52.03	54.85	23.56	24.19	95	14.47	47.26
4.	F.L Width	0.03	0.08	12.98	19.92	42	0.24	17.42
5.	No. of Tillers/ hill	7.43	8.29	24.55	25.93	90	5.32	47.88
6.	No. of Panicles/ hill	6.42	6.82	25.93	26.73	94	5.06	51.82
7.	Panicle length (cm)	4.84	5.03	8.78	8.96	96	4.44	17.74
8.	No. of Spikelets/ panicle	1898.09	1908.13	28.74	28.81	99	89.51	59.04
9.	Days to maturity	113.40	128.68	8.14	8.67	88	20.59	15.74
10.	Biological yield per hill (g)	515.02	521.53	42.05	42.31	99	46.46	86.08
11.	Harvest Index %	50.73	52.53	19.58	19.93	97	14.42	39.65
12.	Test Weight (g)	5.63	7.32	11.26	12.83	77	4.29	20.34
13.	Grain yield / hill	78.03	78.65	43.25	43.43	99	18.13	23.75

VG= Genotypic Variance, VP=Phenotypic Variance, GCV=Genotypic Coefficient of Variation, PCV=Phenotypic Coefficient of Variation, h<sup>2</sup>(bs)= Heritability(broad sense), GA= Genetic Advance





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**Table 4: Estimates of Genotypic correlation coefficient between yield and its related traits in 19 rice genotypes**

S.No	Character	Days to 50% Flowering	Plant Height	Flag Leaf Length	Flag Leaf Width	Tillers/ Plant	Panicle/ Plant	Panicles/ Length	Spiklets/ Panicle	Days to Maturity	Biological Yield	Harvest Index	Test Weight	Seed Yield/ Plant
1	Days to 50% Flowering	1.00	0.47**	0.11**	0.16**	0.07	0.05	0.02	0.16**	0.44**	0.13**	0.01	-0.37*	0.14**
2	Plant Height		1.00	-0.01*	0.17**	0.34**	0.37**	0.05	0.45**	0.07*	0.73**	-0.25*	-0.22**	0.60**
3	Flag Leaf Length			1.00	0.87**	-0.41**	-0.44**	0.60**	0.35**	-0.18	-0.19*	0.54**	0.47**	0.11*
4	Flag Leaf Width				1.00	-0.54*	-0.54*	0.81**	0.43**	-0.17*	-0.29*	0.50**	0.31**	0.02
5	Tillers/ Plant					1.00	0.98**	-0.37*	0.23**	-0.33*	0.56**	-0.63*	-0.49*	0.44**
6	Panicle/Plant						1.00	-0.38*	0.11**	-0.31*	0.55**	-0.55*	-0.37*	0.38**
7	Panicles/ Length							1.00	0.19**	-0.19*	-0.16*	0.39**	0.26**	0.04*
8	Spiklets/ Panicle								1.00	0.06*	0.35**	-0.02*	0.03	0.44**
9	Days to Maturity									1.00	-0.27*	-0.00	-0.05*	0.26**
10	Biological Yield										1.00	-0.46*	-0.29*	0.79**
11	Harvest Index											1.00	0.70	0.16**
12	Test Weight												1.00	0.04*
13	Seed Yield/ Plant													1.00

(\*) & (\*\*) represent significant levels at 5% and 1% respectively.

**Table 5: Estimates of phenotypic correlation coefficient between yield and its related traits in 19 rice genotypes**

S.No	Characters	Days to 50% flowering	Plant height	Flag leaf length	Flag leaf width	tillers per hill	Panicles per hill	Panicle length	Days to maturity	Spikelets per panicle	Biological yield	Harvest index (%)	Test wt.	Grain yield per hill
1	Days to 50% flowering	1.00	0.45**	0.10	0.07	0.07	0.07	0.04	0.40**	0.15	0.13	0.01	-0.32	0.14
2	Plant height		1.00	-0.01	0.10	0.32*	0.36**	0.05	0.07	0.45**	0.72**	-0.24	-0.19	0.59
3	Flag leaf length			1.00	0.54**	-0.36**	0.42**	0.56**	-0.17	0.34**	-0.18	0.52**	0.38	0.12
4	Flag leaf width				1.00	-0.29*	-0.32*	0.53**	-0.14	0.27*	-0.20	0.36	0.16	0.01
5	Tillers/ hill					1.00	0.93**	0.34**	-0.26*	0.22*	0.54**	-0.57**	-0.37	0.42
6	Panicles/ hill						1.00	0.37**	-0.28*	0.10	0.53**	-0.52**	0.36**	0.38
7	Panicle length							1.00	-0.18	0.19	-0.11	0.37**	0.24**	0.04
8	Days to maturity								1.00	0.19	0.34**	-0.01	0.03	0.44
9	Spikelets per panicle									1.00	-0.25	0.08	0.09	-0.25
10	Biological yield/ hill										1.00	-0.44**	-0.26*	0.78
11	Test weight											1.00	0.60**	-0.15
12	Harvest index												1.00	-0.04
13	Grain yield per plant													1.00

(\*) & (\*\*) represent significant levels at 5% and 1% respectively.

**Table 6: Estimates of direct and indirect effects between yield and its related traits in 19 rice genotypes at phenotypic level**

S.No	Character	Days to 50% Flowering	Plant Height (cm)	Flag Leaf Length	Flag Leaf Width	Tillers/ Plant	Panicle/ Plant	Panicles / Length	Spiklet/ Panicle	Days to Maturity	Biological Yield	harvest Index	Test Weight	Seed Yield/ Plant
1	Days to 50% Flowering	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.00	0.00	0.00	0.00	0.00
2	Plant Height (cm)	-0.02	-0.05	0.01	-0.6	-0.01	-0.02	-0.02	-0.02	-0.04	-0.04	0.01	0.01	-0.03
3	Flag Leaf Length	0.02	-0.04	0.2	0.11	-0.07	-0.08	0.11	0.07	-0.03	-0.03	0.1	0.07	0.02
4	Flag Leaf Width	0.07	0.09	0.04	0.09	-0.02	-0.02	0.04	0.02	-0.01	-0.01	0.03	0.01	0.01
5	Tillers/ Plant	0.02	0.11	-0.12	-0.09	0.33	0.31	-0.11	0.07	-0.09	0.18	-0.19	-0.12	0.14
6	Panicle/Plant	-0.01	-0.05	0.06	0.05	0.01	-0.01	0.06	-0.01	0.04	-0.08	0.08	0.05	-0.06
7	Panicles/ Length	-0.2	-0.01	-0.02	-0.01	0.01	0.01	-0.03	-0.06	0.06	0.04	-0.01	-0.08	-0.01
8	Spiklets/ Panicle	0.06	0.04	0.03	0.02	0.02	0.01	0.02	0.01	0.01	0.03	-0.02	0.03	0.04
9	Days to Maturity	0.02	0.04	-0.01	-0.08	-0.01	-0.01	-0.01	0.05	0.06	-0.01	0.05	0.06	-0.01
10	Biological Yield	0.11	0.64	-0.16	-0.18	0.48	0.47	-0.1	0.3	-0.22	0.88	-0.39	-0.23	0.69
11	harvest Index	0.03	-0.04	0.09	0.06	-0.1	-0.09	0.06	0.03	0.01	-0.08	0.17	0.1	-0.02
12	Test Weight	-0.01	-0.01	0.02	0.09	-0.02	-0.02	0.01	0.01	0.05	-0.01	0.03	0.05	-0.02
13	Seed Yield/ Plant	0	-0.03	0.02	0.01	0.14	-0.06	-0.01	0.04	-0.01	0.69	-0.02	-0.02	-0.04





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Table 7: Estimates of direct and indirect effects between yield and its related traits in 19 rice genotypes at genotypic level

S.No	Character	Days to 50% flowering	Plant height cm	Flag leaf length cm	Flag leaf width cm	tillers/ hill	Panicles/ hill	Panicle length cm	Spikelets per panicle	Days to maturity	Biological yield per plant	Harvest index	Test weight	Grain yield per hill
1	Days to 50% flowering	-0.05	-0.02	-0.06	-0.09	-0.04	-0.03	-0.01	-0.09	-0.02	-0.07	-0.01	0.02	-0.08
2	Plant height cm	-0.26	-0.52	0.09	-0.09	-0.19	-0.20	-0.03	-0.24	-0.04	-0.40	0.13	0.12	-0.32
3	Flag leaf length cm	0.04	-0.06	0.36	0.31	-0.15	-0.16	0.22	0.12	-0.06	-0.07	0.19	0.17	0.04
4	Flag leaf width cm	0.01	0.02	0.10	0.11	-0.06	-0.06	0.09	0.05	-0.02	-0.03	0.05	0.03	-0.02
5	Tillers/ hill	-0.012	-0.61	0.73	0.97	-1.76	-1.74	0.65	-0.41	0.59	-1.00	1.12	0.87	-0.78
6	Panicles/ hill	0.09	0.71	-0.85	-1.03	1.87	1.89	-0.73	0.21	-0.59	1.04	-1.06	-0.70	0.074
7	Panicle length cm	-0.01	-0.02	-0.02	-0.03	0.01	0.01	-0.04	-0.08	0.08	0.04	-0.01	-0.01	-0.01
8	Spikelets per panicle	0.05	0.14	0.11	0.14	0.07	0.03	0.06	0.32	0.02	0.11	-0.06	0.01	0.14
9	Days to maturity	0.08	0.01	-0.03	-0.03	-0.06	-0.05	-0.03	0.01	0.018	-0.05	-0.05	-0.01	-0.05
10	Biological yield per Plant	0.015	0.87	-0.23	-0.35	0.67	0.65	-0.13	0.41	-0.33	1.18	-0.54	-0.35	0.93
11	Harvest index	0.02	-0.04	0.10	0.09	-0.12	-0.10	0.07	-0.04	-0.05	-0.08	0.18	0.13	-0.03
12	Test weight	0.12	0.07	0.16	-0.10	0.16	0.12	-0.08	-0.01	0.01	0.10	-0.24	-0.34	0.01





## Rice Landraces – A Review on the Story of Their Origin and Domestication in South Odisha

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### ABSTRACT

Southern Odisha is considered as the rice bowl of the state and is home to a rich diversity of rice landraces. Rice landraces are ecotypes which are cultivated in pristine habitats since time immemorial by tribal communities who serve as custodians of these races and thereby contribute immensely towards the conservation of their gene pool. The Jeypore tract in Koraput district of Southern Odisha is recognized for its rich diversity of Asian cultivated rice (*Oryza sativa* L.) and is one of the agro-biodiversity hot spots in India. Traditional rice landraces are important reservoirs of valuable traits such as nutrition, taste, aroma, excellent cooking and eating characteristics, tolerance to abiotic and biotic stresses, medicinal properties and other special features thereby sheltering a potential genetic diversity. The present work is an attempt to review the origin and domestication of rice landraces of Southern Odisha with an emphasis to provide information on their important attributes which will be helpful for farmers, researchers, food processors, nutritionists, physicians in selecting different rice landraces for food fortification processes to combat nutritional and elemental deficiencies. The study concludes that the rice land races of Odisha need immediate attention to conserve their gene pool for future generations and restore the rice biodiversity of Southern Odisha. Further the information provided in the study would help in broadening the crop genepool for their successful exploitation in various rice breeding programs.

**Keywords:** Landraces, ecotype, diversity, fortification, genepool





## INTRODUCTION

The Indian sub-continent is a mega centre of biodiversity and is a treasure house of rice landraces which are grown in pockets in different states. Each state of India has its own special traditional rice varieties that have been maintained by a small group of marginal farmers mainly for their individual consumption and for sustaining certain religious rituals and social ceremonies (Bhagwat *et al.*, 2008; Agnihotri and Palni, 2007). The cultivation of these races is believed to have spread from the foothills of the Himalayas, Southwest into the Indian subcontinent, into Southeast Asia, and eastward into China and Japan. Rice landraces in India are traditionally cultivated in regions having contrasting eco-climates and therefore represent a wide array of genetic diversity for adapting to climates from sea level to high altitudes, to water stress from dry to submerged, to temperatures from cold to 45°C.

Well-known Indian rice researchers (Richharia and Govindasamy, 1990) in their book *Rices of India* have provided vedic and literature evidence to show that the country had been endowed with more than 2 lakhs (200,000) rice varieties, a rich biodiversity that no other country on earth possesses. Each and every variety of rice is the result of the vision and hard work of women and men of generations past who toiled to select rice varieties adapting to different climates, soil types, topography and agronomic practices. The famous book entitled *Seeds of Tradition, Seeds of Future* (Deb, 2005) provides morphological descriptions of 416 Indian folk rice varieties. Similarly, other workers Kangle 1966, Keith 1967, Cleveland *et al.* 1993, 2000, Arumugasamy *et al.* 2006 and Sathya *et al.* 2007 had recorded large numbers of traditional rice varieties from different parts of India and their adaptation to specific conditions like tolerance to drought, frost, water-logging, salt stress, resistance to diseases, insect pests etc. Various surveys and collection programmes taken up by the National Rice Research Institute (NRRI), Cuttack, Indian Agricultural Research Institute (IARI) and National Bureau of Plant Genetic Resources (NBPGR), New Delhi and State Agricultural Universities (SAUs) for conserving rice germplasm have indicated that nearly 50,000 local rice varieties are still being grown in the country (Roy, 1979).

The traditional rice landraces cultivated in India hold potential for a good number of characteristics such as drought tolerance, frost tolerance, disease resistance, pest resistance, tolerance to salinity and alkalinity, yield rate, suitability of growth in various ecological habitats, medicinal and nutritional traits. The information about selected rice landraces with their unique characteristics is given in Table 1 and Table 2.

### Rice landraces of Southern Odisha

Odisha is known as the genetic paradise of rice and rice constitutes the main crop and staple food for the people of Odisha. Odisha has a rich and diverse genetic wealth of rice and most of the diversity found at the national level is found in Odisha. The first collection of 1,745 types of rice landraces was done from a small tract in Jeypore representing practically the entire range of genetic variability and it helped in establishing the region as the "Secondary centre of origin of cultivated rice" (Ramiah and Ghosh, 1951; Govindswamy and Krishnamurty, 1958). This area has been an amalgamation of primitive tribes who had been preserving their culture and conserving the traditional crops and their wild relatives for thousands of years (Sharma *et al.*, 2000). The region and its surrounding areas constitute a major "Gene Treasury" for rice germplasm. The districts representing South Odisha like Koraput, Nawarangpur, Rayagada and Malkangiri is the home to a vast tribal population who belong to the Proto-Australoid ethnic stock speaking the Munda language of the Austro-Asiatic ethno-linguistic group and patronizing the age old rice landraces for several generations by way of domestication and conservation of these races including shifting cultivation. The dominant tribes including Bhattada, Gond, Paroja, Bhumia, Gadaba, Kandha, Amanatya, Bhatra, Bhumia, Didayi, Dora, Rana, Sabarkandha, Soura Langia, Soura, Pentia, Bondo and Koya (Mishra, 2009) residing in this region have played a crucial role in the domestication of rice by way of its cultivation, conservation and enhancement. The rice landraces used in various occasions like festivals, ancestral ceremonies, family functions and rituals were given top priority for conservation. The traditional life style of these people has always been insulated from the present modern ways of life and comforts. The rice landraces found in Odisha represent a wide range of





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genetic variability particularly for more useful characteristics such as growth in various land types (upland, medium land, lowlands), possession of strong aroma, drought tolerance nature, stable yield (without the use of chemical fertilizers), weed competitiveness, moderate tolerance to pests/diseases, good cooking quality as well as taste, higher grain number, suitability for various fast food preparations etc. During 1955-59, the National Rice Research Institute (NRRI), Cuttack collected 1,745 germplasm accessions of cultivated rice and 150 accessions of wild rice from Jeypore tract of Odisha under a project Jeypore Botanical Survey (Govindaswamy and Krishnamurty, 1958). Among the collections some perennial wild species (*O.rufipogon*), annual wild species (*O.nivara*), and natural hybrids (Spontanea rices) were dominant. Natural hybrids are still available in plenty in the cultivated fields as weeds. Resource poor and tribal people harvest the grains of these weeds from the cultivated fields for their own consumption. Processed wild rice like *Titing chuda* is sold during festivals and eaten on days of fasting (Tripathy, 1994; Sharma, 2005).

The rice landraces cultivated today were allowed to evolve naturally with the changing environment and agricultural practices and they are the products of careful and continuous selection by tribal women and men. The tribal farmers adopt age-old cultivation practices and grow a number of traditional rice varieties timed to mature in months matching festive or ritual occasions. The rice landraces are harvested in months of September when the earlier harvested food gets exhausted. The socio-cultural characteristics of the different tribes found in Jeypore tract vary and are geographically distinct with unique cultures, traditions and practices. These tribal women and men have largely remained unrecognized and unrewarded (Swaminathan, 1996) for several generations. A total of 256 rice landraces documented from 67 tribal villages were claimed to harbor many dominant genes including genes for resistance to diseases, insect pests, physiological stress as well as their nutritive quality, palatability etc. (Tripathy et al., 2005). The National Rice Research Institute, Cuttack and the National Bureau of Plant Genetic Resources (NBPGR), New Delhi jointly explored the undivided Koraput district (1995-96) for rice germplasm covering a distance of 3,080 Kms and collected 318 accessions of which 120 were upland varieties and 198 were medium land and lowland varieties which represent less than one-third of the collections made during the Jeypore Botanical Survey in the late 1950s (Patra and Dhua, 2003). M.S.Swaminathan Research Foundation created partnership for conservation of biodiversity and reduction of poverty involving tribal women and men of Jeypore tract. It was one of the 25 projects that were awarded the Equator Initiative Innovative Partnerships Award for Sustainable Development in Tropical Ecosystems at the World Summit on Sustainable Development held in Johannesburg in August 2002.

M.S.Swaminathan Research Foundation collected 325 rice varieties from Jeypore tract mainly from Koraput, Kalahandi and Phulbani districts. As for the other districts in Odisha, only 3 varieties were collected from Bolangir and Nuapada districts. They found that the traditional varieties available in Bolangir and Nuapada are different from those collected from other places. Out of the total collection, they studied the characteristics of 102 varieties as per NBPGR descriptor. Farmers' opinions on some of the characteristics were also recorded. The traditional varieties were collected with the objective of purifying the seed in participation with the farmers and make the seed available to the farmers. It was found that the yield increases significantly (up to 30%) after purifying the variety.

**Prominent organizations involved in the collection and evaluation of rice landraces of Odisha:**

- National Rice Research Institute, Cuttack, Odisha
- Orissa University of Agriculture & Technology, Bhubaneswar (Departments of Plant Breeding and Agronomy), Odisha
- Orissa University of Agriculture & Technology, Bhawanipatna, Odisha
- Krishi Vigyan Kendra, Bhawanipatna, Odisha
- Sahbhagi Vikas Abhiyan, Bolangir, Odisha
- Action aid, Bhubaneswar and Bolangir, Odisha
- Department of Agriculture, Bolangir, Odisha
- M.S. Swaminathan Research Foundation, Jeypore, Odisha





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## Important Attributes of Rice Landraces

### Disease Resistance

Genetic diversity substantially decreases a crop's vulnerability to diseases. Rice resistance genes remain effective only for a few years of agricultural production before becoming susceptible to pests but diversification in rice landraces has served as a successful pest management strategy. According to reports, farmers cultivating 50 different rice landraces in two upland municipalities in the Alkan province of Philippines do not face any rice pest infestation. The same was also found true for the rice landraces cultivated in the Yunnan province where rice could be cultivated in more than 40,000 hectares of rice land. (Zhu *et.al*, 2000; Frei and Becker, 2004).

### Cultural and Market Value

Rice landraces form an integral part of the rural culture in Asia. A large diversity of rice landraces is still maintained in areas attributed with a cultural value to these races. The most highly valued varieties are reserved for festivals and social occasions or sometimes offered to distinguished visitors. Some of the varieties are used for the preparation of sweetmeats while others with relatively higher yields are used as everyday food. Many varieties are characterized by a very specific taste and seeds of different varieties are exchanged among neighbours and relatives or given as presents. The demand for rice landraces is so high that certain varieties can only be obtained by ordering in advance directly from the farmers. The high status of rice landraces and their superior quality is reflected in a higher market value which in turn makes their cultivation economically attractive. The local rice varieties are sold as 'food for the royals' in the local markets and this has caused the price level to soar three times than that of the ordinary high yielding varieties of rice (Kennedy and Burlingame, 2003).

### Yield Potential

A number of rice landraces have high yield potential even under adverse conditions. When the supply of water is adequate and naturally occurring nitrogen fixing organisms exist in the paddy fields, no synthetic fertilizers are required to produce upto 2 tonnes/ ha of the local variety of rice (Swaminathan, 1984). Characteristics that determine the yield potential of rice cultivars are the nodal number of productive tillers per hill panicle density (number of grains per panicle and grain weight). Many rice landraces have greater mean panicle density and grain weight than most high yielding varieties.

When yield is calculated as production of grains per unit inputs of water and agrochemicals, most of the local rice landraces have better yields than that of high yielding varieties (Cleveland *et al.*, 1993; Deb, 1995, 2000). The yields of most local rice landraces seem to be spectacularly higher when compared to high yielding varieties. A significant feature of rice is that the grain to seed ratio is very high. A single panicle of any of the native rice varieties may contain between 80- 400 grains and in wet cultivation, each plant may produce up to 30 tillers. Thus, an average transplanted native rice variety may produce upto 1,200 grains per seed.

### Grain and Straw Quality

Rice landraces are highly valued for their high grain quality characteristics. Grain quality refers to the palatability, texture and particularly the nutritional value. The attractive grain appearances, nutritional value, cooking and eating quality characteristics have made the rice landraces highly popular among the consumers. The grain consists of the starchy endosperm, the bran including the embryo, the outer grain layers and the inedible fibrous hull. The endosperm contains mostly starch and around 6-10% protein. The bran is diverse in its composition and contains protein, lipid, fiber, vitamins and minerals. The major vitamins are the B-vitamins (thiamine, riboflavin, niacin) and vitamin E ( $\alpha$ -tocopherol). The mineral fraction is mainly composed of phosphorous, potassium, magnesium, zinc, calcium, iron. Carbon, hydrogen, nitrogen and sulphur basically make up the elemental profile. The physical, chemical and cooking quality characteristics of the grain has assumed much greater importance as its demand for local and export consumption are on the increase.





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### Nutritional Value

The traditional rice varieties serve as important elements of crop genetic resources and are highly valued by plant breeders and farmers for their diversity, rarity and adaptability. Rice landraces harbor rich nutrient value in the bran and possess excellent eating quality attributes leading to their nutritional excellence.

### Carbohydrates

Rice is basically a starchy food which provides a large proportion of dietary energy. The properties of starch therefore serve as an important factor in determining the grain quality of rice. The proportion of amylose and amylopectin differ widely in different grain types of rice. Amylopectin containing varieties absorb less water upon cooking and have a sticky structure whereas the amylose containing varieties absorb more water and have a fluffy texture after cooking. The landraces of rice contain a high proportion of amylose and thereby offer fairly slower starch digestion and hence a lower glycemic index was observed in many types (Frei and Becker, 2003). The amylose content in the rice landraces not only decides its cooking and processing behaviour but also the brightness of the grain. (Frei and Becker, 2003).

### Protein

Rice serves as an important source of protein in diet and rice protein is of very high quality compared to other food crops. The protein quality in rice is determined by its amino acid composition and by its digestibility. Rice landraces not only have a higher protein content but also have a higher proportion of lysine which is the limiting amino acid and is particularly essential for the growth of children. Protein content in the high yielding varieties range from 6-10% but rice landraces exhibit protein content up to 14% which is double the amount for an ordinary high yielding variety. The highest values reported in scientific literature reach upto 16 percent of protein for Chinese fragrant long grain rice (Kennedy and Burlingame, 2003).

### Oil and Essential Fatty Acids

Rice lipids, commonly denoted as oil ('rice bran oil') are characterized by a high nutritional value. The liquid consistency of the oil is caused by the high proportion of unsaturated fatty acids accounting for up to 80%. Due to its high level of unsaturation, rice bran oil is known to have blood cholesterol lowering effects. The major unsaturated fatty acids in rice oil are oleic acid (a monounsaturated acid) and linoleic acid (an essential polyunsaturated fatty acid). The average lipid content in the rice landraces was significantly higher than that of the high yielding varieties (Frei and Becker, 2004). The fatty acid content in the high yielding varieties (brown rice) ranged between 2.0 and 2.1 percent, the average value for the landraces was 2.3 percent with individual varieties reaching upto 3.2 percent.

### $\beta$ -Carotene and other Carotenoids

Carotenoids play important roles in photosynthetic processes and act as antioxidants against oxidative damage.  $\beta$ -Carotene is the most effective vitamin A precursor of all carotenoids and play an important role in diets lacking animal products. Rice is usually a very poor source of provitamin A. While the endosperm is virtually free of carotenoids, some traces may be present in the bran fraction. Higher levels of  $\beta$ -carotene are found only in pigmented, i.e. coloured rice varieties. Such coloured rice varieties, especially red and black sorts are only cultivated in areas that maintain a high diversity of rice genotypes. The analysis of  $\beta$ -carotene concentrations revealed upto 0.38 mg/kg in a black/purple landrace rice from the Philippines (Frei and Becker, 2005).

### Iron

Iron deficiency anaemia is considered as one of the most widespread micronutrient disorders in the world. Some estimates say that around half of the world's population is deficient in dietary iron supply. Analysis of a number of rice samples grown under greenhouse conditions at the International Rice Research Institute (IRRI) showed that local varieties had iron content up to 2.5 times higher than that of the common high yielding varieties. In contrast to landraces, the most commonly grown high yielding varieties were at the lowest end of the scale with an average iron



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content of around 10 mg/kg. The highest value cited in the same study was 26 mg/kg for a landrace (Kennedy and Burlingame, 2003).

**Zinc**

Zinc plays an important role in many enzymatic reactions in the body and is also essential for DNA synthesis. Zinc present in the rice grain is found in the outer layers therefore the preference of consumers for milled rice substantially reduces the availability of zinc. Zinc values ranging from 14-59 mg/kg are available in different rice varieties as is proved from the scientific literatures. Zinc concentration is comparatively higher in certain rice landraces than in the commonly grown high yielding varieties. A set of rice landraces from Southeast Asia exhibited an average zinc content of 41mg/kg with values reaching as high as 57mg/kg. (Gregorio,2002).

**Antioxidants**

The bran of rice varieties is rich in antioxidant compounds. Antioxidants play a role in the sequestration of aggressive and carcinogenic molecules which serve as free radicals and thus protect the body tissues and DNA from oxidative damage. The diverse rice landraces serve as rich sources of antioxidants and thus exert important physiological effects on the systems of humans. These landraces also offer tremendous scope for the rice scientists to investigate the potential for the synthesis of antioxidants and their possible beneficial effects (Ling et al, 2001, 2002).

**CONCLUSION**

*In situ*, on-farm conservation is an important means to *ex situ* conservation of traditional crop varieties as this form of management is easy to implement and links farmers' economic concerns with conservation. Crop diversity management can promote on-farm conservation of rice landraces in a feasible and sustainable way. The rice landraces of Odisha need immediate attention for conserving their gene pool in view of the introduction of many high yielding rice varieties which has led to the erosion of local germplasm and their genetic diversity. Rice landraces are thriving in the farmers' field only due to their special phenotypic characteristics that are controlled by the respective genes. The typical rice landraces with useful genes are finding tough replacement challenge from modern rice varieties to survive *in situ*. Therefore the collection, documentation, morphological and molecular characterization of germplasm of each of these varieties is important for utilizing the appropriate attribute based donors in breeding programmes and for protecting the gene pool of these unique rice landraces. Further the diversity and unique features of the rice landraces examined in this study could be quite relevant to both domestic and global rice development. The need of the day is to aggressively market these varieties and promote them through greater public awareness about their important attributes especially among the younger generation to save the qualitative and quantitative traits for future exploitation and restore the rice biodiversity of Southern Odisha.

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**Table 1. States of India with prominent rice landraces (Deb, 2005)**

SL. No.	Name of the States	Important rice landraces
1.	Assam	Rangajoha, Bhabeli, kanjoha, kanku, Bagribhog, Tulasibhog, Rampal, Badshshbhog, Prasadbhog, Malbhog, kalajira, Ranga, Kopausali, Khorikakala, Manki, Tezpuria, Saphila, Koiamari, Kola ahu, Bengoonguti, Hatidotia, Nania, Kolajoha.
2.	Bihar	Sonachur, Badshshbhog, Kanakchura, Shapasand, Tulsiphool, Tulsimanjari, Kesarbani, Marueya, Lakhisar, Kamini, Deobhog, Ramjain, Tulsipasand, Sonalari, Mohinidhan, Sagarbhog, Hansraj.
3.	Gujrat	Krishnakamod, Zeersal, Pankhali.
4.	Haryana	Karnal local, Kaithal.
5.	Himachal Pradesh	Madhumalati, Mushkan, Ramjawain, Achhoo.
6.	Jammu & Kashmir	Muskkanti, Tumlazag, Gul Zag, Qadir Baig.
7.	Karnataka	Krishnapasangi, Kunsumkesari, Kalabatta, Kavali, Ratansagar, Vasane Sanna Batta, Yalakkisali, Jeerigisanna, Kagisali, Gandhsali, Gulvadi, Karigajaville, Mugad Sugandha, Beeraga, Huggibhatta.
8.	Kerala	Gandhakasala, Jeerakasala, Velumbala, Chomala, Kayama, Kothampalari, Pookkilathari.
9.	Madhya Pradesh	Chakarbhata, Badshshbhog, Chhatri, Chinoor, Badshshbhog, Chirnakhai, Dubraj, Gangaprasad, Adamchini, Antraved, Amarjyoti, Kapursar, Loktimanchi, Srikamal, Samor chini, Vishnuparag, vanaspatri, Chiranki, Tedai.
10.	Maharashtra	Gham, Ghansal, Banaspatri, Chinoor, Krishna sal, Ambemohor.
11.	Manipur	Chakao poireiton, Chakao angouba, Chakao amubi, Phoren mubi, Langgphou Anganba.
12.	Mizoram	Tai, Pharate, Phanrai, Mawang buh, Zongam, Bawang buh.
13.	Odisha	Thakurbhog, Durgabhog, Pimpidibasa, Tulasiphulla, Gangabali, Sitakesari, Barangamalli, Mugajai, Laxmivilas, Suragaja, Dubraj, Basnaphalli, Kalajira, Jhilpanjiri, Lektimahi, Karpurakali, Nalidhan, Chinikamini, Tikichudi, Asamchudi, Baunsidubraj, Deulabhoga, Kanakchudi, Muktabali, Kalamalli, Kandulakathi, Dudhamani, Sapuri, Umuriachudi, Tulasiganthi, Pathangada, Sunaseri, Mugudi, Baramasi.
14.	Punjab	Quadian basmati, Basmati 370.
15.	Rajasthan	Zed zeera, Sutar, Danger, Pathania, Ratipanne.
16.	Tamilnadu	Jeerakasambha, Dharichal, Dular, Tilak kacheri, Kappakar, Samba mosanam.
17.	Tripura	Kalijira, Govindbhog, Sadakhaja, Kalakhau.
18.	Uttarpradesh	Kalanamak, Adamchini, Bindli, Badshshbhog, Batanphul, Hansraj, Benibhog, Dulhania, Kamalijira, Lalmati, Jeerabati, Tulsimanjri, Vishnuparag, Tilakchandan, Ramjawain, Dhania, Shakarchini.
19.	West Bengal	Badshshbhog, Tulasibhog, Govindbhog, Seetabhog, Chinisakar, Ramtulsi, Kalijira, Mahishadhan, Tulaipani, Kataribhog, Patina, Kalonunia.



Koustava Kumar Panda *et al.***Table 2. List of some important rice landraces with unique characteristics (Deb, 2005)**

Name of the Landrace	characteristics
Dharichal, Dular, Tilak Kacheri	Suitable for different ecotypes
Kapakkar	Tolerant to drought, floods, pests and diseases
Samba Mosanam	Tolerant to water logging
Kelas, Bhutmuri	Suitable for dry land
Jabra, Lakshmi, Dighal, Pantara	Deep water varieties
Katari Bhog, Bans kathi, Kamal Bhog, Srabanti Sal, Simul kuri, Ban Kata, Heera Moti, Kabirajsal, Kaya Kelas, Tulasi manjari, Gangajal, Sharita, Dahar Nugna, Sindur Mukhi,	Disease resistant varieties
Agnisal , Ashu, Kalam Kathi, Bou Bhog, ,	Tall varieties
Mala, Narayanmani	Semi-dwarf varieties
Kalam Kathi, Lakshmi Chura, Padmasal,	Long straw yielding varieties
Badshahbhog, Chinnikamini, Jagannath Bhog, Tulasi Manjari, Swarnakanthi, Garam Masala, Talsa, Gandhamalati, Jata Subasita, Rani Kajal, Mohon Bhog,	Fragrant rice varieties
Tenduphool, Njavara, Bhat Mooori, Parmai-sal, kabiraj-sal, Karunguruvai,	Medicinal rice varieties
Bahupuri, Kabiraj sal, Darkasal, Tulsu Mukul,	High yielding varieties
Ashphal, Bakul phool, Bokva, Ganga sal, Patnai	Varieties with heavy grains
Ashphal, Bahurupi, Bansh Pata, Juqal, Kabiraj-sal, Kerala-sundari, Panjab-sal	Higher panicle weight

**Table 3. Comprehensive list of some important rice landraces from Odisha**

S.N.	Southern Odisha	Western Odisha	Eastern Odisha	Northern Odisha
1.	Basubhoga	Dubraj	Kedara Gouri	Krishnbhog
2.	Deulabhoga	Laxmi Bhog	Padma Kishori	Govindbhog
3.	Baunsudubraj	Karpurakanti	Khas Kamini	Tulsibhog
4.	Kalamalli	Pruthiraj	Gobinda Bhog	Prasadbhog
5.	Bayagunda	Sorishaphula	Pimpudi Basa	Badshahbhog
6.	Sunaseri	Mayur chulia	Kalajeera	Rajbhog
7.	Muktabali	Nadiakata	Ratna Chudi	Kaminibhog
8.	Pandakagura	Nadiakora	Kannia Patia	Kalajeera
9.	Haldichudi	Tulasibasa	Sohra	Durgabhog
10.	Kandulakathi	Dhoba-Baspatri	Kalakiyari	Pimpudibasa
11.	Asamchudi	Jeerabati	Nadia Phulo	Basnaphali
12.	Machhkanta	Jeeradhan		Barangamalli
13.	Loktimachhi	Barli		Nalidhan
14.	Meher	Kalikaranji		Manasi
15.	Matidhan	Yubraj		Prabhatjeera
16.	Sapuri	Saria		Jala
17.	Umuriachudi	Setka		Lekhtimahi
18.	Kalahandia Meher	Karani		
19.	Bodikaberi Dhan	Harishankar		





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20.	Kanakchudi	Kusuma		
21.	Gangabali	Jhilli		
22.	Mahulakunchi	Gelehi		
23.	Paradhan	Asamchudi		
24.	Dangarchudi	Poradhan		
25.	Tikichudi	Lahadel		
26.	Bhatagunda	Chinger		
27.	Pathangada	Latia		
28.	Basumati	Dengbarei		
29.	Dudhamani	Kusuma		
30.	Tulasiganthi	Cheregudi		
31.	Mugudi	Menakadhan		
32.	Baramasi	Harisankar		
33.	Baunsidubraj	Menka		
34.	Badshabhog	Dawanra		
35.	Samudrabali	Mahipal		
36.	Chinidhan	Sapuri		
37.	Tulasi	Sankari Banko		
38.	Kuyerkulig	Changeri		
39.	Kaliasura	Suragaja		
40.	Kalajeera	Lakshmibilas		

**Table 4. Rice landraces conserved in M.S.Swaminathan Research Foundation, Jeypore**

S.N.	Name of the traditional variety	Ecosystem	Duration(Days)	Special characters
1.	Pathangada	Low land	140-145	Puffed rice
2.	Dudhamani	Low land	140	Scented
3.	Tikichudi	Lowland	110	Scented
4.	Samudrabali	Lowland	180	Scented
5.	Bayagunda	Lowland	180	Scented
6.	Bastabhog	Lowland	150	Scented & deep water
7.	Pandakagura	Lowland	120	Pressed rice
8.	Umuriachudi	Lowland	135	Popular
9.	Sunaseri	Lowland	150	Pressed & puffed rice
10.	Bagada Bayagunda	Lowland	145	Scented
11.	Sapuri	Lowland	140	Flood resistant
12.	Asamchudi	Lowland	140	Flood resistant
13.	Haldiganthi	Lowland	160	Flood resistant
14.	Baunsidubraj	Lowland	140	Scented
15.	Kandulakathi	Lowland	160	Flood resistant
16.	Haldichudi	Lowland	145	Scented
17.	Badshabhog	Lowland	150	Scented
18.	Kanakchudi	Lowland	180	Flood resistant
19.	Gangabali	Lowland	140	Flood resistant
20.	Kalajeera	Lowland	140	Scented
21.	Loctimachhi	Lowland	150	Scented
22.	Machhakanta	Lowland	150	Scented
23.	Desidubraj	Lowland	140-145	Scented



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24.	Deulabhog Dhan	Lowland	140-150	Scented
25.	Sunaseri	Lowland	130	Scented
26.	Baramasi	Lowland	120	Popular
27.	Bodikaberi Dhan	Medium land	115-120	Scented
28.	Bhatagunda	Medium land	120	Scented
29.	Bhatamakada	Medium land	100-120	Puffed and pressed rice
30.	Bhata Dhan	Medium land	90	Scented
31.	Nimchudi Dhan	Medium land	120	Flood resistant
32.	Kalahandia Meher	Medium land	110-120	Flood resistant
33.	Bagudi	Medium land	120	Scented
34.	Meher	Medium land	120	Flood resistant
35.	Muktabali	Medium land	120	Popular
36.	Bhatasundari	Medium land	120	Scented
37.	Pandakagura	Upland	120	Drought resistant & popular
38.	Dangarbayagunda	Upland	100	Popular
39.	Matidhan	Upland	90	Puffed & pressed rice
40.	Basumati	Upland	90	Popular
41.	Kanei	Upland	90	Popular
42.	Mahulakunchi	Upland	120	Popular
43.	Dangarbasumati	Upland	120	Popular
44.	Dangarchudi	Upland	120	Popular
45.	Paradhan	Upland	90	Popular

Table 5.Characteristics of some purified rice landraces of Southern Odisha (Adapted from MS Swaminathan Research Foundation, Chennai)

Accession No.	Name of landrace	Landtype	Duration (days)	Leaf sheath colour	Husk colour	Kernel colour	Quality
J1	Bobblihutta	Upland	105	Purple	Fawn	White	Super fine
J2	Mohulkunchi	Upland	110	Purple	Brown	White	Medium fine
J3	Chitikana	Upland	125	Purple	Fawn	White	Coarse
J4	Sourmundabali	Medium land	145	Green	Fawn	White	Medium fine
J5	Chudi	Medium land	150	Green	Fawn	White	Medium fine
J6	Ratnamali	Medium land	150	Green	Yellow	White	Super fine
J7	Karandi	Lowland	165	Green	Fawn	White	Coarse
J8	Lakadi Machi	Upland	135	Green	Fawn	White	Coarse
J9	Khichidi Samba	Lowland	150	Green	Fawn	White	Medium fine
J10	Barang Chudi	Upland	130	Green	Fawn	White	Coarse
J11	Bayagunda	Lowland	150	Green	Fawn	White	Medium fine



Koustava Kumar Panda *et al.***Table 6. Important rice landraces of Southern Odisha and their characteristics (Adapted from MS Swaminathan Research Foundation, Chennai)**

S.N.	Name of the Varieties	Duration required for flowering(days)	Specific Characters	Avg.YI (QI/ha)
1.	Asamchudi	138	Tall plant, long slender grain, strong and long straw, disease and pest resistant	15-20
2.	Barapanka	142	Medium quality grain having good yield potential	15-20
3.	Bhaktichudi	130	Medium slender grain, best for fried rice	15-20
4.	Dangardhan	100	Early matured, popular variety, medium grain, drought resistance, provide food during lean period	17-20
5.	Gathia	122	Popular variety, bold grain, drought resistant, tasty, early cooked	15-19
6.	Haldichudi	130	Popular variety, slender grain, better market price (Rs 16/kg), tasty, best for preparing fried rice & biriyani	15-20
7.	Kalamalli	140	Long medium sized grain, tasty, long straw used for thatching, cultivated by the tribals to have a control over wild rice in the field due to black base colour	15-20
8.	Kandulakathi	147	Medium grain, best for puffed rice, strong straw, provides more energy	17-22
9.	Machhakanta	140	Long slender grain, flood resistant, better local market price (Rs 18/kg), tasty, good for fried rice	15-20
10.	Muktabali	120	Dwarf variety, medium grain, very good yield potential, high tillering density, disease and pest resistance, used as food for daily needs	20-25
11.	Osagathiali	90	Early matured, popular variety, medium slender grain, used by tribals for NUAKHAI (eat first rice in the festival)	10-12
12.	Pathangada	142	Tall, bold grain, tasty, provide more energy to the tribals to work for longer durations, used for perched rice	15-20
13.	Pandakagura	110	Early matured, drought resistant, bold grain, tasty, popular, cultivated by almost by each and every tribal household, provide food during lean period, cultivated singly as well as in mixed cultivation	10-12
14.	Sapuri	130	Medium slender grain, good yield potential, good market price (Rs 13/kg) locally, good quality straw	25-30
15.	Sekra	132	Awne black husk, used as boarder plant to save main crop	15-18
16.	Sindhikoli	145	Cluster spikelet, medium grain, tasty	15-20
17.	Paradhan	100	Early matured, drought resistant, medium grain, tasty, popular, cultivated by almost each and every tribal household, provide food during lean period, cultivated with both solo and mixed cultivation, used by tribals for the first menstrual festival of the young girl child	15-20
18.	Umuriachudi	150	Medium grain, popular variety, disease, pest & flood resistant, tasty, long straw	20-25





## Statistical Time Series Modelling for Price Forecasting of Crops

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### ABSTRACT

Time series modelling is a dynamic research, which mostly aims to carefully collect and rigorously study the past observations of a time series to develop an appropriate model which describes the inherent structure of the series. Further, this model is used to generate future values for the series, i.e. to make forecasts. Time series forecasting thus can be termed as the act of predicting the future by understanding the past. Forecasting the price of agriculture commodity such as vegetables, fruits (Horticultural crops) cereals, pulses, oilseeds (Agricultural crop) etc. is important related to economic concerned, farmer perspective, Agriculturist and Industrialist. Price forecasting help famers to take effective decision regarding market price (mandi price) or selling price of their crop, which crop to grow to earn profit, ultimately improve the condition and income of famer and also helps policy maker for agriculture decision. For forecasting area, production & productivity of agricultural crops, mostly ARIMA (Autoregressive integrated Moving average) Model is used but in case of price forecasting of agricultural crops ANN (Artificial Neural Network) is used. Neural Network approaches are applied in the field of agriculture for price forecasting in both short term and long terms. Large amount of data related to commodity price, daily market price, arrival price is available. Neural approach with fuzzy can be used and also neuro fuzzy system may help in future for future price forecasting of commodity.

**Keywords:** Time series modelling, price forecasting, ARIMA, ANN, fuzzy

### INTRODUCTION

Time series forecasting can be termed as the act of predicting the future by understanding the past. Due to the indispensable importance of time series forecasting in numerous practical fields such as business, economics, finance, science and engineering, etc. proper care should be taken to fit an adequate model to the underlying time series. It is



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obvious that a successful time series forecasting depends on an appropriate model fitting. A lot of efforts have been done by researchers over many years for the development of efficient models to improve the forecasting accuracy. As a result, various important time series forecasting models have been evolved in literature.

**ARIMA Model**

One of the most popular and frequently used stochastic time series models is the Autoregressive Integrated Moving Average (ARIMA). The basic assumption made to implement this model is that the considered time series is linear and follows a particular known statistical distribution, such as the normal distribution. ARIMA model has subclasses of other models, such as the Autoregressive (AR), Moving Average (MA) and Autoregressive Moving Average (ARMA) models. The ARIMA model, also known as the Box-Jenkins model or methodology, is commonly used in analysis and forecasting. It is widely regarded as the most efficient forecasting technique in social science and is used extensively for time series. The use of ARIMA for forecasting time series is essential with uncertainty as it does not assume knowledge of any underlying model or relationships as in some other methods. ARIMA essentially relies on past values of the series as well as previous error terms for forecasting. However, ARIMA models are relatively more robust and efficient than more complex structural models in relation to short-run forecasting

**SARIMA Model**

For seasonal time series forecasting, Box and Jenkins had proposed a quite successful variation of ARIMA model, viz. the Seasonal ARIMA (SARIMA) The popularity of the ARIMA model is mainly due to its flexibility to represent several varieties of time series with simplicity as well as the associated Box-Jenkins methodology for optimal model building process. But the severe limitation of these models is the pre-assumed linear form of the associated time series which becomes inadequate in many practical situations. To overcome this drawback, various non-linear stochastic models have been proposed in literature however from implementation point of view these are not so straight-forward and simple as the ARIMA models.

**ANNs Model**

Recently, artificial neural networks (ANNs) have attracted increasing attentions in the domain of time series forecasting. Although initially biologically inspired, but later on ANNs have been successfully applied in many different areas, especially for forecasting and classification purposes. The excellent feature of ANNs, when applied to time series forecasting problems is their inherent capability of non-linear modelling, without any presumption about the statistical distribution followed by the observations. The appropriate model is adaptively formed based on the given data. Due to this reason, ANNs are data-driven and self-adaptive by nature. During the past few years a substantial amount of research works have been carried out towards the application of neural networks for time series modeling and forecasting. In 2008, C. Hamzacebi had presented a new ANN model, viz. the Seasonal Artificial Neural Network (SANN) model for seasonal time series forecasting. His proposed model is surprisingly simple and also has been experimentally verified to be quite successful and efficient in forecasting seasonal time series.

Artificial neural networks (ANNs) as a soft computing technique are the most accurate and widely used as forecasting models in many areas including social, engineering, economic, business, finance, foreign exchange, and stock problems. Its wide usage is due to the several distinguishing features of ANNs that make them attractive to both researchers and industrial practitioners. As stated in ANNs are data-driven, self-adaptive methods with few prior assumptions. They are also good predictor with the ability to make generalized observations from the results learnt from original data, thereby permitting correct inference of the latent part of the population. Furthermore, ANNs are universal approximator as a network can efficiently approximate a continuous function to the desired level of accuracy. Finally, ANNs have been found to be very efficient in solving nonlinear problems including those in real world. This is in contrast to many traditional techniques for time series predictions, such as ARIMA, which assume that the series are generated from linear processes and as a result might be inappropriate for most real-world problems that are nonlinear. There is growing need to solve highly nonlinear, time-variant problems as many



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applications such as stock markets are nonlinear with uncertain behaviour that changes with time .ANNs are known to provide competitive results to various traditional time series models such as ARIMA model .

**Price Forecasting**

Price forecasting helps farmer and agriculturist to know about the growth or trend or price value of product before selling to mandi also help the policy maker for creation of different policy by generating rules according to price analysis. By analysing the price value, demand or supply as well as cultivated area related to crop helps farmer for decision making activity and ultimately helps in economic growth of our country.

**LITERATURE STUDY**

Shih *et al.* proposed a model for price prediction based on weighted case-based reasoning approach. Three cases such as equal wighted,unequalweigth and linear weighted CBR are investigated and compare. Most suitable weight for features are selected by genetic algorithm. For prediction model data related to imported chicken ,economic index and production data from Taiwan agriculture is used. Result of proposed research shows that CBR approach performance is better than other predcition approach such as linear regression,regressiointree,CART and neural net.Result also give information that colourful boiler and chiks price affect the price . Kohzadiet *al.* for price forecasting of commodity compare neural network model with time series model. They used price data of US live cattle and wheat of forty years taken from USDA. Multi Layer Feed forward neural approach a supervised leraning technique is compared with ARIMA. Slinding window and walk forward approach is used. They suggested that NN perform better than ARIMA and Mean square error is about 27 and 56 percent lower than ARIMA. Also other measure shows by a neural network such as absolute mean error and mean absolute percent error were also lower.Neuralnetwokr has the capabiltiy to show major turning points for both wheat and cattle. Zouet *al.* for forecasting china food grain price, explore and compare the neural network and time series model.

Researcher gives a new concept to create a model by combining two model such as time series model ARIMA and neural network approach such as back propagation using Equal weight method i.e using arithmetic average of individual forecast as it is an easy method. Two kinds of evaluation criteria such as quantitative evaluation such as MSE,MAPE,and MAE and turning point is evaluated by advance version of Mertons test used by researcher. The result shows that forecasting performance of combine model is better then individual in terms of error evaluation measurement. Network structure such as 2\*4\*1 is selected to model price series and ARIMA(1,1,0) is realtively best as per researcher findings.Also suggested that ANN is best suited model for capturing profit and turning points and better then traditional ARIMA and also accuracy achieve by combine model is better than individual one. In financial market, back propagation is used for discovering nonlinearity in financial data. But back propagation suffer from problem of low converges and is not robust method so the researchers Haofei*etal.*for price froecasting learning task in nerual nets bring in concept of multi stage optimization in back propagation.

In their paper they state that problem of backpropagation can be overcome by MSOA and performance of forecasting in terms of error and directional evaluation measurement is better achieved by MSOA. Average Training time of MSOA is 4.25s and of Back propagation is 7.83s respectively. Yu *et al.* uses neural network as a meta learning technique for designing a time series forecasting model to increase prediction accuracy while data consist of noise. Researchers do metamodelling by performing data partition and sampling for creation of different subset of training based on that base learning model is created and Fuzzy neural network is used in study for both as base learner and meta learner. They used PCA technique for model selection and pruning and then meta model is created from selected model.They concluded that prediction performance of nonlinear metamodelling technique is better when compare to single time series forecasting models such as ARIMA, FNN and SVM and other linear metamodelling technique such as simple averaging, simple MSE, Stack dregression ,variance weighting for financial time series data.netwrok perform well with pruning using PCA. Gan-Qiong Li *et al.*, proposed a forecasting model where short term price forecasting of tomato has been done by three layer Feed forward neural network and result compared



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with time series ARIMA model and shows that neural network performs better for price prediction of one day with accuracy is about 90 % or week before price prediction with accuracy about 80 %. Riberio *et al.* proposed a hybrid commodity price forecasting model for sugar price prediction using feed forward neural network such as multilayer perceptron model and Kalman filter. Data from Brazilian and Indian market is taken for study. Kalman filter is used to consider price as stochastic process and also include future price in forecasting and also minimize the error measure. ANN is used for Exogenous variable analysis and also ANN applied to Kalman filter result to get improvement in result. Subhasree *et al.* predict the next day price of vegetable using time series data. Machine learning algorithm such as Radial basis function, back propagation neural network and genetic based neural network is used for study and comparative result concluded that predictive accuracy achieved by genetic based neural network is about 89% and error rate is 0.11 which is better than both back propagation whose accuracy is about 79 % and error rate is 0.21 and radial basis function accuracy is 52 % and error rate of 0.48. Ahumada *et al.* discussed that the forecasting accuracy of individual food price model can be improved by considering their cross dependency.

Food price of Soyabean, corn and wheat are strongly correlated. They estimated Equilibrium correction model for each food price and then studied the residual cross correlation for interdependency and thus perform a joint modelling. Four different econometric model are studied such as EqCM, DEqCM, DVAR and random walk econometric model are tested for each food price with different time horizon and scheme such as recursive or fixed. And they concluded that EqCM (Single for wheat and joint for corn and soyabean) perform best for time horizon  $h=4$ . For forecasting price of agricultural product in Brazil, researchers Pinheiro and Senna perform multivariate analysis of price of products and also use neural network application for forecasting price i.e., combine the ANN model with multivariate analysis. They study on time series of price for product. Product chooses based on the export volume growth of product. Daily time series data is converted into weekly data. In their study, Forecast for ANN-MSSA and ANN are compared with 12 week data to final week sample. In this study the difference between ANN-MSSA and the ANN model is given by the treatment to separate noise from the original time series. Empirical data states that performance of MSSA-ANN methodology is better than that of ANN model. Study combines MSSA to decompose the time series with ANN model and good alternative for forecasting price of different commodity. Result will be useful to formulate and implement policies directed to agriculture sector.

**CONCLUSION**

To maximize profit in agriculture marketing, there is need to forecast the future price of commodity among the farmers and other participant of market. In the aforementioned work a study of different forecasting methodologies is done in agricultural market environment. Multiple factor such as seasonality, trend, cycle, holidays, economic index etc., affects the price of commodity, for that reason price forecasting is not a simpler task. It can be concluded that Forecasting require filtering, smoothing of data due to missing and noisy data, storage and retrieval of historical data, model creation for processing past data and predicting future trend or value. Performance measure such as MSE, MAPE is used for evaluating the performance of forecasting model. There are several linear and nonlinear method individually or jointly used for forecasting such as ARIMA, Hybrid ARIMA-GARCH, and back propagation, Feed forward neural network, radial basis, genetic is used for optimization etc. are used by the researcher for forecasting. Accordingly, in future other Time series modelling, Evolutionary approach with fuzzy can be used for better forecasting and also one can employ deep learning with big data for agriculture commodity price forecasting.

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## Waste Land Management –A Case Study on Impact of Land Use and Land Cover by Using Various Survey Aspects in Vizianagaram District of Andhra Pradesh State

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### ABSTRACT

Plot use and plot cover changes are derived by natural process and anthropogenic interference in ecosystem. Appropriate management of natural resources requires quick and up-to-date information for effective decision making. The aim of this study is to generate such kind of information using RS (Remote Sensing) and GIS (Geographical Information System) technology to support the land use planning and strategy formulation of the newly emerging problem of the study area. Two satellite imageries of LANDSAT TM, MSS 2000, and LANDSAT MSS 2010 were utilized for detection of LULC with wasteland demarcation. Land under cultivation (Cultivated area), waterbodies, Land not suitable for cultivation (waste land) and other classes.

**Keywords:** Remote Sensing, Monitoring, Work environment, Land Use, GIS, Land Cover

### INTRODUCTION

A cutting edge country, as an innovative corporate must have enough numbers on several complex interconnected parts of its exercises so as to settle on choice. The land which is used as perspective, so far the information regarding the use and also its spread has acquired a significant progress with time as intends to conquer issue the random, turn of events, decaying ecological quality, loss of prime horticultural grounds, and decimation of significant wetlands. Land use is just a single such perspective, yet information about land use and land spread has gotten progressively significant as the Nation intends to conquer the issue of random, uncontrolled turn of events, decaying ecological quality, loss of prime horticultural grounds, decimation of significant wetlands. The information on spatial land spread data is basic for legitimate administration, arranging and observing of normal assets.



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Land use/land spread mapping both by visual understanding and advanced investigation is conceivable by satellite remote detecting procedures. The land use/land spread classes can be extended or decreased to any degree and be made progressively receptive to the data the client needs. Late innovative advances made in space made of spatial innovation causes impressive sway in arranging exercises. Quick pace of industrialization, urbanization, rural turn of events what's more, populace development have squeezed the utilization of land, water and vegetation in all aspects of the earth. Land, one of the most significant assets of Himalayan district is under consistent pressure and is quickly changing over into no man's land. The well-balanced land and vegetation/crop affiliations have been disturbed. In real practice, the condition is abandoning terrible to more regrettable. Along these lines, there is an earnest need of recovering these corrupted terrains by proper practices, which relies on the consciousness of individuals.

This coordination of spatial information and their joined investigation is performed through GIS strategy. It is a PC helped framework for catch, recovery, examination and show of spatial information and non-spatial characteristic information. With expanding consideration being paid to alleviating the impacts of a worldwide temperature alteration, there has additionally been an ascent in consideration about vitality strategy. In the United States, the arrangement of Barack Obama as President and his course of action of Stephen Chu as the Secretary of Vitality – the two devotees to an unnatural weather change and promoters of bringing down dependence on fossil energizes – vows to acquire changes national vitality strategy. National vitality strategy alludes to government the executives and guideline of vitality creation, appropriation, also, utilization, which can have suggestions for state and nearby government vitality strategy. Significant partners in national vitality strategy can incorporate the president, Congress, bureaucratic associations (Department of Energy), state and close by governments, Native American nations, industry, and publics. President Obama's (Whitehouse.gov 2009) national game plan for "ensuring about our essentialness future" remembers diminished dependence for remote wellsprings of fossil powers and expanded dependence on household petroleum derivatives, sustainable power source, biofuels, and atomic force alongside the advancement of vitality effectiveness.

## LITERATURE REVIEW

Each package of plot on the world's surface is exceptional in the spread it has. Land use and land spread are unmistakable yet firmly connected quality of the Earth's surface. Land Use is the way where individuals utilize the land and its assets. Example of land use incorporate agribusiness, urban turn of events, brushing, logging, and mining. The term land cover originally referred to the kind and state of vegetation, such as forests, wetlands, pasture, roads and urban areas. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover, but it has broadened in subsequent usage to include human structures such as building or pavement and other aspects of the natural environment, such as soil type, biodiversity, and surface and groundwater.

Land use influences land spread and changes in land influence land use. A change in either anyway isn't really the result of the other. Changes in land spread via land use don't really infer a debasement of the land. Be that as it may, many moving area use designs, driven by an assortment of social causes, bring about land spread changes that effect global climate and biosphere ( Riebsame, Meyer ,and Turner ,1994). Land use/land bay changes has been the center program of worldwide ecological change inquire about. Its effects on local natural condition are one of the significant substance of land use/land spread research. This paper investigated the impacts of land use/land spread changes on provincial atmosphere, climatic quality, soil properties, water amount and quality. Land use/land spread changes impact territorial atmosphere by adjusting the surface albedo and the organization of green gas and follow gas in environment. They influence some dirt biological procedures and various organizations of land use/land spread effect sly affect supplement stream in soil. Non-point source contamination is the primary techniques by which land use/land spread changes impact water quality, numerous significant Non-point contamination sources are connected with the changes. Some eco-natural issues brought about by human ill-advised utility, for example, soil disintegration, land corruption, water shortage and ocean drawing closer are likewise proposed. The loss of



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rainforests all through the tropical areas of the world because of deforestation for lumber assets and transformation to farming grounds has become a subject of worldwide consideration with the guide of across the board media inclusion. Examination authorities, for example, Skole and Tucker (1993), Skole et al (1994), and Kummer and Turner (1994) perform broad investigations trying to point out further this circumstance by concentrating on the social ramifications and the ecological debasement related with tropical deforestation in the Amazon of South America and in Southeast Asia.

### **RS and GIS for Plot use /Plot Cover**

Development of Remote Sensing and Geographic Information System (GIS) technologies have lead to the advancement of mapping and interpretation techniques as a means of understanding and effectively managing the natural resources in a sustainable manner. At present, remote sensing in combination with the land use/land cover dynamics (Codjoe, 2007). As a result, the GIS Serve as a tool for analyzing interaction among and within the various spatially referenced data schemes.

GIS have four principle capacities identified with information:

- A. Information input,
- B. Information stockpiling, recovery, and database the board,
- C. Information examination (information control, investigation, and affirmation), and
- D. Yield (show and item age)

### **Description of the Study Area**

This territory was governed by various Hindu heads of Kalinga (old Orissa) up to the medieval period. After the fall of the brought together Gajapati realm of Orissa, the locale was represented by the Golkonda rulers. The progenitors of the Maharajas of Vizianagram are expressed to be plunged from the Ranas of Udaipur, the Sisodia part of the Guhilot clan and Vasishtgotra.

### **Location and Composition**

Vizianagram area was shaped on first June 1979, with central station at Vizianagram according to G.O.Ms.No 700/income (U) Department dated fifteenth May 1979 with partition cut from srikakulam & Visakhapatnam Districts. Vizianagram district is situated within the geographical co-ordinates of 17-16' and 18-16' of the northern latitude and 85-00' and 84-47' of the western longitude. The district is bounded on the east by Srikakulam District on the west and south by Visakhapatnam districts, on the south east by the Bay of Bengal and North West by Orissa State.

### **Geography**

Vizianagram is located at 18.12 N 83.42E. It has a normal rise of 74 meters (244 feet).

### **Demographics**

As of 2003 Indian census, Vizianagram had a populace of 200,000. Male establish 45% of the populace and females 53%. Vizianagram has a normal education rate of 67%, higher than the national normal of 58.5%. Male education is 75%, Female education is 62%

### **Earths**

The fundamental muds in the areas remain red soils, dirty topsoil's and sandy dirt and they establish 96% of the all-out zone. The dirt's in the locale are overwhelmingly loamy with medium richness. Around persist for the most part red loamy soils, undoubtedly and earth loamy in the event of wet terrains.



**K. Lalit Kumar****Natural Resources**

The Major rivers flowing in the district are

1. Nagavali
2. Champavati
3. Gomukhi
4. Krishna
5. Bansadhra
6. Godvari

**Total Geographic Area 1243 hec.**

Uncultivated land covered 16.46% of total area .Forest area covered by 3.34% Scrubs, vegetation and plantation covered 0.8%, 5.16% and 9.6% of the study area respectively. The percentage of classification is shown below.

**RESULTS**

To determine wastelands lands and landuse classification in the study area (viziangarammandalam, vizianangram district, A.P) satellite imageries, topo sheet and statistical hand books data has been studied. Field check was done to verify the results of unsupervised classification .For Accurate results Supervised classification of land use was done using G.I.S. Base map of vizianangrammandal has been prepared and merged the satellite data to identify the classification of land use using unsupervised classification.

**CONCLUSIONS**

The following conclusions are made in this study built up lands and water bodies are also classified in this work. it is observed that Cropped area is decreased by 30% in 2010.80% LULC classification concurrent when compared to statistical reports of Vizianangrammandal 2000 and 2010.98% of the results obtained in this study are concurrent in forest area demarcation.85% of the results obtained in this study are concurrent in the waste lands covered by the study area.

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**Table 1. Aftereffects of Land use Land Cover Classification in 2000**

S.No.	LULC-2000	AREA(hec)	% of Total
1	Built –up Lands	580.24	4.66%
2	Cultivated Lands	7397.55	59.48%
3	Fallow Lands	501.48	4.03%
4	Forests	416.00	3.34%
5	Plantation	1200.55	9.60%
6	Scrubs	100.55	0.80%
7	Un-Cultivated Land	2047.54	16.46%
8	Vegetation	642.00	5.16%
9	Wasteland	264.02	2.12%
10	Water bodies	153.22	1.23%





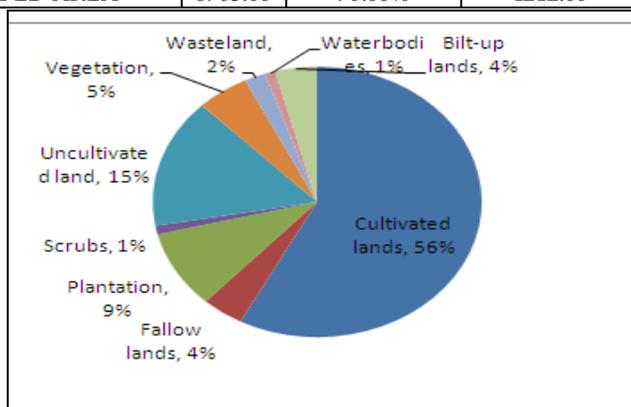
**K. Lalit Kumar**

**Table 2. Results of Land use Land cover classification in 2010**

S.No	LULC-2010	AREA (hec)	% of Total
1	Built-up Lands	654.29	5.26%
2	Cultivated Lands	3664.45	29.47%
3	Fallow Lands	2626.90	21.12%
4	Forests	418.00	3.365%
5	Plantation	1225	9.84%
6	Scrubs	140.74	1.13%
7	Un-cultivated Land	3781.68	30.40%
8	Vegetation	652.25	5.24%
9	Wasteland	267.09	2.14%
10	Water bodies	167.99	1.35%

**Table 3. Statistical hand book reports of 2000 & 2010**

S.No	Land Classes	LULC -2000	% of Total	LULC-2010	% of Total
		Area (in Hec)		Area (in Hec)	
1	FOREST	420.00	3.40%	420.00	3.40%
2	BAREEN AND UNCULTIVATED	248.00	2.00%	247.00	2.00%
3	LAND PUT TO NON AGRICULTURAL USES	2497.00	20.00%	4502.00	36.20%
4	CULTIVATED WASTE	59.00	0.50%	60.00	0.50%
5	OTHER FALLOW LANDS	468.00	3.80%	859.00	6.90%
6	CURRENT FALLOWES	129.00	1.00%	2217.00	17.80%
7	TOTAL CROPPED AREA	8703.00	70.00%	4212.00	33.90%



**Figure 1. Percentage of Plot use & Plot cover classification in 2000**





## Teenagers and Substance Abuse

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### ABSTRACT

The article here speaks about the teenagers and their addiction towards the substance abuse. The analysis in this article is all about how the young adults harm themselves with the usage of the compelling substance abuse. As the teenager brain is not fully developed but is in a developing state until they reach the mid-20s. It indicates that what ever decision they take may not be wise for them and can ruin them mentally and physically. They fail to decide what is right and wrong because of lack of thinking capability and get influenced by various dominating factors which lug them towards substance abuse like drug, tobacco and alcohol. This article highlights the genesis that leads to substance abuse used by the teens as well as showcase the safeguards to plug up the path that steer the movement of the teens and make them aware of the perilous substance abuse.

**Keywords:** Substance abuse, Teenagers, Addiction

### INTRODUCTION

Discerning the drivers of dependence producing drug, adoption among youth is alarming and has become a threat all over the world. It is becoming wonted atop the indefinite continued progress in the past as well as in the present scenario. Young adults are more attracted towards this substance abuse. The degree of consumption of substance abuse is more in teenagers than the older adults. Teenagers, especially students joining college and university have more feasibility of exposure of being attacked or harmed by dependence drug that leads to addiction. Now a days, it is not only that young adults experience their independence after joining college[1], university and acquire the freedom of staying in hostel, or outdoors, get attacked by the dependence drug but also the teens staying at home also experience the feeling of freedom are likely to be stormed by the abusive substances. It has been also observed that teenagers are not only attacked when they reach college or university but are also striked by substance abuse, by the time they reach the high school. The thought of independence that prevails in the mind of the teens and they try to explore it for gaining new experiences, like socializing and partying, making new friends navigate them towards



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these substance abuse[1][3]. They have the mentality that having these substance abuse help them in standardizing their status among their friends and peer group[1]. The college life and the young adulthood work as a perfect storm for substance abuse like drug, tobacco, alcohol and many more. Observation states that, nearly 60% of pupils having the age group between 18-22 are thumped by these substance abuses. Teens basically follow their impulses for getting pleasure in the connection to taking alcohol, tobacco and drug. These narcotics are of great menace to young adults, because their brain are still in the stage of development until and unless an individual reaches mid 20s[6].

Although the young adults are at risk to the substance abuse, these enslavement can be treated and avoided. This is possible only if proper guidance and support of the parents at home as well as of teachers at schools, colleges and universities is provided to the teens by means of counselling and proper educational guidance, regarding the impact and effect of these dependence producing drug. As all most all school, colleges and universities promote awareness campaign against these narco products and promote drug free environment which proves to be very effective and will escort the young adults to follow healthy path to live a fit and disease free life.

**Drug dependence and Addiction**

Drug dependence involves the physical or mental feature which is regarded as indicating a condition of disease showcasing dependency or compulsion progress of the high endurance for the material or substance, as the body acclimatize to the drug, which further drives to a proclivity for immense and perennial dosage. Behavioural changes can be observed when the dependence of drug in an individual increases. The dependency of drug lead to physical indication of withdrawal when an individual tries to avoid its consumption[5]. If a person is addicted to drugs and has not taken for a period of time, may lead to physical reaction and the symptoms of withdrawal take place when the body experience mental or emotional strain or tension without the intake of drug, alcohol or tobacco. without being dependent on drugs addiction can eventuate and vise-verse. Addiction and dependence may involve certain aspects that are observed in an individual that showcase the attributes like

1. unable to keep away or stop oneself from imbibing alcohol or ingesting drug or tobacco notwithstanding aftermath.
2. Impuissant to occlude using drug, alcohol and tobacco.
3. Rundown from family and socialization as well as from the course of action to which a person is morally or legally bound due to usage of drug, alcohol and tobacco[1].
4. Makes a person more forbearing to the negative consequence and continue to have the substance abuse in increased quantity.
5. Anxiety and depression level increases due to dependency on the substance abuse if the person fails to quaff or utilize it[5].
6. Cause weakness in the muscles with a continual and protract plodding soreness in part of one's body if the abusive substances are not utilized at the required time[3][5].
7. Cause vomiting, nausea and sweating of a person if addicted or has become dependable for the substance abuse and fail to get in time[5].
8. Finally the addiction and dependency on substance abuse like alcohol, tobacco and drug leads to body collapse.

**Teens and Substance Abuse**

Substance abuse is very dangerous for all human beings. It is very minacious especially for the teenagers who have the feeling of independence after gaining adolescence and after joining college or university[1]. The teenagers travel through the phase of independence, where they are involved in making friends and traverse different types of escapade that further unlock the chapter that pave the way towards substance abuses. Observation says, there are many such minor enfeeblement or eccentricity in one's character that leads towards the tribulation. Some of the units of the unlocked chapter that teens are attacked by substance abuse are as follows;





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**Inquisitiveness**

It can be considered as one of the factor that enforce the young adults of being pounced by the substance abuse. Inquisitiveness or we can say curiosity is a natural phenomenon that bring about or instigate the young people to do or try something which they know very well is not to be desired or approved of. Teens are very much eager to know that how it feel like after having drug or alcohol and how it feels like after having it, drags them towards the substance abuse. These young adults have the misconception that nothing can harm them even if they know the consequences of the usage of substance abuse.

**Experience Escalation**

To escalate certain experiences, teenagers take the help of drug and alcohol. Teens have the feeling that these abusive substances help them to increase their strength and capabilities and also escalate their focus, when negative thoughts surround them. They consider these substance abuse as a strong support to accomplish the task. They also have the feeling that taking drug and alcohol works as relaxing agents, that help them to relax mentally and physically.

**Depression**

This is another factor which has an influence upon the young adults to get enticed towards drug and alcohol. They have the feeling these substance abuse acts as an anti depression pill that helps them to forget their pain and sorrows and bring them to the state of happiness and normalcy. At that moment, the teens are in such a state where the sense of understanding and the knowledge fails to stop them from these evil substances.

**Stress**

Teens believe that life is all about fun, freedom and enjoyment. Some of the teens have a mindset that they need not have to do anything and achieve what they want. This type of mind set make them lethargic. They lack confidence and positive attitude to accomplish any given task. They come under stress when they have to perform certain task, say educational task and other curricular activities and to subdue the stress they take succour of the addictive and dependence abuse or substance abuse for relaxation.

**Peer Coerce**

It has been observed that peer influence is another element for substance abuse by young adults. Experimentation of drug and alcohol takes place among the teens due to peer coerce. It can be rightly said that peers have great impact on the individual who does not take drug and tobacco or drink alcohol and that first time becomes the routine or schedule for every day. A teen get influenced by the other members in the group that force the teen to think "if others can do, then why can't I". Teens believe that if they take drug, alcohol and tobacco then only they will be recognized in the group and will become popular in the group. Specially in parties and gatherings where they involve themselves in these abusive substances to be able to fit in.

**Body Shaming**

It is good to look attractive and to maintain good physic. This good looking concept is there in the society from the beginning but this has become a trend in this 21 st century. All love to have good physic. But it becomes very difficult for most of the teens to maintain a proper shape of their body and face mockery or criticism leading to body shaming. To get over from this body shaming, the teens lose patience to do work out and have healthy diet to get a perfect body shape, instead they simply opt for the most easiest way of losing weight by taking drugs which help them to reduce their weight within a very short time period and slowly they get addicted to it and these substance abuse give them the desired result with much more negative effects.



**Suchismita Nayak****Subdued Self-Respect**

Lack of self respect, paves the way for self destruction. Poor performance in academics, physical appearance and rareness of companions and family pressure to achieve the target level set by the parents are the reasons that give development to subdued self respect which further brings a lot of devastation among the teens. These factors are responsible in stimulating the teen towards the substance abuse as they lose belief in themselves, if they fail to reach the standards set for them. Teenagers believe that drugs, alcohol and tobacco act as an healing agent and feel that these abusive substances give them support in escaping from the reality.

**Idleness**

“An idle brain is a devil’s workshop”. This quote states that, when an individual has nothing to do, then that particular person invite troubles and get involved in it. It is clear from the quote that empty mind is the devil atelier for all worthless work and decision. It is wise that the young adults must keep themselves engaged or employed in some type of positive productive activity. From the above quote, we can conclude that, when teens or the young adults have nothing to do they get bored and don’t have an urge to do something worthwhile and end up experimenting with the substance abuse like drug, tobacco, and alcohol with friends of same class.

**Now or Neve**

This is a situation where the teenagers have the feeling that they belong to the age group where they can try, experiment and experience all that they can. They think that it is the right time and perfect age to experiment and gain experience and if this phase passes away can never return. This thought process leads them towards the substance abuse, later turns out to be fatal.

**Inherent Attributes**

In some cases, it has come to the light that some of the teenagers inherent the quality of experimenting with substance abuse as because of their family history. The teenagers get very much influenced, if they observe that someone in their family is addicted to drug, tobacco and alcohol. Teenagers try to experiment these substance abuse in the absence of the family members which later becomes an habit and they get addicted to it.

**Deadly Effect of Substance Abuse**

Addiction of substance abuse always has negative effect upon all individuals. Teenagers are the ones who get badly affected by these substance abuse. It has an instantaneous effect with long term upshot. Critical changes are observed in the behaviour of the person addicted with drug abuse. It is deleterious for the teenagers as they start harming themselves by using these abusive substances which reduce their ability to do something and also truncate their life span. Some of the deadly effects of drug abuse are;

- Brain dys functionality takes place, where the brain stops functioning normally leading to loss of memory, lack of attentiveness, thinking and decision making capability.
- Substance abuse weakens the immune system which opens the door for different malicious diseases.
- Weight loss is observed due to change in appetite with abdominal ache and vomiting[3].
- Abnormal heart rates are observed, further causing heart attack and crumble of trachea and blood vessel due to substance abuse.
- Damage of liver and lungs occurs due to the practice of substance abuse.
- Friend circle change is observed[3].
- Career gets washed out because of the substance abuse.
- Lying and stealing becomes a part and parcel of the life to satisfy the need for substance abuse.
- Deterioration of relationship with family members and caring friends occur due to the abusive substances.



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### **Inhibitory Measures**

There are numerous reasons that why a teenager is exposed to the substance abuse. It is all important to understand the degree and guard the teens from being attacked by this dreadful substance abuse consisting of drug tobacco and alcohol. Inhibitory measures must be adopted by the parents as well as educators for failing or preventing the usage or practice of substance abuse.

### **Family Guidance**

It is rightly said "Charity begins from home". The same quote is applicable in the prevention of substance abuse by teens. First and foremost duty of the parents is to have a friendly atmosphere at home and need to spend quality time with their children[7]. This creates a positive environment and the teens get never distracted. Parents can educate their children about the dreadful consequences of substance abuse and create awareness within their children.

### **Drug Awareness Program**

To create awareness among the young adults or the teenagers. It is very much essential to create awareness program by the government agencies as well as by the NGOs. These programs must feature videos showcasing the devastating effect of substance abuse and also to highlight the specific preventive measures, to enlighten the young adults about the fatalistic impact of the substance abuse. All most all educational organisations must have a session on weekly basis based on the awareness of drug and also to screen stories of drug addict and their sufferings[7]. Inviting doctors to the campus and organizing sessions with the students to make them aware of the deadly consequences of the substance abuse must be initiated to stop and remove these deadly substance abuse as a whole to protect the teenagers, society and the nation.

## **CONCLUSION**

Teenage is the age where lots of changes and development occurs in the brain and body of an individual. At this stage the brain is not completely developed and it is in the developing form. The area which the brain uses for critical thinking and decision making is pre-frontal cortex, which is not fully developed of a teenager until an individual reaches mid-20s[6]. It is clear that the teenagers lack the capacity to analyse, do critical thinking and take correct decision. It is the duty and responsibility of the parents as well as the educators to have friendly atmosphere so that the teens never hide anything to them and share feelings, emotions and any wrong deeds without any hesitation[7]. Both parents and educators must make the young adults aware about the hazardous effect of substance abuse educate them to analyse, what is ethical and beneficial for them.

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Fig.1. Drug Dependence and Addiction

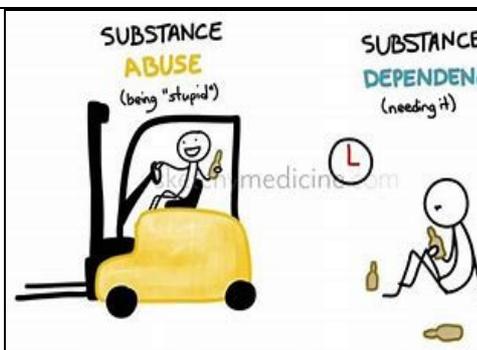


Fig.2. Substance Abuse & Substance Dependence



Fig.3. Slave of Substance Abuse



Fig.4. Prevention is Better than Cure





## A Framework for English Language Curriculum Development in the Context of Technical Education in India

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### ABSTRACT

There have been different models of language curriculum proposed by many. These include classical humanism, reconstructionism and progressivism. These models can broadly be divided into either a 'product' approach to curriculum development, or a 'process' approach to curriculum development. The paper highlights how each model is a part of various approaches and suggest which model would be best suitable for technical education in India. Further, it has been argued in this paper that there is a need to adopt any approach based on the needs of learners.

**Keywords:** Models of Curriculum, Process and Product Approach and Language Curriculum

### INTRODUCTION

As Clark(1987) has referred to the frame work developed by Selinker to explore how they are related to the curriculum planning. The three models i.e. Classical Humanism. Reconstructionism and Progressivism vary from one another in different ways and they have their own principles and ideologies.

#### Classical Humanism: A Product Approach

Classical Humanism is more bent towards product approach than the process approach. An orientation of the classical humanism development focuses on the transmission of content and knowledge. The curriculum is 'content driven'. The syllabus is pre-determined. 'What is taught is what is learnt' is the intention of this approach. As has been pointed out by Clark (1987), Classical Humanism takes the following things in to considerations in curriculum design(Clark, 1987):

- Promoting intellectual capacity
- A coursebook to carry various aspects of information and knowledge
- Graded information



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- Learners should progress in the same pace
- Conscious awareness of rules and patterns
- Norm-reference reference

It can be observed from Clark's points that classical humanists look to the curriculum planning from a product-oriented approach. Classical humanism believes in the model of input-output. Here learners are treated as mere objects and learning can be planned and pre-determined. There is therefore a linear progression of teaching and learning of language, as the listing items to be taught in each academic semester/year. Here teachers are 'instructor, explainer, transmitter of knowledge predetermined in advance'.

**Reconstructionism: A product-process Approach**

Unlike 'contents' of the classical humanism, reconstructionism focuses on the 'objectives', as the main objective of reconstructionism was to bring about some social changes. According to Richards and Renandya (2002) this model provides:

1. clarity of goals
2. ease of evaluation
3. accountability

Further, Clark (1987:15) states that Reconstructionism emphasizes 'objective-driven' curriculum. This model believes in clarity of goals, which has been fixed earlier the teaching and learning programme. Here more focussed is given to 'mastery learning'. What is learnt is more than how to learn. As the model already has got a pre specified objectives, the success of the programme is evaluated how far the set objectives have been fulfilled. So emphasis is given to pre-determined goals. As in classical humanism teachers are not playing any role in the process of making the syllabus rather, they are now playing the role of manager, who will look out how far the objectives are to be achieved. Because of the pre-determined programme, in this model, like classical humanism, the progression is linear. This mode strongly believes Tyler's ends-means approach, as particular ends can be achieved through proper instructional planning. Taba (1962) clearly points out the high product orientation of this model.

**Progressivism: A Process Approach**

Unlike Classical Humanism and Reconstructionism, Progressivism believes in process approach. In Clark's (1987:49) view, progressivism offers 'a learner-centred approach to education'. In other words, all the decisions made on the curriculum are related to learners needs and requirements. Developing holistic personality is one of the key roles of the approach. Making errors in the process of learning imply that learners are making attempts to learn and thus errors are considered to be a part of learning and thus highly encouraged. The central idea of it is 'growth through experience' which learners develop through proper inputs from the classroom and support from outside the classroom. Thus, through education learners develop skills to learn by themselves and progressively become 'autonomous'. Teachers need to take conscious and firm decisions on 'what' and 'how' of learning. This requires teachers to undertake proper research of their students to recommend. The methodology, unlike the earlier two models, provides focuses on providing opportunities for learners, spontaneous learning through experience. It is clear that learners experience and creativity is value. Roger (1969) rightly agrees with this concept and believes that an educated man should be able to learn by oneself and focus should be given to the process of learning.

Progressivism is a process-oriented approach, has been clearly stated by Clark (1987). This approach is based on 'individual growth' through exposure to environment stimuli and learning through personal experience. Further, a speculative knowledge-view is highly suggested where the focus is given on natural ways of learning. Learner as a social being is also recognised in this model where learning is emphasised through interaction and learners need to take partial onus on themselves.





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Here the stress is on the development of the whole person, on process and sequencing of tasks. The curriculum is a flexible one, there is much more importance to learning how to learn, not to any predetermined or fixed objectives. Much more emphasis is given to teaching methodology. Unlike the earlier two models, here the role of learners is significant. They rather impose their own sequence what to learn and what not. This model takes care on learn how to learn. It looks to the learning process rather the end product.

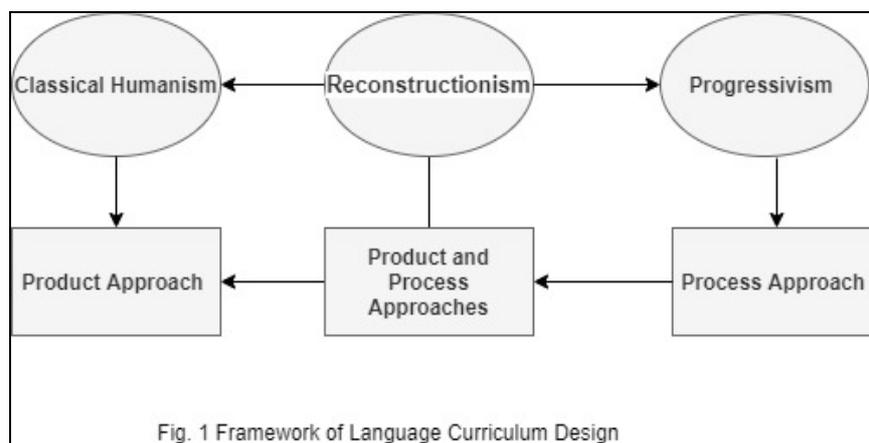
Richards and Renandys (2002) rightly emphasize that '*the purpose of education from the point of view of the process model is to enable the individual to progress towards self fulfilment*'. Unlike, mere reception of knowledge, progressivism gives importance to the development of understanding, further they say that the goals of education is not the end but the process, where individual develops understanding and creates the possibility of future learning.

## CONCLUSION

English language plays a significant role in technical education. There has been an argument which model of curriculum to be adopted to suit the needs of the learners. It is not possible to discard the role and significance of each model. Both process and product approaches to language learning has its own relevance. However, a mixed approach is always recommended where the best of each approach can be taken into consideration keeping the needs of the learners into consideration. The curriculum should not be completely rigid and fixed. It should provide space for the teachers to tailor it keeping his or her learners needs.

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## Application of Sinusoidal Pulse Width Modulation Based on Matrix Converter

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### ABSTRACT

This paper is concerned on the basic idea on pulse width modulation techniques & the application of SPWM on matrix converter. This matrix converter is famed as forced commutated ac-ac converter. Using the Sinusoidal Pulse Width Modulation (SPWM) technique, the output can be generated from matrix converter. This techniques has many advantages like less switching loss, low harmonic content & the method of implementation is easier. This uses a reference (modulated) signal & carrier wave to produce pulse & generate output. The many intersection on triangular carrier wave of sine modulated signals generate the gate signals for switches used in the circuit. This can be presented & simulated through MATLAB/Simulink.

**Keywords:** Pulse Width Modulation, Matrix Converter, SPWM Technique, Sinusoidal Pulse Width Modulation, Forced Commutator

### INTRODUCTION

As the name PWM suggests, it stands for Pulse Width Modulation Technique. It is a method for generating a modulated output signal from analog device using a digital source. It is mostly used in communication devices for encoding the amplitude of the signal to the precise pulse width of the carrier signal. It is the most well liked method for controlling output voltages. The benefit of PWM is that the power losses are very minimal.

#### Different Types of PWM

- Single Pulse Width Modulation
- Multiple Pulse Width Modulation
- Sinusoidal Pulse Width Modulation



**Dinesh Kumar****Single Pulse Width Modulation**

One pulse width equals to one half cycle in this modulation technique. The adjustment of the single pulse width is done in order to regulate the output voltage of the inverter. In this method, the rectangular modulated signal is carried over the triangular carrier wave & the output voltage frequency is determined by the modulated signal's frequency. This technique produces high harmonic content which is the main disadvantage. This Single PWM can be understood from the following figure.

**Multiple Pulse Width Modulation**

This Multiple PWM techniques overcomes the drawback of Single PWM by lessening the high harmonic content. This is done using more pulses in each half cycle of the output voltage as shown in the following figure 2. The gate signals are generated for turning on & off of a thyristor by comparing a modulated signal to a triangular carrier wave. The no. of pulses is determined by the carrier wave's frequency & the output frequency is set by the modulated signal frequency. In this technique modulation index administers output voltage. This technique is advantageous over the Single PWM technique & however it has its drawback too. In order to produce large no. of pulses per half cycle, continual turning on & off of thyristors is required which increases the switching losses.

**Note:** Modulation Index ( $m$ ): It is the ratio of the peak magnitudes of the modulated signal to the carrier wave & its magnitude lies within 0 to 1 i.e.  $0 < m < 1$ .

**Sinusoidal Pulse Width Modulation**

Sinusoidal PWM is a technique of pulse width modulation mostly applied in inverters & have a large applications in industries. This technique is also famed as Wave Shaping Technique in power electronics. In this method, by comparing a sine modulated signal to high frequency triangular carrier wave, the gate signals could be generated. Since this needs high frequency carrier for voltage modulation, hence also known as carrier-based PWM technique or Triangle-comparison PWM technique. The magnitude of the sine modulated signal should be sparse to the peak magnitude of the triangular carrier wave. Utilising the frequency of the sinusoidal modulated signal, the output frequency can be determined. But controlling the output rms voltage can only be done by Modulation Index & this modulation index is controlled by the peak amplitude of the modulated signal. The no. of pulses per half cycle is directly proportional to carrier wave frequency.

The range of the modulation index limits from 0 to 1 i.e.  $0 < m < 1$ . This region is called linear modulation region. In this consideration, the PWM inverter can be known as voltage amplifier with a unit gain. The region where modulation index gets greater than 1 i.e.  $m > 1$ , it's called overmodulation region as shown in the above figure 6. The efficiency of the SPWM technique gets to 78.5% of the max. output voltage. The switching frequency PWM inverter is equivalent to that of the carrier wave. Once every time period of the triangular carrier wave, the switch is turned on or off having the advantage of constant switching frequency. Due to this advantage, it's feasible to compute the switching losses. In addition of a low-pass filter to designed inverter circuit, the reducing of harmonics gets easier. The supremacies of SPWM are increased fundamental component, enhanced harmonic contents, less number of switching power devices & decreased switching losses.

**Application of SPWM Technique**

Sinusoidal Pulse Width Modulation (SPWM) technique is utilised to produce control pulses for the Matrix Converter switches to generate the output. The sequences of switching for the Matrix Converter to work as cycloconverter can be represented & evaluated using MATLAB/Simulink.

**Matrix Converter**

The matrix converter converts direct ac-ac power in the absence of intermediate dc-link circuit. An array of controlled bi-directional semiconductor switches are utilised in this device as the master power circuit, or so it is named as a forced commutated ac-ac converter. Variable ac voltage with unhindered output frequency is transferred from ac





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input voltage through this device. This converter has an array of 'm x n' bi-directional power switches where 'm' represents the phase voltage source & 'n' represents the phase load. A 3-ø matrix converter comprises of 9 switches laid in 3x3 matrix form. The positioning of BDS is made in such a manner that random input phases A, B, C is concatenated to random output phases a, b, c. These laid switches are administered in a precise manner that the average output voltage is a sinusoidal of required frequency & amplitude. The laid switches in 3x3 matrix form provide 512 amalgamations of switching states.

The pragmatic model of this forced commutated converter needs bi-directional switches (BDS) proficient of blocking voltage & conducting current in both directions, yet no such method is available in present time. BDS can be executed by wielding a befitting amalgamation of unidirectional switches with diodes. The Matrix Converter utilizes an array of controlled 9 bi-directional IGBT switches which are the default power elements to produce a changeable output voltage system with unrestricted frequency. Each IGBT are proficient of conducting current in both directions, blocking forward & reverse voltages. The SPMC is added only in passive (i.e., R, R-L) load conditions. SPMC topology is confined due to intrinsic restraints. One of those restraints is the truanting of the natural free-wheeling path.

The input & output voltage of the Matrix Converter is given by (a) and (b) respectively with loads in (c);

$$V_i(t) = 2V_f \sin \omega_f t \dots\dots\dots (a)$$

$$V_o(t) = 2V_o \sin \omega_o t \dots\dots\dots (b)$$

$$V_o(t) = R i_o(t) + L \frac{di_o(t)}{dt} \dots\dots\dots (c)$$

When the model of Matrix Converter is evaluated through MATLAB/SIMULINK, these are the reports framed from it. The computation time for the simulation is the main constraint during the theoretical analysis of a matrix converter. The mathematical model bridges the drawback that favors the operation of power conversion stage of Matrix converter. This study compels the ensuing research on Matrix converter easy and buoyant. The functioning of Matrix converter was pursued for loads with both 0.866 voltage transfer ratio.

**CONCLUSION**

There are various methods of PWM techniques that can be adopted on different converters according to our desired output. But SPWM technique has acquired a lot of attention in present time due to its benefits & in application of matrix converter as cycloconverter. The BDS used in these simulation act as freewheeling path with amalgamation sequences of switching, thus providing a converter topology for further research. A matrix converter can input either AC supply & using SPWM technique it generate a synthesized AC desired output. For the operations & maintenance of these converters skilled manpower & expertise is highly essential.

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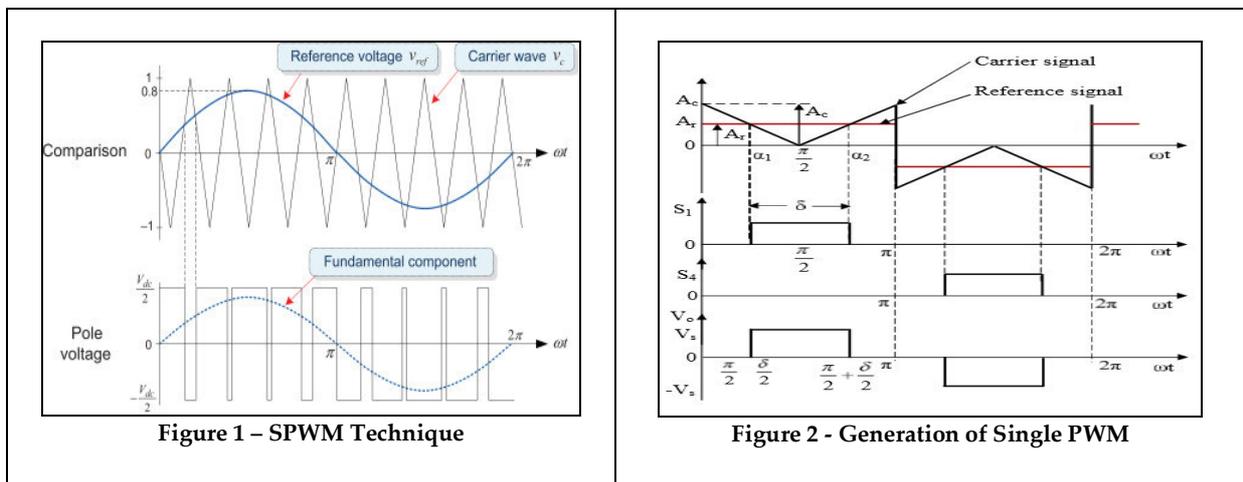
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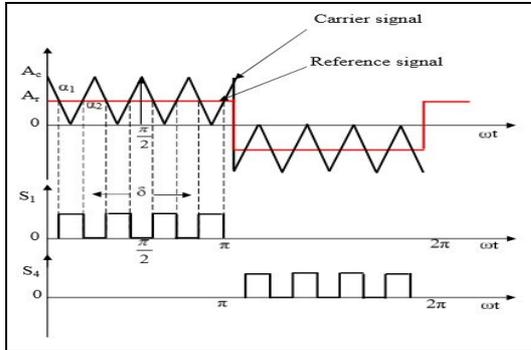


Figure 3 - Generation of Multiple PWM

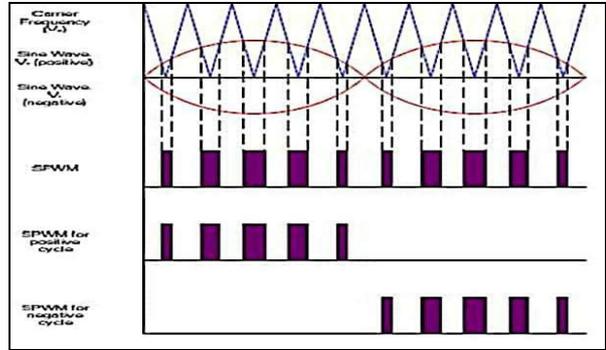


Figure 4 - Generation of Sinusoidal PWM

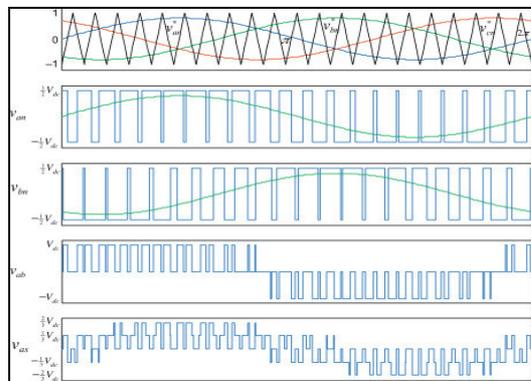


Figure 5 - SPWM Technique for 3-ø Inverter

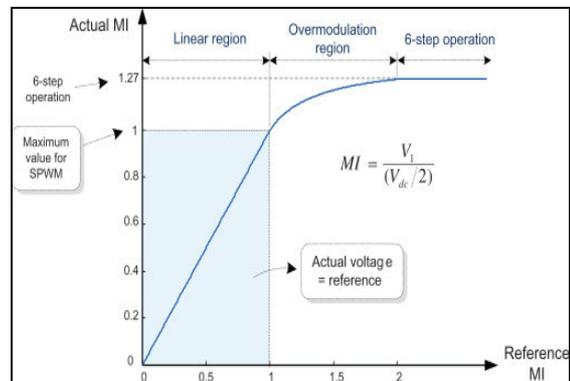


Figure 6 - Voltage Modulation Index

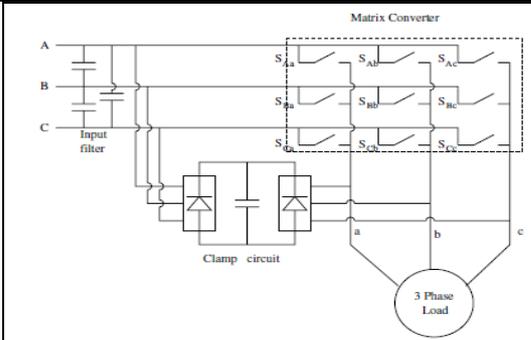


Figure 7 – Matrix Converter Practical Scheme

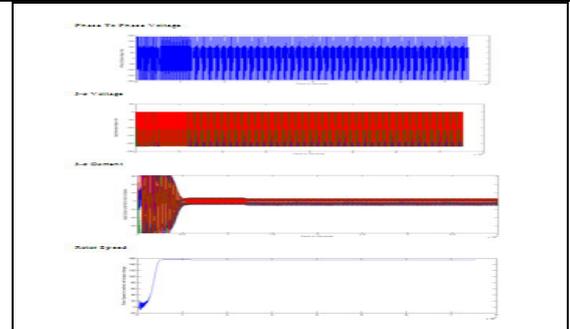


Figure 8 – Phase To Phase Voltage





## Solid Waste Management in Rayagada Municipality

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### ABSTRACT

Waste management may be world environmental issue which concerns about a terribly important drawback in nowadays world. There may be a considerable amount of disposal of waste without correct segregation that has cause each economic and surroundings sufferings. It's still practiced in many cities. There is a tremendous quantity of loss in terms of environmental degradation, health hazards and economic descend because of direct disposal of waste .It's higher to segregate the waste at the initial stages where it's generated, rather than going for a later choice which is inconvenient and expensive There has got to be acceptable coming up with for proper waste management by means of analysis of the waste state of affairs of the world. The study represents preliminary study of legal framework for local solid waste management and explains the issue and challenge that stand in the way of India's objective to establish a solid waste management system which is comprehensive, consolidated, cost-saving, expendable and tolerable to the community.

**Keywords:** Solid waste management, India, legal framework, consolidated.

### INTRODUCTION

Waste is generated in a large mass by the society. Disposal of this waste is now a global issue for a healthy environment. Solid waste includes street sweeping, household wastes, sanitation part etc. Direct dumping of these wastes without any treatment effects the environment. The waste dumping without proper inspection and separation causes environmental pollution and become perennial problems for mankind. When we think about the waste management policies, we may have been in Neolithic time. Till 2000 we had low concern about the pollution and waste management. A number of laws were adopted in India such as water Act (prevention and control of Pollution) on 1974, Air (prevention and control of pollution) act on 1981 and environment protection act in 1986. But the subject of MSW was neglected legislatively. Other rules and laws were also adopted in India like Hazardous waste rules in



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1989 and biomedical waste rules in 1998 (suppressed) dealt with the MSW tangentially. The day by day crisis on solid waste management brought later versions of laws to protect the environment. They are solid waste (management and handling) 2000, solid waste management rules 2016, hazardous and other waste (management and transboundary movement) 2016, construction and demolition waste management rules 2016, biomedical waste management rules 2016, plastic waste management rules 2016 and e waste management rules 2016.

### **Analysis of Qualitative and Quantitative Measures on MSW**

Various categories of MSW such as kitchen waste, rubbish, commercial waste, educational wastes, garbage, building construction wastes and sanitation waste. The waste contains recyclable substances and non recyclable substances. The recyclable waste likes plastic, metal, paper, glass, etc, organic matter, toxic substances such as paints, pesticides, insecticides, inverter batteries, medicines foils, sanitary napkins, disposable syringes and used cotton etc. The quantity of MSW generated depends on a number of factors of the society such as standard of living, food habits, commercial activities and seasons. The planning for collection and disposal systems is mainly depends on the data on quantity variation and generation. The change in life style is responsible for the increase of MSW. Presently more than 90 million tones of solid waste are generated annually as byproducts of various processes. As per the table 1 data ward no 19 shows the highest range of solid waste produced i.e 2500kg/day and ward no 4 produced 629.5 kg per day (if each person produce 0.5 kg/day solid waste approx.). Therefore a total of 36 ton approx is produced in each normal day. In a month it is calculated as 1080 ton approx. in a year it is calculated as 12960 ton approx. The rate of waste may fluctuate due to festivals, other holy occasions.

### **Disposal of the Solid Waste in Rayagada Town**

In general view solid waste disposal is the placement of solid waste so that it is no longer more implants in the society. The garbage is either understood fully so that they can no longer be reorganization in the environment. The total solid waste management includes Assortment, dumping, and betterment. Around 36 tons of waste is caused in the town daily and is dumped between Burdalpamma and Majhigariani temples. The total dumping area is about 3 acres. This is the unused area near the famous temple Maa Majhigouri. There is also 12 acres of rubbish heap plant is also recognized near Antariguda village of Rayagada block, which remains unexploited.

### **Modes of Transportation of Garbage**

Out of 24 numbers of wards, local municipality manages 8 numbers of wards and rest 16 wards are managed by private contractors. In this work around 4 tractors are engaged.

## **CONCLUSION**

No doubt the disposal of the waste is done in a defeated manner in Rayagada to fill the dump yard near the Majhigouri Temple, Rayagada. Due to the waste dumping the temple surrounding gets polluted, which affects the health of the Thousands of pilgrims coming to the Temple every day. But if we see the positive side of dumping, then we will find the un-useable area of 3 acres of land in the heart of the town will become a flat land for reuse by the people of Rayagada. From the dumping a lots of materials are collected back by the scavengers (scrape collecting people), for getting their bread and butter. This dumping when complete, there will be a direct path for the Rayagada people to reach the temple in a short distance.





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**Table : 1 MSW Rate In Different Wards In Rayagada Town.**

WARD NO.	TOTAL POPULATION (2011) APPROX.	MSW(KG/DAY)APPROX.
1	4304	2152
2	2065	1032.5
3	2955	1477.5
4	1259	629.5
5	2793	1396.5
6	1812	906
7	2968	1484
8	4631	2315.5
9	2803	1401.5
10	3799	1899.5
11	4337	2168.5
12	2772	1386
13	1376	688
14	3252	1626
15	2897	1448.5
16	3844	1922
17	3175	1587.5
18	2540	1270
19	4993	2496.5
20	2661	1330.5
21	2113	1056.5
22	2285	1142.5
23	1889	944.5
24	3685	1842.5





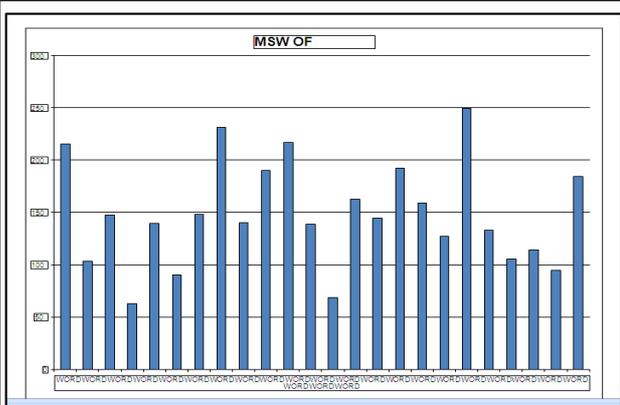
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**Table :2 Shows The Types Of Vehicle Used Municipal Solid Waste (MSW) Management**

TYPES OF VEHICLE	NUMBER OF VEHICLES USED
JCB	1
TRACTOR	4
AUTO TIPPER	2
TRUCK(DUMPER BIN CARRIER)	1
CESSPOOL	3



Picture 1 Shows the Rayagada Town Map



Picture 2 MSW Rate in Different Wards in Rayagada Town



Picture 3 Shows the arial view of dumping yard at Rayagada



Picture :4 Shows The Types Of Vehicle Used Municipal Solid Waste (MSW) Management





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Picture :5 Shows The Types Of Vehicle Used Municipal Solid Waste (MSW) Management



Picture :6 Shows The Types Of Vehicle Used Municipal Solid Waste (MSW) Management



Picture :7Shows The Types Of Vehicle Used Municipal Solid Waste (MSW) Management



Picture :8 Shows The Types Of Vehicle Used Municipal Solid Waste (MSW) Management



Picture :9 Shows The Types Of Vehicle Used Municipal Solid Waste (MSW) Management





## Harmful Effects of Plastic Bags on Environment, Human Health and its Alternatives: A Review

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### ABSTRACT

Population growth rate is increasing every year and everywhere. So the use of different varieties of products are also increasing directly and indirectly. To carry the light and medium weight substances generally plastic bags are being used by most of the community. Also for the packaging of the heavyweight substances and goods polythene is used. These plastics are now days reused and recycled, but after this also plastics are considered as a threat to the environment. This threat can be vanished or eradicated by simply avoiding and saying no to the use of plastics. But the fact is that, what can be used in the place of plastic bags are the point of discussion. The plastic bags are easy to manufacture, less cost, available everywhere and can be used by everybody. But its effect is harmful to the nature. So to avoid the use of plastics, different biodegradable bags are now available in the market. By using these eco-friendly products we can get the same facilities like plastic bags with a promise to the environment to protect it from pollution. This paper work focuses on the collection of information on different impacts of plastics and plastic bags on environment, human health with the alternatives bags that can be used instead of plastic bags like paper bag, jute bag, cotton bag, etc.

**Keywords:** Plastic bags, Nature, Biodegradable bags, Eco-friendly, Pollution, Paper bag, Jute bag.

### INTRODUCTION

Everyday for the livelihood the buying and selling actions are going on restlessly around the globe. Everywhere the large sized items, goods, heavyweight machineries, small items, food items, vegetables, footwear are being sold and purchased by the consumers. Mainly during the dealings of small items, light weight items, daily use items, vegetable items the plastic bags are generally used and comes into the attention of everyone. The plastics bags are used extensively by everyone starting from the persons those who are moving door to door to do business for earning for their livelihood like vegetable sellers, fruit sellers, milk mans to the persons those who are dealings in

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large shopping malls and multiple starer hotels. The reason for the huge use of plastic bags is it is cheap, available everywhere, light weight, easy to handle, easy to carry and can be thrown out after a single use of it. Also during the packaging of heavy machineries plastics are used as cushioning element with the bubble like air packages formed around the base plastics that are made up of plastics. Also nowadays before using the costlier items, quartz, steel items, one layer of plastics is used as coating element and just before the use it is removed from the product. After the use, these plastic items are thrown to the dustbins or exposed to the atmosphere any how. These plastic elements are then may be collected by the plastic collectors for the recycling purpose, dumped somewhere for land filling, openly placed in the dump yards or burned by the local community of people. Then the effect of it is on the environment and pollute it and when the environment get polluted then it affects everyone those who are present inside the atmosphere.

Today everyone including the marine animals and the animals residing beneath the earth's surface are affected by these plastics indirectly or directly. Animal's food digestion system is affected by plastics that leads to the death of the animals[8]. Marine animals are also affected by the plastics by eating the debris, the animals are choked by plastic elements and unable to breath and swim and finally facing the death. Birds are also consuming the tiny plastic items during the consumption of food and finally meets death. Plastics releases chemicals in soil, that chemicals affect the crops grown in that soil. Due to plastics in the soil the water in the soil is contaminated and when it is consumed by any one it affects their lives. So new technologies were developed by using the ideas of the environment friendly persons those who are thinking to protect this environment. Instead of using plastics, first the focus was given on the materials that are biodegradable in nature. Materials those are extracted from plants are everyone's concern then, as plant extracts are quick biodegradable and organic in nature. Then some chemical processes are also analyzed and experimented where the bags like plastic bags can be manufactured from some chemicals and eatable oils, but these bags are looking like plastic bags and they are biodegradable in nature. Focuses on these biodegradable carrier bags are now a major concern for the technologies developers and everyday new processes are analyzed, tested and implemented to get the better solution for the problem of use of plastic bags. In the following paragraphs the detail analysis of effect of plastic bags on environment and the alternatives that are accepted against it are described briefly.

**Reviews on Effects of Plastic and Plastic Bags On Environment and Human Health**

Plastic bags are made up of plastics, which is the combination of polymers and additives. These polymers are the summation of monomers and monomers are the chemicals. So when these plastic bags are exposed to the environment it affects badly to the residents of the environment which includes everyone such as human beings, animals, birds, plants, air, water and soil.

**Impact on Environment**

Plastic bags, when present on or wrapped around the leaf of the plants they obstruct the sunlight to reach the leaves and affects the photosynthesis process [10]. Also plastic bags are easily flown away by the air from one place to another and makes the environment ugly[11]. Animals when eat the plastics during the grazing, then they are facing the diseases and most of the time facing death[10]. Plastic bags, when buried under soil then it acts as a layer of insulation for the rain water and and the other fertilizers from going down at that particular place[10]. Due to the lightness properties plastics floats on the water and create a required environment for the development of bacteria[10]. plastics also block the passages of water channel and affects the irrigation process[10]. Even though plastic bag materials are very thin, the roots of the plants are unable to pass through them and unable to get the required nutrients from the soil and the agricultural issues are also generated due to the plastic bags[11]. These plastics also affects the nitrogen fixation, decreases the soil fertility and affects the life of flora and fauna of soil[11]. The earthworm who is called as the farmer's friend also day by day decreasing in number due to the pollution created by plastics and chemicals used. When plastics are burned, as these are produced from the fossil fuels so they emitted toxic and harmful gases to the environment. Also during the extraction of plastics it releases harmful gases that pollute the air. When plastics are burnt they emits the harmful gases like chlorine dioxide, carbon dioxides,



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acids, dioxins and other gases that affects everyone's life[10]. Polystyrene, used for the packaging of teacups and burger is very dangerous for ozone layer as it contains chlorofluorocarbon(CFC) gas[10]. Death of millions of sea birds, one lakh marine mammals and huge number of fishes were happened due to the plastic waste [12]. The marine animals were also entangled in the plastic waste like fishing nets, these nets travels through the water bodies like seas and oceans from one place to another and numbers of animals like shark, tortoise and sea birds trapped and facing death[13]. Ingestion of plastics affects the digestive tract, reduced appetite as the plastic present inside stomach feels like full of stomach and leads to starvation of the animals[12]. Micro plastics are found in river, lake and oceans which affects and pollutes water and its residents[9].

**Impact on Human Health**

When plastic bags are used for packaging purposes of hot food, pickle and fatty foods then the plastics have interacted with the heat generated and produces carcinogenic dioxin[10] that leads to the development of cancer. Water, that is coming through the tap is also having plastic pollution. Plastics are having a greater impact on human health. Diseases like failure of vision, cancers, lung diseases, reproductive problems, skin infections, headaches are the major problems that are found due to the use of plastics that are toxic in nature. Additives in the plastics are provided to make it more hard, clear, flexible and resilient. The additives like Bisphenol A can causes cardiovascular diseases, type 2 diabetes and hormonal changes in adults[12], this additives affects more to the fetus and children[14]. Additive, Phthalates also having negative effect on testicular dysgenesis syndrome that affects the reproductive system of animals [15]. Both the additives Bisphenol A and Phthalates can also causes aggressive behaviour, decreased male fertility and early sexual maturation in human beings[16]. Persistent organic pollutants are the plastic additives that causes neurological and reproductive damages[17]. The additive, polychlorinated biphenyls affects the thyroid hormones [17]. Today 60% of the medical plastic wastes are incinerated which are infectious wastes[18], if the incineration process is improper then it affects the human health as it releases the dioxins[19]. The incineration produces ashes that ashes are also disposed for landfill but these are toxic in nature and that can affect the groundwater that is present below the landfill and affects the life of human beings as ground water is consumed for drinking purposes [19].

**Alternatives Available for Plastic Bags**

Nowadays the problems due to the plastics are present everywhere. The air we breathe and the water we drink are also under the harmful effects of plastic. To reduce the use of plastics used as bags can be replaced by the following options.

**Paper Bags**

Paper bags, as the name suggests these are bags which are manufactured from the recycled paper. These bags are fashionable, also can take medium loads, for most of the shopping items, vegetable items, malls these paper bags are most suited. As these are mainly produced from the paper waste so the overall waste of the globe is also reduced. Also these bags are reusable for certain number of times. Once they are worn out, again they can be recycled. If these bags are exposed to atmosphere, then also these are biodegradable [3].

**Cotton Bags**

These are the bags that can be used in place of plastic bags. These bags are produced from the different types of cottons such as traditional cotton, recycled cotton and organic cotton. Out of these three organic cottons are produced without the use of chemicals and recycled cottons are produced from both traditional and organic cottons. Traditional cottons are grown by using some chemicals. These cotton bags can be used for hundreds of time. Unlike paper bags these can be washed and water cannot harm these bags. They can bear more load than the polythene carriers and paper bags. Again, these bags are biodegradable and whenever exposed to the environment it will not pollute anything [3].





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#### **Jute Bags**

Jute bags are the made from the plant fibres naturally. More impact on jute bags also enhances the agricultural growth for jute plant and other plants plants from where jute can be extracted. Jute bags are also designed to take various types of loads. These bags can be used many times and the end it can be recycled once again, if it is exposed to atmosphere then it is completely biodegradable [2].

#### **Denim Bags**

Denims are durable, degradable and reliable. Bags can be made out of old denims and denim bags can take more load than the plastic bags. Also it is washable and can be used again and again. The denim bags can be made at home also. When the denim bags are worn out, these are biodegradable [1,6].

#### **Compostable Bags**

These are the bags made from the raw materials that can be renewable. These bags after the use can be converted into compost. But they are having limited life and limited use [3].

#### **Metal Containers as Bag**

Stainless containers can be used as carrier object. Different shapes and sizes of the container is available. These metallic bags can be used for a longer period of time. Also at the end it will be recycled and can be used again.[6]

#### **Required Behavioral Changes in Human Beings to Say No to Plastic Bags**

Plastics bags and its wastes are found only when we use it, in order to reduce the quantity of plastic bag wastes or single used plastic carriers wastes globally, the use of theses commodities should be decreased and if possible the production of new plastic bags should be stopped and the existing plastic bags will be recycled to the maximum number until it will be completely unusable. Ban on plastic bags are imposed on various regions across the world, but after it also the generated waste is huge. When the individuals will think about their own life along with the environment then the use of these plastics may be reduced. Instead of using the use and through or single used water bottles, food packaging systems, plastic bags, the options like refillable water bottles, reusable food packaging systems and multiple time usable non plastic bags can be used[20]. If these practices will be accepted at individual, corporate and social level then a large change in the pollution will occur that will be the advantage for the whole world. Some coffee shops are providing discounts for them, those who are coming with reusable cups[20]. The discount is important but higher priority is that people are changing and that puts positive impacts on environment and everyone's life. Complete prohibition of plastic bags in the corporate sector, zoological and botanical area will also helps in to say no to plastic bags in these areas.

### **CONCLUSIONS**

First, all of us should educate ourselves and others to not accept the things that are harmful to the environment and human beings. The whole world is facing the problems related to plastics today, the replacement for the plastic bags are the important topic to rethink for everyone. In this work the ill effects of plastics are discussed along with the different varieties of non plastic bags, these bags can be used in a better way than the plastic bags. Some of these non plastic alternatives are washable, multiple time usable, more load bearer than plastic bags and finally they are biodegradable. By using these environment friendly and user friendly bags the environment can be protected, the overall waste of the world can be reduced. The animals of the planets will not be affected if the above discussed five varieties of bags used by everyone. It is believed that new technologies and new ideas will be developed soon as other alternatives to the use of plastic bags.





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## Shaping of Academically Poor Students: Centurion University as the Suitable Ecosystem

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### ABSTRACT

Among the different concerns of syllabus designers, teachers, curriculum developers and the whole educational body, poor academic performance of students is treated as the main concern now a days. In this case one has to identify the causal factors which influence the poor academic performance of the students and then find the interventions for it. Centurion University that aims to shape especially the academically poor students made it successful by identifying the factors and then implementing the necessary interventions. 255 students were examined carefully who enrolled for Diploma program at Centurion University of Technology & Management. The academically poor students were categorized in to two main groups, ignored students and other academically poor students. Accordingly necessary interventions had been implemented to improve their academic performance and concluded as the performance of the academically poor students can be improved by providing some extra focus to them.

**Keywords:** Bridging Classes, Ecosystem, Ignored students, Social service

### INTRODUCTION

Education is one of the most important aspects of human resource development. Every child should have the opportunity to achieve his or her academic potential. In January 2019, India had over 900 universities and 40,000 colleges. This indicates that, the country has suitable number of institutional facilities for higher education. Still, it is generally noticed that at least 20% of children in a classroom get poor marks - they are "scholastically backward". Poor school performance should be seen as a "symptom" reflecting a larger underlying problem in children. This symptom not only results in the child having a low self-esteem, but also can cause significant stress to the parents. It is essential that this symptom be scientifically analysed to discover its underlying cause(s) and find a remedy. State enacted multi-sector University, Centurion University of Technology and Management, established in the remote



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district of Gajapati in Odisha reviews the causes for children having poor academic performance and describes its management.

**Centurion University as a Suitable Ecosystem**

Centurion University of Technology and Management is a multi-sector, private state university from Odisha, India. With its main campus at Paralakhemundi in the Gajapati district and another constituent campus located at Jatni, on the fringes of Bhubaneswar. The university offers under-graduate, post-graduate and doctoral courses in the fields of engineering & technology, agricultural sciences, architecture planning and design, mining, teachers' education, media and communication, paramedics and allied Health Sciences, pharmacy and life sciences, management, applied sciences and a number of vocational trades in its two major campuses, to provide alternate pathways to young people who have dropped out of formal education. It further provides an opportunity for these young people to get back into formal education if they so desire. The University has also set up a number of social enterprises which operate as teaching and learning laboratories for students, staff and alumni with the intention of making a last mile connect with the local populations, be it tribal farmers, women entrepreneurs or young unemployed youth with little skills. Now a days, most of the pupils are getting admitted in various academic programs without setting their goals even not having any interest to learn. It has also been found that, some of them have intention only to get a certificate. Lastly a few of them will be found to be both academically & financially poor from the ground level. In this situation, the University also works as an incubator for the academically poor students to explore new ideas for enhancing production & productivity. Further, the promoters, mentors and senior management of the University have a 'grounded intelligence' and 'grounded imagination' that considered 'ground up' learning as the best and application of theories in the 'local' and 'context-specific'.

**The Ignored Students**

There are some pupils upon whom, not only the society but also their parents even the pupils themselves lost hope that, they can't do anything. They don't have any curiosity and are very casual in academic learning. Such pupils may be here named as ignored pupils. Among the 255 examined students (selection held on September 2015) of the University, 77 of them were found to be of this category. The promoters of the University suggested the faculties to identify the positivity inside them carefully. Being a skill university, the positivity was strictly in terms of both existing skill and the skills in which they had interest. Basing upon this, all the 77 students were found to be of 6 categories. They had been encouraged and accordingly provided special training on their specified skill categories and allotted their academic branches aligned to the respective skill categories. Exactly 16 of them were provided special training on electrician, 15 for sewing, 11 for CCD (Cafe coffee day), 11 for software designing, 17 for MMV (Mechanic Motor Vehicle), and 7 for Entrepreneurship. It has been marked that, almost all the ignored students became motivated after their special skill training (October 2015 to March 2015) which they were practicing after their regular academic classes. Further being academically poor, they were being provided some extra focus from the faculty's side regarding their academic courses. In June 2018, they completed their Diploma and up to that time 9 from electrician, 7 from CCD, 10 from sewing, 9 from software designing, 11 from MMV had been selected in some campuses. Again till December 2019, in total 14 from electrician, 11 from CCD, 13 from sewing, 10 from software designing, 16 from MMV had been placed in different companies & 3 from Entrepreneurship have been started business( 2 of them started chicken firm & 1 have dairy firm).

**How did they learn?**

There were some strategies adopted by the university in order to shape this category of students. According to the instruction of the higher management team, all the teaching and non-teaching staff included by making a correlated team to make then streamlined. Basically the following four strategies like "Learning by Social Service", "Learning by Doing", "Learning by Group" and "Learning by Shaping" were followed for this purpose. Those each of the strategies have one aim, but they acted as different objectives to reach the aim.



**Aloka Kumar Rana****Learning by Social Service**

The students of different trades were allowed to visit door to door in the nearest community. They had to ask each door about their needs in terms of maintenance which the students can do in free of cost. The main aim was to learn the students, whereas the mode was through social services. In this mode the students were serving the people according to their trade knowledge. For example, the Electrical students were serving people by repairing their electrical equipment like fan, grinder, washing machine, motor, air conditioner etc. Students from MMV trade were repairing the vehicles and so on. In this mode of learning the students were not only gaining knowledge but also the mental satisfaction that was reflecting from the face of the people being served. Once they were ignored not only by themselves but also by the family and the community. But now the community started to encourage them both on the spot and in terms of some expectations in the future to be served once again in more advance manner. All those things created some aspirations to improve further by gaining more knowledge and skills [4].

**Learning by Doing**

The personal nature of experiential learning engages the students' emotions as well as enhancing their knowledge and skills. When students see the concrete fruits of their labour, they experience greater gratification and pride, thus enhancing their enthusiasm for continued learning. Being a Skill University, the Centurion University provides many skill courses in which the students have learn by doing or practicing a particular skill. The skill courses includes RAC, CCD, Solar, CNC etc. In the courses the students were given both training and practice from the first day. Practicing from the beginning avoided the fear to gain a theoretical or conceptual knowledge. This mode of learning also increased the students involvement consequently decreasing boring and making them more curious and happy. Once they were ignoring themselves. But doing something from the first day induced some aspirations to improve. A person having knowledge without any skill suffers a lot to survive in the society. Practicing the skill courses from the first day helped the students to survive easily. Also the students were visited to different Orphanages and Old age homes to serve the physically. This activities were conducted by the CSR team. Directly the activities induced humanity and social responsibilities inside the students and taught them to be a good human being. Consequently this influenced to improve again their performance academically [1].

**Learning by Groups**

Studying with other individuals gives each other the opportunity to utilize auditory learning by talking through the material at hand. When a student study with other students of his/her class, he/she will ensure he/she covering all of the bases and not leaving out any important information. Additionally, he/she can gain different perspectives from other students. For instance, there might be material that seems confusing to him, but could potentially be clear to his study partner. Study groups are the perfect place to gain different viewpoints on the same topic. By studying with a group of people, the students have the opportunity to quiz each other on difficult subject matter and allow themselves to stay focused on their studies. Reaching the full potential in college courses is widely dependent on how you choose to spend your time. Refining your studying techniques can help improve your grades and optimize your learning. Keeping this as objective, Centurion University provides group learning strategies which not only helpful to accelerate the academically poor students but also for all. Especially the ignored students who lost their faith upon then could be encouraged and learned from each other. While visiting the nearest community to serve people in terms of maintenance, they noted their difficulties as well as the success and shared with each other at night. As a result of which all of them could be benefited at a time [6].

**Learning by Shaping of Habits & Discipline**

Here the word shaping includes all the physical and mental development techniques that are responsible for the enhancement of concentration and curiosity which consequently make them to think about a right path for themselves. Generally the strategies like motivation, counselling and guidance services, physical exercises, yoga, remaining away from toxic substances etc. Though all those opportunities are open for all the students in Centurion University, still it influenced a lot for the ignored students. The management of the university provides serious focus



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on the execution of all those activities. The hostellers are guided to rise earlier in the morning and the go to bed in time at night. In the morning and evening they had to do the physical exercise and yoga. All of them were also provided motivational classes and proper guidance counselling services. The parents were given required instructions to guide their children accordingly. Every month the most disciplined students were rewarded. All those interventions taken by the university could change the habits of the students and consequently enhancing their curiosity and concentration level [5].

**Other Academically Weak Students**

This category of students includes those having below average or poor standard in academic performance due to different reasons. For example some of them having lack of fundamental knowledge from the primary to high school level. Some of them had not proper financial support where as some had no support from family side or some have health related issues. Due to the lack of either one or all the factors the students were marked to be having either lack of interest or less interest in study and were academically weak. The mission and vision of the university was to shape those students and empower the community, some necessary interventions were taken to improve their academic performance.

**Bridging Classes**

Basically the weak standard in academic performance in college or university level is due to the lack of fundamental knowledge up to high school level. In addition to some of the students after completing their school study in their local language may face problem which comes due to the change in the medium of study to English in the college level. To make the basic fundamental level stronger, Centurion University offers the Bridging classes before the commencement of the classes of regular academic session. The syllabus of the classes includes all the basic mathematics and science topics. The concerned faculties were instructed to teach the topics in simple English language [8].

**Productive Environment**

The role of environment is a vital part of learning. Without a suitable environment one can't achieve an efficient knowledge. For example studying near a TV, with the kitchen only a step away, keeping cell phone on the table are all distractions that can waste the study time [3]. Centurion University tracks all those activities during study hour for hostellers by wardens, security staff, hostel coordinators and visiting faculties. Similarly to improve the quality of room teaching, initially the School of Vocational Education and Training (SoVET) and gradually all Schools started class room decoration by the respective students. They painted the class room by themselves, made a mini library inside the class room, kept some teaching learning materials inside the class room and so on. The faculties used to teach students to use visual images. In addition to this SoVET also initiated "Open Air Classes" and "Free Learning Day" especially to enhance the curiosity of the weak students. The Open Air Classes were conducted outside the class room either on the lawn, near the swimming pool or over the roof etc. This could made the teaching-learning process interesting and increased their curiosity. During the Free Learning Day, the students could visited to any lab, workshop to gain any knowledge as per their interest. The lab or workshop in charges were also instructed to guide the students accordingly. This strategy also helped the students to enhance their curiosity and gain independently [7].

**Retrieval Practice for Students**

Research has shown that long-term memory is enhanced when students engage in retrieval practice. For example, taking a test is a retrieval practice, which is the act of recalling information that has been studied from long-term memory. Thus, attaining the practice tests can be very helpful for students. When teachers are reviewing information prior to tests and exams, they could ask the students questions or have the students make up questions for everyone to answer rather than just retelling students the to-be-learned information. Also, if students are required or encouraged to make up their own tests and take them, it will give their parents and/or teachers information about whether they know the most important information or are instead focused on details that are less important [2].



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Taking this in to account, Centurion University gives special focus on the retrieval classes. The academically weak students were motivated to attain the classes by some special counselling team and the faculties. The absentees were marked and motivated again. In this way of repeated follow up made the students to attain the classes finally which became a part of the reasons behind their improvement.

**Preparatory Classes**

To enhance the End semester performance, Centurion University offers preparatory classes just before one week from the semester examination. Each theory subject is allotted a total duration of 12 hours to complete the whole topic in a week. Just before one week from the commencement of the classes the concerned faculties have to share a question bank containing 75 number of questions in accordance with the semester examination pattern. The students are instructed to find and practice the answers by themselves and note down the doubts within 7 days. After that when the preparatory classes start, the concerned faculties discuss all the questions from the question bank and clear the doubts that have been noted by the students. Each day the faculties also give some assignments on the topics that had been discussed in that day and verify the same on the next day. It has been found that, after conducting the preparatory classes the performance in the semester examination improved.

**CONCLUSIONS**

This research has provided valuable contributions to literature. It has increased our knowledge about the types of motivational beliefs and learning strategies used by Centurion University and how these beliefs and strategies have implications for the academic performance of the academically weak students. Specifically, we have been able to establish the stimulating forces (beliefs) and mechanisms (strategies) propelling their progression or retrogression in learning various subjects both at school and home. At the same time, we juxtaposed the belief and strategy constructs as well as investigated participants' genders in the framework of motivational beliefs and strategy use for learning. Furthermore, the research enabled students to identify potential hindrances to their learning in order to derive a way of alleviating the challenges. Drawing from the findings, this study offers a number of conclusions, vital for teaching, learning, and policy-making, particularly in Centurion University. The following are conclusions of this research.

- There are some students upon whom the society, their family and they themselves lost hope and think that, they can't do anything in their life. Those students are mentally harassed and are named as ignored students.
- There are also some category of students those are academically weak due to different reasons like lack of fundamental knowledge from the primary to high school level, poor financial condition of family, lack of resources or health related issues etc.
- There are some interventions taken by Centurion University to shape the ignored students and enhance their academic performance. The major strategies includes "Learning by Social Service", "Learning by Doing", "Learning by Group" and "Learning by Shaping".
- There are also some interventions taken by Centurion University to shape the academically weak students and enhance their academic performance. The strategies include "Bridging Classes", "Productive Environment", "Retrieval Practice for Students" and "Preparatory Classes"
- All those interventions not could be able to improve the academic performance of the students but also became helpful to be a good human being in future.

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## Teacher Education and Impact of Open Educational Resources on Learning Process

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### ABSTRACT

Excellence and Quality are the major concerns in our education sector. Focus has been given on imparting quality and excellence in higher education as well as teacher education. Discussion on what teacher quality is, how it is developed, and its connection to student achievement has become the facet of educational jargon in the 21<sup>st</sup> century. Quality of the teaching-learning process is primarily shaped by policy and to review how quality is cultivated in teachers. Several factors such as poor quality teaching, lack of accountability and quality assurance, shortage of faculty, outdated and rigid curricula and pedagogy and in concurrence of research and training strongly affects the process of teacher education. Also, a weak ecosystem for innovation and low levels of industry engagement are the major issues in teacher education. The three central pillars of the government's plans for education reflect these realities: expansion, equity and excellence. We are living in an era of knowledge revolution. With the advent of new and innovative ICT tools, teaching and learning process become more innovative and effective. Adapting Open Educational Resources in science education, facilitates cost effective and yet quality science education for all. Digital learning technologies like management and support systems in teacher education, online and blended learning, instructional design possesses huge potential. Within this scope, this article provides an overview of teacher education in India and issues and challenges in it. The present study seeks to address the prevailing teacher education process and highlights the significance of open educational resources.

**Keywords:** Quality, excellence, teacher education, effective, open educational resources.



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## INTRODUCTION

Since pre-independence days, education policy has played an enormously vital role in the development of an educational system in India. Education policy sets the framework ranging from development of course curriculum to pedagogical practices. Time to time the thrust of educational policies has been changing in India in response to the emerging socioeconomic needs of the nation. Post independence, a number of education commissions have been set up by the Government of India. Teacher education primarily refers to the policies and procedures designed to equip teachers with the skills, knowledge, behaviours and attitudes they require to effectively execute their tasks. It is well known that for the development of an inclusive education system, teachers play a pivotal role. Highly trained, motivated and qualified teachers are key factors for ensuring timely access to education. Teacher education is the process for the growth of adeptness and aptitude of teachers which in turn enable and empower them for meeting the requirements and challenges in the present context. Teacher education encompasses professional skills, teaching skills and sound pedagogical practices. In the 21st century the world is becoming more and more technologically oriented. The industrial age gave way to the information age, an info-tech era which is highly crucial because this has brought changes to education, business and society.

Today, the objectives of education have become multidimensional. Following the classical teaching methods such as classroom lectures only, would not suffice in achieving the objectives of teacher education. Flexible methods of teaching, is the need of the hour. With the current pandemic lockdown due to COVID 19, many educational institutions have resorted to on-line teaching. There are several digital platforms created to meet the demand for imparting education using such mediums. This has opened up a whole new area in use of digital medium for providing education in schools and higher educational institutions. Technological interventions can tackle the shortcomings of the present education system. At present, Computer Assisted Instruction (CAI) is being widely used for providing instructions to the learners of different groups to update their existing knowledge. CAI is one of the most valuable methods of providing individualized and self-paced instructions to the learners in classroom situations. Primarily CAI includes presentation of the instructional materials to the learners having varied individual differences [1-3]. We are living in an era of knowledge revolution. With the advent of new and innovative ICT tools, teaching and learning process become more and learning process become more innovative and effective. Reaching the widespread segment of the country which is considered to be one of the largest schooling systems in the world is a concern. Open Educational Resources (OER) by the means of enabling free use, reuse and remix of high quality teaching learning materials improves the access and quality of education in India.

### Policy Initiatives

Investing in the process of teacher development has always been prioritized as evident from several educational policies. Several vital steps essentially to improvise the teacher building capacity were adopted earlier in the Plan of Action (1992) and National Policy of Education (NPE) 1986. During 1997-98, over 400 District Institutes of Education and Training (DIET) were established. Also, the National Council of Teacher Education (NCTE) was established in the year 1995. Primarily, the Curriculum Framework for Quality Teacher Education was established by NCTE in 1998 and subsequently a revised National Curriculum Framework on Teacher Education was put in place in 2009. By and large, this framework resulted into a paradigm shift from behaviourism to constructivism approach, emphasizing particularly on collaborative learning, experimental and hands-on training. Teachers were related to be facilitators of learning.

### Open Educational Resources (OER)

According to William and Flora Hewlett Foundation "OER are the teaching learning and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and repurposing by others." OER in general includes all teaching learning contents like syllabi, full courses, modules, learning objects, PPT's, lecture notes, data etc, all tools that assist in generation of teaching learning process such as



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content development tools, software that supports OER development, or their delivery, enrichment etc [4]. National Repository of open Educational Resources (NROER) launched during the National Conference on ICT for school education is an initiative of MHRD Govt of India and CIET-NCERT. The aim of NROER is to bring together all the digital resources in different languages, cultures and social context in one platform. Students who used open textbooks have enrolled in more credits compared to students who used traditional textbooks [5]. Hilton III and Laman have observed that students who used open textbooks had better overall outcomes, than students who used traditional textbook [6]. There were significant differences in students' performance in courses with the open online textbooks controlled for students' previous academic performance [7]. Grewe and Davis analyzed the effect of enrolment in an OER course had on student academic achievement [8]. Results indicated a significant positive correlation between OER and students achievement. What was observed was that OER has direct impact on the factors related to student's performance and self reflection on the part of educators [9]. The current state of repositories of open educational resources (ROER) in higher education at international level has been analyzed [10]. It revealed that most of the ROER that included one or more of the proposed reuse indicators was created exclusively for educational resources. Educational aspects are not yet firmly embedded into ROER. Broad use of digital downloads as learning materials, conflation of open educational resources with free online resources have been identified [11].

**12<sup>th</sup> Five Year Plan (2013-17): Key Reforms in India**

Three foremost challenges named as excellence, equity and expansion in the higher education sector were addressed in the twelfth five-year plan (2013-17). *Excellence* primarily deals with the improvisation techniques to be employed in the teaching-learning process. Excellence also includes faculty development programmes, learning outcomes, teaching-research integration. International partnerships in the research and teaching sector are also vital. Connecting institutions through consortia and alliances is also significant. *Equity* largely targets the undeserved and underprivileged populations irrespective of their gender, disabilities, geography and, other social divisions in society. *Expansion* chiefly refers to the augmentation in the existing institutional capacity, rather than creating new government-funded institutions. Expansion also deals with enhancing growth in the engineering and technical sector. Skill-based learning is also given due importance, to be practiced throughout the nation. Privatization to be encouraged keeping an eye on the economic needs of the society.

**Concluding Remarks**

Improving teacher education quality for employability and better learning outcomes is need of the hour. This can be achieved, provided that high-end educational opportunities reach to all citizens, irrespective of caste, creed, gender, economic ability and geography, social position and so on. At the district levels, large numbers of comprehensive institutions can be set up primarily to look after the pre-service education of teachers for elementary schools and instructors for the non-formal and adult education programmes, as well as in-service education of teachers. Distance education through electronic media communications could be heavily used to meet the increasing needs of large numbers of learners and teachers. Open Educational Resources should be prioritized which would help the learners to be digitalized and also lead to a fun and exciting way to approach learning.

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## Religious Tourism and its Effect on the Spread of COVID-19

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### ABSTRACT

2019 Novel corona-virus (2019-nCoV) also referred to as severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire world into unrest. Unavailability of specific drug against the virus is more imperative. The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe. The city of Wuhan was the epicentre where the outbreak of this human pathogen emerged, and resulted to human ailment, termed as COVID-19. The current pandemic has exposed the frailty and responsiveness of healthcare systems across the globe. The article highlights the impact of mass religious gatherings and religious tourism on the spread of COVID-19 and what measures can be taken to mitigate its negative consequences.

**Keywords:** 2019-nCoV, pandemic, outbreak, healthcare, tourism.

## INTRODUCTION

Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1, 2, 3]. Several countries have widely adopted precautionary measures, such as use of face masks, frequent use of hand wash/sanitizer, strict social distancing so as to restrict the outbreak of 2019-nCoV. There are two significant questions which would give us an insight on the spread of COVID-19 across different countries. To start with, how did COVID-19 spread from one country to another? It is also important to factor in the extent to which countries are prepared to deal with the crucial issue of mass gatherings in future? There are several theories being put out in print and social media on spread of the virus across and within countries. The paper however, will focus on the latter question, more specifically religious tourism.

### Religious Tourism

Religious tourism or mass religious gatherings primarily signifies for visit to sacred places of any given country. Religious tourism has significant contribution towards a country's economy. It is a huge market that brings in large revenue in countless countries. Huge numbers of tourists are attracted for religious places like temples, gurudwaras, churches, shrines, mosques and others places of religious significance [4]. Essentially, religious tourism is observed throughout the year but as peaks are observed mainly during specific months where the mass religious gatherings

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takes full swing. This poses a considerable public health risk essentially in the context of spread of infections across the territories. It has always been demanding for the state authorities to effectively implement preventive measures against diseases that have potential to lead to an epidemic during religious mass gatherings. For instance, the epicentre of the current pandemic shifted swiftly from China to Iran and finally to Italy in no time. Introspecting the current perspectives related to mass religious gatherings or religious tourism, may assist us to be prepared for future such pandemics. A few worldwide recognized mass religious gatherings are enlisted in Table 1. *KumbMela*, *Hajj* has already been acknowledged as the source for spread of respiratory infections and antibiotic resistant bacteria [5]. Present pandemic also have been linked to mass religious gatherings contributing to the fast spread of COVID-19.

A mass religious gathering event at Malaysia where almost 19,000 people gathered led to spread of COVID-19, whereby 35% of Malaysians were infected, which included 1,500 foreigners from 30 different countries [6]. This event was organized by a muslim evangelists group known as *Tableeghi Jammata* at Sri Petaling Mosque in Kuala Lumpur. Unfortunately, this infectious transmission occurred due to this religious mass gathering now has been recognized as the largest vector for the spread of 2019-nCoV to other countries [7]. Similarly in India too, the *Tableeghi Jammata* event held in mid-March at Nizamuddin Markaz in New Delhi, was responsible for 30% Covid 19 cases in India at that time. Out of a total of 14,378 total cases, 4,291 were linked to the religious event, during that time. Countries like Iran attract around 8 million foreigners annually and generate a good amount of revenue from religious tourism sector. During this pandemic, officials of the Iranian state did precious little to ban mass religious gatherings of pilgrims from attending holy shrines until Iran was declared as the new epicentre of the virus.

The infected pilgrims spread the pandemic in their home countries such as seen in the case of Pakistan where a large number of infectious cases were observed particularly in the province of Punjab and Sindh. In Pakistan also, several mass religious gatherings occurred. For instance *Raiwind Tableeghi Jemata*, gathered almost 250,000 pilgrims from 70 different countries during the month of March, which was believed to be a very critical phase for the spread of this pandemic. The worst affected countries owing to such mass religious gatherings were Indonesia, Kyrgyzstan, Palestine and Malaysia [8]. Another such instance is the *Hajj* which is considered to be the obligatory pilgrimage for muslims. Around 2.5 to 3 million pilgrims join for this event at Mecca, Saudi Arabia. Previously it was observed that *Hajj* pilgrims suffered from respiratory infections owing to substandard preventive measures and contributed largely for previous MERS outbreak (2013) and pandemic of H1N1 (2009) [9,10]. But for the current pandemic situation, Saudi government cancelled the Hajj in 2020. However, they are considering opening up their borders for Hajj-2020 (28<sup>th</sup> July- 2<sup>nd</sup> August), keeping in view the religious emotions of pilgrims and more importantly the economic benefits. Complete closure of Hajj may contribute to a loss of \$8.5 billion in revenue. In this case, it would be mandatory to follow stringent policies and regulations to avoid any further outbreak of the pandemic and its irreparable consequences in terms of loss of lives.

**Concluding Remarks**

Religious tourism or mass religious gatherings possesses significant amount of religious emotions. However, conservative religious rejection of science as part of the extreme cultural and political polarisation makes it impossible to reach consensus, and make progress, on many social and environmental problems [11]. It would be inappropriate to ban the religious gatherings provided strict surveillance mechanisms are deployed. Any country opening their territory during pandemics like Covid 19, for outsiders must exhibit competence to execute sufficient preventive measures and diagnostic capabilities. Furthermore, to stay away from any potential ramifications, it is suggested that restrictions should be put on the religious pilgrims, primarily from hotspots and epicentres, chronic disease patients, pilgrims over 50 years old, pilgrims with cardiovascular complications. Politicising the issue and blaming specific religions for their fallacy in spread of the virus is no solution to the dangerous pandemic. Countries need to organize a defensive approach for all the required arrangements. More than anything, it is imperative to convince the religious leaders of different religions as they wield a lot of influence on followers, to understand the scientific complexity of the pandemic and its implications. This can not be forced on anyone. People have to be convinced that religious gatherings can prove to be super-spreaders of the virus. This reality has to be internalised by





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the religious leaders first and transferred to the followers. The jeopardy of the virus spread due to mass religious gatherings is a reality and is a wake up call for governments and religious institutions to view the scenarios scientifically and take action for the sake of humanity.

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**Table 1: Mass Religious Gatherings in the World**

<b>Name of the religious event</b>	<b>Country</b>	<b>Frequency</b>
Kumbh Mela	India	After every 6/12 years
Makara Jyothi	India	Annual
Hajj	Saudi Arabia	Annual
Arba'een Pilgrimage	Iraq	Annual
Bishwa Ijtema	Bangladesh	Annual
Black Nazarene	Philippine	Thrice in any year
Raiwind Tableeghi Ijtema	Pakistan	Annual





## Haematological Profiles of *Clarias batrachus* and *Gallus gallus domesticus* in Mining areas of Talcher, Odisha

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### ABSTRACT

The Indian mining sector plays a critical role in economic growth and improving livelihoods, as well as providing space for degrading the environment. It also impacts environmental instability on local air, water, and natural resources. This study represents an overview on haematological parameters *Clarias batrachus* and *Gallus gallus domesticus* of Talcher mining area. Haematological indices have shown important results in the measurement of concentration of haemoglobin, total red blood cells, white blood cells, packed cell volume, mean cell haemoglobin and mean cell haemoglobin concentration. Nevertheless, mining plays an significant role in socio-economic growth, but it does build mitigation for environmental sustainability. Proper management strategies can help to conserve biodiversity in the mining areas. Haematological profiling plays a crucial role in nutritional and physiological status of an animal, as blood constituents' change in relation to an animal's micro and macro-environment.

**Keywords:** Haematology, *Clarias batrachus*, *Gallus gallus domesticus*, mining

### INTRODUCTION

Indian mineral sector plays a significant role to generate employment opportunities and improved livelihoods . Development of socio-economic status of a country as well as the bio-physical characters of an environment are generally changed by the influence of mining at that particular region [1]. Minerals are an important resource that has supported the economic development of our country. The ongoing decline in the quality of the natural environment in mining areas seriously threatens to public and animal health and prevents sustainable resource and environmental sustainability [2]. Long term effect of mining areas create negative impact on local water ,air, climatic condition as



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well as depletion of natural resources. Blood is a fluid connective tissue and it contains many cellular constituents along with liquid portion consisting of carbohydrates, lipids, proteins, amino acids and other macromolecules [3]. Haematology generally helps in determining the basic profiles of cellular elements and the use of these results in the diagnosis and monitoring of disease [4]. The haematological parameters provide essential information on the balance between the production and destruction of cells of the circulatory system as well as the blood's ability of clotting [5]. Haematological studies are very significant for diagnosing of the structural and functional status of an animal's body [6]. Haematological analysis help us to obtain knowledge about the haematological parameters like red blood cells (RBC) count, white blood cells (WBC) count, concentration of haemoglobin (Hb), Packed cell volume (PCV), mean corpuscular haemoglobin(MCH), Mean cell volume(MCV) and Mean corpuscular haemoglobin concentration (MCHC). These parameters can indicate the health status of different vertebrates of mining area and disease caused due to their environmental conditions. Haematological analysis can contribute to the understanding of physical adaptations which simplifies the use of different habitats by the species[7].This study provides a haematological base line of *Clarias batrachus* and *Gallus gallus domesticus* in Talcher mining area of Odisha.

**MATERIALS AND METHODOLOGY**

This present experimental study included collection and identification of the species with haematological analysis. This entire investigation study was undertaken from the month of November, 2019 to March, 2020. The vertebrate species taken for the experimental work were catfish (*Clarias batrachus*) and domesticated fowl (*Gallus gallus domesticus*).The experimental analysis was done in the Laboratory of Department of Zoology of Centurion University of Technology and Management, Bhubaneswar Campus, Odisha.

The blood sample of the vertebrates was collected from the meat and fish market of the mining area. The blood sample from the hen was collected from its wing vein. For fish the number of methods employed for the collection of blood include; the puncture of dorsal aorta or cardiac and caudal vein. The blood was drawn with the help of a 2.5 ml syringe (needle size 0.55\*25 mm) manufactured by Hindustan Syringes and Medical Devices LTD; 174,178/25, Ballabgarh, Faridabad, India-121004. The blood was then transferred immediately to EDTA vial of 2 ml which acts as an anticoagulant. The haematological analyses were done for the examination of haemoglobin concentration with the help of Sahli's Haemocytometer, Red blood cell (RBC) and white blood cell (WBC) count by using Neubauer Chamber, Packed Cell Volume (PCV) was calculated by taking blood in Wintrobe's Tube and centrifuged at 3000 rpm for 30 minutes, total RBC and WBC count in neubauer's chamber. Concentration of Hb was done with sahli's haemocytometer, PCV, MCH, MCV and MCHC), were analysed by standard protocol[8]. Erythrocytes indices such as Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), and Mean Corpuscular Haemoglobin Concentration (MCHC) were calculated as per the formulae[8].

**RESULTS AND DISCUSSION**

Results of haematological analyses of *Clarias batrachus* of the area are shown in Table 1. Mean value for haemoglobin (g/dl) differed significantly ( $P < 0.001$ ) between blood samples of the two *C. batrachus* of the mining area. The result of this study revealed the effect of pollutants on blood parameters of catfish. The mean value of RBC differed significantly ( $P < 0.05$ ) between the two fishes. The value of RBC is higher in catfish number in comparison to that of the second catfish. This is due to the bioaccumulation of heavy metals like Fe, Zn, Cu, Mn, Ni, Cd, Pb and Cr in the various tissues of catfish [9,10]. The value of WBC differed significantly and the value of WBC was higher in the second fish which indicates that the immune system is working against the pollutants/heavy metals accumulated in the body. PCV value was slightly higher in the first fish and MCV value differed significantly between the two fishes. MCH values were not statistically significant between the fishes. High value of MCHC indicates more Hb in a unit of RBC and the value is higher in fish A. The value of MCHC differed significantly ( $P < 0.001$ ). MCH value refers



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to the average quantity of haemoglobin present in a single red blood cell. MCH is calculated by dividing the amount of haemoglobin in a given volume of blood by the number of red blood cell present. The mean corpuscular volume is the estimation of the average volume of Red blood corpuscles [11].

The results of haematological analyses of *Gallus gallus domesticus* are shown in Table 2. Mean value for haemoglobin (g/dl) differed significantly ( $P < 0.01$ ) between the two *G.gallus domesticus*. The mean value of RBC differed significantly ( $P < 0.05$ ) between the two hens. The value of RBC is higher in the first hen in comparison to that of the second one. The value of WBC was slightly higher in hen-2 and is not statistically significant. The increase in WBC observed could be due to stimulation of the immune system in response to the accumulation of pollutants in the tissues. PCV value differed significantly ( $P < 0.01$ ) between the two hens whereas the values of MCV and MCH were not statistically significant. The high level of MCHC indicates more Hb in a unit of RBC [12] and the value of MCHC did not differ significantly. The blood parameters have been used as sensitive indicator of stress in different vertebrates exposed to different toxicants and pollutants, such as metals, chemical industrial effluents, biocides, etc. The most common hematological parameters measured during stress included red blood cells (RBCs) and white blood cells (WBCs), hemoglobin content, haematocrit (PCV) value and red blood cells indices. The haematological parameters are often determined as an indication of the health status. The RBC of the vertebrates determines the dissolved oxygen carrying capacity. Fluctuations in the blood cell indices correspond with values of RBC count, PCV and hemoglobin concentration.

A significant decrease erythrocyte (RBC) counts, haemoglobin (Hb), increase of white blood cells (WBC) of the vertebrates from its normal value can be related to the effect of pollutants due to the mining in that area and the decrease in RBC counts during the study may be due to anemic condition and haemolysis caused by chromium since chromium is one of the major resulting wastes of coal mining activities along with Ni, Cu, Zn, Cd and Pb[13]. The blood parameters level decrease due to Pb. The level of RBC decreased may be due to the effect of Pb and Cd, the decrease in Hb synthesis and the reduced life span of RBC may be also due to the effect of high level of Pb. The increase in the WBC level and MCH may be due to Cd present at high level in that area [14].

## CONCLUSION

This study focused on vertebrates being subjected to mining environment and its effect on their haematological parameters. Assessing those haematological indices determines an organism's physiological status. The impact of this mining zone may pose a threat to the biodiversity. The effect of mining environment was demonstrated by a significant reduction in haematological parameters such as erythrocytes, haemoglobin as well as an increase in MCH, MCHC and MCV values. Since mining activity is an integral part of development, it does have some mitigation with society. So appropriate management strategies should be taken for socio-economic status development and sustainable ecosystem development.

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**Table 1 Values of haematological indices of *Clarias batrachus* in mining area**

SL NO	Haematological Parameters (Units)	Fish A(X±SD) (n=5)	Fish-B (X±SD) (n=5)	P Value
1	Haemoglobin (g/dl)	10.54±0.4545	9.66±0.4202	0.000819
2	RBC (×10 <sup>6</sup> /mm <sup>3</sup> )	3.6±0.2738	2.58±0.1772	0.007039
3	WBC(×10 <sup>3</sup> /mm <sup>3</sup> )	2.86±0.1435	3.72±0.1881	0.003322
4	PCV (%)	28.4±0.5099	25±1	0.008167
5	MCV(fl)	804.563±52.3305	980.197±45.0917	0.017286
6	MCH(pg)	353.248±17.1739	378.357±16.3506	0.160289
7	MCHC(%)	44.0996±0.8533	38.617±0.1505	0.000113

**Table 2 Values of haematological indices of *Gallus gallus domesticus* in mining area**

SL NO	Haematological Parameters (Units)	Fowl A (X±SD) (n=5)	Fowl B(X±SD) (n=5)	P Value
1	Haemoglobin (g/dl)	6.02±0.235	5.42±0.2009	0.00097
2	RBC(×10 <sup>6</sup> /mm <sup>3</sup> )	2.82±0.185	2.2±0.1304	0.01282
3	WBC(×10 <sup>3</sup> /mm <sup>3</sup> )	4.2±0.3271	4.58±0.243	0.18941
4	PCV(%)	28.6±1.077	26±1.5492	0.00405
5	MCV(fl)	1183.0139±109.837	1181.783±9.491	0.49568
6	MCH(pg)	243.9297±7.972	247.826±6.5195	0.35751
7	MCHC(%)	21.0663±1.233	20.979±0.601	0.47539





## Marketing Models for Solar Products in Rural Areas of Odisha

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### ABSTRACT

A survey has been undertaken in some parts of South Odisha in particular where there was a prospect of marketing of solar lights in particular. This paper consist of two sections. The prices for all these solar products should be kept low or the same unless it is manufactured in large whether it is consumer electronic, FMCG or renewable energy product. Product share pricing strategy is another concept where the rural consumers if cannot afford high value solar operated products even if they need it, they cooperate with other consumers who wants to use the same product. Another model for solar product marketing in the rural areas can be through Pay-as-You-Go (PAYG) business model. The Entrepreneurial-cum- SHG model was adopted in rural context for marketing of solar products in rural areas of South Odisha.

**Keywords:** marketing, Product, consumers, solar

## INTRODUCTION

This study examines the different models undertaken for marketing of solar products in the rural areas of Odisha. A survey has been undertaken in some parts of South Odisha in particular where there was a prospect of marketing of solar lights in particular. This paper consist of two sections. The first section focuses on different models undertaken and also suggests some strategies for marketing of solar products in the rural areas of Odisha and the second section focuses on the survey and the implementation of Entrepreneurial-cum- SHG Model for selling of solar products.

### Marketing of Solar Products

The size of rural market for solar products is huge but the the companies generally target the rural region closest to its area of operation – a convenient and obvious choice for them by which people living in distant are deprived of it. Hence, an effective distribution model should be in place for last mile consumer (Solanki, 2005). The prices for all these solar products should be kept low or the same unless it is manufactured in large whether it is consumer electronic, FMCG or renewable energy product (Solanki, 2005). Direct marketing is an option, by having a store in a rural location. Example: Electrical stores, Mobile sales and service shops, Cable TV DTH service shops etc.

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The crucial factors for a broader marketing of PV systems are: financial incentives, government led initiatives, reduction of investment costs, and increase in reliability, dissemination of information and environmental awareness. A persuaded individual can make an adoption decision that a person with inadequate knowledge cannot. There are different marketing and selling strategy are being adopted for different rural consumers depending upon the location factors. Other factors that help in promoting the solar business in Odisha are documentation, quality, process, design and innovation, production capability and, finally, cost effectiveness.

Among the few which are highly required for marketing are door to door selling of solar operated products, selling in haats, melas, etc. There are different models of distribution, most effective one is the Entrepreneurial-cum- SHG Model which is discussed in the later part of the paper. Here, the members are sensitized for using solar product for lighting purpose and other income generation activity. Explaining and demonstrating the use of solar product to the SHG members at the village level during their weekly meetings, preferably in evenings is a low cost distribution model needs to be adopted for PV penetration in the rural areas of Odisha. Affordability, availability are the major concern for any rural consumer to think on getting a product. Having access to get a credit is a major concern for rural people to get hold to the product. They need to spend less but they deserve a good quality product. Many households in rural Odisha neither have access to electricity, and more importantly, nor do they have access to credit. Why is access to credit important? When a reliable product say a solar light is introduced into the market its cost is naturally higher which in turn makes it not affordable to buy.

Affordable does not mean its cheap quality product but rather it should be able to generate repayments and help in income generating. Rural consumers should be provided with a low-interest credit which becomes a headache for both institutional and financing organisation. For example, if a household wants to purchase a solar home lighting system, then he finds it difficult to pay the full amount, now some of the organisations are giving these systems on credit and going for payments in a equal monthly instalments (EMI) but it affects the organisation in terms of the running of the business the operational cost more precisely to say. Hence, a desirable system like jointly purchasing the product and giving it for rent, would be a good option for it. There are different branding and advertising strategy but for selling solar operated products the following strategy are adopted like that of word of mouth where the company people organise "tea party" at the home of satisfied customers, where people from around the village are invited to watch a demonstration of how the solar product is working. They do often create noise so that people come outside to see what is happening which further acts like a free publicity (SELCO Case Study). Other initiatives like banks themselves plays an important role in marketing the solar product at their own branch, when they identified a potential customer who could afford and benefit from the system they give loan to purchase it (ibid).

Another model is the demonstration model where the company installs a system in the house of a influential or wealthy person of a village as a part of a one-to-two month trial. The program starts off with a tea party similar to one described above. At the end of the trial period technicians return and began to disconnect the system. The experience of living with the lighting along with the family and social pressures eventually induced most customers to take the loan and purchase the system (SELCO, Yale SoM, Case Study). Product share pricing strategy is another concept where the rural consumers if cannot afford high value solar operated products even if they need it, they cooperate with other consumers who wants to use the same product. for example the use of solar operated drip irrigation system was purchased by a farmer at Rs. 25000/- then it was shared with other farmers for irrigating their fields which could be near by., the system is given in rent with a specific amount, per hour basis or per day basis. This business model acts as a income generation activity for the farmer and subsequently helping him to lead good living condition. Solar being an emerging industry, trade shows and exhibitions are another powerful avenue for marketing the products. Participating in an expo attract a good number of customers and subsequently helps in building a network chain of customers if the product is of good quality, this helps in scaling up the production and fulfilling the target, in all it is targeted and very efficient advertising campaign.



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Solar products can be financed by providing micro-credit to rural people. Micro credit refers to purveyance of loans in small quantities. The term “micro” literally means “small”, as per micro credit special cell of the Reserve Bank of India (RBI), the borrowing amounts up to the limit of Rs 25000 could be considered as micro credit products and this amount could be gradually increased up to Rs 40000 over a period of time. Micro-credit providers through different schemes often comes with a relatively high interest rate because of the high costs of repayment collection, irregularity of loan payment and absence of securities. The loan extended to members of community-based savings, cooperatives and other finance institutions have high interest rate. The interest rates vary from 23 to 25 percent in India. Rural consumers are unable to reimburse the overall amount in which the interests represent a non-negligible amount. As a result a group based delivery model for financing of solar products products is advised which can be used by different members of the SHG by involvement of various financial institutions.

A group is formed by the rural consumers in the target community to offer finance services (micro savings, microcredit, micro-insurance, etc.) to themselves. Groups is composed of rural youth, or women from the local regions as they can create support structures for micro-enterprises and other work-based issues. This method can be the basic unit of operation for the Micro-Finance Institutions (MFIs). As MFIs have to provide collateral free loans, group methodology can help in creating social collateral (peer pressure) that can effectively substitute physical collateral. In lending agreements, collateral is a borrower's pledge of specific property to a lender, to secure repayment of a loan. The collateral serves as a lender's protection against a borrower's default and so can be used to offset the loan if the borrower fails to pay the principal and interest satisfactorily under the terms of the lending agreement. The group approach delegates the entire financial process to the group rather than to the financial institutions. All financial activities like savings, getting loans, repayment of loans and record keeping should be managed at the group level. In this method, 10-20 members are organised to form a group. These group members need to make regular savings of fixed amount in a common fund. The amount and frequency of savings is mutually to be decided by the group members.

After the successful working of such a group for some months the group is required to be linked to a financial institution for getting credit. The financial institutions will issue loan in the name of group and whole group will be responsible for repayment. The amount of loan will depend upon the total accumulated amount of saving of the group. The group itself will select its members before acquiring a loan. Loans will be granted to selected member(s) of the group first and then to the rest of the members. Most financial institutions require a percentage of the loan that is supposed to be saved in advance, which points out the ability to make regular payments and serve as collateral. Group members themselves will decide about the criteria of dividing the loan among their group members. With this loan the whole group may jointly start a micro-enterprise or the members may start their individual businesses.

An individual may also use his loan for consumptive purpose or meeting other priority needs. Group members will be jointly accountable for the repayment of each other's loans and will usually meet weekly to collect repayments. To ensure repayment, peer pressure and joint liability needs to work well. The entire group will be disqualified and will not be eligible for further loans, even if one member of the group becomes a defaulter. The creditworthiness of the borrower will therefore be determined by the members. This type of group based delivery method can help to empower the group members because they will remain involve in various group activities. They will visit the bank, market and hold group meetings which would help them to increase self-confidence. This model will help in self-sustaining of the group and will also act as an effective monitoring mechanism for repayment of loans, for the products and services they buy.

### **Entrepreneurial-cum- SHG Model**

In order to create an entrepreneurial-driven market for solar energy products a model has been devised called entrepreneurial-cum- SHG model for solar products intervention into the rural areas through the SHG or cooperative. Here, we need to understand how an SHG, which is a community based organisation can help in marketing of any solar product into the rural areas. Any SHG group consist of 5-10 members that identify possible



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initiatives to be undertaken for the development of the livelihood in local context specific. The members in the SHGs are like minded group and consist of farmers, vendors, street hawkers, etc. who live in close vicinity to each other and can avail many schemes related to bank and others. Sometimes bank become reluctant to lend them loans to poor households for any solar products, for instance for the use of solar home lighting systems. Bank worries over the defaults and the high transaction costs associated with the small sized loans. For the same SHG can play an important role by bridging between the consumers and the bank.

In this model, the clean energy organisation approaches to an SHG to market their products, whether in form of an CSR initiative or from marketing perspective. The SHG leader who acts as a Solar Energy Entrepreneur (SEE) must be trained by the clean energy organisation to provide technical, managerial support to the consumers. Now, if the bank provide loans to SHG (here SEE needs to identify and submit loan proposals which can be finally sanctioned by the bank manager, before the loans are granted, more time and effort should be spend for training the SHGs members on banking habits, policies and how to maintain the books of accounts) then they would meet with the SHG members on a weekly basis who would pay the loan in instalments. The interest rates depends upon the bank which provides the loan to the SHG. Training sessions can be given to each SHG at the field level quarterly or semi-annually.

The important aspects of this model is that once the loans are provided to the SHGs, they can conduct meetings on weekly basis or every 15 days with the members, where instalments are collected. Conducting such weekly meetings can be a check against the default members and subsequently it creates a platform for a discussion. This model not only can offer an easy finance but also SHG members can deposit a nominal fee with SHG leader so as to promote banking habits. The socio-economic benefits is that the by the use of solar products people can advance in their secondary sources of livelihood. From entrepreneurial perspective now if the loan is provided to the SEE directly through the bank, then the SEE can procure the Solar Products (SP) from the clean energy organizations, companies and market it to the members, or generate possible leads, subsequently going for selling of the product. Consumers can take loans from the SHG through SEE (who is also a member of the SHG) and he/she constantly monitor the actual utilization of all types of loans to prevent non-payments or any diversion.

For this purpose, a solar energy programme card can be prepared for keeping the track of payment of installments. Two cards can be prepared and one card will be maintained with the SEE and the other card will be kept by the consumer, bearing the same serial number. Duration for the loan of any solar product (like solar light, solar operated irrigation pump, solar dryer, etc.) can be kept for a short term period say 6-8 months depending on the interest and other terms and conditions of the bank. Consumers need to pay the amount within the particular time period.

**Pay-as-You-Go (PAYG) Model**

Another model for solar product marketing in the rural areas can be through Pay-as-You-Go (PAYG) business model. Here the consumers make a small deposit for the installation of the product and then pay regular installments through mobile payment systems. It will have two main approaches that is energy as service approach, where the consumer pays for the electricity provided and does own the product and other approach is lease-to-own model, where the consumer becomes the owner of the product after a period of time. Out of these two models, lease-to-own is the most appropriate one. Two of the possible models has been recommended for solar product marketing. In this model the consumer pays a down payment for the product, which is attached to the smart meter. Regular payment has to be made by the consumer, if the consumer is unable to pay the amount then it will defer. The credit recharge, the payment point sends the consumer identification and recharge information to the service provider and it sends a recharge code. Then, the consumer uses this recharge code to unlock the system and gets the energy credits, further allowing the consumer to use the system till the energy credit gets exhausted. After the completion of 28 months the system permanently unlocks and the system is owned by the consumer. The meter locks the system after the consumer energy credit have run out.



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Another possible model where the consumer purchases the solar product by paying some initial amount and takes the system and installs it. Consumer uses the system till the energy credits are exhausted, when finished the consumer brings the system attached to the charge controller to the service provider, where the provider attached the dongle to his/ her mobile and transfers the energy credits pertaining to the amount paid by the consumer. Dongle gets updated and the recharge is done. The consumer plugs the dongle into the charge controller and the system gets activated. This process goes on till full payment for the system is done and the system gets unlock for lifetime of the product.

**Product Sharing Model**

The product sharing model where the rural consumers when cannot afford high priced product even if they need it, they can share it with other consumers who wants to use the same product. For example the use of a solar operated drip irrigation system by farmers for irrigating their fields. The system given in rent with a specific amount, per hour basis or on day basis. This business model can acts as a income generation activity for the farmer, repayment of loans and subsequently helping leading him to a better quality of life. For any model to be successful it is required to build a partnership between companies and institutions, distributors, dealers, SHG members, cooperatives etc. for an effective distribution of products and services into the rural areas.

**Survey for Marketing of Solar Products in South Odisha and Implementation**

A survey was conducted in the areas of South Odisha preferably the districts of Koraput, Nabarangapur and Malkanagiri. Samples were collected from Jeypur, Kotpad, Kundra, Boipariguda, and Koraput blocks of Koraput district. Similarly samples were also collected from Papadahandi, Chatahandi and Nabarangapur blocks of Nabarangapur district and Mathili block of Malkanagiri district. About 120 respondents were taken into account for this survey. From the survey it was found that 63 percent of the respondents depended on the agricultural activity for their livelihood. Rest of the respondents undertook various activities such as livestock, forestry, tailoring, carpentry, etc. Forty one percent of the respondents were members of a cooperative, operating locally. About, 72 percent of the respondents were having a BPL card. From the survey it was found that 59 percent of the respondents did not have electricity at their homes and were facing the problem of lighting. Although 41 percent of the respondents were having electricity connection but they were facing the problem of fluctuation and low voltage due to which they were not getting a continuous supply of electricity during evening hours. Almost all respondents used kerosene for lighting purpose at home. Five percent of the respondents used 1 ltr, 26 percent used 2 ltr 31 percent used 3ltr, 26 percent used 4ltr, 7 percent used 5ltr and 5 percent used 6ltr of kerosene on each day for lighting, cooking and other activity during evening time. From the survey it was also found that about 83 percent of the respondents were not able to carry out any activity due to lighting problem and 69 percent of them required good lighting for at least 8 hours from evening till dawn of next day.

From the survey it was also found about 74 percent of the respondents did not have any idea about solar lighting and about 73 percent of them were interested to know about solar lighting. It was also found that, about 17 percent of the respondents could buy solar light with the range from Rs 1000-2000, 58 percent from Rs 2000-3000, 18 percent from Rs 3000-4000 and 7 percent from Rs 4000-5000. After undertaking the survey a model was initiated for marketing of the solar products. The model of Entrepreneurial-cum- SHG model was adopted for use of solar products. Here, the SHG members helped in marketing of any solar product into the rural areas. SHG members identified possible initiatives to be undertaken for the development of the livelihood in local context specific. The members in the SHGs were like minded group and consist of farmers, vendors, street hawkers, etc. who lived in close vicinity to each other. They availed many schemes related to bank and others. Sometimes bank was reluctant to lend loans them for solar products, for instance for the use of solar home lighting systems. Bank worried over the defaults and the high transaction costs associated with the small sized loans. For the same SHG played an important role by bridging between the members and the bank.





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In this model, the clean energy organisation, here the Auroville Energy Products (AEP) approached to the SHG to market their products. The SHG leader who acts here as a Solar Energy Entrepreneur (SEE) was trained by AEP to provide technical, managerial support to the consumers. Bank provided loans to SHG and they meet with the SHG members on a weekly basis who paid the loan in instalments. The interest rates depended on the bank which provided the loan to the SHG. Training sessions were given to each SHG at the field level on a quarterly. The important aspects of this model was that once the loans were provided to the SHG, they conducted meetings on weekly basis with the members, where instalments were collected. Conducting such weekly meetings helped in checking the default members and subsequently it created a platform for a discussion. This helped not only for an easy finance but also SHG members could deposit a nominal fee with SHG leader so as to promote banking habits. The socio-economic benefits was that the by the use of solar products members could advance in their secondary sources of livelihood.

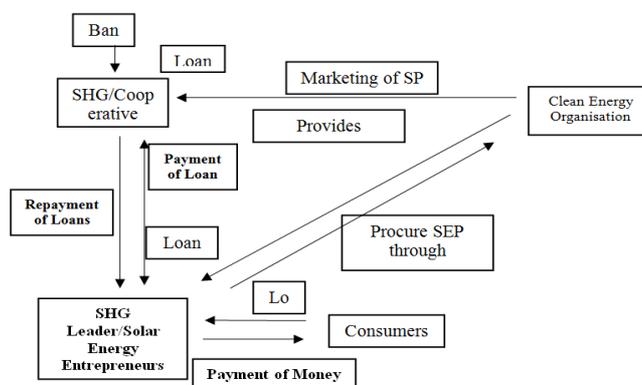
For this purpose, a solar energy programme card was prepared for keeping the track of payment of instalments. Two cards can be prepared and one card was maintained with the SEE and the other card was kept by the member, bearing the same serial number. Duration for the loan of the product (like solar light, solar operated irrigation pump, solar dryer, etc.) kept for a short term period of 6 months depending on the interest and other terms and conditions of the bank. Members paid the amount within the particular time period.

**CONCLUSION**

Although there are different models still prevailing in rural India for marketing of solar products, here a snapshot of models prevailing in rural Odisha and in South Odisha in particular was undertaken. The Entrepreneurial-cum-SHG model was adopted in rural context for marketing of solar products in rural areas of South Odisha.

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**Fig1: Entrepreneurial-cum- SHG Model**





## Clean Energy Products and Distribution, Revenue Collection Model

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### ABSTRACT

A majority of Indian population resides in villages. Once Mahatma Gandhi has said real India resides in villages and we need to put effort to develop our villages. The most common clean energy sources are solar, wind, biomass, hydropower and geothermal. "Clean technology" refers to any goods, services and process that reduces negative environmental impacts by adopting a major energy efficiency advancement, by the use of sustainable resources, and going for environmental safe guard initiatives. Lighting for work after dark improves the productivity and income, particularly in the areas where the consumers have a demand for evening services. Government and its agencies through its policies are important actors which initiates and guides to promote and achieve current and future deployment goals towards an energy transition. Target areas needs be accessed where there is non availability of electricity or is available in scarcity.

**Keywords:** population, agencies, policies, reduces, environmental

### INTRODUCTION

A majority of Indian population resides in villages. Once Mahatma Gandhi has said real India resides in villages and we need to put effort to develop our villages. Key ingredient for socio-economic development of any country depends on the use of energy (World Energy Resources, 2013). Energy is the foundation of modern industrial economy (ibid). Every sector whether it is agriculture, industry, transport, businesses and households requires energy to fulfill the basic needs. Having link to energy is required for improving health, agricultural productivity, education (UNDP, 2001). Growing need of energy has led to depend on harnessing and use of fossil fuels in a large quantity. This has led to environmental degradation, pollution and ecological imbalance. In providing solution to it the role of clean energy is maximum. Hence, there is a need to focus on shifting from conventional source of energy to clean energy. This paper consists of two sections. The first section focuses on two aspects. First it describes the clean



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energy and clean energy products. Second it focuses on mapping of possible clean energy products with different activities in rural context. Second section focuses on a distribution and revenue collection model which can help in diffusion of clean energy products in rural areas.

**Clean Energy, Clean Energy Product and Rural Users**

“Clean energy” is basically derived from clean, zero-emission sources, as well as energy saved through efficiency measures (energync.org). The most common clean energy sources are solar, wind, biomass, hydropower and geothermal. “Clean technology” refers to any goods, services and process that reduces negative environmental impacts by adopting a major energy efficiency advancement, by the use of sustainable resources, and going for environmental safeguard initiatives (Clean Edge, 2011). Although there is no standard definition of “Clean Technology”, but it can be described as a diverse range of products, services and process that harness clean materials and energy sources, dramatically reducing the use of natural resources, eliminating emissions and wastes (ibid). It also includes a variety of technology related to use of clean energy products, recycling of products, use of e-vehicles, energy efficient motors, smokeless chulha, DC lighting systems etc. “Clean energy product” are those products which uses this technology. Use of clean energy products help in creating new avenues for earning, reduce cost, reduce drudgery and improve health conditions, thus enhancing quality of life in rural areas. In the present context, quality of life can be visualized as a better living conditions in terms of accessing to modern services like electricity, modern cooking fuel, etc. “Clean energy services” are those services which basically starts from the site selection, to project management of the construction, installation, and operation and maintenance. For example, installation of a solar based home lighting system, to provide training services on how to operate it, maintain and repair it when damaged, etc.

**Clean Energy Products**

There are different clean energy products available in the market such as solar lights, solar pumps, biomass cook stove, solar cook stove, LPG cook stove, biomass gasifier, PNG, LPG etc. Table 1 focuses on classifying the clean energy products on the basis of cooking, transforming energy and utility. With different clean energy products available, there is need to compare these technologies to have a clear understanding which technology is more sustainable. Table 2 focuses on a comparison between different clean energy options available under various parameters like cost, availability, ease of handling, health, sources, efficiency etc. From table 2 it was found that solar operated products are cleanest, more sustainable, with high degree of efficiency with respect to other clean technology options. Solar operated clean energy products are absolutely clean, efficiency is high, sustainable and the requires low operational cost.

Energy is required at every levels, starting from household to organisation level, from cooking to manufacturing of a product, to processing to marketing of a product or service. It is also required for shared services from schools to health centres to transport to telecommunication network setc. There is a basic connection between energy access and livelihood. Lighting for work after dark improves the productivity and income, particularly in the areas where the consumers have a demand for evening services. Lighting helps in increasing flexibility of operating hours, allowing other activities to be performed. Energy services like heating, cooling, use of information communication technology applications including mobile, TV, radio etc. helps in providing comfort and entertainment to all stakeholders. Diffusion of clean energy product in rural context is important. In table 3 an attempt has been made for mapping of possible clean energy products with different activities in rural context on the basis of service, manufacturing and processing.

**Clean Energy Access: An Institutional Web**

“Clean energy access” is the process of transferring clean energy products and services to a household, community or a place that people require towards lighting, cooking, heating, cooling, etc. It is the right for every people in this world. Clean energy access cannot operate in isolation. It can only be achieved when the households, community,



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organisations, etc. be in a web. Here all the members need to work together to achieve clean energy access. "Government and its agencies through its policies are important actors which initiate and guides to promote and achieve current and future deployment goals towards an energy transition" (Chapman, Itaoka, 2018). "Policies are the result of interactions between government and various interest groups or actors within a society and play an important role in providing a collective strategic direction in promoting a social change" (ibid). "They make contributions to create and support development, infrastructure and provision of locations for experimentation-enabled innovation" (Foxon, Hammond, Pearson, 2010; Sovacool, 2012). Govt. take initiatives that help in access of clean energy products and services through its policies. Policies is framed at Govt. level and is implemented through institutions at ground level. It is made by legislative assembly, parliament, planning commission, ministries of power and other related to energy (conventional and non-conventional) both at state and central level. At the central level, the Ministry of New and Renewable Energy (MNRE) is the nodal ministry of the Government of India (GoI).

Altogether ministries (industry, agriculture, rural development etc,) Central Electricity Regulatory Commission (CERC), independent power producers, government owned generating and transmission companies, private distributors, financial institutions (banks, international agencies, rural electrification corporation etc.), peoples institutions like cooperatives, SHG, producers company, farmers club, joint liability groups etc. work in ground level for diffusion of clean energy products and services. Supporting agencies like equipment suppliers (DC pumps, batter, LED lights, panels, charge controller, conductors, insulators, wires etc.) service and maintenance agencies, standard organisation like (Bureau of Energy Efficiency), consulting agencies, panchayat raj institutions, industry organisations and civil society are some of the other institutions. Figure 1 gives the institutional web for different actors involved in framing of policies and implementation both at central and state level. Altogether the presence of institutions, Govt policies, etc. should be made available for access of clean energy products and services in the rural areas. MNRE, IREDA, electricity board, tax department, district industry corporation, presence of block development office, presence of panchayat office, presence of testing centres, R&D labs, rural development agencies and other agencies both at state and central level are all possible members of this web.

**Clean Energy Product-Services Distribution, Revenue Collection Model for Rural Area**

Considering the access of any clean energy product significantly depends upon on the distribution of product, there has been a number of innovative methods in rural distribution. One such method which can be initiated by private companies is the model of distribution and revenue collection model. The model is presented in Figure 3. Under this model, it is envisaged that each village should have a Village Clean Energy Committee (VCEC) to act as an interface between the rural consumers and the company. The VCEC with appropriate power can provide a platform to the consumers to give their thoughts regarding the products and services received and facilitate the company through giving feedback and collecting revenues. Some of the key activities that VCEC should be engaged in handholding of consumers in providing information about the product, EMI schemes, maintenance and repair, complaint redressal, revenue collection, disconnections and reconnections, maintaining of stock the product, etc.

The VCEC should represents all sections of the village and should be constituted after careful consideration of the village dynamics. It should have a 5 to 10 members, including president, secretary of the area and a village contact person. Some of the advantages which can arouse from the creation of village clean energy committee are it will facilitate active involvement of consumers in the decision making process. It will increase the level of awareness on usage, utility etc. It will help in effective and time bound delivery of service and maintenance. It will lead to timely redressal of consumer complaints. Help in timely collection of revenues and information flow. The companies should use VCEC for improving service delivery, sensitising people to adopt clean energy product and how clean energy product can be used as a income generating activity. This model is a sustainable business model which will help in revenue flow from rural consumers to the companies, service flow from the company to the rural consumers, and incentive flow from company to village clean energy committee. This model will help in effective access of any clean energy product across our country, helping in generating entrepreneurs and creating an ecosystem for sustainable access.





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## CONCLUSION

Marketers need to intervene into the market by developing products according to their consumers needs and want. They need to ensure to provide high quality product with low price accompanied with timely service. Purchasing of these products needs to be financed through EMI schemes, loans, subsidy, grants, etc. so as even a poorest of poor will get a better product. Target areas needs to be accessed where there is non availability of electricity or is available in scarcity. For promotion of clean energy products emphasis should be given for conducting awareness camps at village levels, in haats, group meetings, cultural events, conducting like cycle rallies, conducting workshops in colleges, universities, sensitising youths and their parents, etc. Organising national and international exhibition, event sponsorships, etc. will also help in diffusion of clean energy products. For access of clean energy products in rural context there is a need of clarity on policy in the ground level, availability of last mile delivery people, availability of skilled manpower, availability of apathetic financiers, and supportive institutional environment. There is a need for proper coordination and collaboration with all members for having a successful access of clean energy products.

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**Table 1: Classification of Clean Energy Products**

Cooking	Transforming Energy	Utility
Biomass cook stoves Solar cook stove LPG Cook Stove	Biomass Gasifier Household and Community based Biogas Plant Liquefied Petroleum Gas (LPG) and Piped Natural Gas (PNG)	Solar Operated Products  • Solar Light • Solar Irrigation etc.





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**Table 2: Comparative Analysis between different Energy available in Rural Area**

Parameters	Biomass	Solar	LPG	Conventional Electricity
Availability	For one day it is OK, but not for longer period of time	No limitation	Certain extent- depends upon Govt Policy	Not in rural areas
Cost	Less Cost	Initial Investment is high	Limited until Government provides subsidy	High price
Ease of Handling	Risky	Difficult due to weak supply chain	Problem in Handling	Handling difficult in rural areas
Health	Hazardous	Absolute Clean	Moderately Clean	No impact on health
Sources	Abundantly available in rural areas	Open Market	Restricted/Regulatory sources	Regulatory sources
Efficiency	Very low efficiency	High Efficiency as heat is intact	Reduction in Efficiency	Efficiency is high
Sustainability	Sustainable	Sustainable	Need to be studied	Questionable
Regeneration	Not possible but takes lot of time	Already regenerated energy	Questionable	Not possible
Operational Cost	Minimum	Less Amount	Requires OC: Filling and maintenance of Gas Chulha and Cylinder	High

Source: From different sources and expert opinion

Dark Green: Indicates high positive, Light Green: Indicates low positive

Dark Red: Indicates high negative, Yellow: Less possibility, Purple: Not possible

**Table 3: Mapping of Possible Clean Energy Products with different Activities in Rural Areas**

Serviced-based Activities			
Activity	Present Energy Supply	Present Available Products	Possible Clean Energy Product
Tiffin/Food Outlets	Charcoal	Stove	LPG, Efficient Biofuel Stoves
Small Joint Etries	Charcoal, Kerosene,	Induction Stove	LPG, Efficient Biofuel Stoves
Laundry	Charcoal	Flat iron	Solar Iron
Tailoring	Mechanical Power, Electricity	Sewing Machines and Irons	DCSewing Machines with Efficient Motors and Solar Irons





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<b>Bars/Restaurants</b>	Electricity, Coal, LPG	Refrigerator, Stove, Cookers, Grills	LPG, Efficient Biofuel Stoves, Solar Grills
<b>Taxi Service and Commercial Pick-up Transport</b>	Petroleum based Products	Petrol Engine and Diesel Engine	LPG efficient Internal Combustion Engines, Battery Operated Engines, Solar Powered Rickshaw, CNG
<b>Rice/Wheat Grinding</b>	Electricity, Mechanical power	Grinders, Compressors	Solar Powered Grinder
<b>Tyre Puncture Repair</b>	Kerosene, Electricity	Heaters, Compressors	Solar Operated Compressor
<b>Electrical Goods Repair</b>	Electricity	Soldering Equipment	Solar Operated Soldering
<b>Shops</b>	Mechanical Power, Electricity	Incandescent Lights	LEDs and CFLs
<b>Manufacturing-based Activities</b>			
<b>Activity</b>	<b>Energy Supply</b>	<b>Product used</b>	<b>Possible Clean Energy Product</b>
<b>Metal Works</b>	Electricity, Gas	Welding Equipments, Lathe Machines, Grinders, Incandescent Lights	Efficient Electric Motors, Tubes and CFLs
<b>Blacksmith</b>	Coal	Air blower	Solar Operated Air Blower
<b>Pottery Products</b>	Mechanical power, Wood	Rollers	Solar Dryers, Electric rollers
<b>Furniture Woodwork</b>	Mechanical power, Electricity	Cutting Equipment, Lathe	Solar Powered Motors, and DC Compressors
<b>Construction</b>	Electricity and Mechanical	Colour Painting	Solar Sprayer for Colouring
<b>Paint Manufacture</b>	Mechanical power, Electricity	Mixers, Incandescent lights	Efficient Motors, Tubes and CFLs
<b>Processing-based Activities</b>			
<b>Activity</b>	<b>Main energy supply</b>	<b>Appliance used</b>	<b>Possible Clean Energy Product</b>
<b>Bakeries</b>	Electricity, Mechanical Power	Mixer	Solar Powered Mixer, DC Motor
<b>Fabric Processing</b>	Electricity, Mechanical Power	Motors	Solar Operated Motors
<b>Coffee processing</b>	Electricity, Firewood	Heaters, Blowers, Motors	Solar Dryers, DC Blowers and DC Motors
<b>Rice Milling</b>	Electricity, Diesel	Electric Motors	Solar Motors





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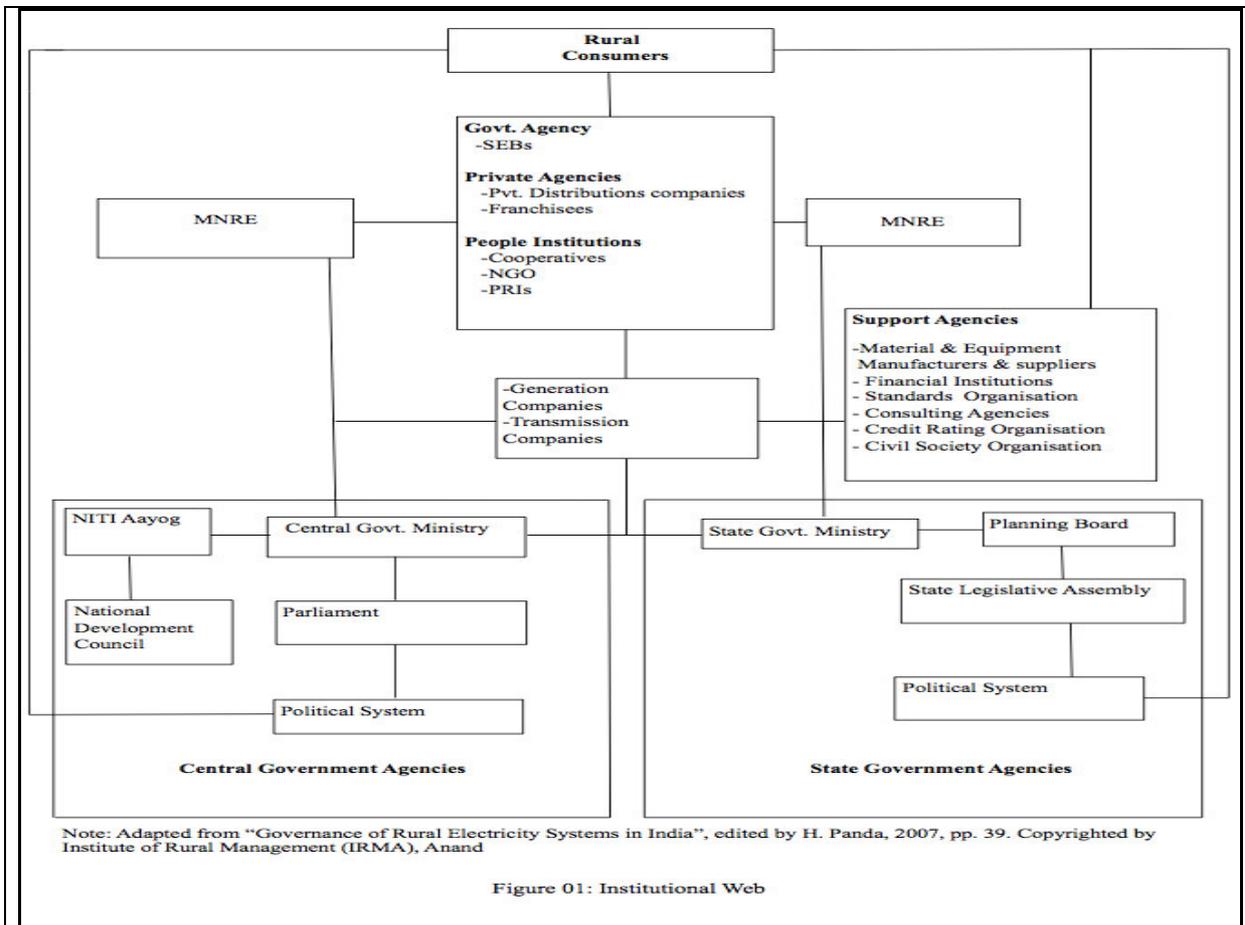
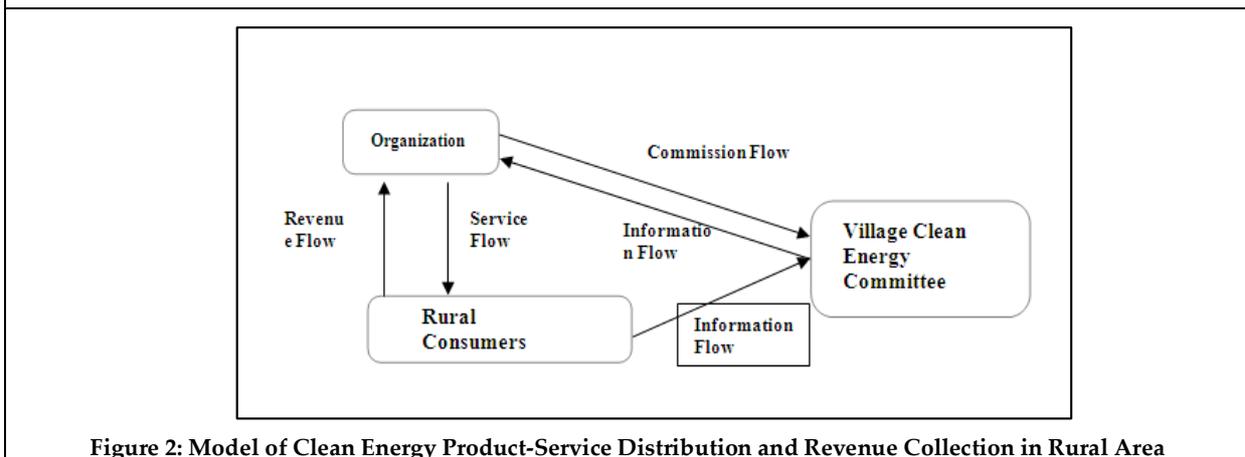


Figure 1 : Institutional Web





## Gondola Design and Material Selection for an Indoor Airship

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### ABSTRACT

It was planned to design an airship to be capable of continuous indoor flight for 30 minutes with a payload of 500g and maintain a flight at constant altitude. In this work it was aimed to sizing of the stabilizer, material selection, propulsion system, gondola box designing, and sensor selection for flight control. The design of the gondola focused on reducing weight whilst still having enough strength to support the weight of the internal components. Ducted fans powered by electric motors were chosen to provide propulsion to the airship. The effects of different fan arrangements on airship maneuverability were then analysed. Statistical analysis of similar airships was done to find out to calculate the area of their stabilizers. Different materials were taken to consider strength to weight ratio for material selection for a small airship. Different design was taken for better performance of the propulsion system. For gondola design many box shape were taken and analysis for better aerodynamics and structural strength. Also sensor and camera selection were done for automatic control low altitude airship

**Keywords:** Airship, Blimp, Gondola, Airship stabilizer

### INTRODUCTION

Aircraft can be divided into two groups: lighter-than-air aircraft (LTA) and heavier-than air aircraft (HTA) [1]. Conventional fix-wing and rotation-wing aircraft which utilize lifting surfaces like wings and blades as the source of lift belong to HTA. LTA is mainly referring to aircraft such as balloons and airships (blimps). Unlike HTA, LTA is designed to contain within their structure a sufficient volume of gas lighter than air (heated air, hydrogen, or





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helium) to acquire enough lift force from the buoyancy of the gas. Without consuming extra fuel to generate necessary lift for floating, airships offer advantages over air cargo transportation in the past. Many different types of aircraft are designed and fabricated for diverse applications and scenarios. A survey of recent developments in aerial robotics gives a general overview of the definition, types, categories, and topics of aerial robotics [2]. This work describes and briefly introduces more than one hundred high-quality aircraft papers from more than thirty thousand that have been published in the top journals and conferences in a systematic way.

In the last 50 years airships have been used for certain niche applications such as advertising, surveillance and aerial photography. The most well known advertising craft is the Goodyear blimp which has been prominent at major sporting events. Smaller craft have been used for advertising and photography in large indoor arenas such as basketball and ice hockey stadiums. The United States Coast Guard has also experimented with using airships for high altitude surveillance of its borders and coastline. Some earlier scientific and technical notes and documents about airship design can be found as technical reports from NASA. There are two famous reports by Tuckerman [3] [4], emphasizing two most critical issues of airship design - the determination of forces on an airship hull and inertia factors.

Regarding airship, [5] introduced the recent researches and conceptual designs of airships and classifies the airships according to its body. In paper [5], a state-of-the-art literature review on airship dynamics modeling is presented. In this aerodynamics and flight dynamics modeling method are described. This also provides the structural flexibility, incorporation of atmospheric turbulence as well. Based on six degrees of freedom, an attractive dynamic model is presented in ref. [6]. In ref. [7], a blimp-based robot and its navigation system are introduced. The blimp is a commercial kit which can be used as platform directly. Ref. [8] introduces a design methodology and fabrication of an easily deployable finless airship for indoor surveillance and advertisement. The detailed and step-wise procedure for designing and fabricating indoor remotely controlled airships are discussed in [9].

A comparison between the airships using design methodology introduced in this work with some other commercially available airships are also exhibited. Paper [10] introduces an airship that mimics fish-like movement in the air, propelling an airship by undulating its hull and a caudal fin. A work on DEA predicted that DEA strip actuators could reach 90% maximal efficiency in optimal conditions. However, an actual peak efficiency of 18% was measured in the experiment due to the high energy loss of such a voltage transform [11]. The propulsion efficiency analysis of fish-like robot is exhibited in [12], the relationship of speed and energy efficiency are analyzed. Ref. [13] does a research on the efficiency of fish propulsion. As a commonly used propulsion unit for indoor airships, small-diameter propellers performance data including energy performance are tested and a reliable database of performance data of many propellers has been created in [14]. Recent years, several fish-like indoor airship projects appeared due to high efficiency of fish propulsion. [15] [16] the propulsion efficiency of both propeller and fish movement is studied. The efficiency of fish movement and propeller is studied in [17] and [18] respectively.

### Stabiliser Design

Stabilisers have a very small frontal area compared to their longitudinal area. The larger longitudinal area produces more resistance to motion in the yaw, roll and pitch planes. Stabilisers are needed on the tail of the envelope to add stability to the airship. The airship's small weight, relative to its surface area, means that it was susceptible to the effects of air currents. As the airship was designed for indoor use, the wind forces are small. Consequently, the stabilisers are not required to be as large as those that would be required for an outdoor altitude. Larger airships which travel at greater speeds use the stabilisers with control surfaces to control airship movement. The comparatively slow speeds of this airship meant that control surfaces would be less effective and hence control surfaces were not included in the design. The area of the stabilisers was calculated using a statistical analysis of similar airships and the area of their stabilisers. From this analysis





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an average ratio of envelope longitudinal area and stabiliser longitudinal profile area was determined. The area of stabilisers for the airship was then calculated using this ratio and the longitudinal area of the airship. The calculations are shown in Table 1

### Propulsion System Design

The propulsion system design requirements were such that the airship could perform the desired modes of flight described in section 3.1. The propulsion system must also provide the required thrust, as discussed in section 3.2. The majority of lift force will be provided by the helium filled envelope. Batteries would provide the power for the electric motors as a combustion engine was determined to be too heavy for such a small airship.

### Propulsion Methods

Three different types of propulsion methods were investigated for use on the airship: ballonets, propellers and ducted fans. Ballonets are air filled bags usually located within the envelope. As air is heavier than helium, deflating or inflating these tanks will cause the airship to rise or fall respectively. Initial research showed that a pump small enough to fit on the airship would not pump air quickly enough to make the airship move within the desired response time. The highest pump rate achievable was found to be 13 litres per minute (Sensidyne 2007). This meant that to produce a vertical thrust of 10 grams, the pump would have to run for over 30 seconds before that force would be achieved. As a result, ballonets were rejected as a feasible design alternative. Propellers and ducted fans were very similar concepts, a ducted fan is essentially a propeller mounted within a cylindrical duct. The aerofoil shaped blades of the propeller and ducted fans rotate to produce thrust. The thrust is a result of the pressure difference on the upper and lower surfaces of the blades.

### Propulsion System Selection

As previously mentioned, the two feasible propulsion options were propellers and ducted fans. To decide which was most suitable, several design criteria were established: reversible thrust, response time, quantity of thrust, safety and size. Reversible thrust was required to reverse the airship out of a corner or to rapidly decrease the altitude of the airship. Propellers can be reversed by changing the direction of rotation, although this results in efficiency losses due to disturbed airflow prior to the propeller. A ducted fan can also be reversed but with more significant efficiency losses. The airship needs to be able to react to situations reasonably quickly and hence response time was significant. Propellers and ducted fans both have quick response times, with only a short 1-2 second delay between the remote input and the propellers producing the required thrust. The quantity of thrust produced was an important consideration in designing the propulsion system. There are many propeller and ducted fan systems available that fulfill the thrust requirements, with most being capable of more thrust than is needed for a small airship. The ducted fans deliver more efficient uni-directional thrust than the propellers.

Safety was also an issue for the design of the propulsion system as the airship will be used indoors and will be relatively close to people. A propeller system has the potential to be dangerous as the spinning blades are unprotected. The ducted fans also contain propellers but they are enclosed within the duct and are hence relatively protected. Weight was a critical factor in the propulsion design as extra weight increases the lifting force required. The lightest of the options was the propeller system with the ducted fans slightly heavier due to the addition of a duct. Each of these criteria has been evaluated for each system and a table showing each criterion, the criteria rating and each methods score was created. From this table a decision upon the most suitable propulsion system was made. From Table 2 it was determined that the ducted fan propulsion system was most suited for the project.

### Propulsion Layout

The propulsion system must be arranged so as to achieve all the flight modes described in section This means the layout must allow the motors to produce thrust vertically, horizontally and a combination of both. Fixed and rotating rods were mounted through the gondola and used to support the engines.





Figure 1 shows one concept for propeller layout. In this concept engine 1 was fixed in position and produces thrust in the vertical direction to control the altitude of the airship. Engines 2 and 3 are mounted on a supporting rod which can be rotated to achieve thrust in the horizontal and vertical direction, as well as a vector combination of both. The speed of Engines 2 and 3 can be altered to control roll and yaw. One feature of this design is that the altitude control is separate from forward motion. The second propeller layout concept, Figure 2, is quite similar to the first layout. Engines 1 and 2 on this design operate the same the engines 2 and 3 did on layout 1. The main difference is that instead of a single engine mounted under the gondola providing altitude control, there are two engines each mounted at the end of a supporting rod. The purpose of this is to give greater stability and control to the airship. Positioning these engines in this way also gives the operator the ability to adjust the pitch of the airship.

The last propulsion layout concept, Figure 3, has two sets of two engines on rotating axles. For this configuration all the engines point in the same direction and hence all produce thrust in the same direction. The required direction of thrust can be achieved by rotating the axles. The benefit of this design is that no engine is inactive during powered flight. To control the yaw, pitch and roll of the airship the speed of certain engines is altered.

### Propulsion Layout Decision

The previously described propulsion layout concepts were analysed based on: their effect on overall stability, their aesthetics and their ability to cooperate with an automatic control system. It was essential that the propulsion layout be able to meet all the requirements of the flight modes. This means that the system can move the airship horizontally, vertically and a combination of both. Stability is enhanced by keeping the design symmetrical as well as increasing the distance between the thrusting force and the centre of gravity of the airship. Layout 1 has one of its engines at the centre of gravity and as a result the pitch of the airship is cannot be controlled. Layouts 2 and 3 have all their engines positioned some distance from the centre of gravity increasing the airship controllability.

As the altitude of the airship is to be controlled automatically, the propulsion layout must easily incorporate an automatic and manual control system simultaneously. Layout 1 and 2 have the altitude control engines separate from the other engines hence it is easier to make the control system using these layouts. Layout 2 would also incorporate a level sensor into the automatic control loop to control the pitch of the airship. The automatic control system for layout 3 would be significantly more complicated as both horizontal and vertical components of thrust would need to be controlled. Each of the criteria was evaluated and a score was given to each design. Above scores a decision matrix (Table 3) was used to select layout 2 as the propulsion layout design.

### Gondola Design

The gondola structure needed to fulfil three main functions: to house the electrical equipment/payload for the airship, to be detachable from the envelope, to hold the engines in place and transfer the engine thrust to the airship.

### Material selection

Potential gondola construction materials were assessed based on their strength, weight and ease of manufacture. The properties of a number of materials are shown in Table 4. The table above shows that foam and balsa wood are suitable for the gondola design due to their low weight. These materials could be used in conjunction with fiberglass and epoxy coatings to ensure that the gondola is strong and lightweight. Steel and aluminium could be used for the engine supporting rods and mountings.

### Shape and Aerodynamics

The form of the gondola was designed based on structural, aerodynamic and aesthetic requirements. Three alternative shape concepts were created with some similarities including: a flat platform to mount parts to, a lip at





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the top to join the gondola to the airship as well as several holes to insert different supports for the engines. The main differences between the designs are their appearance and ease of manufacture. Concept 1 shown in Figure 4 has a rounded base and sides. This has a dual benefit of making the gondola more aesthetically pleasing and also reducing the amount of drag created. However, rounded edges reduce the size of the mounting platform and are also more difficult and expensive to produce.

The second concept (Figure 5) included a simple box shape with an aerodynamic shell. The box is used to hold all the necessary parts for the gondola and being a simple box is easier to make. The aerodynamic shell is a rounded piece that covers the majority of the box. The use of this shell creates a second area between the shell and box, hence increasing the possible storage space in the gondola. Like the 'bath tub' design, the curves of this shell would also be difficult and more expensive to make. The final concept was the shaped box design (Figure 6). This design was based on the gondola box used in concept 2. The box was shaped to create a more aerodynamic profile, leading to a reduction in drag. The lack of curved surfaces in this design meant that it would be easier and cheaper to manufacture. The aerodynamic shaping of the underside of the box means that, like concept 2, there was additional storage space on the underside of the flat platform.

### Design Selection

All three of the concepts adequately met all the structural requirements of the gondola hence the decision on which concept was based on the ease of manufacture and aesthetics. Generally, straight parts are much easier to manufacture than curved parts. Only concept 3 had no curved parts making it easier to manufacture. Concept 1 had a large amount of curved surfaces and hence was considered to be hardest to manufacture. While the gondola box of concept 2 would be easy to produce, the curved shell would cause some difficulties. It was suggested that this could be produced from a blow molded plastic shell, however this was not possible, as the University did not have the machinery required. Balsa wood, used throughout concepts 2 and 3, was also readily available from most model/hobby shops. The curved and shaped pieces used in concepts 1 and 2 gave the airship a more aerodynamic and smooth finish. Concept 3 although not curved, does have an aerodynamic shape to improve its appearance over a simple box. Using these criteria a decision matrix (Table 5) was formed to decide on the best possible design. Concept 3 meets all the structural requirements for the gondola and best meets the aesthetic and manufacturing criteria and hence was chosen for use in the final design.

### Control System Design

The airship was designed to incorporate both automatic and manual control systems. The automatic control governs the altitude and pitch of the airship. The manual system was initially designed to control all aspects of airship flight. Once the automatic control system was implemented, the manual control will be responsible for movement in the horizontal plane.

### Manual Control System

The manual control system will operate via a remote controller hand unit. The two functions of the manual controller are to control the individual speeds of the engines and to control the angle of any rotating axles. Remote control hand unit consist of a number of variable and fixed channels. Variable channels send a variable signal to the onboard speed controllers, which alter the speed of the engines and the thrust produced. The fixed channels produce a binary signal that enables the axle to rotate a set angle. Rotation of the axle was achieved using a servo-motor. The servo-motor would be connected to the axle by means of a belt and gear system.

### Automatic Control System

The automatic control system utilises an onboard microprocessor and a control code to maintain a desired altitude and pitch. The microprocessor determines the thrust required based on the difference between the desired values and the inputs from the pitch and altitude sensor. A computer on the ground wirelessly communicates with the



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onboard processor to change the desired altitude value. A sensor was required to take continuous measurements of altitude during flight. The two main options for an altitude sensor were a pressure sensor or an ultrasonic sensor. The pressure difference in a 6 meter range cannot accurately be determined and hence an ultrasonic sensor was better. The ultrasonic sensor sends a pulse to the ground which is reflected back to the sensor. The time for the pulse to return is used to calculate the height of the airship in the automatic control code. A second sensor was required to measure the pitch of the airship. The two principal options were a capacitance-based tilt sensor and an electrolytic tilt sensor. Each provided similar measurement accuracy and could be integrated into the automatic control system. Capacitance-based sensors were found to be considerably cheaper and more readily available. A capacitance sensor is a strain-based sensor that uses two springs. When the sensor is not level, an unbalance in the two strains is recorded and converted to an output voltage. The microprocessor then interprets the voltage as an angle using the automatic control code.

### **Payload and Ground Station Design**

The airship was to be fitted with a camera to record flight footage. The footage would be sent wirelessly, in real time, to a ground station. A number of different cameras were researched as options. The principal criterion for camera selection was cost, as the budget only allowed \$200 to be spent. As with all other components in the airship, the weight of the camera system was extremely important. The camera also needed to be able to transmit a clear image over a distance of at least 50 meters.

### **Camera Options**

It was possible to use either a still or video camera to record images. A camera for still images generally provides excellent picture quality but is also heavy and expensive. The digital still camera mechanism used by Airship Solutions (Figure 7) has a maximum resolution of 5 Megapixels and can pan and tilt via remote control. The total weight of the camera and frame was roughly 400 grams. The cost of the system was estimated at \$700. The main advantages of a video camera, when compared to a still camera, are its size, weight and ease of use. The JMK wireless video camera weighs only 25 grams and is roughly the size of a 20-cent coin. The receiving unit can be connected to a television or a VCR over a standard composite-video connection. An analogue to digital video converter also allows the stream to be viewed and recorded on a computer. The camera, receiver and converter could be purchased for a total of less than \$200. Another small wireless video camera was also considered as an option. The Jaycar camera had a resolution of 0.3 Megapixels and a range of 100 meters. The range and resolution were therefore equivalent to the JMK camera specifications, although the Jaycar camera was a significantly more expensive option with a total system cost of around \$400.

### **Camera Selection**

A decision matrix was used to determine the most suitable camera system for the airship. The weight and cost of the camera were considered the two most important parameters. The ease of use criterion includes factors such as computer connectivity, power supply and installation into the gondola. The resolution, image interference and range were included under a general heading of picture quality. Based on the total scores in the decision matrix, the JMK camera system was deemed to be the most suitable for the airship.

## **CONCLUSIONS**

This paper aims to sizing of the stabilizer, material selection, propulsion layout design, gondola box designing, and sensor selection for flight control. The area of the stabilisers was calculated using a statistical analysis of similar airships and the area of their stabilisers. The area of stabilisers for this airship was calculated taking the ratio and the longitudinal area of the airship from statistical analysis. From the analysis it was found that foam and balsa wood are suitable materials to make the gondola design due to the low weight for this small type of airship. But Steel and aluminium material can be used for the engine supporting rods and mountings. Three different designs (layouts) were taken for better performance of propulsion system. From analysis it was found



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“layout 2” type better compare with other two types design. Different box design were taken to find out better aerodynamics and structural strength for gondola. It was observed that “Shaped Box” design meets all the structural requirements and better aerodynamics for the gondola and also best meets for manufacturing criteria. This one was chosen for use in the final gondola design. In this low altitude the pressure sensor cannot accurately be determined the altitude and hence an ultrasonic sensor was selected. The ultrasonic sensor sends a pulse to the ground which is reflected back to the sensor. The time for the pulse to return is used to calculate the height of the airship in the automatic control.

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Table 1 - Stabiliser Sizing

Airship	Envelope Longitudinal Profile Area (m <sup>2</sup> )	Stabiliser longitudinal Area (m <sup>2</sup> )	Area Ratio
Airship Solutions 4m <sup>3</sup>	3.32	0.18	18.84
Airship Solutions 11m <sup>3</sup>	6.88	0.34	20.48
NUS Airship 0.55m <sup>3</sup>	1.01	0.03	33.50
Average	3.74	0.18	24
Calculated Values for 3,2 m <sup>3</sup> envelop	2.36	0.10	23.6

Table 2 - Propulsion System Decision Matrix

Criteria	Rating	Ballonets	Propellers	Ducted Fans
Reversible Thrust	20	20	18	8
Response Time	30	5	28	28
Thrust Delivered	40	25	35	40
Safety	40	30	10	35
Weight of System	20	10	14	12
Total	150	90	105	123
		60%	70%	82%

Table 3 - Propulsion Layout Decision Matrix

Criteria	Rating	Layout 1	Layout 2	Layout 3
Flight Mode Requirements	50	50	50	50
Stability of airship	30	15	27	25
Control setup required	40	35	30	15
Efficiency in different flight modes	20	12	12	18
Aesthetics	10	4	6	8
Total	150	116	125	116
		77.3%	83.3%	77.3%

Table 4 - Gondola Material Properties

Material	Density (kg/m <sup>3</sup> )	Tensile Strength (MPa)
Foam (polyurethane)	100	35
Balsa Wood (low density)	140	7.6
Aluminium Alloy	2700	100 - 350
Steel	780	365
Fiber Glass	2600	3448
Epoxy Adhesive	720 – 2800	60 - 100

Table 5 - Gondola Design Decision Matrix

Criteria	Rating	Layout 1	Layout 2	Layout 3
Ease of Manufacture	50	25	30	45
Aesthetics	50	35	35	30
Total	100	60	65	75





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Table 6 - Camera System Decision Matrix

Criteria	Rating	Jaycar	Airship Solutions	JMK
Weight	30	25	15	30
Cost	30	15	5	25
Picture Quality	25	15	25	10
Ease of use	15	15	10	15
Total	100	70	55	80

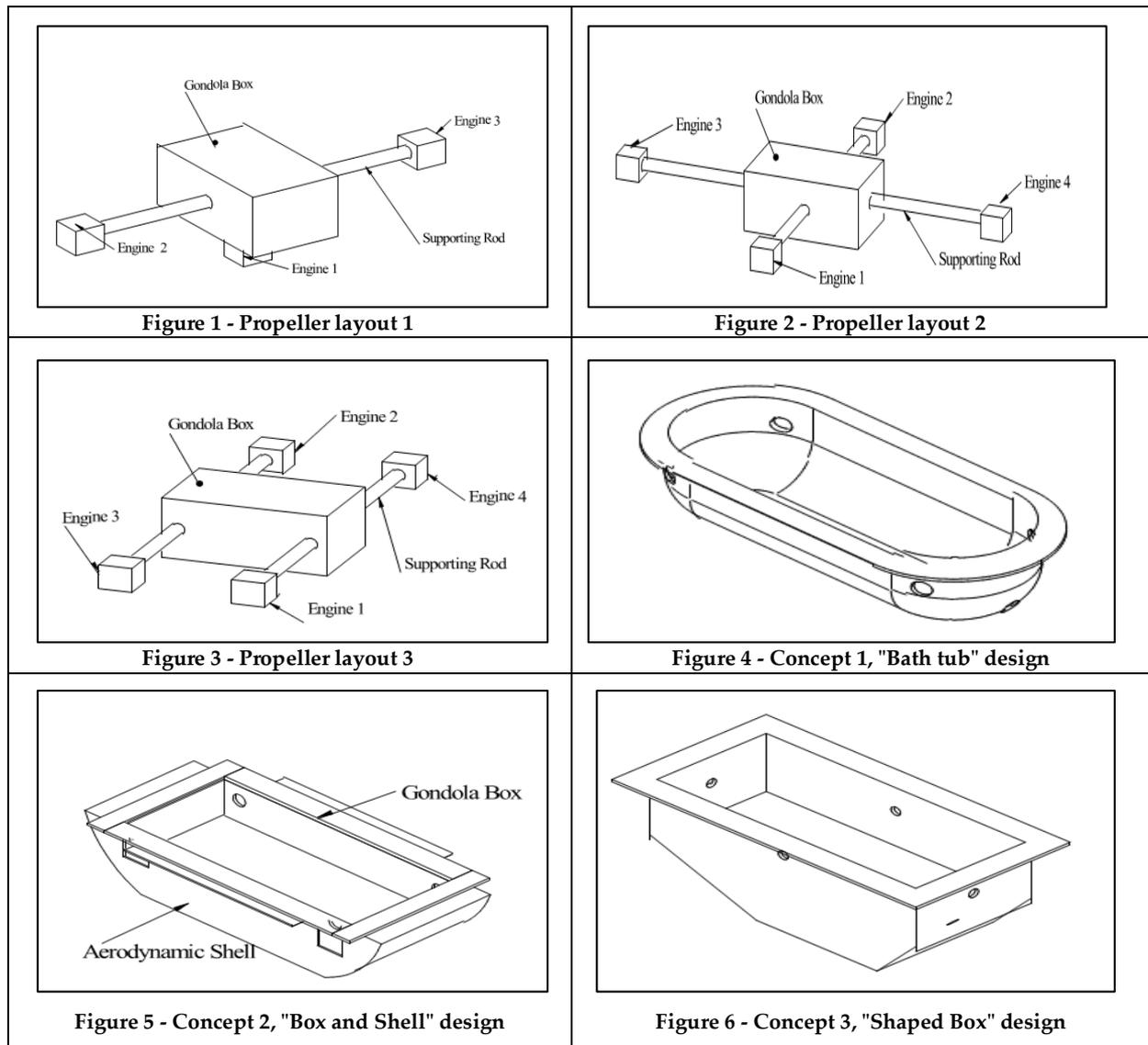




Figure 7 - Heavy Duty SLR / Digital Camera Mechanism



Figure 8 - JMK wireless video camera





## Preparation and Characterization Biomass Briquetting

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### ABSTRACT

Every year millions of tons of agricultural wastes are generated which are either destroyed or burnt inefficiently in loose form causing air pollution. These wastes can be recycled & can provide a renewable source of energy by converting biomass waste into high density - fuel briquettes without addition of any binder. This recycled fuel is beneficial for the environment as it conserves natural resources. For this the biomass briquetting is the main renewable energy resource. In this project the raw material including ground nutshell were densified into briquettes at high temperature and pressure using different technologies. We discuss the various advantages, factors that affecting the biomass briquetting and comparison between coal and biomass briquetting.

**Keywords:** Ash, Volatile matter, Moisture, and Char-coal

## INTRODUCTION

Biomass is a renewable energy resource derived with from the carbonaceous waste of various human and natural activities. Currently, the biomass sources contribute 14% of global energy and 38% of energy in developing countries. Densification and optimization of biomass is briquette. Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumes as a fuel. Its advantage is that it can be used to generate electricity with the same equipment or power plants that are now burning fossil fuels. Availability of biomass in large quantity and scarcity of fossil fuel coal, oil and gas lead industries to use the biomass as fuel. India has started to replace charcoal with biomass briquettes in regards to boiler fuel, especially in the southern parts of the country because the biomass briquettes can created domestically, depending on the availability of land. Therefore, constantly rising fuel prices will be less influential in an economy if sources of fuel can be easily produced domestically. Biomass briquettes are more flexible these can use from house hold purpose to large scale industrial purpose at any were easily. Here the major thing is from which biomass we get high thermal energy with less biomass consumption (simply calorific value) we should know for getting high economical efficiency and to reduce the environmental pollution.



**SCOPE**

- Enhancing the usage of renewable resource (like biomass).
- Providing economically efficient fuel.
- Reducing environmental pollution.
- Reducing energy cost (like thermal and electrical energies etc.).
- Ultimately which leads our country development.

**METHODS FOR CHARACTERIZATION OF BRIQUETTES**

1. x-ray diffraction method
2. scanning electronic microscope
3. Proximate and ultimate analysis

**EXPERIMENTAL PROCEDURE****Briquetting the biomass**

Biomass briquetting and characterization project and is simply a process of converting agro waste and forestry waste into biomass briquettes. The biomass briquetting is the best renewable source of energy for healthy environment and economy. It's a complete ecofriendly project. Successful test have been carried out with groundnut shell. The biomass can be briquetted individually or in combination depending on their availability and blending properties. Main concept of this project is to produce the material as a bio-coal, which is made from the wastages. We cannot destroy the wastage totally. But we can use it with the help of briquetting plant and produce the briquettes, which ultimately produce the energy. The use of these cheap fertilizers gives low yield as compared to the modern fertilizer available however the major quantity of press mud goes just as waste. We can use such above wastage as an input to the briquetting plant machinery to produce conventional source of energy.

**Screw Press and Piston Press Technologies**

High compaction technology or binder less technology consists of the piston press and the screw press. Most of the units currently installed in India are the reciprocating type where the biomass is pressed in a die by a reciprocating ram at a very high pressure. In a screw extruder press, the biomass is extruded continuously by a screw through a heated taper die. In a piston press the wear of the contact parts e.g., the ram and die is less compared to the wear of the screw and die in a screw extruder press. The power consumption in the former is less than that of the latter. But in terms of briquette quality and production procedure screw press is definitely superior to the piston press technology. The central hole incorporated into the briquettes produced by a screw extruder helps to achieve uniform and efficient combustion and, also, these briquettes can be carbonized.

**Characterizing the biomass briquette**

Hare we are followed procedure to characterize the briquette is: Proximate & ultimate analysis and Proximate analysis: Proximate analysis indicates the percentage by weight of fixed carbon

- ⊙ Moisture content
- ⊙ Volatile matter
- ⊙ Ash content
- ⊙ Fixed carbon
- ⊙ Calorific value (heating value)

**Ultimate analysis**

- ⊙ Carbon content
- ⊙ Hydrogen content
- ⊙ Nitrogen content





- ⊙ Sulphur content
- ⊙ Oxygen content

Here we have did ultimate analysis for carbon, hydrogen, nitrogen contents of briquette is by using some empirical equations which are related with proximate analysis results like moisture content, volatile matter, ash content and fixed carbon. These empirical equations are proposed by two scientists 1. Vanloos & 2.J.koppejan.

## RESULTS AND DISCUSSIONS

### Moisture content:

**Observed weight of mass of briquette according to time:** Where the graph indicates that at constant temperature (105°C) according to the time the weight loss of briquette to a certain time, from the particular time the weight of briquette becomes constant the time is optimum time of heating to evaluate moisture content in the briquette.

**Observed weight of mass of briquette according to time:** Where the graph indicates that at constant temperature (300°C) according to the time the weight losses of briquette to a certain time, from the particular time the weight of briquette becomes constant the time is optimum time of heating to evaluate volatile matter in the briquette.

### ASH CONTENT

**Observed weight of mass of briquette according to time:** where the graph indicates that at constant temperature (600°C) according to the time the weight loss of briquette to a certain time, from the particular time the weight of briquette becomes constant the time is optimum time of heating to evaluate ASH content in the briquette.

### Results and comparison of biomass briquette with coal

Proximate analysis  
Ultimate analysis

## CONCLUSION

Biomass samples from different sources and its types needs to be characterized for its proximate analysis and other metal impurities. Prior knowledge of biomass type and its chemical composition would help in understanding combustion related problems for biomass based energy generation. The coal is a non-renewable resource and present days which is available in very less amount with high cost. so, Even the heating value of briquette is less but it is renewable resource, eco-friendly fuel, more amount is available with cheaper cost and also which is a efficient method to generate energies like thermal, electrical etc. Agricultural waste are produced in large quantities and are disposed indiscriminately most especially in the rural areas of developing countries, thereby causing health hazard. The increasingly use of these wastes in composite briquette form, also help in solving disposal problem apart from providing good alternatives to fossil fuel. This study revealed that the biomass briquettes from groundnut shell is suitable for the production of environmentally solid fuel that can be useful of both domestic and industrial heating applications.

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**Table 1 shows a comparison between a screw extruder and a piston press.**

Parameters	Piston press	Screw extruder
Optimum moisture content of raw material	10-15%	8-9%
Wear of contact parts	low in case of ram and die	high in case of screw
Output from the machine	in strokes	continuous
Power consumption	50 kWh/ton	60 kWh/ton
Density of briquette	1-1.2 gm/cm <sup>3</sup>	1-1.4 gm/cm <sup>3</sup>





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Maintenance	high	low
Combustion performance of briquettes	not so good	very good
Carbonization to charcoal	not possible	makes good charcoal
Suitability in gasifies	not suitable	suitable
Homogeneity of briquettes	non-homogeneous	homogeneous

**Table 2. Moisture content**

TIME(min)	Weight loss of briquette at 105°C
0	0
30	0.03
60	0.08
90	0.12
120	0.15
150	0.17
180	0.18
210	0.18

**Table 3. Observed weight of mass of briquette according to time**

TIME(min)	Weight loss of briquette at 300°C
0	0
0.5	0.3
1.0	0.81
1.5	1.21
2.0	1.42
2.5	1.51
3.0	1.52
3.5	1.52

**Table 4. Observed weight of mass of briquette according to time**

TIME(min)	Weight loss of briquette at 600°C
0	0
10	0.51
20	1.23
30	1.64
40	1.82
50	1.91
60	1.934
70	1.934





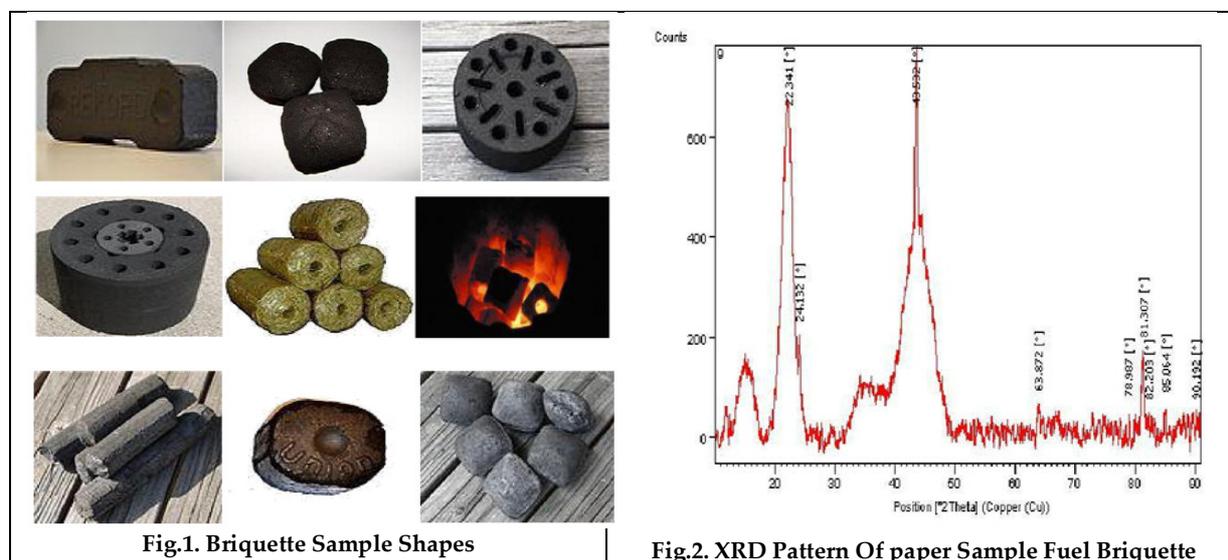
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**Table 5. Proximate Analysis**

PERAMETER	GROUNDNUT SHELL BRIQUETTE (values from our project)	COAL (values from previous results)
MOISTURE CONTENT (%)	9	6.93
VOLATILE MATTER (%)	76	30.41
ASH CONTENT (%)	3.3	8.63
FIXED CARBON (%)	11.7	54.33
CALORIFIC VALUE(KJ/Kg)	16412	32510

**Table 6. Ultimate Analysis**

PARAMETERS	GROUNDNUT SHELL BRIQUETTE(values from our project)	COAL(values from previous results)
Carbon content (%)	59.728	82.8
Hydrogen content (%)	1.1435	4.3
Nitrogen content (%)	1.866	2.4
Sulphur content (%)	0.12	0.6
Oxygen content (%)	28.1625	7.3



**Fig.1. Briquette Sample Shapes**

**Fig.2. XRD Pattern Of paper Sample Fuel Briquette**



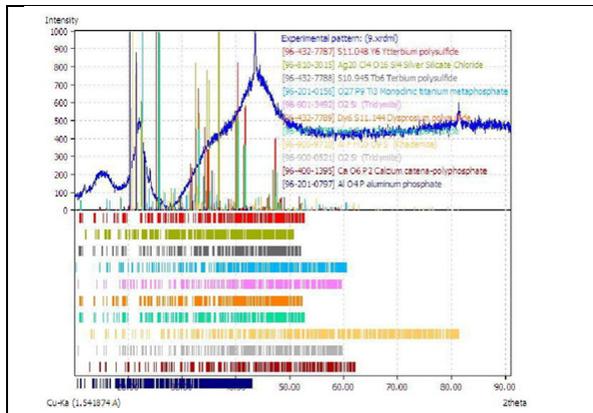


Fig.3. XRD Pattern of paper Sample Fuel Briquette-Matching

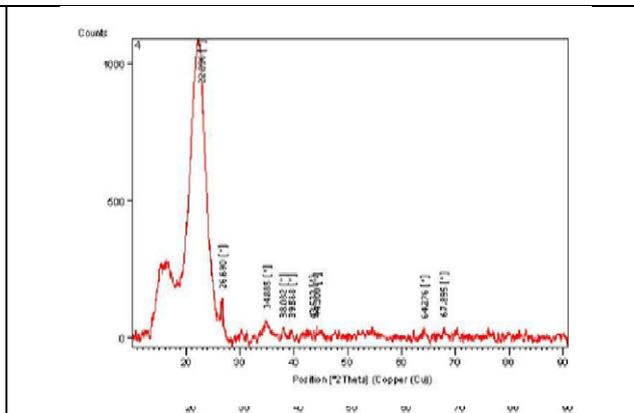


Fig.4. XRD Pattern of Rice husk Sample Fuel Briquette

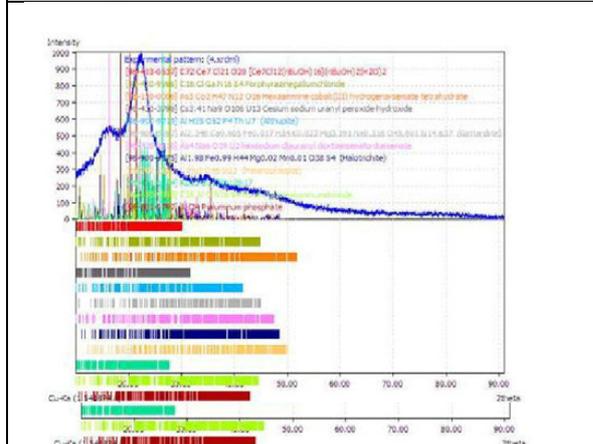


Fig.5. XRD Pattern of Rice husk Sample Fuel Briquette-Matching Compounds

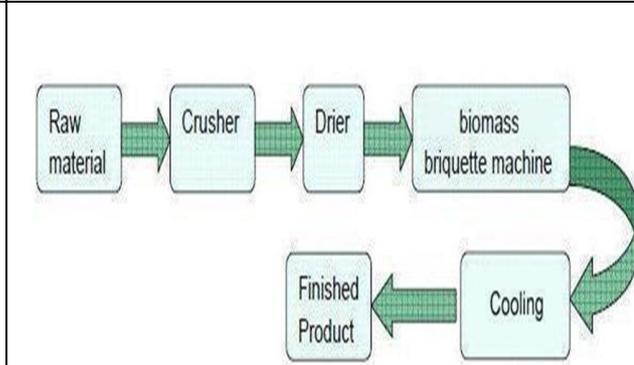


Fig.6. Briquetting the biomass



Fig.7. Screw Press and Piston Press Technologies

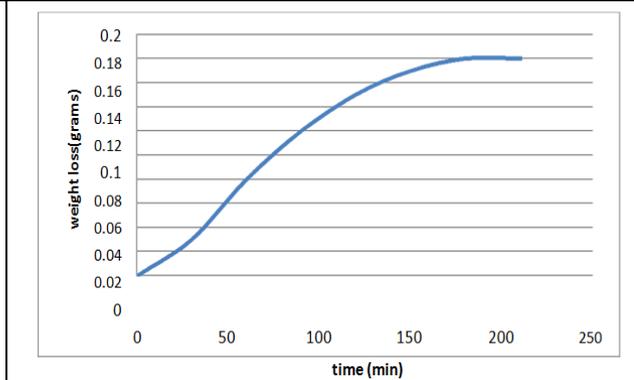
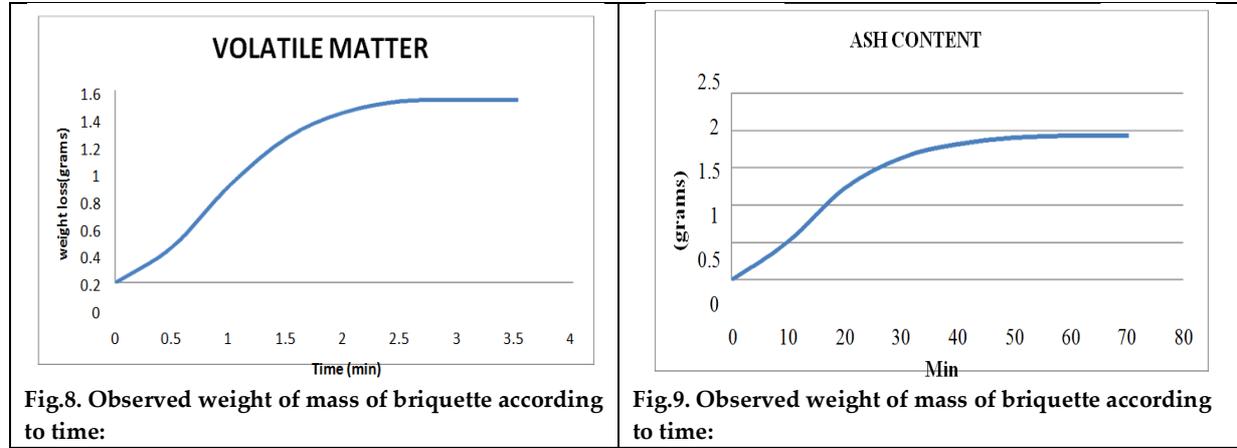


Fig.7. Moisture content





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## Removal of Flouride from Drinking water by Nanomagnesium Oxide

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### ABSTRACT

Preparation of Nanomagnesia (NM) and its application in water purification has been studied in the present work. The synthesis is based on various methods. Various characterization studies confirmed that NM formed is crystalline with high phase purity, and the particle size varied in the range of nm scale. The fluoride adsorption by NM is highly favorable and the capacity does not vary in the pH range usually encountered in groundwater. The effects of various co-existing ions usually found in drinking water, on fluoride removal were also investigated. Phosphate was the greatest competitor for fluoride followed by bicarbonate. The presence of other ions studied did not affect the fluoride adsorption capacity of NM significantly. The adsorption technique is followed to remove the fluoride. A batch process is carried out using precipitation– sedimentation–filtration techniques, addressing the problems of high fluoride concentration as well as the problem of alkaline pH of the magnesia treated water. The method of synthesis reported here is advantageous from the perspectives of small size of the nanoparticle, cost-effective recovery of the material and improvement in the fluoride adsorption capacity

**Keywords:** Adsorption, Defluoridation, Drinking water, Nano magnesia

### INTRODUCTION

Fluorine is one the common elements present in earth crust. Its atomic number is 9 and chemical symbol is F. Its atomic weight is 18.9, melting point of is  $-219.6^{\circ}\text{C}$  and the boiling point is  $-188^{\circ}\text{C}$ . Many fluoride minerals are known, but of paramount commercial importance is fluorite ( $\text{CaF}_2$ ). The soft, colourful mineral is found worldwide. Seawater fluoride levels are usually in the range of 0.86 to 1.4 mg/L, and average 1.1 mg/L. The chloride concentration in seawater is about 19 g/L. The low concentration of fluoride reflects the insolubility of the alkaline earth fluorides, e.g.,  $\text{CaF}_2$ . Fluoride is present naturally in low concentration in drinking water and foods. Fresh water supplies generally contain between 0.01–0.3 ppm. In some locations, the fresh water contains dangerously high levels of fluoride, leading to serious health problems. The fluoride occurs mainly as sellaite ( $\text{MgF}_2$ ), fluorspar ( $\text{CaF}_2$ ), cryolite

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( $\text{Na}_3\text{AlF}_6$ ) and fluorapatite [ $3\text{Ca}_3(\text{PO}_4)_2\text{Ca}(\text{F},\text{Cl}_2)$ ]. As fluorapatite it is found in sedimentary rocks and as cryolite in igneous rocks. These fluoride minerals are nearly insoluble in water. Hence fluorides will be present in groundwater only when conditions favour their dissolution or high fluoride containing effluents are discharged to the water bodies from industries. Fluoride in drinking water has a profound effect on teeth and bones. Fluoride displaces hydroxide ions from hydroxyapatite,  $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ , the principal mineral constituent of teeth and bones, to form the harder and tougher fluoroapatite,  $\text{Ca}_5(\text{PO}_4)_3\text{F}$ . Up to a small level this strengthens the enamel. However, fluoroapatite is an order of magnitude less soluble than hydroxyapatite, and at high fluoride concentration the conversion of a large amount of the hydroxyapatite into fluoroapatite makes the teeth and the bone denser, harder and more brittle.

In the teeth this causes mottling and embrittlement, a condition known as dental fluorosis. With prolonged exposure at higher fluoride concentrations dental fluorosis progresses to skeletal fluorosis. Fluoride is thus considered beneficial in drinking water at levels of about 0.7 mg/L but harmful once it exceeds 1.5 mg/L which is the World Health Organization limit being followed in most of the nations and is also the Australian recommended limit. The difference between desirable doses and toxic doses of fluoride is ill-defined, and fluoride may therefore be considered as an essential mineral with a narrow margin of safety. The effect of fluoride on bone of human body and its effects results in deformation of bone and teeth is called fluorosis. There are two types of fluorosis, they are dental fluorosis and skeletal fluorosis. Dental fluorosis is hypo mineralization of tooth enamel caused by ingestion of excessive fluoride during enamel formation. It appears as a range of visual changes in enamel causing degrees of intrinsic tooth discoloration. The severity of the condition is dependent on the dose, duration and age of the individual during the exposure. In the mildest form there are faint white lines or specks. Slightly more severe cases appear as white mottled patches, while severe fluorosis is characterized by brown discoloration and brittle, pitted and rough enamel. Barring the most severe cases, teeth with fluorosis are relatively resistant to dental caries although they may be of potential cosmetic concern.

**Skeletal fluorosis**

Skeletal fluorosis is a bone disease caused by excessive accumulation of fluoride in the bones. In advanced cases, skeletal fluorosis causes pain and damage to bones and joints. In India, the most common cause of fluorosis is fluoride-laden drinking water which is sourced as groundwater from deep-bore wells. Over half of groundwater sources in India have fluoride above recommended levels. Common causes of fluorosis include inhalation of fluoride dusts/fumes by workers in industry, use of coal as an indoor fuel source, consumption of fluoride from drinking water, and consumption of fluoride from drinking tea. Skeletal fluorosis can be caused by cryolite, and the disease was first recognized among workers processing cryolite.

**Nano particles**

Nanoparticles are particles between 1 and 100 nanometers in size. In nanotechnology, a particle is defined as a small object that behaves as a whole unit with respect to its transport and properties. Particles are further classified according to diameter. Ultrafine particles are the same as nanoparticles and between 1 and 100 nanometers in size, fine particles are sized between 100 and 2,500 nanometers, and coarse particles cover a range between 2,500 and 10,000 nanometers. Nanoparticles are of great scientific interest as they are, in effect, a bridge between bulk materials and atomic or molecular structures. A bulk material should have constant physical properties regardless of its size, but at the Nano-scale size-dependent properties are often observed. Thus, the properties of materials change as their size approaches the nanoscale and as the percentage of atoms at the surface of a material becomes significant.





## SYNTHESIS OF NANO PARTICLES

The methods employed to prepare the nanoparticles are:

- Sol-Gel process,
- Self-propagated combustion,

## SOL GEL PROCESS

The sol-gel process is a wet-chemical technique also known as chemical solution deposition widely used recently in the fields of materials science and ceramic engineering. Such methods are used primarily for the fabrication of materials typically a metal oxide starting from a chemical solution sol, short for solution, which acts as the precursor for an integrated network or gel of either discrete particles or network polymers.

## MATERIALS REQUIRED

**CHEMICALS:** Chemicals used in this study were of analytical grade. Magnesium nitrate, urea and potassium permanganate was procured from Ranbaxy Fine Chemicals Limited, India. Glycine was procured from SRL, India. A stock solution of 1000 mg l<sup>-1</sup> fluoride was prepared from sodium fluoride using distilled water. Required concentrations of the samples were prepared by serial dilutions of the stock solution.

### Self-propagated combustion

Materials required:

Calcium nitrate

Urea

Potassium permanganate

Glycine..

- In method of the calcium nitrate trapped in cellulose fibers.
- Glycine and urea are the most commonly used fuels in most of the self-sustained combustion reactions.
- The In a typical synthesis process, calcium nitrate, urea, glycine and cellulose fibers were initially mixed and kept overnight.
- The weight ratio of calcium nitrate : urea : glycine : cellulose used mixture was then heated on a hot plate under stirring for 20min to evaporate the excess water and was subsequently fired in a muffle furnace at 450 °C for 45 min.
- Combustion time of 45 min was used to completely burn the organic matter present in the product so as to get pure CaO.

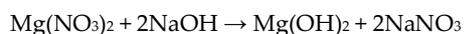
## PREPARATION OF NANO MAGNESIUM OXIDE

For preparation of Nano magnesium oxide we are used SOL-GEL method.

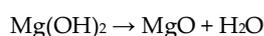
**Reagents:** The following chemicals are use in this preparation, they are Magnesium nitrate, Mg(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O , Sodium hydroxide, NaOH, and Distilled water.

**Procedure:** In this method we prepare solution of 0.2 M Magnesium nitrate was dissolved in 100 mL of DD water and taken in a 250 mL beaker. And we will make another solution of 0.4 M NaOH was dissolved in 100 mL of DD water and taken in a 250 mL beaker. Now both solutions are prepared. Now the 0.2 M Magnesium nitrate solution was kept under stirring using magnetic stirrer then 0.4 M NaOH was added drop by drop. The molar ratio of metal ions to hydroxide ions was maintained as 1:2. The mixture was stirred for 2 hours at room temperature to form magnesium hydroxide without any agglomeration. After two hours the mixture is allowed to settle for an one hour then a precipitate is formed at bottom of the conical flask. That is nothing but magnesium hydroxide. the chemical reaction is as follows.



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Now filter the solution using whatman filter paper, such that we collected the precipitate and place it in 250ml glass jar. And allow it dry for some time after that add 50ml of ethanol to the precipitate and place the jar in drier for 24 hours and temperature 120°C is maintained for 24 hours. So that any water molecules present in precipitate will be evaporated and form as a small crystal formed. Now place the precipitate powder in muffle furnace and calcined at 400°C for 4 hours then it is taken out of furnace and cooled then it is grinded then it forms white powder nothing but nano magnesium oxide. The following chemical reaction takes place in the calcination reaction and results in the nano particles or nano magnesium oxide.



Such that by removing water molecules from magnesium hydroxide magnesium oxide is formed.

**Characterization of material**

The synthesized samples were characterized by the following analytical techniques, such as FTIR, SEM and XRD.

**FTIR:** Fourier transform infrared spectroscopy (FTIR) is a technique which is used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high spectral resolution data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer which measures intensity over a narrow range of wavelengths at a time

**FTIR graph:** FTIR Spectra of MgO particles are shown in below graph. Peaks at 3664 cm<sup>-1</sup>, 3448 cm<sup>-1</sup> corresponding to the O–H stretching mode of hydroxyl groups were present on the surface due to moisture.

**Scanning Electron Microscope:** A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum, in low vacuum, in wet conditions, and at a wide range of cryogenic or elevated temperatures.

**Results of SEM:** The following one is the picture nothing but result of SEM. Size of the particle found, Minimum: 72nm. Maximum: 1420nm, Average: 700 nm.

**XRD analysis:** X-ray powder diffraction (XRD) is a rapid analytical technique primarily used for phase identification of a crystalline material and can provide information on unit cell dimensions. The **analyzed** material is finely ground, homogenized, and average bulk composition is determined.

**REMOVAL OF FLOURIDES:** Prepare 8 ppm concentration of flouride solution. molecular weight of NaF =41.98. Prepare 1 lit solution of 8 ppm conc. NaF solution. By taking 19.52 milligrams of nano magnesium oxide and preparing a stock solution by adding that in the one litre solution. Later divide the samples into 7 various 100ml samples and add 10, 20, 30, 40, 50,60, and 70 mg of MgO in each sample respectively and place it on magnetic stirring for 15, 25, 35 minutes respectively. After stirring filter the sample using whatman filter paper and collect the sample in conical flasks. Calculate the concentration of fluoride in the sample by using fluorimeter. Take each sample and follow the method.





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**Optimum time:** From the graphs the optimum time is determined as 15 minutes since her maximum removal of flouride takes place.

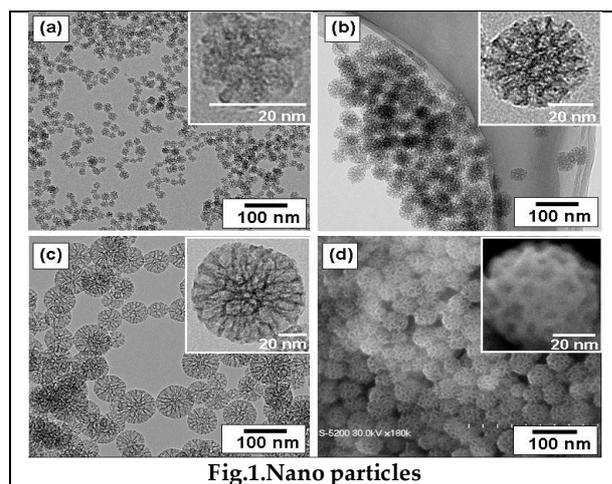
**Optimum dosage:** From the graph the optimum dosage is found as 50 mg since at this point maximum removal of flouride takes place. The concentration reduces from 8ppm to 3.1ppm.

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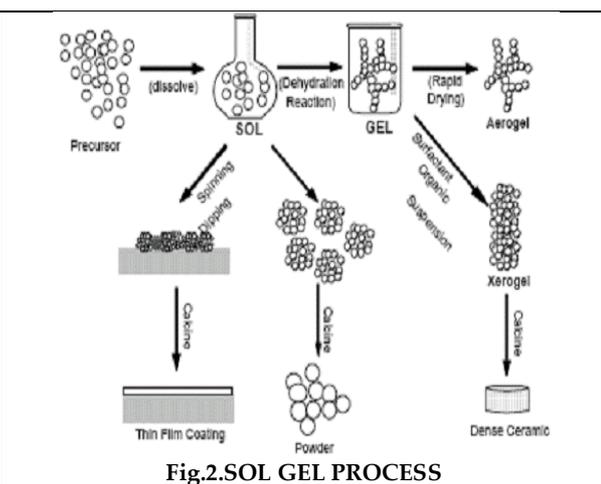
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**Table 1.of reading values:**

Weight in mg	15 minutes	25 minutes	35 minutes
10	7.1	7.42	7.35
20	4.8	6.1	6.02
30	4.1	5.92	5.87
40	3.6	5.23	4.94
50	3.1	5.04	4.00
60	3.08	4.94	3.901



**Fig.1.Nano particles**



**Fig.2.SOL GEL PROCESS**





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Fig.6.FTIR System

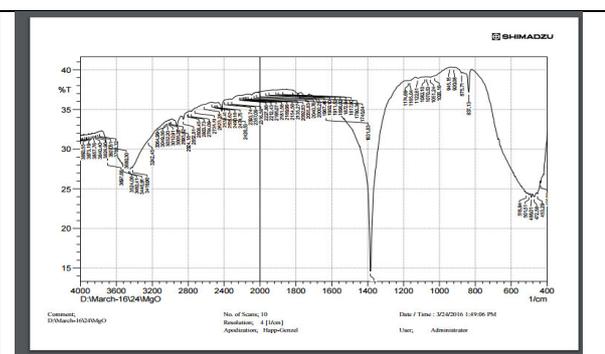


Fig.7.FTIR graph

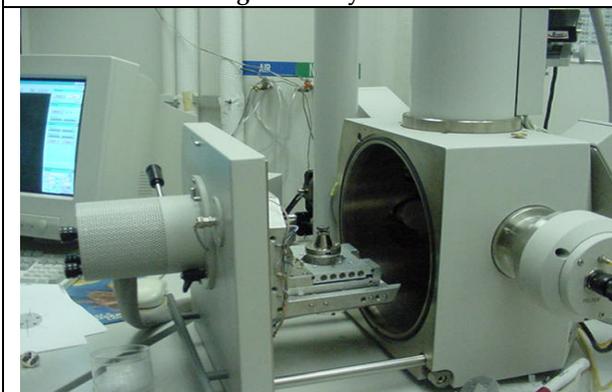


Fig.8.Scanning Electron Microscope

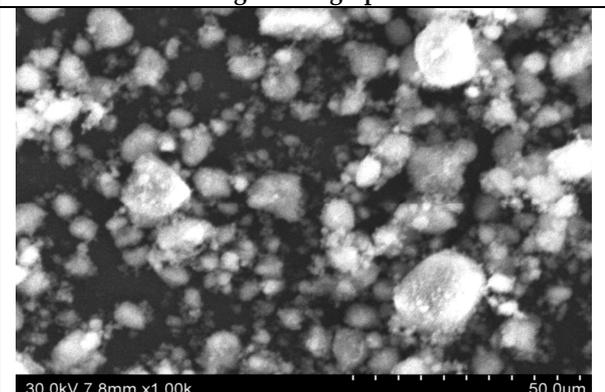


Fig.9.SEM particle Size



Fig.10.XRD system



Fig.11. REMOVAL OF FLOURIDES





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Fig.12.Fluorimeter

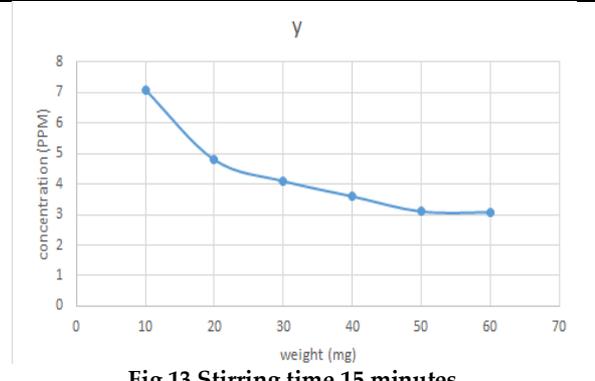


Fig.13.Stirring time 15 minutes

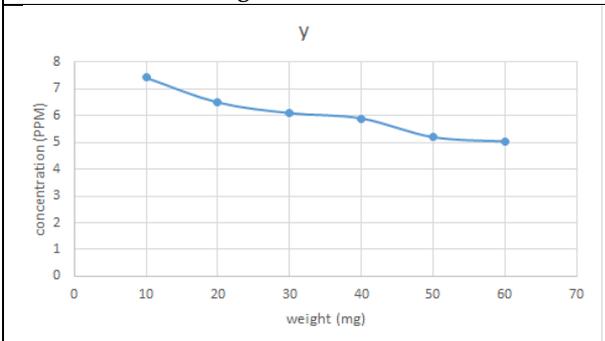


Fig.14.Stirring time 25 minutes

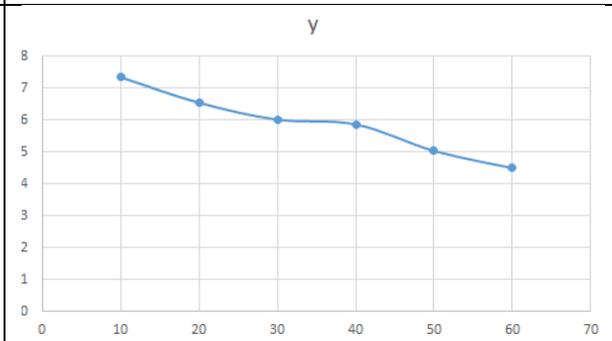


Fig.15.Stirring time 35 minutes





## RESEARCH ARTICLE

## Comparison of Different Drying Methods in the Preservation of Agricultural Food Materials

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### ABSTRACT

Drying processes has been one of the oldest technologies among the industrialized processes in the preservation of agricultural food materials and the oldest food preservation method known to man since it has great effect on the quality of the dried products. The major objective in drying agricultural products is the reduction of the moisture content to a level, which allows safe storage over an extended period. The dent in the food production caused by crop failures as well as significant seasonal fluctuations in availability can be ignored out by food conservation e.g. by DRYING. In this regard some of the vegetables have been traditionally processed by drying to extend their storage life well beyond few weeks and make it available in off season.

**Keywords:** drying, food products, moisture content, hot air drying

### INTRODUCTION

Vegetables and fruits are indispensable part of human diet and can be regarded as the fuel for physiological processes. Despite large numbers of national food production still does not meet the needs of the population. The wastage during handling from point of production to consumer's places, lack of appropriate preservation & storage systems causes considerable losses, thus reducing the food supply significantly. Drying is a heat and mass transfer process resulting in the removal of water moisture, by evaporation from a solid, semi-solid or liquid to end in a solid state. It provides a long term conservation and marketability of product. Nowadays, food safety and quality, first of all the preservation of active ingredients, are strongly focused on by researchers, producers, processors, and consumers (Vadivambal & Jayas 2007). Good quality is judged by the freshness, expected appearance, flavor, and texture. Food safety characteristics are mostly defined by legislations – i.e. there are defined limits of undesirable impurities, chemical compounds, heavy metals, and microbial count. The changes in quality that can occur in any product during drying are those in its optical properties (color, appearance), sensory properties (odor, taste, flavor), and structural properties (density, porosity, specific volume, textural properties, etc.). Drying of fruit and vegetables

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may result in physical, structural and nutritional changes such as case hardening, shrinkage and loss of volatile components and antioxidants. Many of these changes are functions of shrinkage, moisture content, temperature and time. Therefore, knowledge of the shrinkage behavior, the average moisture content and temperature gradient of the product as a function of the drying time is needed in order to maintain its stability during storage, evaluate its final quality and simulate the drying process. Fruit and vegetables can be dried in different forms such as halves, slices and quarters during the drying process and it is reported that this process is a complex procedure in which heat and mass transfer phenomena contribute to moisture removal leading to substantial reduction in mass and volume product minimizing packaging, storage and transportation costs, to enhance the storage and enables storability of the product under ambient temperatures. Drying studies are usually performed at constant drying conditions of temperature, velocity and humidity using a thin layer of sample. Basically, constant condition batch thin layer drying experiments will consist of measurement of moisture loss with time. Drying processes can be classified as batch, where the material is inserted to the drying equipment and drying proceeds for a given period of time, or as continuous, where the material is continuously added to the dryer and dried material continuously removed.

For this purpose, heat is added by different ways, such as, by direct contact with heated air at atmospheric pressure and the water vapor formed is removed by air. The other way is to add the heat indirectly by contact with a metal wall or by radiation. It is important to determine the drying parameters of drying process for the food materials that result in minimal change of quality parameters, we need to mathematical equations. There are several mathematical models are found for determining the drying parameters of the food materials such as Page's, Henderson & Pabis, Wang & Sing, Midilli, Weibull and Logarithmic models. The mathematical modeling allows the food researchers to choose the most suitable operating conditions either to describe the drying equipment or minimize the drying times for the final product specifications. These models can be categorized as theoretical, semi-theoretical, and empirical. Recently, there has been a lot of research in mathematical modeling and experimental studies of the drying characteristics of various vegetables and fruits. The plot of moisture content against time is known as the drying curve. The slope of a tangent to a point on the drying curve is the drying rate.

The plot of drying rate against moisture content is called the drying rate curve (Watson and Harper, 1988). The thin layer drying curves of agricultural products were usually modeled using empirical, semi-empirical and analytical equations. The drying characteristic curves of most of these food materials were modeled using different drying models such as the Newton model (O'Callaghan et al., 1971), Page model (Akpınar et al., 2003), Henderson and Pabis model (Karathanos and Belessiotis, 1999), logarithmic model (Yaldiz et al., 2001), two term exponential model (Akpınar et al., 2003). The studies based on simulation models are needed for design and operation of dryers as well as useful in improving the existing drying system. Thus, several researchers in recent times have investigated the drying characteristics or behavior of different food materials including fruit and vegetables, sea food products using different drying methods such as open sun drying for grapes ((Togrul and Pehlivan, 2004), fish (Jain and Pathare, 2007), and onion slices (Arslan and Ozcan, 2010); solar drying for green pepper (Akpınar and Bicer, 2008), strawberry (Beltagy et al., 2007), Brook mangoes (Dissa et al., 2011), and okra (Doymaz, 2011; Ismail and IbnIdriss, 2013)); and hot air drying for red pepper (Simal et al., 2005), okra (Doymaz, 2005), tomato (Doymaz, 2007), and carrot (Zielinska and Markowski, 2010), respectively.

## MATERIALS AND METHODS

### Material

The bottle gourd, *Lagenaria siceraria* (synonym *Lagenaria vulgaris* ser.), also known as opo squash or long melon is a vine grown for its fruit, which can either be harvested young and used as a vegetable, or harvested mature, dried, and used as a bottle, utensil, or pipe. It is having various pharmacological activities. The chemical constituents present in the bottle gourd responsible for treatment of various diseases. Various literature survey revealed that the pharmacological properties of *Lagenaria*. The bottle gourd are generally available in the warmer region of the world.



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All the cucurbitaceae family plants having major medicinal and nutritive values (Habib-ur-rahman2003). Among the cucurbitaceae family lagenaria species having major medicinal properties. Bottle gourd belongs to genus lagenaria that is derived from the word lagna means bottle.. The lagenaria available in two variety one is bitter bottle gourds and another one is sweet variety useful bottle gourd. The bitter variety available as wild plant and used for the pharmacological application, sweet variety used as vegetable. Due to scarcity nowadays sweet variety using as medicine.

**Different species of lagenaria are available**

*Lagenaria vulgaris* (common) in olden literature

*Lagenaria leucantha* (white flowered gourd)

*Lagenaria siceraria* (Mol) standal in recent literature survey.

*Lagenaria abbreviflora* (Benth)

*Lagenaria asphaerica*

Drying processes range from open sun drying to industrial drying

**Hot air drying**

Currently hot air drying is the most widely used method in post-harvest technology of agricultural products because of its simplicity and low cost. Using this method, a more uniform, hygienic and attractively colored dried product can be produced rapidly. Convective drying, mainly using tray driers, is also widely used, especially by small producers. This process can eliminate the disadvantages of the natural drying. Drying out to the desired level and achieving the equilibrium moisture content (Krokida&Marinos-Kouris 2003) is extremely difficult. Under- or over drying is likely to occur. The consequence of under drying, with the moisture content higher than equilibrium, results in a higher microbial count (Martinovet al. 2007). This procedure could also result in an undesirable reduction of active ingredients contents and inadequate rehydration characteristics.

Drying of material is considered to occur in two stages, a constant rate period followed by a falling rate period. In the constant rate period the rate of drying corresponds to the removal of water from the surface of material. The falling rate period corresponds to the removal of water from the interior of the material. The rate in either case is dependent on:

- a). Flow rate of air
- b). Material characteristics
- c). Tray material.

In tray dryers, the food is spread out, generally quite thinly, on trays in which the drying takes place. Heating may be by an air current sweeping across the trays, by conduction from heated trays or heated shelves on which the trays lie, or by radiation from heated surfaces. Most tray dryers are heated by air, which also removes the moist vapors. A typical drying procedure was applied with tray dryer to investigate properties of tray dryers, its advantages or disadvantages, drying kinetics of foods that are dried in tray dryers. For these purposes, equilibrium moisture content, drying rate, mathematical and experimental Drying time were calculated with some engineering formulas.

**Drying procedure**

Bottle gourd slices are weighting about 100 g were placed in a stainless steel tray in a tray drying unit, which is placed in the middle of the drying unit. Air flowed parallel to the horizontal drying surfaces on the samples. The mass flow rate of the drying air was regulated by a blower driven via a variable speed motor and the temperature was regulated using a rheostat.. Each drying experiment was independent, and the bottle gourds used for all trials were from the same farm and had the same average initial moisture content. During the experiments, the sample weight and temperature (ambient, before and after the tray) were recorded at every 10 minutes. Furthermore, the velocity of the air was constant for all the trails. The moisture loss of samples was determined with the help of a





digital electronic balance having an accuracy of 0.01 g. drying was continued until the sample reached the desired moisture level.

### Open sun drying

The traditional open sun drying practiced on a large scale in the rural areas of the developing countries. The traditional way of drying food materials has been by open sun drying.

### Drying procedure

The open sun drying experiment is carried out during the periods of February-March under the clean climatic conditions. Each experiment started at 10:00 am and continued till 3:00 pm. To determine the moisture loss of drying samples during experiments, bottle gourd samples were taken out and weighed at various time intervals, ranging from 30 min at the beginning of the drying to 1hr during the last stage of the process. The moisture loss of samples was determined with the help of a digital electronic balance having an accuracy of 0.01 g. The drying process was continued until no further changes in their mass were observed.

## EXPERIMENTAL PROCEDURE

### Hot Air Drying

- Tray dryer (TD) is popular for drying due to a relatively short drying time, uniform heating and more hygienic characteristics.
- The temperature ranges from 110 to 170°C (approximately 20% of moisture content).
- This temperature range gives maximum color values and minimizes the loss of volatile oils
- Selected bottle gourd (100 grams) were processed in a tray dryer and they were dried under controlled temperature and parallel air flow until constant weight.
- The water removed during the drying process was determined by periodic weighing of the samples using a digital balance.
- The drying tests were conducted at temperatures of 110, 130, 150 and 170°C and at constant air velocity for two hours.

### Open Sun Drying

Approximately 100 g of sliced okra samples of thickness 10 and 20 mm were spread in different metal tray and then placed in the open sun from 10.00 a.m to 4.00 p.m daily.

- During experiment, bottle gourd samples were taken out and weighed at various time intervals, generally for every 1hr.
- The weights were determined by using digital electronic balance.
- The drying process was continued until no further changes in their mass were observed

## RESULTS AND DISCUSSION

The effect of different drying methods on drying time, color and texture of the bottle gourd slices were determined. The result shown that there was a general decline in moisture content of the sample from 100 g to 10 g in all methods of drying. Time required for open sun drying of bottle gourd was 4 hours where as hot air drying was found to be quicker drying method. It took lesser time of about 100 minutes at 170°C air temperature for 95.5 grams reduction, 120 minutes at 150°C air temperature for 95.3 grams reduction and 120 minutes at 130°C air temperature for 93.4 grams reduction and 120 minutes at 110°C for 62.6 grams reduction. The results pertaining to drying of bottle gourd as recorded in two different methods *viz*, open sun drying and hot air drying are shown in fig. 1 and 2. The data indicated that the loss of moisture was at its highest magnitude in the first hour of drying however the moisture loss was slowed down in the subsequent drying period. The reduction in moisture content of bottle gourd during first



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hour in hot air drying was at higher rate than the samples dried in open sun drying condition. Similar trend was also observed by Bhosale and Arya (2004), in cabbage, cluster bean, fenugreek, spinach and okra. Among the drying methods the removal of moisture from okra slices was found to be at faster rate in hot air drier followed by open sun conditions. This was attributed to the level of temperature and rate of air flow in the dryer which might be responsible for higher difference in loss of moisture. Differences in final weight were observed with the samples dried under different methods of drying. The final weight achieved were, 9.7gm under open sun drying. Similarly final weight recorded with different levels of air temperature under hot air drying were 37.4 gm, 6.6 gm, 4.7 gm and 4.5gm at the air temperature of 110°C, 130°C, 150°C and 170°C respectively.

Figure 1 reveals the percentage of moisture content in dry basis of bottle gourd samples during the air drying at the different temperatures were studied. As expected, there is an acceleration of the drying process due to the increase in the temperature of the drying from 110 °C to 170 °C. However, in the early stages of drying the temperature of 170 °C shows a much faster decrease of percentage of moisture content in dry basis as compared to the temperature of 110 °C, 130 °C and 150 °C. It is evident from these curves that the moisture content decreases continuously with the drying time. As expected, the air temperature had a significant effect on the moisture content of samples. During the drying experiments, the weather was generally sunny. The ambient air temperatures were reached the highest figures between 11:00 and 16:00. Fig.2 suggests drying curves for bottle gourd dried by open sun drying method. Whereas the drying is smooth and controlled by temperature variation using hot air dryer. From the above graph we can say that moisture content removal takes less time in hot air dryer at 170 °C compared to open sun drying. Figure 4 shows that how the drying rate changes with time for different temperatures 110°C, 130°C, 150°C, 170°C. Drying rate increases with increasing air temperature. Figure 5 shows that The drying rate increases up to certain time and then decreases with time. Profile shows Dryingrate versus moisture content curve for temperatures of 110, 130, 150, and 170 °C with constant air velocity. It also show that the period of constant Drying rate, which sometimes is observed in fruits, is very small or does not exist for the four temperatures studied. In addition, the rise in temperature allowed an increase in the drying rate.

## CONCLUSION

Although good progress has been made in drying technology, there is a need for further development of cost effective and energy efficient drying methods. During the drying process, the desirable aspects of fruits and vegetables must be preserved. Combinations of drying techniques produce products that are most appreciated by consumers and reduce heat-induced spoilage in fruits and vegetables. The consumption of large amounts of energy by the instruments used for drying increases the cost of the finished final product. The application of the natural drying method not only reduces the cost but is much easier to use. The main drawback of the natural drying method is that it is time consuming and the drying conditions cannot be manipulated compared to the artificial drying method.

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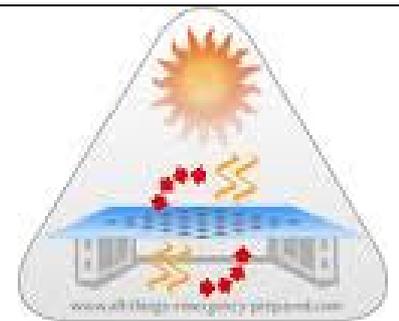
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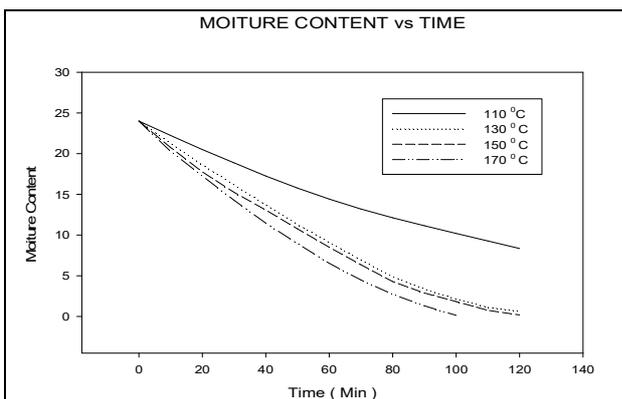
**Fig.1. Bottle Gourd**



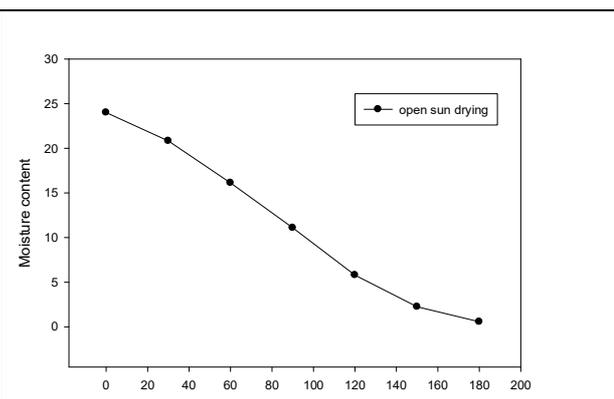
**Fig.2. Hot air dryer**



**Fig.3. Open sun drying**



**Fig.4: Moisture content Vs Time (Hot air dryer)**

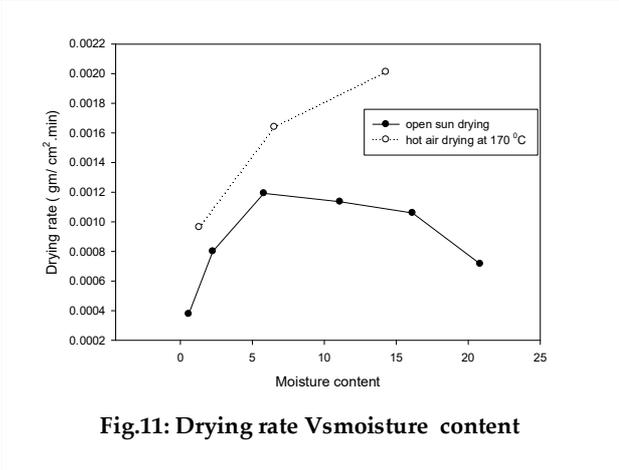
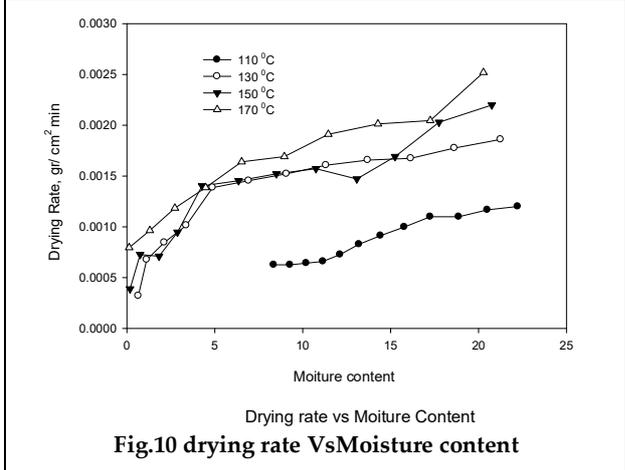
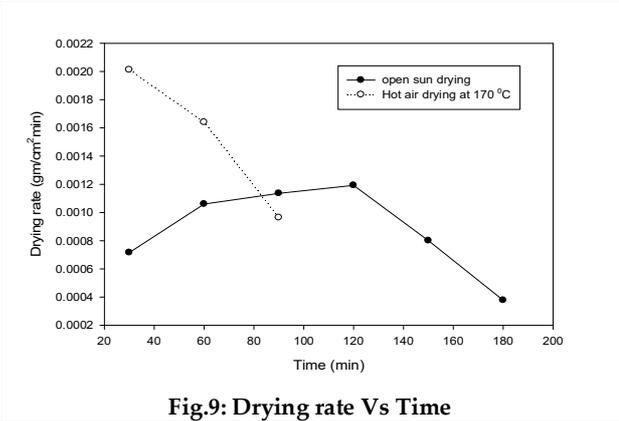
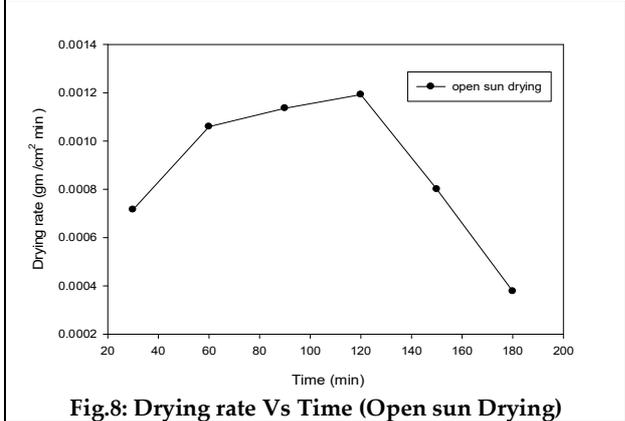
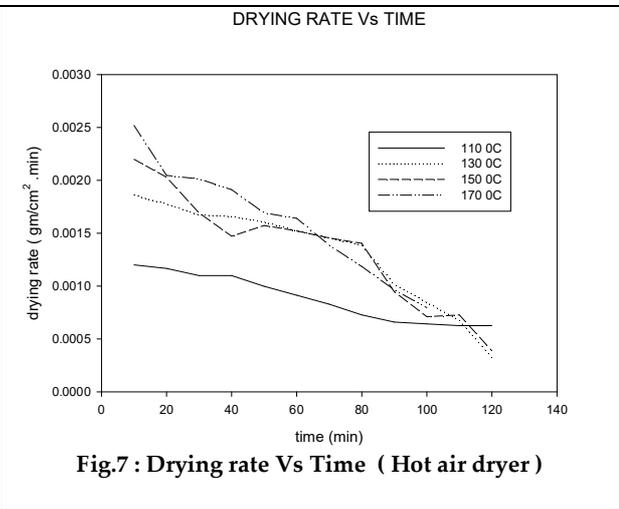
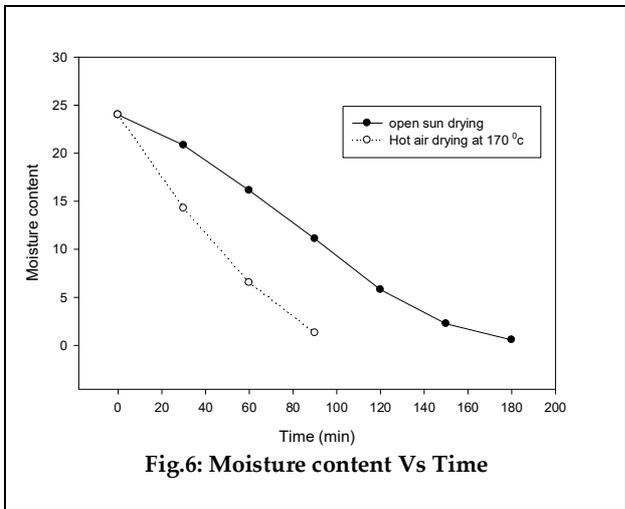


**Fig.5: Moisture content Vs Time (Open sun drying)**





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## Scope of 3D Technology for Mine Planning and Designing in Indian Mining Industry- A Review

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### ABSTRACT

This paper tries to give a scope on application of 3D technology for Planning and designing in Indian mining industry. As per present production target of Coal India 2023 -24. There is an immense need of software modules and technology for optimal production in a safe environment. In order to implement and adapt the new technology to the industry there is a need for wide understanding of the software modules. In this discussed about the software band pack and in detail about the modules. The modules like 3D visulisation, date base management, tools for reserve estimation . It also dicuss about scope of 2D -3D mapping, Graphical image, user interface interactivivty, current trends in the 3D technology, virtual simulation, Artificial Intelllignce. It also tries to throw light on present available softwares available in market and its review ratings.

**Keywords:** 3D technology, exploration, planning and designing

### INTRODUCTION

Coal India has a target for the production of 1 billion ton of coal for the year 2023-24. In India production of iron ore in the year 2018-19 is 200.96 million tonnes. The Production of metallic ore bauxite is 22,313 thousand tonne during 2017-18. From the above facts it can be understood that the mining industry need a strategic planning and design as required. For meeting such challenges required quantification of downstream processes and their integration into orebody models; spatial characterization of geo metallurgical variables and their integration into block models, scheduling and mine optimization. (Dowd, 2016). Opencast mining has been proved very economical for low grade coal lying at shallow depth and there a lot of scopes(Valmike Sahu, 2017). Mining company needs a promising technology like 3D to manage explorations and production, optomize the human resources and equipment. The planning and designing factors have a direct or indirect bearing on the mine scheduling decision making for mining companies (Malisa, 2019)





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### Background

In modern mining, it is inevitable to have sharing of stream flow of data between corporate level and to the field level. The clefs that arise between these ovals creates a poor environment for managerial people to get a timely information efficient decision making. Any mining industry requires needs instantaneous visibility on production, quality, day shift timings, equipment status, and other regular centred operational parameters to achieve optimum and effective operations. Adapting of Industry 4.0 technologies at a mining industry, the integration of shattered a shop floor and production level systems enables absolute communication in discharging outstanding operations. Wireless sensor networking technologies have evolved significantly, and industrial sector is one of the beneficiaries. Communication technologies such as Zigbee etc.

### 3D modelling Technology in Band

**The normal functionality of these 3D modelling software modelling carried out by packages include**

**Visualization:** In 3d visualization includes realistic 3D graphics, exploring it immersively through virtual reality (VR) and analysing overlaid information through augmented reality (AR) without having to trawl through siloed databases is starting to gain traction in the industry. geological exploration data, Statistical data management, (MINING TECHNOLOGY, 2020) .

**Modelling:** 3D modelling software comprises of tools which can perform exploration of geological data, block modelling, surveying, drill and blast data, geological reserve estimation, design of open pit and underground minng, design of ramps, design of raods in open cast mines (MAPTEK, 2020)

**Database Management :** The data management software provison to deal data like drillhole datamanagement, it manages, stores and process the data. It records the data related to equipment, personnel, material. This data management provides the overall view of the current status of the mine. (MICROMINE , 2020)

**Reserve estimation:** The reserve calculation comprises of block model which is the foundation of almost all the design and planning decisions made during the mining process. Resource estimation relies on the development of detail resource model using data from different resources including data management . (MICROMINE , 2018)

- Mine Design
- Mine Planning and Scheduling

**Model of Mine Planning and design Software:** Flexibility is a routuine vague in all the advanced mine planning software packages. Regularly in any software there will be a core program that governs remaining modules and enables data exchange between the modules. The modularity function enables the user to import, validate and displays a wide variety of surface surface, drillhole and subsurface data (MICROMINE , 2017). Plenty modules are commonly available in hands, everything with specialized functionality. Such modules can include:

- 2D 3D mapping ,
- Contouring algorithms,
- Resource estimation
- Block modeling editor
- Reserving module
- Open pit design
- Underground design



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**Graphical image:** The 3d graphical features governs every aspects of visualization and editing and analysis of data. Information from various sources such as packet databases, strings block models, etc. are visualized in 3D within the graphical environment. The 3D graphical mapping reveals the rock complexity of the mine. Graphical tools made it possible to document the geological phenomenon in digital form (Marcisz, 2018). In drill hole graphics interpretation uses a database data has a input source. Interactive graphic manipulation is performed by using the color graphics. Digitising with VULCAN tool is accomplished by using large format table digitiser (JOHNSON, 1987).

**File Structures and Data Exchange:** In the minerals industries, data comes from many different sources like such as drill data, assalyum data, survey data, field data or real time vehicle locations. So how the data will be shared or exchanged between two sever systems, even at offices and also two different software packages. In Open Mining format supports basic structures including points, lines, surfaces, meshes and volumes. Mining requires a huge spatial data and new technologies add to its complexity (GMG group, 2017).

**User Interface and Interactivity:** 3D user interface since long period have a provision of desktop computing, Virtual environment, augmented reality, large screen display. In latest advance mining Virtual Reality has become a boon to the mining industry. User interface must be adaptive and customizable. The graphical environments give the user the visual capabilities to work with the data. The integrated interactive mine software for planning and scheduling is important for stream data flow (Kim, 2019).

**Future Trends other than 3D technology:** Mining design software has to face severly competitive market place which stable drives the levels of improvement to new levels. 3D imaging technologies plays a great role and have transformed the exploration of bigger mines. The 3D laser scanning which helps to capture the spatial data using laser light which is a new technology.

**Industrial Internet of things IIOT** is a network of physical things adding sensors and interconnectivity to vehicles, machinery. This helps to advanced automation and operation of machines, ensure miner and equipment safety and visibility.

**Virtual simulation and Artificial Intelligence -AI** trying to reduces the time and cost requirement associated with physical testing by experimenting and analysing in a virtual setting. Mining companies aims how quickly and efficient can adjust parameters and re-simulate everyday mining processes with 3D modeling software (Mines and Technology London, 2019).

- Automated Machinery
- Robotics in Mining
- Driverless Vehicles in Mining

**Current Industry needs :** The 3D image approach for geological and mine exploaration is a good potential to estimate the reserves while designing the safe mining. Automated drilling helps in reducing the human intervention and safety . This manless operating drilling can be possible by the combination of control systems and Information Technology. This type of advancement technology helps in achieving mininmizing the casualties and fatal rates. It can smoothens the tasks and helps to reach the high levels of accuracy compare to human acitivities. The 3D printing is one area where still miming sector need to adapot at faster rate. 3D printing is process of making of physical objects from a digital model Mining (Bartels, 2016) . The table 6.1 shows about the data that how different softwares developed and popular in mining market and its rating from the reviews . The fig 6.1 depicts the different brand softwares developed for mine exploration and data interpretation.





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## COCLUSIONS

The 3D modelling software provide the band pack with features like Data Visulisation, modelling, Database management, mine designing, mine planning and scheduling. The Software module for designing and planning enables to exchange the data between different collegues and departments.The 3D image approach is best approach and a good potential to estimate the reserves. There is a hunger need for the industry to optimise the production at minmal cost in exploration, this all can be possible by proper prediction, sharing of information among different personnels in optimal decision making. So Indian mining industry has to wake up at faster pace and has to adapot the change.

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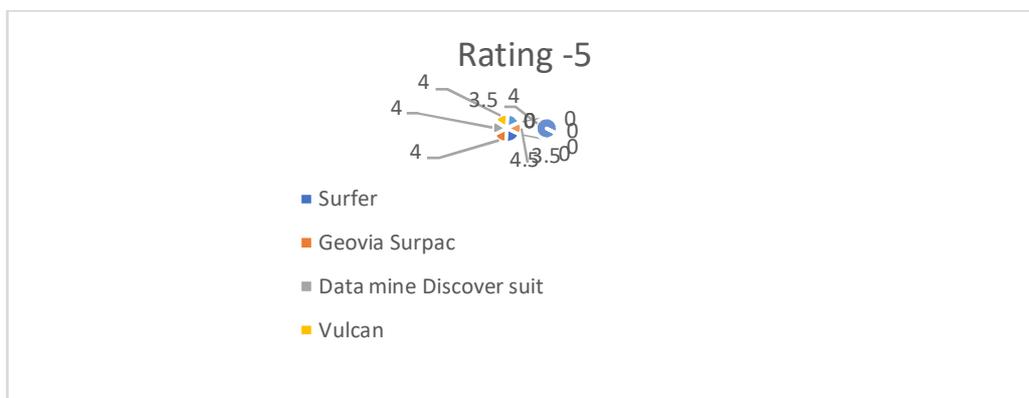




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**Table .1 Different Brand softwares internationally developed for Mines (g2.com reviews)**

S.no	Brand Software Packs available in the year 2020	Features	Rating out of 5
1	Surfer	2D, 3 D models, Contour maps	4.5
2	Geovia Surpac	Geology, Open pit and underground operations.	4.0
3	Data mine Discover suit	Compiling, visualizing, analysing, and mapping 2D and 3D spatial geoscience data	4.0
4	Vulcan	Validate and transform raw mining data into dynamic 3D models, mine designs, and operating plans	4.0
5	XLMiner	Business analytics, predictive model creation and testing	4
6	BIMS - Blast Information Management System	Planning, Controlling and decision making for optimizing mining operations	0
7	Carlson Basic Mining	AutoCAD/IntelliCAD mining add-on to Carlson Civil	0
	Carlson Geology	Manage drill hole data, plus calculate strata models, block models, quantities and qualities	0
9	Carlson Surface Mining	Mine design by testing layouts in plan, section and 3D	0
10	Geobank -Micromine	Capturing, validating and managing data	0
11	Coal Software & Systems	Surface mining, underground mining and wall mining solutions.	0
12	CXL Pit to Port	Plan, record, track, optimize, account, reconcile and report the tonnage, quality and value of bulk materials	0
13	Examine3D	Analysis for underground excavations in rock	3.5



**Fig 1 Pie of pie Chart shwing different brand mining softwares and rating**





## RESEARCH ARTICLE

## Quercitin Possibly May Stall the Activity of the Post Fusion Core of 2019-nCoV S2 Subunit

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Quercitin effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Quercitin.

## INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that quercitin, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Quercitin to be used as COVID-19 therapeutics.





## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>PRO</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Quercetin was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Quercetin has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Quercetin, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

## CONCLUSION AND FUTURE PERSPECTIVES

As the coronavirus outbreak became the nightmare for the whole human society and the devastation caused by it is unpredictable and beyond imagination, the world has not left with enough time to discover a new drug or vaccine for it due to the requirement of sufficient time. Due to its highly contagious nature, it is considered as global pandemic within no time by taking many lives of people. But future studies on Quercetin may become the building block for the medication and treatment against the SARS-CoV-2. The current *in silico* molecular docking based study reveals that Quercetin can target the reported Post Fusion Core of 2019-nCoV S2 Subunit. It would be extremely noteworthy being confirmed *in vivo*. It is crucial to develop diagnostic tools, potential therapeutics and antibodies selectively for the COVID-19 proteins. Phytochemicals like Quercetin is commercially available and thus may be effectively prescribed to circumvent the current global scenario. Essentially, this study makes an attempt to reveal simple phytochemicals like Quercetin which can be employed for designing novel therapeutics.

### Author contribution statement

GKP conceived the idea. GKP, PKP, SKS performed the experiments. All authors have significant contribution in drafting the manuscript

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Ligand	Receptor		Interaction status		
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Quercitin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-22.34	-25.87





## Rosmaniric Acid Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Rosmaniric acid effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Rosmaniric acid.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Rosmaniric acid, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Rosmaniric acid to be used as COVID-19 therapeutics.





## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Rosmaniric acid was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking :** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Rosmaniric acid has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Rosmaniric acid, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

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**Table 1: CDOCKER ENERGY and CDOCKER INTERACTION ENERGY values generated for the interaction of Salicylic acid with the active site of Post Fusion Core of 2019-nCoV S2 Subunit.**

Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Salicylic acid	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-8.69	-12.57





## Post Fusion Core of 2019-nCoV S2 Subunit interacts with the Benzyl Isothiocyanate

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Benzyl Isothiocyanate effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Benzyl Isothiocyanate.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Benzyl Isothiocyanate, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Benzyl Isothiocyanate to be used as COVID-19 therapeutics.





## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>PRO</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Benzyl Isothiocyanate was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Benzyl Isothiocyanate has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Benzyl Isothiocyanate, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

## CONCLUSION AND FUTURE PERSPECTIVES

As the coronavirus outbreak became the nightmare for the whole human society and the devastation caused by it is unpredictable and beyond imagination, the world has not left with enough time to discover a new drug or vaccine for it due to the requirement of sufficient time. Due to its highly contagious nature, it is considered as global pandemic within no time by taking many lives of people. But future studies on Benzyl Isothiocyanate may become the building block for the medication and treatment against the SARS-CoV-2. The current *in silico* molecular docking based study reveals that Benzyl Isothiocyanate can target the reported Post Fusion Core of 2019-nCoV S2 Subunit. It would be extremely noteworthy being confirmed *in vivo*. It is crucial to develop diagnostic tools, potential therapeutics and antibodies selectively for the COVID-19 proteins. Phytochemicals like Benzyl Isothiocyanate is commercially available and thus may be effectively prescribed to circumvent the current global scenario. Essentially, this study makes an attempt to reveal simple phytochemicals like Benzyl Isothiocyanate which can be employed for designing novel therapeutics.

### Author contribution statement

GKP conceived the idea. GKP, PKP, SKS performed the experiments. All authors have significant contribution in drafting the manuscript

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Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Benzyl Isothiocyanate	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-6.57	-9.84





## Ferulic Acid may inhibit the Activity of Post Fusion Core of 2019-nCoV S2 Subunit

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Ferulic Acid effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Ferulic Acid.

## INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Ferulic acid, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Ferulic Acid to be used as COVID-19 therapeutics.





## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Ferulic Acid was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Ferulic Acid has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Ferulic Acid, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

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### Author contribution statement

GKP conceived the idea. GKP, PKP, SKS performed the experiments. All authors have significant contribution in drafting the manuscript

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Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Ferulic acid	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-6.69	-10.27





## Myricetin May Stall the Activity of Post Fusion Core of 2019-nCoV S2 Subunit

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**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Myricetin.

## INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Myricetin, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Myricetin to be used as COVID-19 therapeutics.





P.K. Prusty *et al.*

## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Myricetin was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Myricetin has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Myricetin, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

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Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Myricetin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-26.57	-27.81





## Apigenin May Freeze the Activity of Post Fusion Core of 2019-nCoV S2 Subunit

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**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Apigenin.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Apigenin, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Apigenin to be used as COVID-19 therapeutics.



P.K. Prusty *et al.*

## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>PRO</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Apigenin was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

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## CONCLUSION AND FUTURE PERSPECTIVES

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Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Apigenin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-17.49	-22.26





## Luteolin May Congeal the Activity of the Post Fusion Core of 2019-nCoV S2 Subunit

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Luteolin effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Luteolin.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Luteolin, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Luteolinto be used as COVID-19 therapeutics.



P.K. Prusty *et al.*

## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Luteolin was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Luteolin has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Luteolin, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

## CONCLUSION AND FUTURE PERSPECTIVES

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Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Luteolin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-17.66	-21.46





## Alliin may interact with the Post Fusion Core of 2019-nCoV S2 Subunit

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**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Alliin.

## INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Alliin, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Alliin to be used as COVID-19 therapeutics.





## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>PRO</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Alliin was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

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Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Alliin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-6.38	-9.67





## Caffeine Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Caffeine	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-9.67	-13.87





## Genistein Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Genistein.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Genistein, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Genistein to be used as COVID-19 therapeutics.



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## METHODS

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## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Genistein has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Genistein, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

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Ligand	Receptor			Interaction status	
	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
Genistein	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-11.85	-19.67





## Daidzein may Freeze the Activity of the Post Fusion Core of 2019-nCoV S2 Subunit

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**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Daidzein.

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## Kaempferol may Freeze the Activity of the Post Fusion Core of 2019-nCoV S2 Subunit

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## Coumarin May Congeal the Activity of the Post Fusion Core of 2019-nCoV S2 Subunit

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**Table 1: CDOCKER ENERGY and CDOCKER INTERACTION ENERGY values generated for the interaction of Coumarin with the active site of Post Fusion Core of 2019-nCoV S2 Subunit.**

Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Coumarin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-8.96	-12.08





## Theobromine Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Theobromine effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Theobromine.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Theobromine, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Theobromine to be used as COVID-19 therapeutics.





P.K. Prusty *et al.*

## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>PRO</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Theobromine was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Theobromine has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Theobromine, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

## CONCLUSION AND FUTURE PERSPECTIVES

As the coronavirus outbreak became the nightmare for the whole human society and the devastation caused by it is unpredictable and beyond imagination, the world has not left with enough time to discover a new drug or vaccine for it due to the requirement of sufficient time. Due to its highly contagious nature, it is considered as global pandemic within no time by taking many lives of people. But future studies on Theobromine may become the building block for the medication and treatment against the SARS-CoV-2. The current *in silico* molecular docking based study reveals that like Theobromine can target the reported Post Fusion Core of 2019-nCoV S2 Subunit. It would be extremely noteworthy being confirmed *in vivo*. It is crucial to develop diagnostic tools, potential therapeutics and antibodies selectively for the COVID-19 proteins. Phytochemicals like Theobromine is commercially available and thus may be effectively prescribed to circumvent the current global scenario. Essentially, this study makes an attempt to reveal simple phytochemicals like Theobromine which can be employed for designing novel therapeutics.

### Author contribution statement

GKP conceived the idea. GKP, PKP, SKS performed the experiments. All authors have significant contribution in drafting the manuscript

### Funding

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**Table 1: CDOCKER ENERGY and CDOCKER INTERACTION ENERGY values generated for the interaction of Theobromine with the active site of Post Fusion Core of 2019-nCoV S2 Subunit.**

Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Theobromine	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-10.28	-14.51





## RESEARCH ARTICLE

**Post Fusion Core of 2019-nCoV S2 Subunit Interacts with the Gallic acid**

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**ABSTRACT**

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Gallic acid effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Gallic acid.

**INTRODUCTION**

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Gallic acid, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Gallic acid to be used as COVID-19 therapeutics.





## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Gallic acid was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Gallic acid has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Gallic acid, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

## CONCLUSION AND FUTURE PERSPECTIVES

As the coronavirus outbreak became the nightmare for the whole human society and the devastation caused by it is unpredictable and beyond imagination, the world has not left with enough time to discover a new drug or vaccine for it due to the requirement of sufficient time. Due to its highly contagious nature, it is considered as global pandemic within no time by taking many lives of people. But future studies on Gallic acid may become the building block for the medication and treatment against the SARS-CoV-2. The current *in silico* molecular docking based study reveals that like Gallic acid can target the reported Post Fusion Core of 2019-nCoV S2 Subunit. It would be extremely noteworthy being confirmed *in vivo*. It is crucial to develop diagnostic tools, potential therapeutics and antibodies selectively for the COVID-19 proteins. Phytochemicals like Gallic acid is commercially available and thus may be effectively prescribed to circumvent the current global scenario. Essentially, this study makes an attempt to reveal simple phytochemicals like Gallic acid which can be employed for designing novel therapeutics.

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Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Gallic acid	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-16.28	-19.51





## Post Fusion Core of 2019-nCoV S2 Subunit Interacts with the Capsaicin

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**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Capsaicin.

## INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Capsaicin, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Capsaicin to be used as COVID-19 therapeutics.





## METHODS

### Viral Protein Structure and Phytochemical dataset collection

The 3D structure of M<sup>Pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Capsaicin was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

### Molecular docking

For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Capsaicin has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Capsaicin, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

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Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Capsaicin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-18.57	-25.17





## Post Fusion Core of 2019-nCoV S2 Subunit Interacts with the Trans-Resveratrol

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### ABSTRACT

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**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Trans-resveratrol.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Trans-resveratrol, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Trans-resveratrol to be used as COVID-19 therapeutics.





P.K. Prusty *et al.*

## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>PRO</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Trans-resveratrol was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Trans-resveratrol has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Trans-resveratrol, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

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**Table 1: CDOCKER ENERGY and CDOCKER INTERACTION ENERGY values generated for the interaction of Trans-resveratrol with the active site of Post Fusion Core of 2019-nCoV S2 Subunit.**

Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Trans-resveratrol	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-12.34	-16.52





## RESEARCH ARTICLE

## Ellagic Acid Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Ellagic acid effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Ellagic acid.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Ellagic acid, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Ellagic acid to be used as COVID-19 therapeutics.





## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Ellagic acid was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Ellagic acid has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Ellagic acid, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

## CONCLUSION AND FUTURE PERSPECTIVES

As the coronavirus outbreak became the nightmare for the whole human society and the devastation caused by it is unpredictable and beyond imagination, the world has not left with enough time to discover a new drug or vaccine for it due to the requirement of sufficient time. Due to its highly contagious nature, it is considered as global pandemic within no time by taking many lives of people. But future studies on Ellagic acid may become the building block for the medication and treatment against the SARS-CoV-2. The current *in silico* molecular docking based study reveals that like Ellagic acid can target the reported Post Fusion Core of 2019-nCoV S2 Subunit. It would be extremely noteworthy being confirmed *in vivo*. It is crucial to develop diagnostic tools, potential therapeutics and antibodies selectively for the COVID-19 proteins. Phytochemicals like Ellagic acid is commercially available and thus may be effectively prescribed to circumvent the current global scenario. Essentially, this study makes an attempt to reveal simple phytochemicals like Ellagic acid which can be employed for designing novel therapeutics.

### Author contribution statement

GKP conceived the idea. GKP, PKP, SKS performed the experiments. All authors have significant contribution in drafting the manuscript

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Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Ellagic acid	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-10.81	-18.27





## Sulforaphane Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Sulforaphane effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Sulforaphane.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Sulforaphane, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Sulforaphane to be used as COVID-19 therapeutics.





## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>PRO</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Sulforaphane was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Sulforaphane has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Sulforaphane, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

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GKP conceived the idea. GKP, PKP, SKS performed the experiments. All authors have significant contribution in drafting the manuscript

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Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Sulforaphane	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-8.50	-10.27





## Eugenol may Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Eugenol.

### INTRODUCTION

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P.K. Prusty *et al.*

## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Eugenol was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Eugenol has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Eugenol, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

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Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Eugenol	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-8.34	-10.64





## Isorhamnetin May Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Isorhamnetin .

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Isorhamnetin, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Isorhamnetin to be used as COVID-19 therapeutics.





P.K. Prusty *et al.*

## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Isorhamnetin was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Isorhamnetin has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Isorhamnetin, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

## CONCLUSION AND FUTURE PERSPECTIVES

As the coronavirus outbreak became the nightmare for the whole human society and the devastation caused by it is unpredictable and beyond imagination, the world has not left with enough time to discover a new drug or vaccine for it due to the requirement of sufficient time. Due to its highly contagious nature, it is considered as global pandemic within no time by taking many lives of people. But future studies on Isorhamnetin may become the building block for the medication and treatment against the SARS-CoV-2. The current *in silico* molecular docking based study reveals that like Isorhamnetin can target the reported Post Fusion Core of 2019-nCoV S2 Subunit. It would be extremely noteworthy being confirmed *in vivo*. It is crucial to develop diagnostic tools, potential therapeutics and antibodies selectively for the COVID-19 proteins. Phytochemicals like Isorhamnetin is commercially available and thus may be effectively prescribed to circumvent the current global scenario. Essentially, this study makes an attempt to reveal simple phytochemicals like Isorhamnetin which can be employed for designing novel therapeutics.

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GKP conceived the idea. GKP, PKP, SKS performed the experiments. All authors have significant contribution in drafting the manuscript

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Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Isorhamnetin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-15.66	-20.37





## Malvidin may Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Malvidin effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Malvidin

## INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Malvidin, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Malvidin to be used as COVID-19 therapeutics.





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## METHODS

### Viral Protein Structure and Phytochemical dataset collection

The 3D structure of M<sup>Pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Malvidin was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

### Molecular docking

For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Malvidin has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Malvidin, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

## CONCLUSION AND FUTURE PERSPECTIVES

As the coronavirus outbreak became the nightmare for the whole human society and the devastation caused by it is unpredictable and beyond imagination, the world has not left with enough time to discover a new drug or vaccine for it due to the requirement of sufficient time. Due to its highly contagious nature, it is considered as global pandemic within no time by taking many lives of people. But future studies on Malvidin may become the building block for the medication and treatment against the SARS-CoV-2. The current *in silico* molecular docking based study reveals that like Malvidin can target the reported Post Fusion Core of 2019-nCoV S2 Subunit. It would be extremely noteworthy being confirmed *in vivo*. It is crucial to develop diagnostic tools, potential therapeutics and antibodies selectively for the COVID-19 proteins. Phytochemicals like Malvidin is commercially available and thus may be effectively prescribed to circumvent the current global scenario. Essentially, this study makes an attempt to reveal simple phytochemicals like Malvidin which can be employed for designing novel therapeutics.

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Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Malvidin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-18.33	-27.87





## RESEARCH ARTICLE

## Peonidin may Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Peonidin effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Peonidin

## INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Peonidin, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Peonidin to be used as COVID-19 therapeutics.





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## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Peonidin was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Peonidin has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Peonidin, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

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Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Peonidin	Post Fusion Core of 2019-nCoV S26 Subunit	LXT	Positive	-19.52	-27.31





## Epicatechin may Interacts with the Post Fusion Core of 2019-nCoV S2 Subunit

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## RESULTS AND DISCUSSION

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2	Epicatechin	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-20.16	-28.97





## Post Fusion Core of 2019-nCoV S2 Subunit may be stalled by Phenyl Isothiocyanate

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### ABSTRACT

In past two decades, the globe has faced many infectious disease outbreaks. 2019 Novel Corona-virus (2019-nCoV) or the severe acute respiratory syndrome Corona-virus 2 (SARS-CoV-2) emerged as a global risk and put the entire globe into unrest. Unavailability of specific drug against the virus is more imperative. This demanding situation requires development of biomolecules for competent treatment against the SARS-CoV-2. *In silico* Molecular Docking revealed that the phytochemical, Phenyl Isothiocyanate effectively binds to the active pocket of the SARS-CoV-2 main protease.

**Keywords:** 2019-nCoV, SARS-CoV-2, SARS-CoV-2 main protease, docking, phytochemicals, Phenyl Isothiocyanate.

### INTRODUCTION

The pandemic situation caused due to the 2019-nCoV represents a severe public health calamity across the globe [1,2]. SARS-CoV-2 belongs to the Beta corona-virus genus, closely related to the previously identified severe acute respiratory syndrome corona-virus (SARS-CoV) [3,4]. Public Health Emergency of International Concern (PHEIC) was declared by the World Health Organization (WHO) owing to its fast rate of transmission within the humans [1,5,6]. Crystal structure of the Post Fusion Core of 2019-nCoV S2 Subunit proves to be an exceptional ground for screening specific ligands [7]. SARS-CoV-2 main protease can be beleaguered for developing antibodies, diagnostics and vaccines [8,9,10]. The effectiveness of traditional medications on the restriction of COVID-19 growth does not have any scientific back up as of now, since the underlying molecular mechanisms are unclear. The phytochemicals are fundamentally bioactive compounds and has the potential to amend cellular physiology. Here, we report that Phenyl Isothiocyanate, a phytochemical, mostly enriched in some selected plants binds into the active site of the SARS-CoV-2 main protease as revealed by the *in silico* molecular docking and thus further studies may reveal the effectiveness of Phenyl Isothiocyanate to be used as COVID-19 therapeutics.





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## METHODS

**Viral Protein Structure and Phytochemical dataset collection:** The 3D structure of M<sup>pro</sup> was accessed from Protein Data Bank accession 6LXT. The SDF accession corresponding to the Phenyl Isothiocyanate was obtained and consequently both the protein and the ligands were used for *in silico* analysis.

**Molecular docking:** For the *in silico* molecular docking, BIOVIA's Discovery Studio docking method [11] was used for molecular docking. The catalytic pocket of the Post Fusion Core of 2019-nCoV S2 Subunit was specified and targeted for binding of the ligand. -CDOCKER Energy and -CDOCKER Interaction Energy signify the affinity of the ligands with the protein receptors (Table 1). Basically, high positive values of the CDOCKER Energy, CDOCKER Interaction Energy and a diminutive difference between the -CDOCKER Energy and -CDOCKER Interaction Energy are considered to be the most favourable [12].

## RESULTS AND DISCUSSION

Through the process of molecular docking i.e. *in silico* molecular docking, some phytochemicals have shown their effectiveness against the particular disease. Through *in silico* molecular docking, Phenyl Isothiocyanate has remarkably shown the effectiveness against COVID-19 by binding to the active sites of Post Fusion Core of 2019-nCoV S2 Subunit. It was found that Phenyl Isothiocyanate, a common phytochemical, specifically binds to the active pocket of the Post Fusion Core of 2019-nCoV S2 Subunit, as apparent from higher -CDOCKER energy and -CDOCKER interaction energy.

## CONCLUSION AND FUTURE PERSPECTIVES

As the coronavirus outbreak became the nightmare for the whole human society and the devastation caused by it is unpredictable and beyond imagination, the world has not left with enough time to discover a new drug or vaccine for it due to the requirement of sufficient time. Due to its highly contagious nature, it is considered as global pandemic within no time by taking many lives of people. But future studies on Phenyl Isothiocyanate may become the building block for the medication and treatment against the SARS-CoV-2. The current *in silico* molecular docking based study reveals that like Phenyl Isothiocyanate can target the reported Post Fusion Core of 2019-nCoV S2 Subunit. It would be extremely noteworthy being confirmed *in vivo*. It is crucial to develop diagnostic tools, potential therapeutics and antibodies selectively for the COVID-19 proteins. Phytochemicals like Phenyl Isothiocyanate is commercially available and thus may be effectively prescribed to circumvent the current global scenario. Essentially, this study makes an attempt to reveal simple phytochemicals like Phenyl Isothiocyanate which can be employed for designing novel therapeutics.

### Author contribution statement

GKP conceived the idea. GKP, PKP, SKS performed the experiments. All authors have significant contribution in drafting the manuscript

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### Conflict of interest

The authors declare that they have no conflict of interest.

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**Table 1: CDOCKER ENERGY and CDOCKER INTERACTION ENERGY values generated for the interaction of Phenyl Isothiocyanate with the active site of Post Fusion Core of 2019-nCoV S2 Subunit.**

Ligand		Receptor			Interaction status	
1	Phytochemical	Protein	PDB Accession	Docking Result	CDocker Energy	CDocker Interaction Energy
2	Phenyl Isothiocyanate	Post Fusion Core of 2019-nCoV S2 Subunit	6LXT	Positive	-10.92	-15.83





## Analysis of the Mechanical Properties of Stainless Steel Plasma Nitrided AISI304

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### ABSTRACT

In the presence of N<sub>2</sub>:H<sub>2</sub> gas mixtures of 80:20 and 20:80 ratios, plasma nitriding was performed on AISI 304 stainless steel samples at 500 °C under 4 mbar pressures for 24 h. X-ray diffractograms indicate that the untreated sample consists of a total of four phases of  $\alpha$ Fe (austenite) and one phase of  $\alpha$ Fe (ferrite), while the plasma nitrided samples consist of mixed phases of Fe<sub>3</sub>N + CrN, Fe<sub>3</sub>N + Fe<sub>4</sub>N and Fe<sub>4</sub>N. A Vickers micro hardness tester was used to evaluate the surface hardness as a function of indentation depth ( $\mu$ m). The treated samples were analysed by X-ray diffraction (XRD) to explore the changes induced in the crystallographic structure. The XRD pattern confirmed the formation of an expanded austenite phase ( $\gamma$ N) owing to incorporation of nitrogen as an interstitial solid solution in the iron lattice. For rising concentrations of N<sub>2</sub> the strength of those peaks is slowly increased. In the sample handled at 80N<sub>2</sub>:20H<sub>2</sub> a maximum hardness of 1020 Hv and a case depth of 105  $\mu$ m were achieved.

**Key words:** Plasma nitriding, Stainless steel, Hardness, and Case depth.

### INTRODUCTION

Stainless steel having more than twelve percent chromium content [1] is commonly used in the chemical and food processing industry because of its high corrosion resistance [2-4]. This is seldom used in tribological applications [3] and manufacturing parts for engineering equipments and machine because of poor wear resistance, surface hardness and low load bearing capacity [4-6]. There were several ways to increase the surface hardness, wear properties and fatigue properties of steels by using conventional process such as gas nitriding, and several new techniques including plasma nitriding, microwave plasma nitriding, radio-frequency plasma nitriding, and plasma immersion ion implantation [7, 8].



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Plasma nitriding provides better results to provide the mechanical properties and properties of austenitic steel among all conventional processes [9, 10]. It has been reported that plasma nitriding performed at 450°C provides enhancement in mechanical properties without deteriorating the corrosion properties of the stainless steel. This is due to formation of precipitation free hardened layer usually known as S-phase or expanded austenite phase [9-14]. But whenever, plasma nitriding is carried out at above 450°C, it produces significant improvement in hardness and wear properties but poor corrosion resistance. The deterioration of corrosion properties is due to precipitation of Cr<sub>x</sub>N in the surface nitrided layer [15,16].

Nevertheless, in some applications materials should be of high hardness, wear as well as strong properties of corrosion resistance. Therefore the purpose of this research is to investigate the mechanical properties of AISI304 stainless steel plasma nitride in terms of improving surface hardness and other properties. The subsequent post sputtering was performed in an Ar: H<sub>2</sub> plasma atmosphere to achieve the good corrosion properties of the samples nitrided above 500°C without CrN precipitation. The phase analysis, surface micro-hardness, and nitrogen diffusion layer thickness/case depth of plasma nitrided samples were characterized by X-ray Diffractogram, Microhardness tester for Vickers, and optical microscope, respectively.

**Experimental Procedure**

For the present analysis, AISI 304 austenitic stainless steel was selected and has a chemical composition of 0.05C, 18.09Cr, 9.2Si, 2.0 Mn, 0.02S, 0.03P and rest Fe. The sample was in the form of circular disc having diameter 25 mm. The plasma nitriding was done in a stainless steel vacuum chamber built in a diameter of 500 mm and a height of 500 mm. All samples were first sputter cleaned using 80Ar:20H<sub>2</sub> gas mixture. The plasma was developed with a D.C. Pulsed power supply with 10 kHz repeat rate. After the sputter cleaning process had been completed, the plasma nitriding reactor added a mixture of nitrogen and hydrogen gas. For 24 hours plasma nitriding was conducted using gas mixtures of 80N<sub>2</sub>:20H<sub>2</sub> and 20N<sub>2</sub>:80H<sub>2</sub> at a pressure of 4 m bar at 500 ° C.

Microhardness tests were performed with a Leitz Vickers Hardness tester using a load of 100 gm on untreated and plasma nitrided surfaces of samples. Leitz has tested the case depth of the adjusted layer for an optical microscope with a magnification of 100 X. X-ray diffraction (XRD) was performed in two – degree grazing incidence diffraction mode using Seifert made XRD-3000 PTS diffractometer. At 40 kV and 30 mA, the Cu anode X-ray tube was worked to get Cu K $\alpha$  radiation ( $\lambda=1.5418 \text{ \AA}$ ). The patterns of diffraction were obtained in the 2 $\theta$  range of 40- 700 with step of 0.10 and counting time of 3s per step.

**Analysis of Results****Structural analysis**

X-ray diffraction patterns of untreated and plasma nitrided samples are displayed in Figure 1. It reveals that untreated sample consists of total four phases of  $\gamma$ Fe (austenite) and single phase of  $\alpha$ Fe (ferrite). The  $\alpha$ Fe phase is attributed due to stress assisted during polishing of the sample [15]. After plasma nitriding, the mixed phase of Fe<sub>3</sub>N + CrN, Fe<sub>3</sub>N + Fe<sub>4</sub>N and Fe<sub>4</sub>N phase with high intensity were detected. The intensity of  $\alpha$ Fe peaks are gradually increased compare to untreated samples after plasma nitriding with decreasing the N<sub>2</sub> concentration. The highest and lowest intensity of ferrite phase were detected in sample nitrided at 20N<sub>2</sub>:80H<sub>2</sub> and 80N<sub>2</sub>:20H<sub>2</sub> respectively because of Cr is a ferrite stabilizer element [16-18]. The highest and lowest intensity of mixed phase of CrN+Fe<sub>3</sub>N was detected in samples nitrided at 80N<sub>2</sub>:20H<sub>2</sub> and 20N<sub>2</sub>:80H<sub>2</sub> respectively. As the nitrogen percentage increases in gas compositions, the intensity of mixed phase of Fe<sub>3</sub>N and Fe<sub>4</sub>N increase after plasma nitriding. The high intensity mixed phase of Fe<sub>3</sub>N and Fe<sub>4</sub>N contributes due to the maximum diffusion of nitrogen inside the samples.



**Babuli Kumar Jena****Nitrogen diffusion depth/Case depth measurement**

The cross-section of the plasma nitrided samples was observed in optical microscope. The nitrogen diffusion depth/case depth with different gas compositions is quite visible as shown in Figure 2. Case depth measurements indicate that the nitrogen diffusion depth decreases with decreasing the N<sub>2</sub> concentration in plasma nitriding. The maximum case depth of 105 μm is observed in the sample, which is nitrided at 80N<sub>2</sub>:20H<sub>2</sub>. The lowest case depth of 85 μm is observed in sample treated at 20N<sub>2</sub>:80H<sub>2</sub>. The increase in percentage of hydrogen leads to decrease in the density of active nitrogen species and iron ions [17, 18]. But, higher nitrogen contents leads to increase nitrogen species as well as iron atoms. These reactive species reacts in plasma atmosphere to form iron nitride, thereafter it is probably more condense on the surface compared to less nitrogen in plasma atmosphere. Whenever, the hydrogen percentage increases in plasma it tends to increase sputtering rate due to increase in concentration of excited hydrogen species [18], which may lead to lower formation of iron nitride.

**Surface hardness Measurement**

Figure 3 shows the plasma nitrided AISI 304 stainless steel case depth vs hardness profile at a load of 100 gm in the presence of gas mixture 80N<sub>2</sub>:20H<sub>2</sub> and 20N<sub>2</sub>:80H<sub>2</sub>. The value of the hardness increases from about 325 Hv for untreated sample to a maximum value about 1030 Hv for sample nitrided at 80N<sub>2</sub>:20H<sub>2</sub> while the sample nitrided at 20N<sub>2</sub>:80H<sub>2</sub> improves the hardness about 975 Hv comparison to hardness of 525 Hv of untreated samples. The maximum hardness is observed in samples nitrided with more nitrogen concentration in plasma atmosphere. The more nitrogen concentration in plasma produces more nitrogen species near the samples surface with less sputtering rate, which results more nitrogen incorporation in metal matrix. Plasma nitriding at higher temperatures results in surface precipitation of CrN and association of compressive stress in the modified layer that contributes enhancement of hardness [15,19].

Phase analysis reveals that untreated sample consists of total four phases of γFe (austenite) and single phase of αFe (ferrite), while the plasma nitrided samples consist of mixed phase of Fe<sub>3</sub>N + CrN, Fe<sub>3</sub>N + Fe<sub>4</sub>N and Fe<sub>4</sub>N phase. The intensity of αFe peak gradually increased compare to untreated samples after plasma nitriding with decreasing the N<sub>2</sub> concentration. The highest and lowest intensity of mixed phase of CrN+Fe<sub>3</sub>N was detected in samples nitrided at 80N<sub>2</sub>:20H<sub>2</sub> and 20N<sub>2</sub>:80H<sub>2</sub>, respectively. As the nitrogen percentage increases in gas compositions, the strength of the Fe<sub>3</sub>N and Fe<sub>4</sub>N mixed phase increases after nitriding with plasma. The calculation of surface hardness and case depth also reveals behavior depends on gas compositions. The plasma nitrided at higher N<sub>2</sub> concentration produces a maximum hardness ~1030 Hv and case depth~105 μm.

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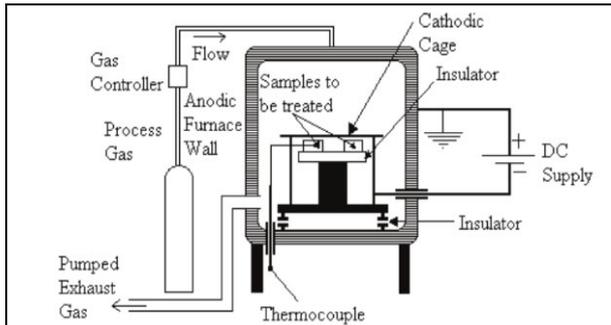


Figure 1 Schematic diagram of the nitriding treatment device

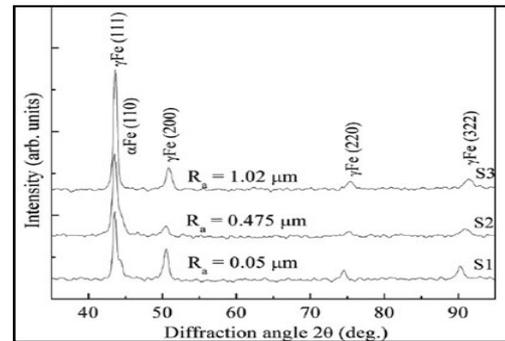


Figure 2 X-ray diffractogram of as-prepared AISI 304 stainless steel samples.

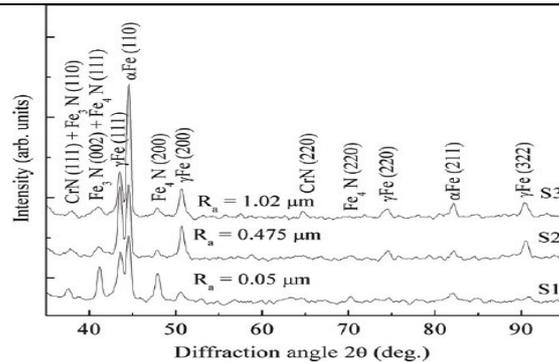


Figure 3 X-ray diffractogram of AISI 304 stainless steel samples after plasma nitriding.

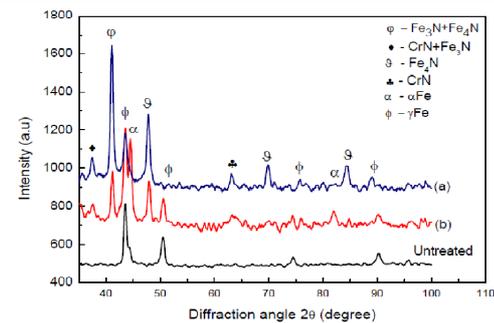


Figure 4: X-ray diffraction patterns of untreated and plasma nitrided at (a) 80N<sub>2</sub>:20H<sub>2</sub> and (b) 20N<sub>2</sub>:80H<sub>2</sub> AISI 304 stainless steel

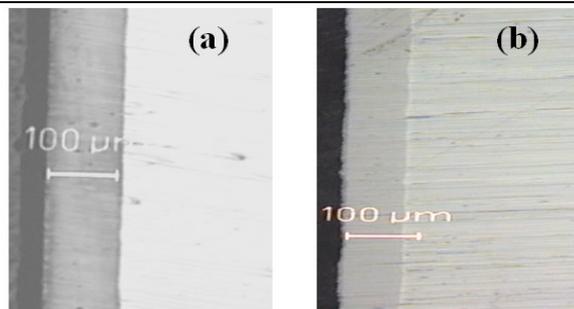


Figure 5: Plasma nitrid AISI 304 steel cross-section micrograms at (a) 80N<sub>2</sub>:20H<sub>2</sub> and (b) 20N<sub>2</sub>:80H<sub>2</sub>

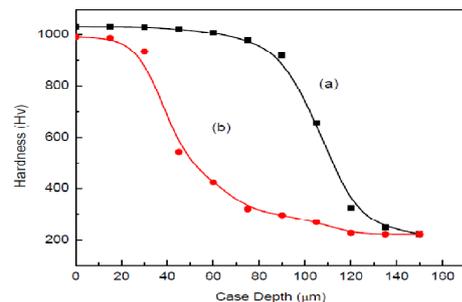


Figure 6: Case depth Vs Hardness of AISI 304 steel nitrid plasma at (a) 80N<sub>2</sub>:20H<sub>2</sub> and (b) 20N<sub>2</sub>:80H<sub>2</sub>





## DOE of Plasma Arc Cutting Parameters using Taguchi Method

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### ABSTRACT

Plasma arc cutting (PAC) is a commonly used industrial method for cutting different types of metals under many conditions of operation. There has been enormous work in machining and technology growth in the last forty years. Compared with its main competitors, PAC is considered a challenging technology: oxyfuel and laser cutting, particularly for cutting mild steel in the thickness range of 5-40 mm. Plasma Arc Machining is one of the most important non-conventional machining processes. Its high precision, coating, machining capacity to produce any hard materials and intricate design enhances consumer demand. The purpose of the research is to maximize the Production of mild steel thin plates, both in terms of cut quality and consumables output, in order to achieve cut quality standards and rates of productivity that are normally achieved via laser cutting processes. By using Taguchi Method as the statistical tool to calculate the optimum level of the operation, the Gas provides, Cutting Speed and Arc Gap were considered as the important parameters. The performance parameters are kerf and roughness of the surface, both are undesirable and thus must be minimized. The Taguchi L9 orthogonal array is implemented with parameters of three stages. The Taguchi method has allowed a deeper understanding of the physical phenomena relating to the crucial aspects initially highlighted and the identification of effective optimum design solutions.

Key words: Surface Roughness (Ra), Kerf, Taguchi method, Process parameters

### INTRODUCTION

Plasma cutting technology is one in which argon, nitrogen and compressed air are used to create a plasma stream, and then nonferrous metal, stainless steel and black metal are cut by the high plasma arc temperature and the strong plasma stream mechanical erosion. Recently, it has been commonly used for blanking processes, rough machining and structural components processed in shipbuilding, computer manufacturing, etc. However, to accurately

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describe the cutting characteristics, it is difficult to establish a special mathematical model, because the power supply has nonlinearity and its cutting parameters have dynamic coupling and static superposition in the cutting. The plasma cutters replaced the typical cutting done by stitching, punching, drilling, machining and cutting. The plasma arc that is considered high temperature cuts at high speed with the aid of different metals. Using the support of plasma torch, plasma arc cutting is considered the tool used to cut aluminum or metals or even other materials. The process of plasma arc method, inert gas i.e. inert gas such as argon is blown through the nozzle with tremendous acceleration and at the same time an electric arc is made from the nozzle to cut surface using that argon which converts some part of the gas into plasma. At high temperature to melt the cut metal and fast movement of plasma helps the blowing metal away from cutting. Plasma is very useful breaking plasma arcs. Using DOE (Experiment Design) fractional factorial, the efficiency and feasibility plasma arc cutting usage needs approval.

**Principle of Plasma Arc Cutting**

This method uses a focused electric arc that melts the material through a plasma beam at high temperatures. Plasma cutting devices with currents from 20 to 1000 amperes to cut plates with inert gas, thicknesses from 5 to 160 mm. Plasma gasses consist of compressed air, nitrogen, oxygen or argon / hydrogen to cut

Additionally, the plasma is bound with a water cooled nozzle. With this energy density inside the plasma beam can be achieved up to  $2 \times 10^6$  W/ cm<sup>2</sup>. Due to the high temperature the plasma expands and flows to the work piece (anode) at supersonic velocity level. Inside the plasma arc temperatures of 30000°C may arise which realize very high cutting speeds on all electrically conductive materials in connection with the high kinetic energy of the plasma beam and depending on the material thickness. This low energy pilot arc prepares the way between plasma torch and job piece by ionization into pieces. When the pilot arc hits the piece of work (flying cutting, flying piercing) the main arc begins with an automatic power increase.

The power source required for the phase of the plasma arc will decay control and high voltage. Although the operating voltage to sustain the plasma is usually between 100 and 160 V, the open circuit voltage needed to initiate the arc can be up to 400 V DC. On initiation, the pilot arc is formed between the electrode and the nozzle within the torch body. In the so called 'transferred' arc mode the arc must be transferred to the work piece for cutting. The electrode has a negative polarity and the work piece has a positive polarity so that most (approximately two thirds) of the arc energy is used for cutting.

**Experimental Procedure**

This research is performed on KALI-100 Plasma Arc Cutter platform. Within these models, we can have three variables that are cutting speed, gas provides and arc gap. The output are Surface Rughness and Kerf that are to be minimized to optimize process parameter settings. The statistical instrument used in the i

**Specimens Preparation**

The actual work pieces of material from the suppliers were in standard size (200 mm x 100 mm x 3&6 mm). With the aid of Handsaw all this content was cut into 25 test samples (100 mm x 40 mm x 3&6 mm) as shown in fig.4 below. The next step is surface finishing with the help of Million Machine to get the test samples accurate. Table 1 below shows the chemical composition of the 1100 aluminum alloy.

**Experiments Conduct**

The tests are performed for PAC method and will proceed in similar setting environment until all conditions are repeated two times. The impact of design factors over the result can be judged and the values and the optimum condition can be predicted. As the optimum condition was gained the confirmation test for the





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purpose of verification of the estimated values is conducted. The results obtained from experiments are then compared with the estimated values in order to achieve accuracy of the work done.

**Design Factors**

Design of Experiments technique has been utilized to obtain the best combination of design factors to achieve optimum performance measures. Plasma Arc Cutting involves several input parameters to be considered during machining process. In this thesis, the combination factors such as Gas Pressure [bar], Cutting Speed [mm/min] and Arc Gap [mm] are considered. These factors are the most important to have the best value for Kerf and Surface Roughness (Ra) when cutting material like Stainless Steel or Nickel Base Alloy etc.

**RESULTS AND DISCUSSION**

The experimental findings were obtained and analyzed from experiment design. The experiment was performed with L9 orthogonal arrays, based on the Taguchi standard protocol. The results from the experiments were described, characterized and analyzed using Mini Tab17 after the variance analysis. Unable to persuade, S/N was used as an analytical method to aid in simple factor response virtualization. Moreover, for the ANOVA analysis, for the determination of Kerf and Ra respectively, the smaller the better was considered. A tabular based on the variance analysis (ANOVA) generated by the experimental values selected an optimal condition through the contribution of parameters in both S/N and percent. The optimum individual level was defined using the optimum condition values, this defined level helps to define approximate values to compare with optimum produced value.

**Linear Model Analysis: SN ratios versus Cutting speed, Gas Provides, Arc gap(mm)**

Estimated Model Coefficients for SN ratios

Term	Coef	SE Coef	T	P
Constant	-45.9687	0.01828	-2515.000	0.000
Cutting 500	0.0068	0.02585	0.263	0.817
Cutting 600	-0.0140	0.02585	-0.542	0.642
Gas Prov 1.5	0.0014	0.02585	0.054	0.962
Gas Prov 2.5	-0.0212	0.02585	-0.820	0.499
Air gap( 1.6	-0.0096	0.02585	-0.372	0.746
Air gap( 1.9	0.0253	0.02585	0.977	0.431

S = 0.05483 R-Sq = 51.3% R-Sq(adj) = 0.0%

Analysis of Variance for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cutting speed (mm/min)	2	0.000883	0.000883	0.000442	0.15	0.872
Gas Provides (Bar)	2	0.002526	0.002526	0.001263	0.42	0.704
Air gap(mm)	2	0.002927	0.002927	0.001463	0.49	0.673
Residual Error	2	0.006013	0.006013	0.003007		
Total	8	0.012350				

**Linear Model Analysis: Means versus Cutting speed, Gas Provides, Arc gap(mm)**

Estimated Model Coefficients for Means

Term	Coef	SE Coef	T	P
Constant	198.810	0.4172	476.479	0.000
Cutting 500	-0.157	0.5901	-0.265	0.816
Cutting 600	0.319	0.5901	0.541	0.643





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Gas Prov 1.5	-0.033	0.5901	-0.056	0.960
Gas Prov 2.5	0.484	0.5901	0.820	0.498
Air gap( 1.6	0.220	0.5901	0.372	0.745
Air gap( 1.9	-0.577	0.5901	-0.977	0.432

S = 1.252 R-Sq = 51.3% R-Sq(adj) = 0.0%

Analysis of Variance for Means

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cutting speed (mm/min)	2	0.4583	0.4583	0.2291	0.15	0.872
Gas Provides (Bar)	2	1.3163	1.3163	0.6582	0.42	0.704
Air gap(mm)	2	1.5240	1.5240	0.7620	0.49	0.673
Residual Error	2	3.1337	3.1337	1.5669		
Total	8	6.4324				

Response Table for Signal to Noise Ratios  
Smaller is better

Level	Cutting speed (mm/min)	Gas Provides (Bar)	Air gap (mm)
1	-45.96	-45.97	-45.98
2	-45.98	-45.99	-45.94
3	-45.96	-45.95	-45.98
Delta	0.02	0.04	0.04
Rank	3	1	2

Response Table for Means

Level	Cutting speed (mm/min)	Gas Provides (Bar)	Arc gap (mm)
1	198.7	198.8	199.0
2	199.1	199.3	198.2
3	198.6	198.4	199.2
Delta	0.5	0.9	0.9
Rank	3	1	2

Factor levels for predictions

Cutting speed (mm/min)	Gas Provides (Bar)	Arc gap (mm)
700	3.5	1.9

**Taguchi Analysis: Kerf (mm) versus cutting speed, Gas Provides, Arc gap (mm)**

**Linear Model Analysis: Means versus Cutting speed, Gas Provides, Arc gap(mm)**

Estimated Model Coefficients for Means

Term	Coef	SE Coef	T	P
Constant	1.33611	0.4037	3.309	0.080
Cutting 500	-0.06378	0.5710	-0.112	0.921





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Cutting	600	-0.28611	0.5710	-0.501	0.666
Gas Prov	1.5	0.22056	0.5710	0.386	0.737
Gas Prov	2.5	-0.37111	0.5710	-0.650	0.582
Arc gap(	1.6	-0.18678	0.5710	-0.327	0.775
Arc gap(	1.9	0.68956	0.5710	1.208	0.351

S = 1.211    R-Sq = 54.7%    R-Sq(adj) = 0.0%

Analysis of Variance for Means

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Cutting speed (mm/min)	2	0.6250	0.6250	0.3125	0.21	0.824
Gas Provides (Bar)	2	0.6271	0.6271	0.3136	0.21	0.824
Air gap(mm)	2	2.2895	2.2895	1.1447	0.78	0.562
Residual Error	2	2.9342	2.9342	1.4671		
Total	8	6.4759				

Response Table for Signal to Noise Ratios  
Smaller is better

Level	Cutting speed (mm/min)	Gas Provides (Bar)	Air gap(mm)
1	-1.4638	-2.9104	1.0688
2	1.9302	0.3920	-4.9891
3	-2.7271	0.2577	1.6595
Delta	4.6573	3.3023	6.6486
Rank	2	3	1

Response Table for Means

Level	Cutting speed (mm/min)	Gas Provides (Bar)	Air gap (mm)
1	1.2723	1.5567	1.1493
2	1.0500	0.9650	2.0257
3	1.6860	1.4867	0.8333
Delta	0.6360	0.5917	1.1923
Rank	2	3	1

**CONCLUSIONS**

This project provided an implementation of the Taguchi process for optimizing Plasma ArcCutting Machine's machining parameters. The Taguchi method, as shown in this study, provides a systematic and efficient methodology for determining optimum parameters with far less work than most optimization techniques would require. The PAC parameters studied were the Cutting Speed, providing power, and using L9 Orthogonal Array, using the Arc Distance. The findings show that the arc distance and cutting speed are the most relevant parameters, accompanied by the gas that provides both surface roughness and kerf.





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**Table 1. Chemical Composition of 1100 Aluminum Alloy**

Elements	Cu	Mg	Si	Fe	Mn	Zn	Ti	Cr
% by weight	0.01	0.02	0.28	0.29	0.02	0.01	0.02	0.01

**Table.2 Process parameters and Levels**

Runs	INPUT		
	Cutting speed (mm/min)	Gas Provides (Bar)	Arc gap(mm)
1	500	1.5	1.6
2	500	2.5	1.9
3	500	3.5	2.1
4	600	1.5	1.9
5	600	2.5	2.1
6	600	3.5	1.6
7	700	1.5	2.1
8	700	2.5	1.6
9	700	3.5	1.9

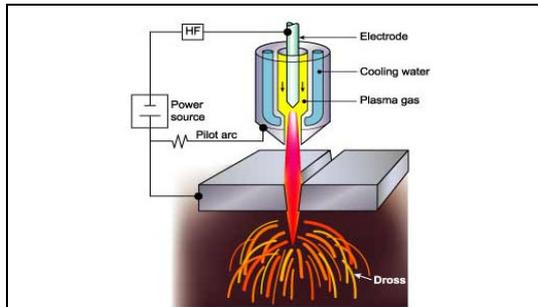




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**Table 3.Values of Output**

INPUT			OUTPUT 1	OUTPUT 2
Cutting speed (mm/min)	Gas Provides (Bar)	Arc gap(mm)	Surface Roughness	Kerf (mm)
500	1.5	1.6	198.01	1.99
500	2.5	1.9	198.9	0.877
500	3.5	2.1	199.05	0.95
600	1.5	1.9	199.01	1.99
600	2.5	2.1	199.14	0.86
600	3.5	1.6	199.237	0.3
700	1.5	2.1	199.31	0.69
700	2.5	1.6	199.842	1.158



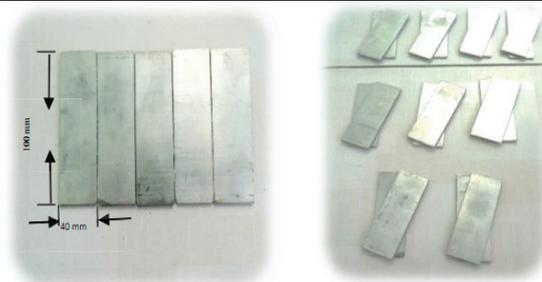
**Figure 1. The principle of the plasma cutting**



**Figure 2. Actual Experimental Setup**



**Figure 3. Plasma Cutting Machine**



**Figure 4. Specimens Preparation**



**Figure 5. Experiments Conduct**





## Expert System for Mould Design in Automated Die Casting Process

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### ABSTRACT

Die-casting demands extensive empirical knowledge of the function and structure of the mould components. As a knowledge based system application it therefore has very good potential for success. Because each tool's design is some what different from each other, each mold or die is complex with its complicated shapes and there are several machining laws to remember, a great deal of experience is needed in the preparation of the machining operations. This paper describes a mould construction process based on sample descriptions which offers an intuitive framework for mould designers integrating methods which elements for the mould functionality.

**Keywords:** Die casting, knowledge-based system

## INTRODUCTION

Die casting is an integral part of the casting industry. Die casting is a versatile process for the production of engineered metal parts by forcing the molten metal into reusable steel mould under high pressure. Die casting utilizes two blocks of heat resistant metal mechanized to meet resistant metal mechanized to meet along the dividing line plane and having cavities machined precisely and smoothly into each one to form opposite shape halves as the shape to be around the edges of the mould. Such moulds can be designed to create complicated shapes with a high degree of precision and reproducibility. This method is particularly suited for high volume casting production with relatively uniform wall thickness and restricted under or complex internal coring. The Die casting processes can be classified as:

- Hot chamber process.
- Cold chamber process.
- Gooseneck type process.

Metal which are commonly cast in die casting process include Al, Zn, Pb, Mg, and alloys of Cu & Sn. In die casting, mould construction for product consistency and effective production is of vital importance. Such efforts should be aimed primarily at improving the entire design process in terms of the achievement of results and accelerating the start of production. It must have enough strength to lock and hold the dies under considerable pressure together, so

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that no leakage occurs at the parting line. Knowledge based mold design procedure which provides an interactive system for mold designers, including methods and mold features.

### Summary of Mould Designing

The basic components of typical die casting mould are as follows.

**Feeding Process:** If a constricted heat flow condition cannot be designed out of the die, the use of a die material with a high thermal conductivity such as molybdenum or tungsten alloy might reduce the calculated gradient. Conversely, if the problem is that of excessive divergence, a low thermal conductivity material such as titanium might be applicable.

**Cooling Process:** To extract heat from the molding, a network of cooling channel from which a coolant is pumped in must be supplied to the mould.

**Ejection System:** The injection method of the die casting machine of the present invention contains the first means of sensing pressure of the pressurized liquid at the injection piston end.

**Mould Construction:** The designer in this case utilizes the automated accelerated ejector pins to strip the casting from the ejector pins. Once free, the casting falls out of the die, usually into a tank of water. A conveyor at the bottom of the water tank delivers the castings out of the water and to a secondary operation, bin, tray or other desired location.

## KNOWLEDGE BASE APPROACH

Broadly speaking, a knowledgebased approach means developing a system, typically called a knowledge based process, solve critical problem-solving decisions in a given domain. A KBS, typically in the form of a smart computer program, uses knowledge and inference technique to solve problems that are complex enough to require considerable human skill to solve them. The facts are a body of evidence that is commonly shared, accessible to the public and usually agreed upon by experts in a sector. The good judgment principles that defined the good decision making experts at the field level.

### The Coding System of a Part Description

#### (A) Part Class

#### (B) Part External Shape:

- Curved rotation axis.
- More than one parallel rotating axis.

#### (C) Under Cut Feature

A under cut can be defined as interface occurring between the mould and molded part when the part is knocked out. The undercut feature can be represented as follows.

#### (D) Material Constant:

Position:	1	2	3	4
Material	0.6	0.7	0.8	0.9
Constant				





**(E) Gating System**

1. Sprue gate.
2. Edge gate.
3. Submarine gate.
4. Pinpoint gate.
5. Tab gate.
6. Film gate.
7. Diaphragm gate.
8. Whirl gate.

**(F) Cooling System.**

- The plate cooled in the cavity.
- Cooled core.
- Cooled cavities.
- Cooled cores and cavities.

**(G) Ejection System.**

**V. Design Details**

In feed system, following factors have been considered.

**1. Pouring Time**

For aluminum alloys, pouring time,

$$t = K \sqrt[3]{W}$$

Where W = mass of the casting, (kg.)

K = constant

For Aluminum K = 1.9

t = 6 sec

Generally for aluminum casting pouring time is 30 – 45 sec.

**2. Choke Area**

The choke area is calculated by using Bernoulli's theorem, and continuity equation as

$$A = W / (d * t * c * \sqrt{2gh})$$

Where

A= Chock area, mm<sup>2</sup>

W= casting mass, kg

d= mass density of the molten metal, Kg/ mm<sup>3</sup>

t= pouring time, sec

g=acceleration due to gravity

h= effective head or sprue height, mm

c= efficiency factor which is a factor of casting system whose value varies between 0.65 to 0.90 , For single runner, c=0.90

A = 4 mm<sup>2</sup> , there for d<sup>2</sup> = 2.25mm





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### 3. Sprue design

Let, the subscripts 1 and 2 denotes the top and choke sections of the sprue respectively.

From continuity equation, we get

$$A^1 V^1 = A^2 V^2$$

$$\text{Or, } A^1 = [A^2 V^2] / V^1$$

Since the velocities are proportional to the square root of the potential head, therefore

$$A^1 = A^2 \left( \sqrt{h_2 / h_1} \right). \text{ There for } A^1 = 6\text{mm}^2 \text{ and } d^1 = 2.8\text{mm}$$

h = height from parting line.

### 4. Pouring basin

Experimentally, we have the following relationship

The entrance in to the sprue is a smooth radius of at least 25mm, pouring basin depth of 2.5 times the sprue- entrance diameter.

Depth = 7mm

### 5. Sprue-base well

Experimentally, sprue base area should be five times that of sprue choke area and the well depth should be approximately equal to that of the runner.

Sprue base well area = 20mm

And well depth 2.8mm

### 6. In-gate design

The in-gate design can be done by the following formulae,

Free height or head of the metal

$$h = 1.6 \sqrt[3]{(q^2 / gb^2) + (v^2 / 2g)}$$

Where, q = metal flow rate, mm<sup>3</sup> / sec.

b = gate width, mm

v = metal velocity in runner, mm/sec

g = acceleration due to gravity, mm/sec<sup>2</sup>.

Therefore, the height of the gate = (h-5) mm = 3mm, and width of the gate = 4 x depth of the gate = 8mm

### 7. Slag- traps system

1. Runner- extension

2. Whirl- gate

### 8. Riser design

For riser design, chaine's method is used

According to the chaine's

$$X = a / (Y - b) + c$$

Where, X = Freezing ratio

$$X = (SA)_{\text{casting}} / (v)_{\text{casting}}$$

$$(SA)_{\text{riser}} / (v)_{\text{riser}}$$

$$Y = \text{Riser volume} / \text{casting volume}$$

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For Aluminum

$$a = 0.1, b = 0.06, c = 1.08$$





Thus, the ratio of the diameter to height for cylindrical riser is calculated from Chaine’s method generally,  $(h/d) = 2$ . Therefore,  $h$  and  $d$  can be calculated from the above.

**9. Air-venting system**

The molten metal is ejected in to the die must displace the gas initially within the die cavity or absorb it as compressed bubbles, for this purpose air venting is necessary otherwise back pressure will directly affects the fluid flow.

**CONCLUSIONS**

The selection of the actual solutions and their final creation into a finished design left to the mould designer so that complete mould design could also add its own intelligent and experience. In general, mold design requires complex and multi related design problems and thus lacks a full quantitative and structural approach. The current methodology involved breaking down the whole problem of design into a number of sub-problems (functional design, e.g. feed system, cooling system, etc.) and developing a knowledge base of solutions for the various sub-problems.

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Figure 1 Casting Machine

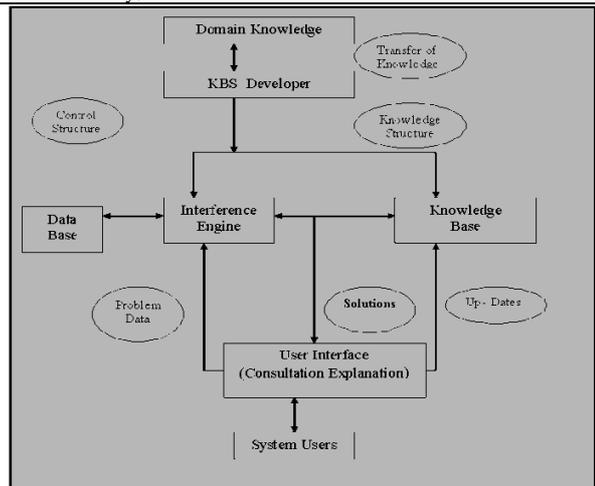


Figure 2 Structure of a KBS





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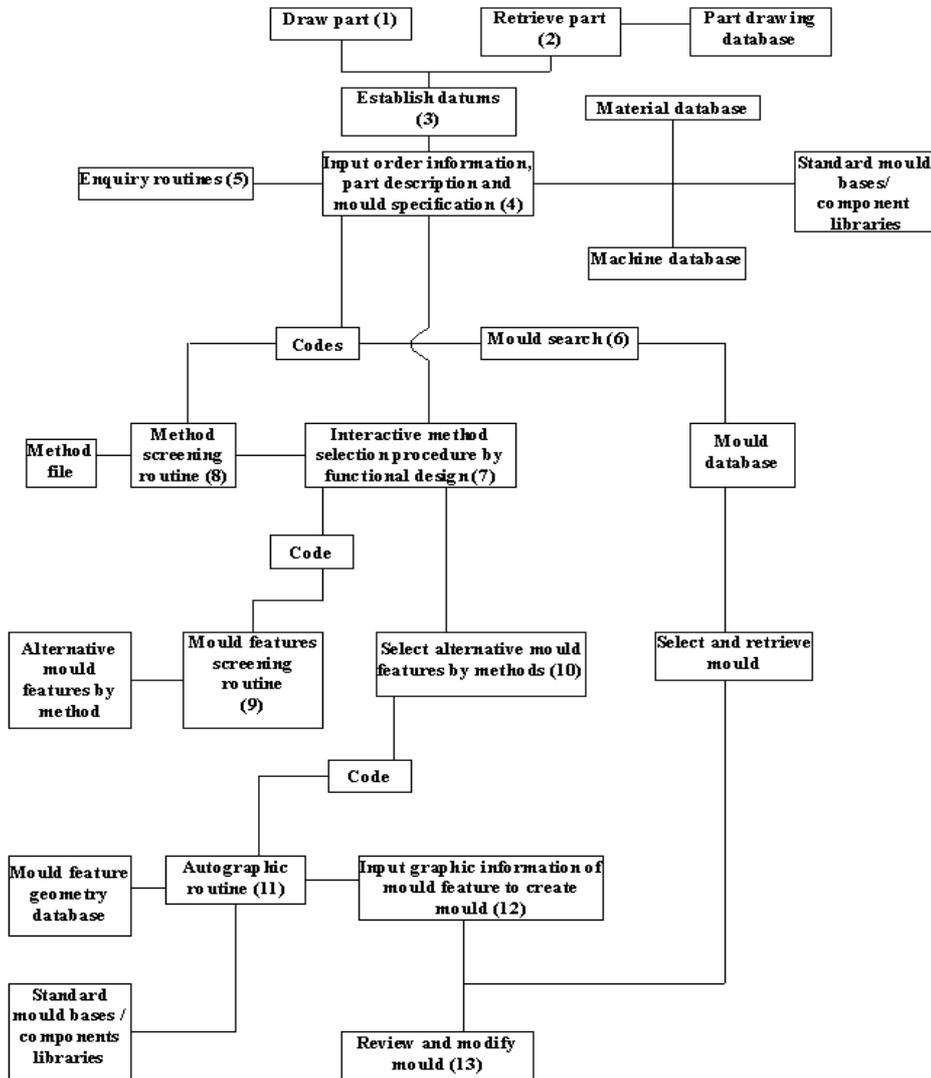


Figure 3 System Structure and Interactive Design





## Simulation in the Design of Computer Integrated Manufacturing System

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### ABSTRACT

Simulation was used as a way of modeling the performance of computer integrated fabrication systems. However, the simulation modeling process for the CIM system is rather complex and expensive. Where simulation is one aspect which should be completely combined with the other components to help real-time decisions. Simulation was also either to explain a fabrication system behavior or to compare multiple alternative configuration schemes. The simulation model built up to now has concentrated primarily on modeling particular device components. CIM programs and how to turn criteria into a working framework that has been widely used in many applications. Its suitability for CIM is currently being tested and there are also presented ways of deriving simulation models from on information repository and generating executable simulation programs.

**Keywords:** Simulation, Computer Integrated Manufacturing

### INTRODUCTION

In the past decade a great deal of attention has been centered on the advantages that computerization can offer to product design and manufacturing practices. It is apparent in technologies such as CAD, CAM, and FMS. However, it is accepted that greater gains could be achieved if functions like these could be merged into a single automated operating system called Computer – Integrated Manufacturing (CIM). The design of production systems is a complex process involving the integration of multiple systems designed by multiple designers to optimize their own sub-systems each. By coordinating work cells, robots, automatic storage and retrieval facilities (AS / AR), and material handling systems, CIM has the ability to largely or completely automate flexible production. This is a fundamentally different use of simulation from the conventional one, whose purpose is to plan. The aim of this paper is to present a general simulation library that is especially appropriate for CIM, in comparison to present simulation software that supports planning but is not well adapted as a feature in a CIM framework. Given these problems, we recommend that the design processes of the

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production processes become less serial and more concomitant, as with the component's concurrent design. CIM stands for a holistic and methodological approach to the activities of the manufacturing enterprise in order to achieve vast improvement in its performance. This methodological approach is applied to all activities from the design of the product to customer support in an integrated way, using various methods, means and techniques in order to achieve production improvement, cost reduction, fulfillment of scheduled delivery dates, quality improvement and total flexibility in the manufacturing system. CIM also encompasses the whole lot of enabling technologies including total quality management, business process reengineering, concurrent engineering, workflow automation, enterprise resource planning and flexible manufacturing.

**EVOLUTION OF COMPUTER INTEGRATED MANUFACTURING**

Computer Integrated Manufacturing (CIM) is considered a natural evolution of the technology of CAD/CAM which by itself evolved by the integration of CAD and CAM. Massachusetts Institute of Technology (MIT, USA) is credited with pioneering the development in both CAD and CAM. The need to meet the design and manufacturing requirements of aerospace industries after the Second World War necessitated the development these technologies. The manufacturing technology available during late 40's and early 50's could not meet the design and manufacturing challenges arising out of the need to develop sophisticated aircraft and satellite launch vehicles. This prompted the US Air Force to approach MIT to develop suitable control systems, drives and programming techniques for machine tools using electronic control. If we review the manufacturing scenario during 80's we will find that the manufacturing is characterized by a few islands of automation. In the case of design, the task is well automated. Thus the implementation of CIM required the development of whole lot of computer technologies related to hardware and software.

**MANUFACTURING ORGANIZATION SIMULATION AND EVALUATION SYSTEM**

The key to the successful "factory of the future" will be the effective coordination of managerial functions and production operations. The simulation model described in this paper addresses this "coordination" issue, especially in terms of managing the impact of interrelated alternatives and activities in an information-rich environment. An evolutionary simulation modeling program, MOSES (Manufacturing Organization Simulation & Evaluation System), has been developed for the purpose of describing, analyzing, and understanding manufacturing organizations. MOSES is evolutionary in several ways: (1) the user is able to build a meaningful manufacturing organization simulation model without writing any computer code; (2) the model spans the entire manufacturing organization, not just the production function; (3) the model includes optimization techniques and heuristics along with traditional logical modeling principles; (4) the model stores and manipulates data using database technology rather than more traditional file techniques; (5) the system includes the user as an integral part of the simulation process.

**CIM HARDWARE AND CIM SOFTWARE CIM**

Hardware comprises the following: i. Manufacturing equipment such as CNC machines or computerized work centers, robotic work cells, DNC/FMS systems, work handling and tool handling devices, storage devices, sensors, shop floor data collection devices, inspection machines etc. ii. Computers, controllers, CAD/CAM systems, workstations / terminals, data entry terminals, bar code readers, RFID tags, printers, plotters and other peripheral devices, modems, cables, connectors etc.,

**COMPUTER BASED SIMULATION**

Computer simulation has long been acknowledged as a powerful tool for studying the behaviour of mathematically intractable complex systems. The near term aim was to research the proposed computer communication structure of the network and to schterm aim was to research the proposed computer communication structure of the network and to schedule execution of the output flow. The simulation is to be real time system status information over the long term and act as a tool for sequencing and scheduling in real time decision making. Consequently,



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the experimental paradigm followed a significantly different methodology than traditional implementations of manufacturing. In standard simulation models of production environments, the algorithm describes the problem from a conventional point of view, taking into account individual workpieces that travel between deeds. This type of structure also fits well with the long-term goal of eventually linking into real time status information, to be processed. The performance measurements used as an indicator for operations are part flow times and use of the equipment. Instead, the simulation logic should be regulated by the real device contact signals dictating robot movement start and end, equipment loading, and cart movement. So the simulation will always reflect the current status of the system. When a decision on the control of system production is needed, multiple simulation runs may be executed under different control decision options for a set period of time.

**CONCLUSIONS**

The use of simulation as a tool of analysis in a CIM environment requires specific consideration of the structure of the computer communication. When it comes to computers Communication controls and delays are accurately modelled, and the insight gained can significantly guide future changes or upgrades to the communication network. The use of simulation as a decisionmaking instrument for system control in real time is attractive. The simulation construction described in the illustrative example, using the signaltriggering concept, shows promise to be able to interface easily with the actual system status when that data becomes available eventually.

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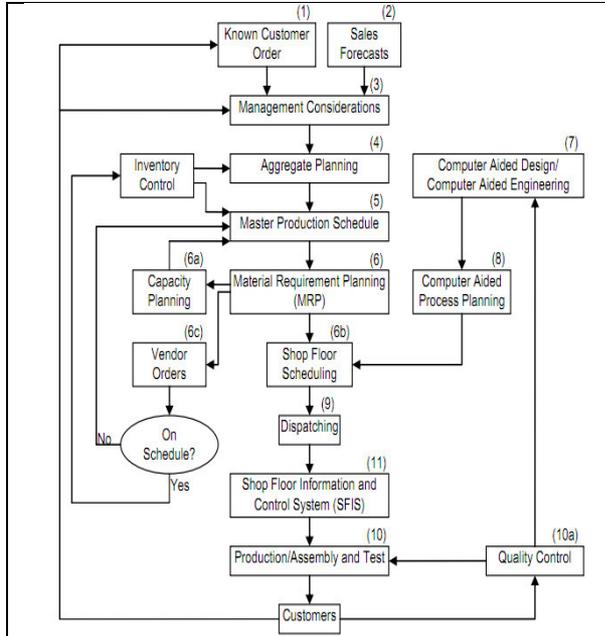


Figure 1. Flow of Operations in CIM

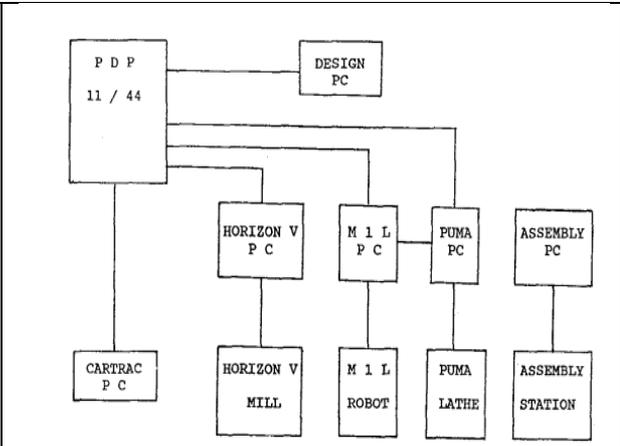


Figure 2. CIM computer communication hierarchy

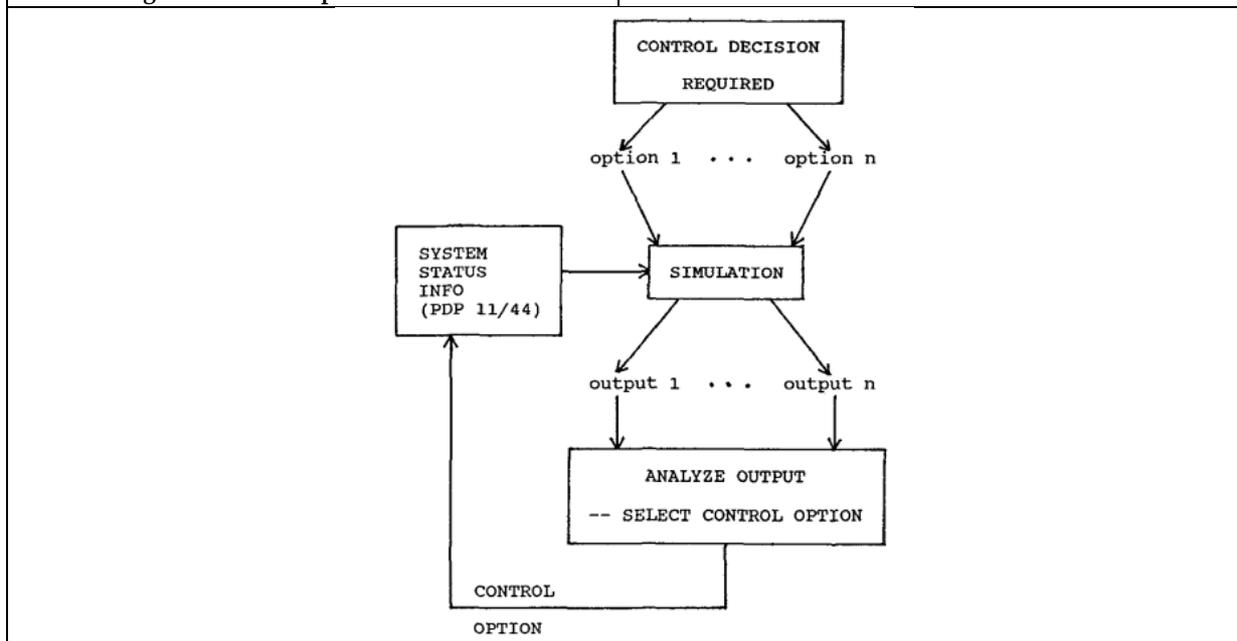


Figure 3. Real-time decision-making mode.





## Distributed System Implementation Using JAVA RMI (Remote Method Invocation)

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### ABSTRACT

This paper describes the implementation of a basic distributed system using the RMI object model in J2SE. A method implemented on a remote JVM is invoked by a JVM acting as a client .RMI implementation is a classic method of remote object access.

**Keywords:** RMI, Remote method invocation, RPC, Request-Response Protocol

## INTRODUCTION

Java RMI is a mechanism of APIs implemented to access objects remotely. Remote method invocation enables us to access objects running completely on a different address space, but can be called and implemented in our accessible JVM. Dynamic loading of classes is also possible in a foreign JVM over the TCP network. Basically RMI is an implementation of RPC model. As RMI is able to load new classes into memory on the go, by providing enough abstraction, developer does not need to worry about the updates of the classes running in the JVM. There are 2 types of class achievable in RMI:-

1. Remote class-This class has the ability to be called or invoked remotely.
2. Serializable class- This class is also known as serializable object, which can be accessed or directly copied from one machine to another through a TCP connection.

### A Basic Demonstration of RMI in J2SE

(i) Remote interface:-

```
import java.rmi.*;  
public interface Gcd extends Remote {  
    public int gcd(int x, int y) throws RemoteException;
```





}

(ii) Remote interface implemented:-

```
import java.rmi.*;
import java.rmi.server.*;
```

```
public class GcdImp extends UnicastRemoteObject implements Gcdcall{
```

```
GcdImp() throws RemoteException{
    super();
}
```

```
public int gcd(int x, int y){
    G1 ob = new G1(x, y);
    return ob.getVal();
}
```

}

(iii) Client implementation

```
import java.rmi.*;
```

```
public class Client{
```

```
public static void main(String args[]){
    try{
```

```
        Adder stub = (GcdImp) Naming.lookup("rmi://localhost:5000/serv");
        System.out.println(stub.gcd(60, 90));
```

```
    } catch (Exception e) { System.out.println(e); }
}
```

}

(iv) Server implemented

```
import java.rmi.*;
import java.rmi.registry.*;
```

```
public class Server{
```

```
public static void main(String args[]){
    try{
```

```
        GcdImp stub = new GcdImp();
        Naming.rebind("rmi://localhost:5000/serv", stub);
```

```
    } catch (Exception e) { System.out.println(e); }
}
```

}





## RESULTS

CLI arguments:-

```
$>rmicGcdImp
```

```
$>rmiregistry5000
```

Output: Fig.1

### Overview of Stub and Skeleton

Stub acts as a gateway, it is present on client side for the remote object identification all the requests from client side is from Stub. It unmarshalls everything. Skeleton acts from the server side, all the requests are handled by Skeleton. It marshalls(packs) everything.

## CONCLUSION

In this article we can use J2SE RMI object implementation to remotely update the classes on the server which are never encountered before, we can implemented synchronized and secure distributed web applications and systems using RMI.

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```
Microsoft Windows [Version 10.0.18363.900]
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F:\ECLIPSE 2020 WORKSPACE\rmi1.zip_expanded\1>javac *.java

F:\ECLIPSE 2020 WORKSPACE\rmi1.zip_expanded\1>rmic AdderRemote
Warning: generation and use of skeletons and static stubs for JRMP
is deprecated. Skeletons are unnecessary, and static stubs have
been superseded by dynamically generated stubs. Users are
encouraged to migrate away from using rmic to generate skeletons and static
stubs. See the documentation for java.rmi.server.UnicastRemoteObject.

F:\ECLIPSE 2020 WORKSPACE\rmi1.zip_expanded\1>rmiregistry 5000

Microsoft Windows [Version 10.0.18363.900]
(c) 2019 Microsoft Corporation. All rights reserved.

F:\ECLIPSE 2020 WORKSPACE\rmi1.zip_expanded\1>java MyClient
38

F:\ECLIPSE 2020 WORKSPACE\rmi1.zip_expanded\1>

Microsoft Windows [Version 10.0.18363.900]
(c) 2019 Microsoft Corporation. All rights reserved.

F:\ECLIPSE 2020 WORKSPACE\rmi1.zip_expanded\1>java MyServer
```

Fig.1 Output





## Comparative Analysis of Network Libraries for Offloading Efficiency in Smartphones and Remote Servers

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### ABSTRACT

Today, smartphones are becoming an integral and essential part of our daily life. To overcome these limitations, mobile cloud computing is introduced which increases the capabilities of smartphones and resources of the cloud to provide better performance and experience to the user. The idea is to save resources in the smartphones by offloading the computationally intensive tasks to the remote servers. In this paper, the objective is to explore more specifically, we are analyzing different types of networking libraries and study their performance on various dynamic factors such as data size, request time and response time, communication media, hardware and software of the device. Here objective is to explore if an application uses the same networking library for all the devices and for all purposes or there is a need to make an adaptive decision based on the local constraints.

**Keywords:** Android, Mobile Cloud Computing (MCC), Network libraries, offloading performance

### INTRODUCTION

In the last decade, we have seen extraordinary and exponential growth in the popularity of smartphones and smart devices. With the modern technology increasing capability of the smart devices, consumers are becoming more demanding, and the developers are building more sophisticated applications with interesting features and complexity. In spite of significant progress, smartphones are unable to accommodate user/application demands, particularly for applications that require resource-intensive processing, memory, and power. To solve the above problem, the concept of *computation offloading* or simply *offloading* is introduced in mobile cloud computing (MCC). Offloading is an idea that has been around for a long time and evolved from various paradigms of distributed



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computing. The concept gained more attention with the popularity of smart mobile devices and the demand for incorporating more sophisticated applications on these well-connected devices.

**Synchronous or Asynchronous Offloading**

An offloading operation can either be executed synchronously or asynchronously dependent upon the requirements of an application. Synchronous execution means the execution in a series. For example, in a chess game, a player makes the next move when the opponent turn is over. Asynchronous execution means to split the problem into multiple tasks and process them independently, for example, the discussion forums where every user can post their views independent of any other user.

**Data Size**

Library performance also depends on the amount of data an application needs to offload. For some application, we need to transfer only a small amount of data such as program files for execution. On the other hand, some application may require transferring large files such as video or images for analysis. Hence, there is a need to decide which of the above libraries is best suited for transferring a particular data size.

**Network Medium**

The performance of the library also depends upon the communication media used for transferring the data, such as Wi-Fi or 4G.

**Hardware/Software**

The effect of hardware configuration and operating system of the mobile devices on these libraries.

**METHOD**

To analyze the performance of the networking libraries, we develop android applications for implementing these libraries. We consider a scenario, where a network library needs to offload data to the cloud, either in synchronous or asynchronous mode, via its underlay communication media. Evaluation is done on a test-bed, involving different file sizes, code execution, network medium and mobile devices of various configuration. For this evaluation, we spawn a virtual machine in Amazon Web Services (AWS) cloud to study and analyze the behaviors of these libraries in a real environment.

**Different network libraries that are commonly used for exchanging Data****HttpURLConnection**

*Http URL Connection* is an abstract class of JAVA extended from the *URLConnection* class. Developers popularly use it for exchanging data from the web servers. As the name suggests, it works on HTTP protocol and contains additional HTTP specific features. A single instance of *Http URL Connection* is used to make a single request from the HTTP server. *HttpURLConnection* can be used only for the synchronous networking calls; it does not support asynchronous calls.

To use the *HttpURLConnection* class for uploading data from a client or smart-device to the server is started by obtaining a new *HttpURLConnection* by calling *URL.openConnection()* and casting the result to *Http URL-Connection* and configure the connection for output using *set Do Output (true)*. If the size of the file or data is known in advance we can call *set Fixed Length Streaming Mode (int)* or *set Chunked Streaming Mode (int)* when it is not. Below we give the abstract code to perform an upload using *HttpURLCon-nection* class:

```
URL url=newURL(uploadServerUrl); HttpURLConnection urlConnection =
(HttpURLConnection) url.openConnection(); try{
urlConnection.setDoOutput(true); urlConnection.setChunkedStreamingMode(0);
OutputStream out =new BufferedOutputStream (urlConnection.getOutputStream());
writeStream(out);
```





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```
InputStream in =newBufferedInputStream (urlConnection.getInputStream());
readStream(in);
}finally{ urlConnection.disconnect();
}
```

#### Ok Http

OkHttp networking library is an open source project which is introduced by Square . OkHttp is an efficient HTTP client which supports HTTP, HTTP 2.0 and SPDY protocols. OkHttp multiplex several HTTP requests over one socket connection. OkHttp is a powerful networking tool which does not require any REST library and its also support both syn-chronous and asynchronous networking calls. It also provides the caching mechanism to cache the response from the server to avoid repeated network request. Below we give an abstract code to perform a file upload synchronously and asynchronously. For synchronous network call, create a call object using client and use the execute method. The synchronous request should be executed on a background thread; otherwise, it gives network error. For asynchronous network call, execute method is replaced with the enqueue method. There is no need for background thread for making asynchronous network calls.

```
OkHttpClient client =newOkHttpClient();
RequestBody file_body = RequestBody.create
(MediaType.parse(content_type), file);
MultipartBody.Builder()
.setType(MultipartBody.FORM)
.addFormDataPart ("name", file_name, file_body)
.build();
Request request =newRequest.Builder()
.url(ServerUrl)
.post(request_body)
.build();

//ForSynchronousCalls Response response =
client.newCall(request).execute();
//ForAsynchronousCalls client.newCall(request).enqueue(new
Callback() { publicvoidonFailure(Call
call,IOException e) {
}
publicvoidonResponse(Call call,final
Response response)throwsIOException {
//dosomethingwihtheresult
}
}
```

#### Volley

Volley is a HTTP networking library introduced by Google in Google I/O 2013. Volley provides many powerful network- ing tools out of the box for the users. Some of the prominent features are multiple concurrent network request, automatic scheduling, and prioritization of the network request, cancel- lation of single or blocks of requests and provide effective memory response caching. Volley is easy to code, and it fetched data asynchronously from the network . Here is the abstract code of sending a file to the server using Volley.

```
RequestQueue queue =
Volley.newRequestQueue(this); String url ="http://www.serverip.com";
```





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```
//Requestastringresponsefromthe providedURL.
```

```
MultiPartRequest request =new SimpleMultiPartRequest(Request.Method.GET, serverUrl,
newResponse.Listener<String>() { @Override
publicvoidonResponse(String response) {
}
},newResponse.ErrorListener() { @Override publicvoidonErrorResponse(VolleyError
error) {
}
});
//AddtherequesttotheRequestQueue request.addFile("name", file); queue.add(request);
```

### Retrofit

Retrofit is type-safe and one of the most popular HTTP client for Android by Square. It is very easy to use and convert the HTTP API into Java interface. It performs network function using REST based web services. Retrofit support both synchronous and asynchronous network request to the remote web server. It also provides a caching mechanism for repeated network request [31]. Retrofit converts HTTP API into Java interface which helps to treat your network calls as simple Java method calls. Below is the abstract code for uploading files to the server in both synchronous and asynchronous manner:

```
Call<LoginResponse> call = RetrofitClient
.getInstance()
.getApi()
.loginTeacher(teach_email,password);
call.enqueue(new Callback<LoginResponse>() {
@Override
public void onResponse(Call<LoginResponse> call, Response<LoginResponse> response) {
LoginResponse loginResponse = response.body();

if (!loginResponse.isError()){
progressBar.setVisibility(View.GONE);

Toast.makeText(TeacherLoginActivity.this,loginResponse.getTeacher().getTeach_name(),Toast.LENGTH_LO
NG).show();
SharedPreferences.getInstance(TeacherLoginActivity.this)
.saveTeacher(loginResponse.getTeacher());
Intent intent = new Intent(TeacherLoginActivity.this, TeachersMainActivity.class);
intent.setFlags(Intent.FLAG_ACTIVITY_NEW_TASK | Intent.FLAG_ACTIVITY_CLEAR_TASK);
startActivity(intent);
}else{
progressBar.setVisibility(View.GONE);
findViewById(R.id.forgot_pass).setClickable(true);
findViewById(R.id.signup).setClickable(true);
Toast.makeText(TeacherLoginActivity.this,"Invalid Credentials",Toast.LENGTH_LONG).show();
}
}
@Override
public void onFailure(Call<LoginResponse> call, Throwable t) {
Toast.makeText(TeacherLoginActivity.this,"Time out Retry again",Toast.LENGTH_LONG).show();
```



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```
findViewById(R.id.forgot_pass).setClickable(true);
findViewById(R.id.signup).setClickable(true);
progressBar.setVisibility(View.GONE);
}
});
}
```

The experiments were performed in different wireless networks, i.e. WiFi and 4G. Moreover, we analyze the effect of hardware and software of the smart devices on the performance of libraries as there is a huge difference in the hardware capabilities of different smart devices. The configurations of the smartphones used in our evaluation are in Table-3. We evaluate all libraries on both mobiles at the same time by executing the process of uploading and downloading on different threads simultaneously. The overall result is averaged.

**Performance Evaluation****Total Delay**

Total delay is the time required for uploading/downloading files to and from a mobile device to the AWS cloud. This includes the time required for reading the file from secondary storage to the internal buffer, transmission time and ACK time from the cloud. This parameter is very crucial for time-sensitive applications.

**Success rate**

The success rate is calculated as a ratio of the total successful acknowledgments received by the total number of files sent. This parameter shows the reliability of a library for an offloading application.

**Battery utilization**

One of the major goals of offloading is to save the energy of mobile devices by migrating heavy computation to the cloud. This parameter evaluates the battery consumption of networking libraries in different circumstances.

**CONCLUSION**

In this paper, a comprehensive analysis of HttpUrl, OkHttp, Retrofit and Volley networking libraries that are commonly used for offloading data from the mobile devices. The main objective of this work is to understand “how to offload” data in a real environment, to optimize the performance of an offloading model. In this paper, we investigate the performance of the libraries for parameters like code execution, data size, network medium, hardware and software of mobile devices. Our evaluation shows that, depending upon the nature of the application, available resources and offloading goals like execution speed, reducing energy consumption, reliability of data transmission, an adaptive network library selection framework can be developed for offloading computational tasks to the cloud. In the future, we intend to propose an offloading framework for adaptive network library selection depending upon the above criteria.

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**Table-1: AWS EC2 Instance Configuration**

EC2 Instances	CPU	Memory	Memory
t2.micro	1 GHz	1 GB	8 GB

**Table-2: Offloading Libraries**

S.No	Synchronous Transfer	Asynchronous Transfer
1	URLConnection	Volley
2	OkHttp Synchronous	OkHttp Asynchronous
3	Retrofit Synchronous	Retrofit Asynchronous

**Table-3: Device Configuration**

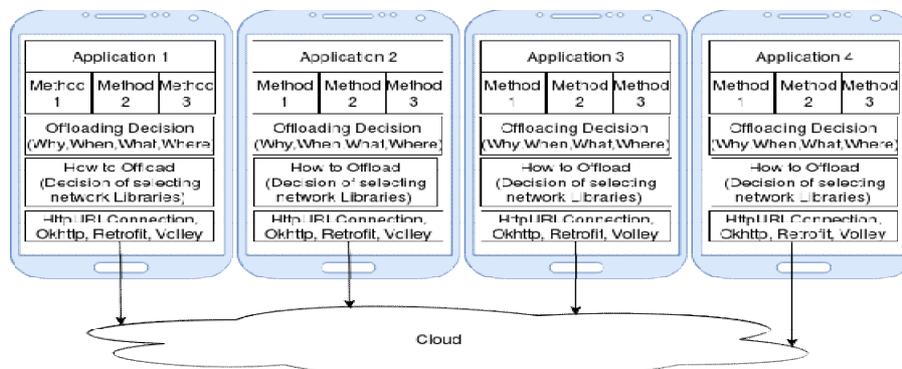
Name	OS	CPU	RAM
Smartphone-1	Android v7.0.1	Quad-core 2.5 GHz Krait 400	3GB
Smartphone-2	Android v8.0	1.0 GHz quad core MediaTek	4GB

**Table-4: Success Rate of Synchronous Libraries**

S.No	Name	Success Rate-WiFi	Success Rate-4G
1	HttpURL	100%	99%
2	OkHttp	100%	99%
3	Retrofit	100%	100%

**Table-5: Success Rate of Asynchronous Libraries**

S.No	Name	Success Rate-WiFi	Success Rate-4G
1	Volley	99%	97%
2	OkHttp	100%	99%
3	Retrofit	100%	100%



**Fig. 1. Method**





## An Overview of Recent Development of Inhibitors against Pathogenic Gram-negative Bacteria: *Salmonella typhimurium* and *Escherichia coli*

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### ABSTRACT

According to recent scientific reports, many of the Gram-negative bacteria such as: *Salmonella typhimurium* and *Escherichia coli* are known for causing life-threatening diseases in human and many other animals. These bacteria have high tendency to survive in the host body rather quickly due to the presence of protective cell wall which defends from invasion of exogenous toxic agent. Therefore, finding potential inhibitors against these pathogenic bacteria is always fascinating to scientific community. Herein, we have covered the recent scientific development of potential inhibitors against the life-threatening pathogenic Gram-negative bacteria. This brief review on inhibitors against gram-negative bacteriamay open up a door way to design highly specific inhibitors with high efficacy against the pathogenic gram-negative bacteria.

**Keywords:** Gram-negative bacteria, *Salmonella typhimurium*, *Escherichia coli*, infected diseases, antibacterial activity, small organic molecule, pathogenic bacteria.

### INTRODUCTION

*Salmonella* is a major type of Gram-negative pathogenic bacteria can cause different infections in case of animals as well as humans [1,2]. *Salmonella* are looks like rod shaped and their size varying from 0.4  $\mu\text{m}$  to 3  $\mu\text{m}$  and this rod shape is because of the actin-like bacterial cytoskeleton [3,4]. *Salmonella* pathogens can cause a number of diseases in humans from minor gastroenteritis to very dangerous typhoid fever [5]. *Salmonellosis* is a major health problem of the world even now and have significant mortality and morbidity. Most of these species can infect a broad range of hosts as in case of *Salmonella enterica* Serovar *typhimurium* (*S. typhimurium*), but other serotype bacteria such as *S. Gallinarum*, *S. Typhi*, *D. Pullorum*, are exquisitely host-restricted in nature [6]. Infection in human being lead to acute gastroenteritis, nausea, diarrhea, abdominal pain and vomiting.



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The pathogen which causes diarrheal disease are *S. typhimurium*, and *S. enteric serovar Enteritidis (S. enteritidis)* and are main cause of acute gastroenteritis [7]. The *S. typhimurium* bacteria is primary enteric gastrointestinal pathogen and can cause many food-borne diseases [8]. The organic compounds such as quinolones and fluoroquinolones are used as antibacterial agents for the bacterial infections [9]. Quaternary ammonium compounds (QAC) were also used to inhibit and remove the bacteria like *S. typhimurium* from chicken skin [10]. To develop them inside the host, bacterial pathogens evolved in variety strategies such as invasion and multiplication, avoidance of human immune system or damage of the gastrointestinal system. For disease the pathogenic bacteria firstly subvert host factors to induce their uptake into nonphagocytic epithelial cells [11-13]. Bacteria pass through the highly acidic gastric fluids present in the stomach and the strongly alkaline secretions from bile duct in the upper small intestine of the host body.

The infection power of the pathogen affected by the gastrointestinal pH and sensitivity of the host with the body. The number of pathogens needed for infection is reduced by reducing the acidity of the stomach by adding antacid agents. Certain food materials or dairy products protects the pathogenic bacteria from being killed by the gastric fluids in the stomach. Bacteria having low infectious ability can easily transmitted by food materials. The bacteria having high infectious ability causes less diseases in the host, contaminated food processing, storage and handling conditions can increase the bacterial infections in the body.

*Salmonella* species are major cause of diarrhea. Several categories of diarrhea genic *Escherichia coli* such as enterotoxigenic *E. coli* (EPEC), enterohemorrhagic *E. coli* (EHEC) and entero aggregative *E. coli* (EAEC), enteropathogenic *E. coli* (EPEC), enteroinvasive *E. coli* (EIEC) are also causes infection in intestine in those geographic areas [14]. *Salmonella* species are recognized as major type of waterborne and foodborne pathogens and can cause significant range of illnesses. *Salmonella* is considered as the most important casual agents for food borne diseases almost everywhere and thousands off the food borne salmonellosis happens every year in the world. Herein, in the latter part of this review, we have briefly overviewed different strategic development of inhibitors against gram-negative bacteria. This overview on inhibitors against gram-negative bacteriamay be highly valuable for designing new potential inhibitors against gram-negative bacteria.

**Overview of antibacterial against gram-negative bacteria****Antibacterial activities of almond gum**

Francisco J. Barba and co-scientist evaluated the antibacterial activity of almond gum against ten different pathogenic bacteria (Figure 1). They have isolated the bioactive poly phenols along with different volatile compounds from almond gum such as: 9-octadecenoic acid, 3-eicosen, hexadecanoic acid, benzyl salicylate etc. These isolated compounds showed strong inhibition against pathogenic bacteria like *Enterobacter spp.*, *Salmonella typhimurium*, *Listeria monocytogenes*, *Micrococcus luteus* and *Bacillus subtilis* [15]. This can be also used as food additive because of their potential effect of controlling the growth of pathogenic bacteria.

**Antibacterial activities of quaternary ammonium compounds**

Philips J. Breen and co-workers studied the inhibition efficacy of different quaternary ammonium compounds (Figure 2) against pathogenic bacteria. The systematic analysis of inhibition properties against the bacteria, *S. typhimurium* clearly showed strong inhibition after staining with small quaternary ammonium compound (QAC) like cetylpyridinium chloride (CPC). The bacteria, *S. typhimurium* generally found in chicken skin. The experimental result clearly showed the inhibition of *S. typhimurium* bacterial growth into a chicken skin after treating with QAC compounds like CPC (0.1%) [16].

**Antibacterial activities of acid and formaldehyde**

Carrique-Mas and co-workers studied potential effect of organic acid or formaldehyde against the growth of *Salmonella* bacteria. They have evaluated the masking of these compounds into animal feed contaminated with





*Salmonella* bacteria. The experimental results showed that the formaldehyde-based compound have more efficacy and less masking ability than organic acid. Both the compounds clearly showed the increase in masking level with increase in *Salmonella* content in the feed. This may act as potential tool for evaluating the level of contamination in feed ingredient upon treatment with formaldehyde or organic acid [17].

#### **Antibacterial activities of organic acid with supercritical carbon dioxide**

Rhee and co-scientists studied the potential effect of organic acids such as: acetic acid and lactic acid in combination with supercritical carbon dioxide (SC-CO<sub>2</sub>) as well as individual effect towards the pathogenic bacteria like *Escherichia coli* present in the fresh pork. The results showed that combination of organic acids with supercritical carbon dioxide were found to be potentially more effective in preventing the growth of food borne pathogens than the treatments of SC-CO<sub>2</sub> and organic acid alone. And this may be useful in the meat industry to help increase microbial safety [18].

#### **Antibacterial activities of organic acid for storing beef**

Disckon and co-workers analyzed the action of organic acids such as lactic acid, acetic acid for avoiding contamination of *Salmonella typhimurium*, *Escherichia coli* during storage of beef. They concluded that the organic acid does not have any effect on sprayed and non-sprayed sample [19].

#### **Antibacterial activities of small organic compounds isolated from Streptomyces**

Ignacimuthu and co-scientists have established an isolation method for small organic compounds such as: Dibutyl phthalate, 8-Hydroxyquinoline and 2-amino-3-chlorobenzoic acid from *Streptomyces* using ethyl acetate as an extracting solvent. The compounds isolated from these methods were tested against different pathogenic bacteria such as: *Staphylococcus aureus*, *Bacillus subtilis*, and *Escherichia coli* by disc diffusion and bioautography methods (Figure 3). The result clearly showed strong anti-bacterial activity against these bacteria [20].

#### **Antibacterial activities of aromatic and heteroaromatic amines**

Herein the authors, Debnath and co-workers carried out a systematic structure-activity study (SAR) to understand the mutagenic activity of *Salmonella typhimurium* bacteria using wide collection of aromatic and heteroaromatic amines [21]. The mutagenic study of such bacteria against these compounds showed a linear relation with hydrophobicity, size of the aromatic ring, energy of the highest occupied molecular orbital, and the energy of the lowest unoccupied molecular orbital of the aromatic and heteroaromatic amines.

#### **Antibacterial activities of roasted coffee filtrate**

Maletta and co-workers studied the antibacterial activity against *Salmonella typhimurium* and *Salmonella enteritidis* in raw ground chicken breast meat using roasted coffee filtrate along with dicarbonyl compounds. The study showed a strong prevention of these bacterial growth in presence of roasted coffee filtrate with dicarbonyl compounds. However, only with roasted coffee extract prevention of these bacterial growth were found to be low [22].

#### **Antibacterial activities of carvacrol, citral and geraniol**

Kim and co-workers evaluated the antibacterial activity of carvacrol, citral and geraniol against *Salmonella typhimurium*. These compounds were found to have potential antibacterial activity against *Salmonella typhimurium*. The comparable inhibition of these strains of *Salmonella* and species of Gram-negative bacteria by carvacrol and geraniol support their application as potential antibacterial agents in food systems [23].



**Biswaranjan Dalai et al.****Antibacterial activities of a hydrolyzed Tenin extract of sweet chestnut wood**

Parys and co-workers analyzed the antibacterial inhibition characteristics of a hydrolyzed Tenin extract of sweet chestnut wood (Globatan) against *S. typhimurium* in both vitro and vivo in pig body. Concluded that, the Tenin extract showed greater inhibition properties in the bacteria in vitro as compared to the vivo [24].

**Antibacterial activities of natural occurring organic molecules with or without the nisin**

Olasupo and co-workers evaluated the antibacterial inhibition property of many natural occurring organic molecules with or without the nisin against *Salmonella typhimurium* and *Escherichia coli* pathogenic gram-negative bacteria [25]. Here, they have carried out the antibacterial study of natural organic compound in combination with nisin which resulted in decreasing the antibacterial activity against gram-negative bacteria.

**Antibacterial activities of combined effect of nisin and ethanol**

Phongphakdee and co-workers studied the combined effect of nisin and ethanol together against pathogenic Gram-negative bacteria. The result showed strong inhibitory activity of such combination against pathogenic bacteria and also analyzed the efficacy of this combination against food substances. And the result suggested that combined solution of nisin and ethanol may be a beneficial sanitizer for food industry to inhibit the growth of *E. coli* and *Salmonella* species (Figure 5) [26].

**Antibacterial activities of lactic acid**

Keersmaecker and co-workers found that lactic acid was main antimicrobial compound against *Salmonella* produced by *L.rhamnosus* GG. In this work they showed that the antibacterial nature of organisms can be mediated according to their effect on redox potential-regulated RpoS induction [27].

**Antibacterial activities of glycosides**

S. N. Devaraj and co-workers analyzed the protective and inhibition role of glycosides produced from *Hemidesmus indicus* against the pathogenesis of *Salmonella typhimurium* bacteria. Here, they suggested that glycosides could change the adherence pattern inside the bacterial species from diffuse to local. Glycosides showed a strong inhibition property against these type of Gram-negative pathogenic bacteria (Figure 6) [28].

**Antibacterial activities of glycosides**

Zhang and co-scientists tested the action of syringaldehyde for protection mice from *Salmonella enterica serovar typhimurium*. They found that the syringaldehyde showed a very strong and systematic protection of mice infected by *S. typhimurium* bacteria and also reduced the mortality about 40 % [29].

**CONCLUSION**

Gram-negative bacteria are responsible for causing many noxious diseases such as: neurological abnormalities, gastroenteritis, and life-threatening Typhoid fever in human being and many other animals. The toxicity nature of these bacteria is because of their high tendency to survive in the host body rather quickly due to the presence of protective cell wall which defends from invasion of exogenous toxic agent. Therefore, developing new organic small molecule with ideally disposed functional unit which can easily prevent the growth of bacteria is always demanding. Herein, we have briefly overviewed different strategic development of inhibitors against gram-negative bacteria. This overview on inhibitors against gram-negative bacteriamay be highly valuable for designing new potential inhibitors against gram-negative bacteria.





## ACKNOWLEDGEMENTS

The authors would like to thank DST-New Delhi, CSIR-New Delhi, IIT-Delhi and CUTM-BBSR for support of this work.

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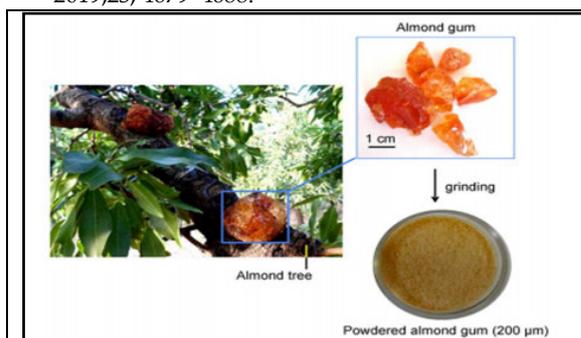


Figure 1: Almond gum isolation and staining against pathogenic bacteria

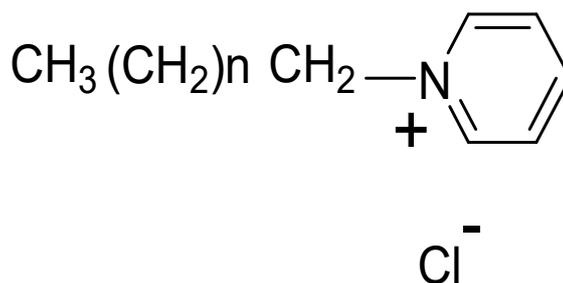


Figure 2: Cetylpyridinium chloride (CPC) inhibit *S. typhimurium* bacteria

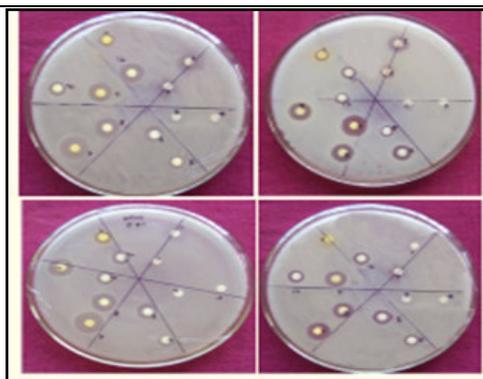


Figure 3: Antibacterial activities study of small organic compounds isolated from *Streptomyces* using Disc diffusion and bioautography methods

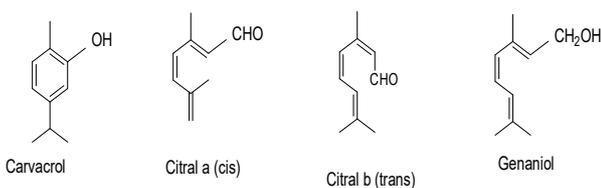


Figure 4: Structure of represented compounds



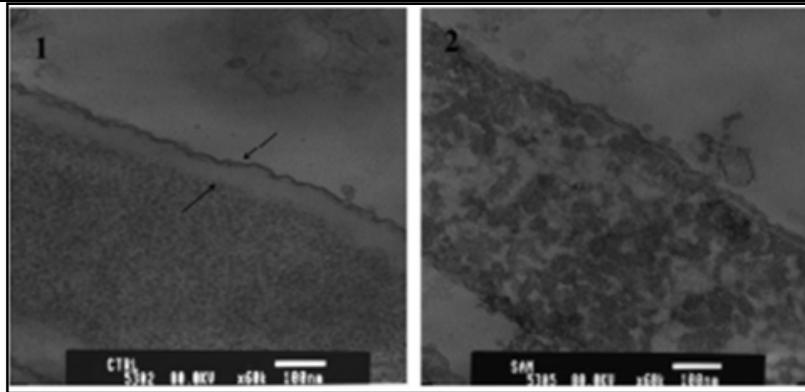


Figure 5: TEM study

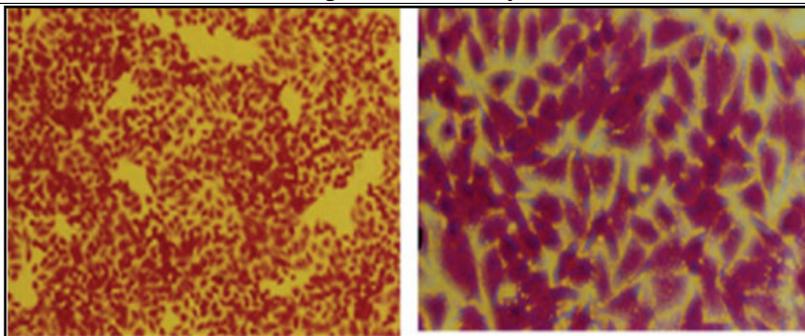


Figure 6: Inhibition assay study





## Finite Element Simulation on Machining of Aluminium Components

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### ABSTRACT

The method of modeling and simulating the machining process attracts researchers to better apprehend the mechanism of chip formation, localized heat generation, the friction properties of the device and the pair, and the accuracy of the machine surface. . Predictions of physical parameters such as temperature distribution and stress play an important role in predicting the technological performance of the processing process. The geometry of the edge of the device is particularly important because of its effect in obtaining the most desired life of the device and the integrity of the surface is very large. Therefore, it is necessary to develop accurate and robust continuous models to study the effect of geometry, tool edges, tool wear mechanisms and shear conditions on residual stresses and surface accuracy on machine planes. The present work aims to analyze the FEM modeling studies that have been conducted inearlier and to employFEM models for the most satisfactory simulation of shear processes and the most reasonable forecasts of shear forces. Temperature and residual stresses on the treated surface of Aluminum Components.

**Keywords:** FEM, Surface Integrity, Simulation, Heat Affected Zone, Residual Stress.

### INTRODUCTION

The engineering examination of mechanical systems is considered by obtaining differential equations related to variables through simple physical ethics such as equilibrium, energy conservation, mass conservation, thermodynamics, Maxwell's equations, and Newton's laws of motion. However, once established, solving the mathematical model obtained is impossible, especially when the obtained model is a non-linear partial differential equation. Only the simplest problems of correct geometry can be tracked, such as one rectangle with the modest boundary conditions.



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The finite element method (FEM) is the dominant modeling technique in structural mechanics. The basic idea in interpreting the physics of FM is the division of mathematical models into non-overlapping components of a simple geometry, called short or finite elements. The response of each element is expressed by the number of degrees of freedom defined as the value of the unknown function or function in the set of nodal points. The answer to the mathematical model is then considered to be similar to the discrete model obtained by the conjugation or aggregation of all elements. The concept of alienation occurs logically in the study of different artificial and natural systems. It is easy to imagine a machine, bridge, bridge, plane, or skeleton made of simple components. Analysis of finite elements in the software system requires the following information. Geographical (geometry) of nodal points, interconnected elements, mass properties, boundary conditions or constraints, details for loading or forcing analysis functions and options. Since the FEMM is a sampling method, the degrees of freedom of the FEM model are required.

Khan et al. Al. And Cunningham et al. Al. [1-2] uses the FE method to simulate drug product consolidation. In both studies, a modified Drucker-Prager model was used, and a non-linear elastic rule was proposed to cover the nonlinear behavior. They implemented their model using the ABAQUS software using a user subform and were able to generate accurate experimental observations. They used the FE and the non-linear model proposed to predict stress and density distributions during the compaction, contraction, and rejection Ma et al. Al. [3] use finite element methods to predict the density and stress distributions associated with both compact and instrumental materials. The formation of multifunctional components in the matrix usually results in an inhomogeneous density distribution.

Arbizu and Perez [4] used factorial designs with regression methods to develop multidimensional, first- and second-order models to predict surface roughness. Madi and Zhang [5] presented a finite element model with a predetermined fracture plane to predict shear and thrust forces in cutting bone composition. They also used the same model of materials and the results of their work agree well with the experimental values. However, the prediction of traction does not match the experimental trend. Jan et al. Al. [6] developed another model with finite elements to study the effects of fiber orientation, shear depth, and tool angle on shear and torque. And this study is only for the orientation of the fiber below 90 degrees. Umbrello et al. Al. [7] states that the application of finite element method (FEM) in metal cutting processes is of great benefit to researchers in the study of metal cutting and chip making. Numerical simulations are useful for studying various phenomena, such as chip distributions, shear forces, and shear velocities. Giles, Esq. Al. [8] states that the shear device operating on a specific digital model is highly dependent on the flow voltage of the working material, i.e. Modeling of stress, velocity and strain, friction and temperature between working material and cutting edge. Ozz et al. Al. [9] states that numerical models are suitable and can predict the effects of machine parameters such as cut, wear, damage, cutter and machine surfaces. Mackerle [10] states that wearing a sampling device using FEM has advantages over conventional statistical methods because it requires less effort and provides useful information such as strain, strain, strain, and temperature in chip formation. Kalhori [11] states that longer chip production causes more network changes, as shown at the end of the established chip. The largest deformities occurred on the primary deformation region followed by the secondary deformation region.

This is the reason for the added stress in this section. The major deformations during the shear process are concentrated in two regions near the edge of the cutter, and the largest deformations occur in the primary deformation region, followed by the secondary deformation region, the slip zone, and the attachment region. Choudhury and Bajpai[12] state that complex technological processes are better appreciated as new technologies with many features, sub-sets, and individual development needs adapted to modern production. This is one of the key destinations for the development of future production technologies. Turning and milling of complex machines has become one of the fastest developing methods for the production of complex machines with a wide range of machines and strong machine capabilities. A study from Stanlow [13] that the impact of grinding machine processing technology is not yet fully known in the manufacturing area, mainly because of the important technology of the implementation of complex laser machining machines, such as the processing of complex sewing machines, the



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technology for NS programming, post-processing and simulation technologies are still in the research stage. Zhang and Yang [14 - 15] stated that by studying the critical technology of the implementation of laser drilling techniques, the development and custom of the processors of the saw-mill processors were well aware of the authenticity of The CNC mill. Software for machining and simulation and optimization of machine performance fully integrates the machining of complex machining centers with tailors and improves performance levels. In the present work, the modeling of the FM and simulations of the orthogonal reduction of aluminum are investigated. The simulation model uses the advantages of simulating the plastic flow around the radial edge of the cutter and eliminates the need for chip separation criteria. The simulation results include the projected chip formation as well as temperature and voltage distributions. These results are crucial for residual stress prediction and other properties of the treated surface.

**FINITE ELEMENT MODELING & SIMULATION**

In the present work, the commercial software code “DEFORM 2D” is used to perform the MAS simulation of orthogonal shear, taking into account the geometry of the edges of the circular device, and all the above characteristics have been successfully applied in this model. The chip formulation is mimicked by the adapter network and the plastic flow of the working material. Therefore, there is no need for chip separation criteria.

The simulation model was developed, including the thermal and mechanical properties of the components, the boundary conditions, the interaction between the device and the component, as shown in Figure 1. For the plane of deformity in the vertebra. The shear process, a dynamic event, causes large distortions, with several steps leading to a great distortion of the network and the end of the simulation. It is very important to use the adapter grid with the optimized parameters to make the plastic stream across the perimeter of the device. Therefore, the frequency, frequency, and frequency of the adaptive mesh are adjusted to the optimum setting to maintain a successful network during shear. During steel shear, the flow voltage is highly dependent on the temperature field as conversed earlier. Therefore, the integrated thermal stress analysis is necessary for accurate prediction in FEM simulations. Figure 2 shows the refined two-dimensional mesh of the part of the thermocouple including the active junction. It establishes the location of the mesh with respect to the geometry. This mesh is acceptable since the elements are undistorted rectangular shaped. The machining of PM Aluminium cylindrical component was simulated at two different cutting speeds i.e. 4.24 mm/min and 18.37 mm/min.

**PARAMETRIC ANALYSIS**

Here, the various aspects are discussed at different steps of simulation. Figure 3 (a) and (b) shows the variation of stress with respect to time during two different cutting process. From the graph it is observed that, the stress value increases linearly with time at the beginning of machining, but at a particular time its value remains almost same with respect to time. This graph was generated by the simulation software at the end of machining process. Figure 4 (a) and (b) shows the variation of effective strain rate which is defined as a ratio between indentation velocity and structure width with respect to time during machining process. From the graph it is observed that, the effective strain value increases rapidly and falls to a constant value after which it remains linear with respect to time. This graph was generated by the simulation software at the end of machining process.

Figure 5 (a) and (b) shows the variation of effective strain with respect to time during machining process. From the graph it is observed that, the stress value increases linearly with time at the beginning of machining, but at a particular time its value remains almost same with respect to time which shows the deformation in material during machining. This graph was generated by the simulation software at the end of machining process. Figure 6 (a) and (b) shows the variation of heat flux which is defined as defined as the rate of heat flow over machining surface with respect to time during machining process. From the graph it is observed that, the heat flux value increases rapidly at the beginning of process and remains almost constant with a high value with respect to time. This graph was generated by the simulation software at the end of machining process.





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The dispersals of the anticipated von Mises stress dispersals are shown in Figure 7 (a) and (b). The figure also shows the distributions of stress on the machined surfaces. From the simulation outcomes, it was detected that there exists a region of very high distortion rate around the round edge of cutting tool. The curved edge of the cutting tool & the extremely deformed has a dominant influence on the residual stresses of the machined planes. The distributions of the anticipated von effective strains are given in figure 8 (a) and (b). The figure also shows the distributions of effective strain on the machined surface. From the results of simulation it was also observed that there exists a county of very high distortion rate around the curved edge of cutting tool. The curved edge of cutting tool and the highly distorted regions underneath has a dominant effect on the effective strain of the machined surface.

Figure 9 (a) and (b) shows the temperature predictions at increments of cutting length as maximum temperatures of 74.5 °C and 191°C respectively at two cutting speeds. It is also observed that, the temperature during machining is maximum at the place of tool specimen interface. For this study the maximum temperature observed was 74.5 °C and 191°C at simulation step no. 530. For this current study at given machining condition. Figure 10 (a) and (b) shows that maximum force developed at simulation step no 530 is 1.00N. It is also observed that, maximum force is developed at tool work piece interface and at the resisting surface. Figure 11 (a) and (b) shows the velocity flow of work piece material and chip as well during machining. It was observed at simulation step 530 that, velocity of work piece material is 71.7 mm/sec and is 307 mm/sec where as the velocity of chip at tool work piece interface is 23.9 mm/sec and is 102 mm/sec for this particular machining condition respectively for both the cutting speeds.

## CONCLUSIONS

The machining of Aluminium components was simulated on DEFORM 2D software for the observation of machining condition and investigation of the complex interaction of parameters stress, strain, temperature, heat flux. The major conclusions of the present work may be summarized as follows: FEM simulation of machining PM Aluminium components gives a better understanding of the complex interaction of the lot of process parameters, which otherwise is very time consuming and expensive to investigate experimentally. In the present study, the interaction of effective stress, effective strain, effective strain rate, heat flux etc with machining time has been investigated. Also, the distribution of effective stress, effective strain, temperature at shear zone, cutting force, material flow velocity etc at tool-chip workpiece interface has been critically investigated and presented. It was observed that, during machining, effective stress decreases as cutting speed increases. Also, temperature at tool-workpiece interface and velocity of material flow increases with increase in the cutting speed during machining. It has also been observed that, the chips produced during machining are deflected away from the tool surface as the cutting speed increases. Also, the distribution of material flow around the tool-workpiece interface is higher at the higher value of cutting speed.

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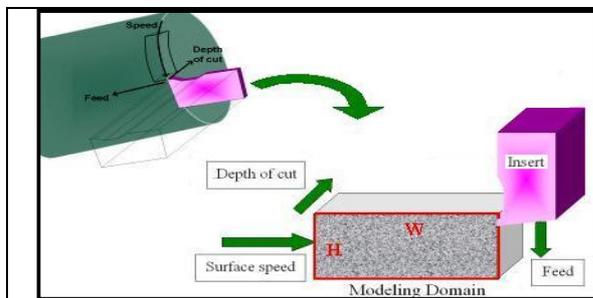


Figure 1: Simulation Model for Turning Operation.

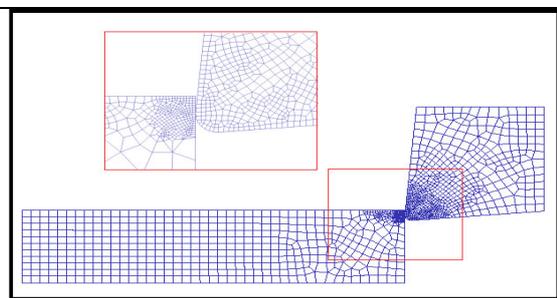
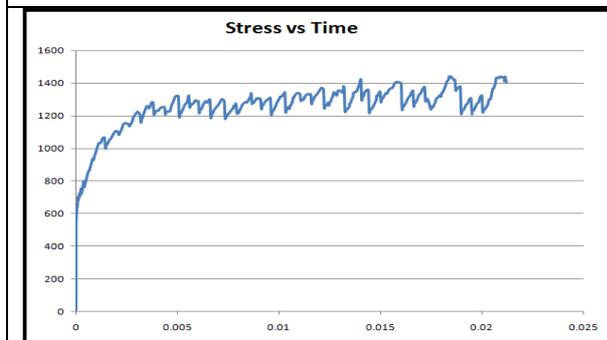
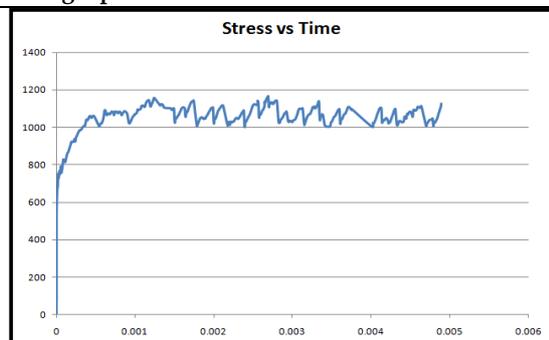


Figure 2: Two Dimensional Meshing Generated during Turning Operation.



(a).  $V_c = 4.24\text{mm/min}$



b).  $V_c = 18.374\text{mm/min}$

Figure 3: Variation of Stress with Time





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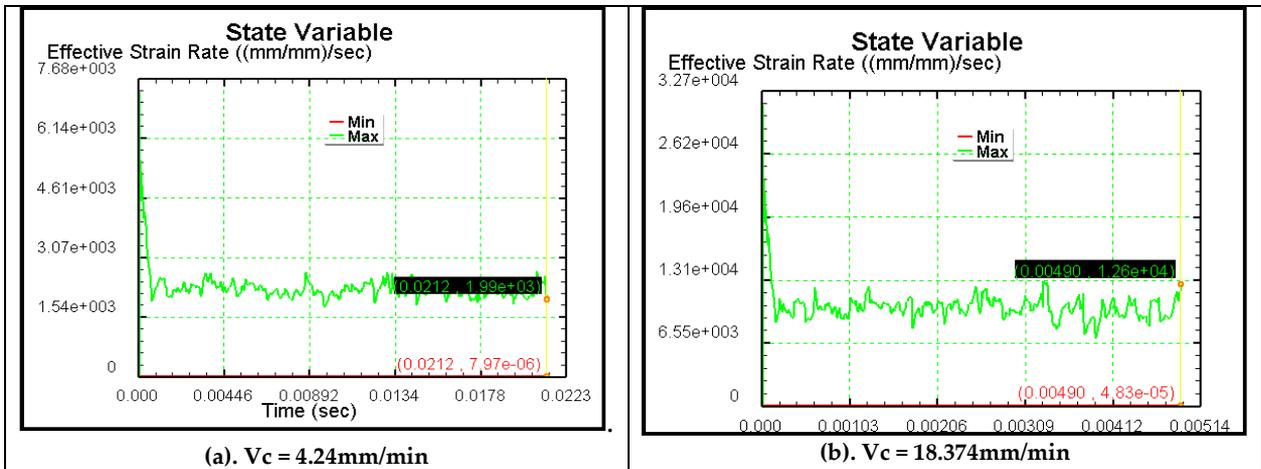


Figure 4: Variation of Effective Strain Rate with Time

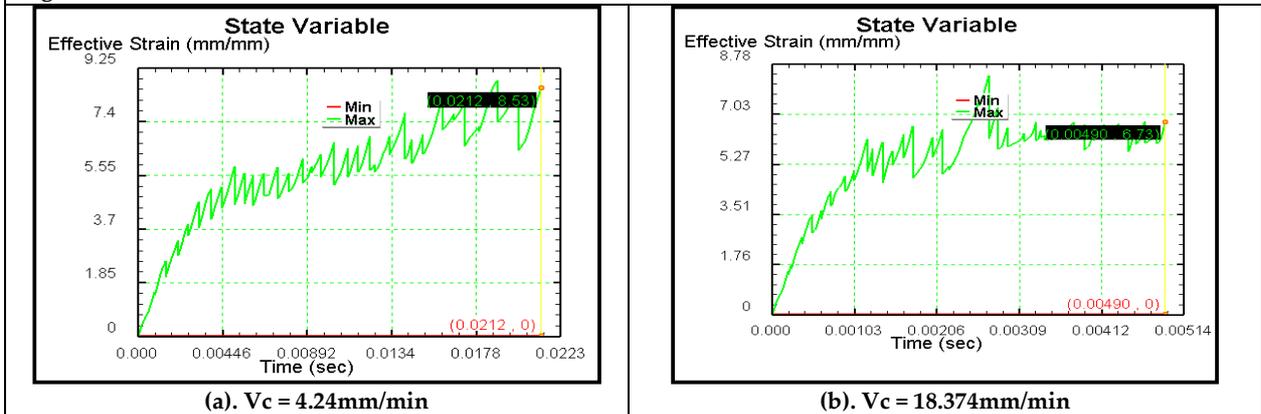


Figure 5: Variation of Effective Strain with Time

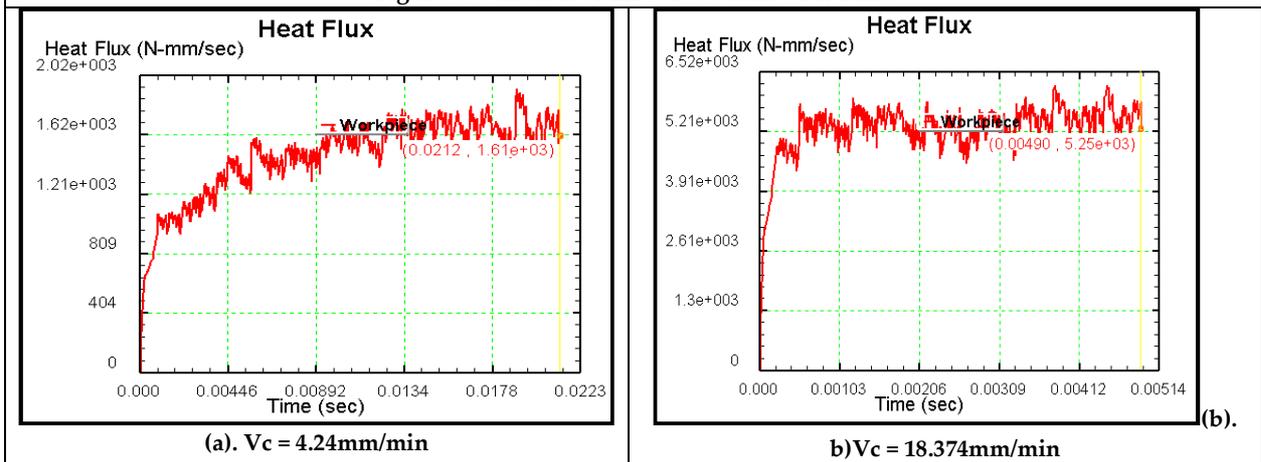


Figure 6: Variation of Heat Flux with Time.





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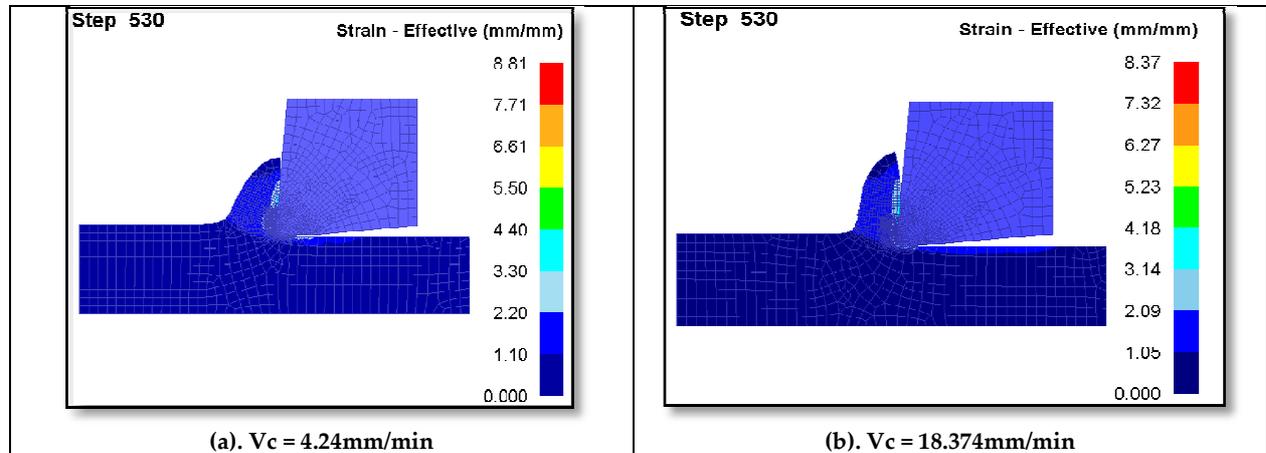


Figure 8: Effective Strain Variation during Machining.

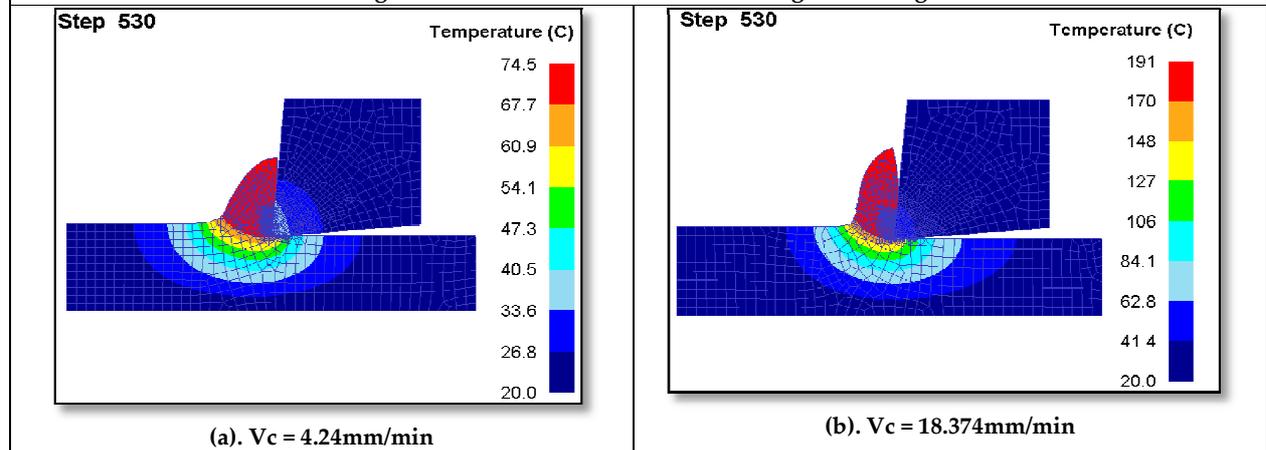


Figure 9: Temperature Variation during Machining

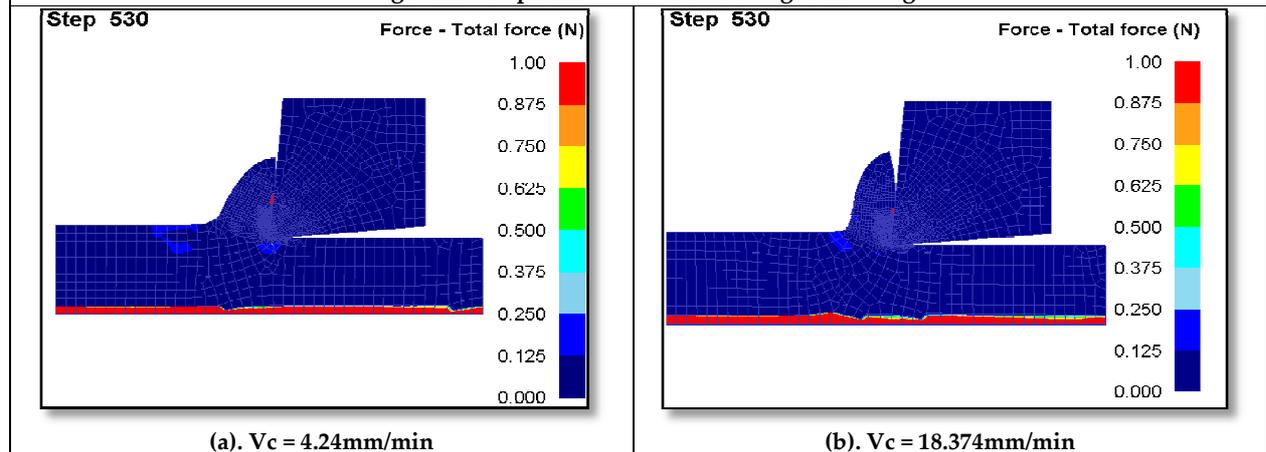


Figure 10: Total Force Variation during Machining



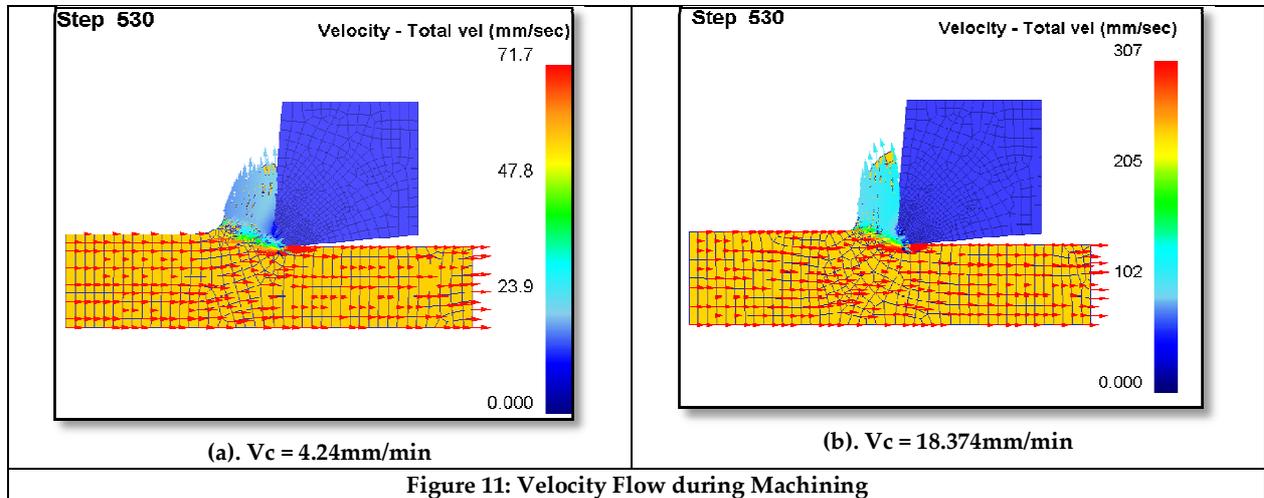


Figure 11: Velocity Flow during Machining





## RESEARCH ARTICLE

## Structural and Antibacterial Study of Ag Doped ZnO Nanoparticles Synthesized by Ultrasonication

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### ABSTRACT

The present study describes the synthesis of ZnO and Ag:ZnO nanoparticles by sonication method. Ultrasonication method was found to be very useful for the synthesis of these nanomaterials. The phase characteristics of samples were characterized by X-ray diffraction (XRD) technique. The XRD analysis reveals that the obtained nanopowder is ZnO with hexagonal wurtzite crystalline structure which shows peaks between 20° and 80 ° regions and the crystallite size is 42 nm. The crystal lattice structure has been analyzed using the Material studio tool of Biovia software which gives information on the c-axis growth of hexagonal ZnO. Ag doping induces an increase in the crystallite size of ZnO which reaches to 62 nm after doping. Surface morphology of the samples was investigated by scanning electron microscopy. The study reveals the Ag doped nanoparticles have rough morphology. Antibacterial property of Ag:ZnO nanoparticles against different bacterial stains has also been studied. The study shows that both ZnO and Ag:ZnO show high inhibition activity towards gram positive and gram negative bacterial strain. But, Ag doping enhances the antibacterial property of ZnO.

**Keywords:** Ag:ZnO, Ultrasonication, X-ray diffraction, Antibacterial property

### INTRODUCTION

Nanomaterials have shown mesmerizing commercial applications in different domains of science and technology [1, 2]. Metal oxide nanoparticles constituting inorganic metal ions, such as silver, copper and gold exhibit good microbe inhibition mechanism, optoelectronic technology, medical implants and ecological remediation [3]. The physical and chemical properties of these nanoparticles often change with their size and also find tremendous application in pharmaceutical and biological industry. So, effort is being devoted in selecting metals and metal oxide nanoparticles showing high impact on eliminating microorganisms such as bacteria present in food chain of the ecosystem.





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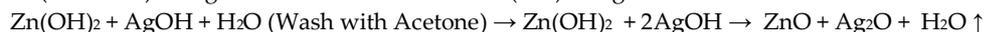
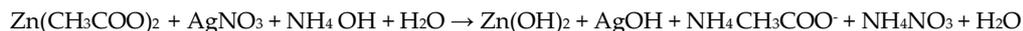
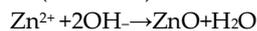
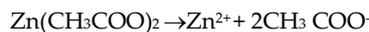
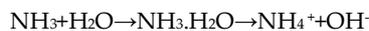
Environmental remediation and water decontamination are also two major dimensions where these nanomaterials are exploited to obtain a sustainable habitat for humans [4]. Metal oxides like ZnO and TiO<sub>2</sub> have been most applicable in these fields with novelty in their properties like good photosensitivity, augmented efficiency, nontoxicity, lower cost, chemical/thermal stability and strong oxidizing power [5-7].

Zinc oxide (ZnO) is a good photocatalyst and has a stable nature with exposure to light. It has a larger band gap (3.37 eV), high excitonic binding energy (60 meV), significantly high biocompatibility and a relatively cheaper material which is utilized in a high scale in industry [8]. Investigations are going on to enhance different properties of ZnO by doping of impurities like Ag which can check the recombination process of electron-hole pair under irradiation of light which significantly uplift the antibacterial and photocatalytic activity of ZnO [8, 9]. Unorthodox physicochemical and geometrical properties are expected to be observed with Ag doping into ZnO which takes place due to events like the crystalline transformation, induction of oxygen vacancies and alterations in light scattering attributes after doping [10, 11]. Ag: ZnO has shown its effectiveness as antibacterial and antifungal agent against many bacteria such as *Staphylococcus epidermidis* which depends upon the size/shape and the Ag doping concentration [12, 13].

These nanoparticles kill the bacterial cell by disrupting the nucleic acids and protein linkages present in the cell of the microbe. Higher antimicrobial activity has been reported with increasing Ag doping provides the availability of silver ions followed by ZnO in generation of hydrogen peroxide [11-13]. So, an amplified inhibitory activity is achieved with Ag and ZnO working in synergistic manner which interferes with the enzymatic assemblage of respiratory chain and annihilating DNA formation. This leads to the development of economical and commercially ascendable antimicrobial product formulation using Ag doped ZnO nanoparticles [14]. A number of methods like sonochemical, hydrothermal, co-precipitation, sol-gel, oxidative reactions, thermo-evaporation and vapor deposition have been adopted for the synthesis of Ag:ZnO nanoparticles [8-14]. In the present study, we have utilized sonochemical method for this synthesis and subsequent study on the structural and antibacterial properties have been carried out.

### Experimental

Zinc acetate (Zn(CH<sub>3</sub>COO)<sub>2</sub>·2H<sub>2</sub>O) and silver nitrate (AgNO<sub>3</sub>) were the starting reagent and source of dopant respectively. Distilled water was used to dissolve these materials and a magnetic stirrer was deployed to stir the resulting solution continuously. A clear solution was obtained by adding liquid ammonia (25%) drop wise to the above solution. The above mixture was subjected to sonication for about 2 hour. The pH of the solution was measured before and after the process of precipitation and the experiment was carried out in the range of 8.5 to 10.5 pH. The precipitates were collected through decant process. These were washed with double distilled water three times and then using acetone. To dry these powders, an oven operated at ambient pressure was deployed to work at 100 °C for 7-8 hr inside. Following the above practice, we synthesized ZnO and Ag (4%) doped ZnO nanoparticles. The chemical reactions behind the synthesis have been given below.



The antimicrobial well diffusion procedure is used with Mueller Hinton Agar plates. The well diffusion method is performed using Mueller-Hinton Agar (MHA), which is the best medium for routine susceptibility tests because it has good reproducibility, gives satisfactory growth of most bacterial pathogens. In this well-known procedure, agar plates are inoculated with standardized inoculums of the test microorganism. Then, discs containing the test





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compound at a desired concentration are placed on the agar surface. The Petri dishes were incubated under suitable conditions. Generally, antimicrobial agent diffuses into the agar and inhibits germination and growth of the three test microorganisms (i.e. *Enterococcus*, *Klebsiella pneumonia* and *Acinetobacter*) and then the diameters of inhibition growth zones were measured. Similarly the minimum inhibitory concentration (MIC) was measured which is the lowest concentration of a chemical, which prevents visible growth of a bacterium or bacteria. For this study Micro broth dilution method using 96-well micro titer plate along with Muller Hinton Broth (MHB) were used [15]. MIC was observed by taking minimum about of broth solution of 1mg/ml, 2mg/ml, 3mg/ml to have an antibacterial study and given in Table-II .

## RESULT AND DISCUSSION

The XRD patterns of ZnO and Ag:ZnO nanoparticles have been illustrated in Figure-1 (a) & (b) respectively. The diffraction peaks at  $2\theta=31.92^\circ$ ,  $34.59^\circ$ ,  $36.32^\circ$ ,  $47.62^\circ$ ,  $56.68^\circ$ ,  $62.95^\circ$ , are assigned to (100), (002), (101), (102), (110) and (103) planes respectively for ZnO for Fig. 1. In Fig. 1(b), along with the ZnO diffraction peaks, some peaks at  $2\theta=38.194^\circ$ ,  $44.36^\circ$  &  $64.47^\circ$  are assigned to (111), (200) and (220) planes of metallic Ag [16]. The wurtzite crystalline structure of ZnO is observed through the sharp XRD peaks observed in the patterns. The slight shifting of XRD peaks indicates doping [17]. Fig.2 is a proposed structure of hexagonal ZnO obtained from Biovia Material Studio tools. To estimate the crystallite size, Debye Scherer equation  $D = k\lambda/\beta\cos\theta$ , was used. Here, D is denoted as the crystallite size in nanometer,  $\lambda$  is the wavelength of the x-ray light used which is  $1.54056 \text{ \AA}$ ,  $k = 0.9$  (a constant),  $\beta$  is termed as FWHM and  $\theta$  is the peak position. The particle size was found to 43 and 62 nm for undoped and 4% Ag doped ZnO respectively.

Scanning electron microscopic tool has been deployed to study the morphological features and size ranges for Ag:ZnO nanoparticles. This has been depicted in Figure-3. It has been report that the inclusion and its concentration variation not only influence the shapes of nanoparticles but size reduction/increase is also observed. It can be noticed that rough surface morphology is exhibited by the Ag:ZnO nanoparticles. The SEM image also shows that synthesized Ag doped ZnO nanoparticles are in nano range and can be of potential interest for photocatalytic and biomedical applications. Generally, the antibacterial activity significantly affected by the particle size of nanoparticles as it is indirectly proportional to the particle size. The antibacterial activity of ZnO is due to the visible light irradiation and its exposure with the microbial cell wall leads to destruction of bacterial cell wall, thus release of antimicrobial  $\text{Zn}^{2+}$  ions, and formation of ROS [18, 19]. In fact, binding between the bacteria (with negative charge) and ZnO NPs is an outcome of the electromagnetic attraction between the above two [20]. Generally bacteria cell wall contain some protein and enzyme with some thiol groups along with lipid membrane .

When silver doped ZnO nanoparticles penetrate inside the bacterial cell the Phosphorous (P) and Sulphur (S) containing molecule or compounds become inactive .The generation of reactive species from the nanoparticles inhibit the growth of bacteria which observed from the zone of inhibition for all the prepared sample. In this study, three types of bacterial strain of gram positive and gram negative have been taken for the antibacterial activity. It has been shown in Fig.4 and the MIC and zone of inhibition for different bacteria with undoped and doped ZnO has tabulated in Table-1. The antibacterial activities of nanoparticles were tested against, gram positive bacterial strains *Enterococcus*, *Acinetobacter* a gram negative bacteria and *Klebsiella pneumonia* gram-negative bacteria. It has been found that the MIC values are below 1 mg for all the doped sample as compare to undoped where the MIC value were more than 2 mg.

The antimicrobial activity of Ag doped ZnO nanoparticles is observed to be the highest for *Enterococcus* as compare to other gram negative strain. *Enterococcus* is an optionally anaerobic gram-positive bacterium and most dominant species in endodontically treated teeth. *Enterococcus* has the ability to adhere to teeth and to form bio films under harsh environmental conditions. Similarly the undoped ZnO shows greater inhibition in *Enterococcus* than other





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bacterial stain. So the prepared sample was found to be effective for gram positive bacteria then gram negative stain. Again in silver doping, silver play an immense role to maximize the bacterial inhibition when exposed to bacteria.

## CONCLUSION

Study on the synthesis and characterization of ZnO and Ag doped ZnO nanoparticles has been carried out. The nanoparticles have been synthesized by sonication method which has been found as a successful technique to produce nanomaterials. The XRD studies of the nanomaterials reveal that with Ag doping the crystallite size of ZnO increases to 62 nm from 42 nm. Further, the prepared nanoparticles are crystalline and having hexagonal wurtzite phase. FESEM studies show that the Ag doped ZnO nanoparticles have rough surface morphology and have an average size of 60-70 nm which matches well with the XRD data. Antibacterial study shows that the prepared sample is very effective towards inhibiting gram positive bacteria and gram negative bacterial stains. Silver doping enhances the antibacterial property of ZnO as silver play an immense role to maximize the bacterial inhibition when exposed to bacteria.

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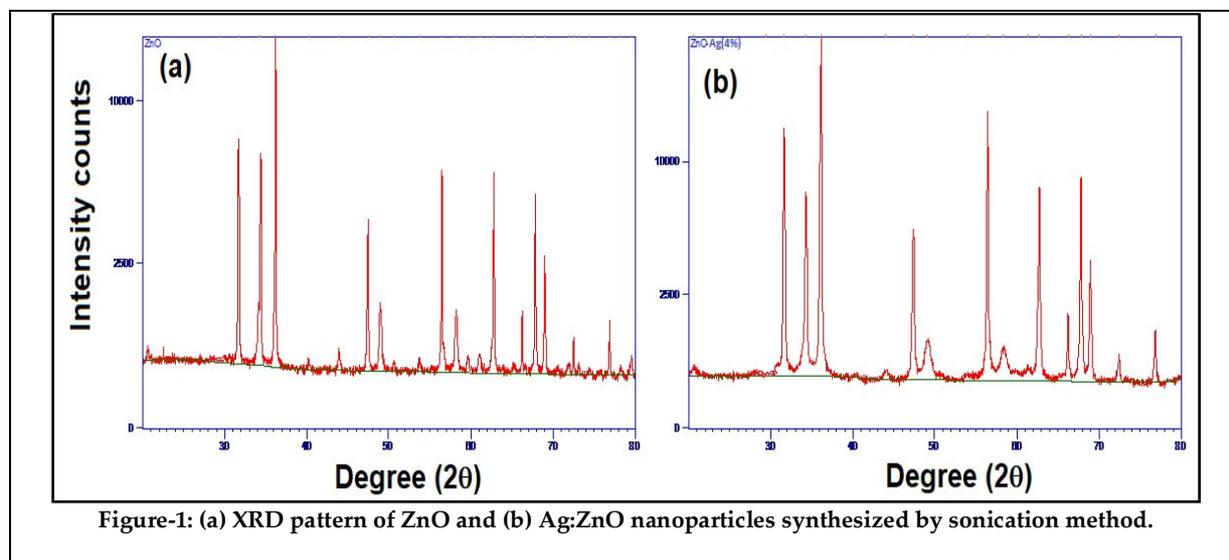


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**Table-1: Zone of inhibition values of Ag<sub>x</sub>Zn<sub>1-x</sub>O (x =0.03) nanoparticles**

Name of sample	Zone of Inhibition(mm)			MIC mg/ml
	<i>Enterococcus</i>	<i>Klebsiella pneumoniae</i>	<i>Acinetobacter</i>	
ZnO	21	9	7	1
Ag <sub>x</sub> Zn <sub>1-x</sub> O (x =0.03)	27	11.3	8.3	1





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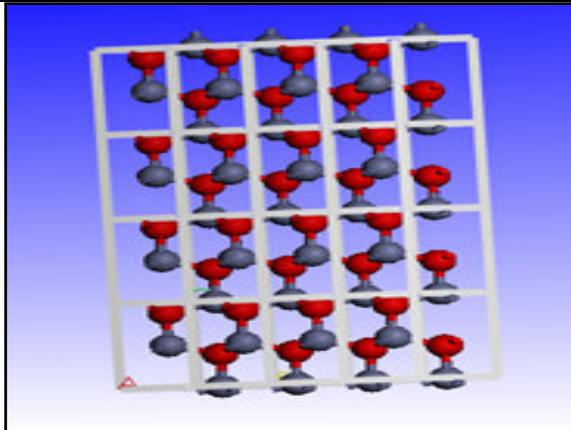


Figure-2: The possible crystal structure of ZnO nanoparticle with C-axis orientation[Material Studio].

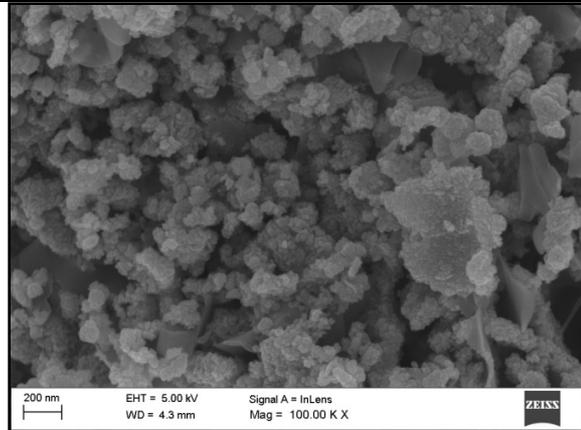


Figure-3: FESEM image of Ag:ZnO.

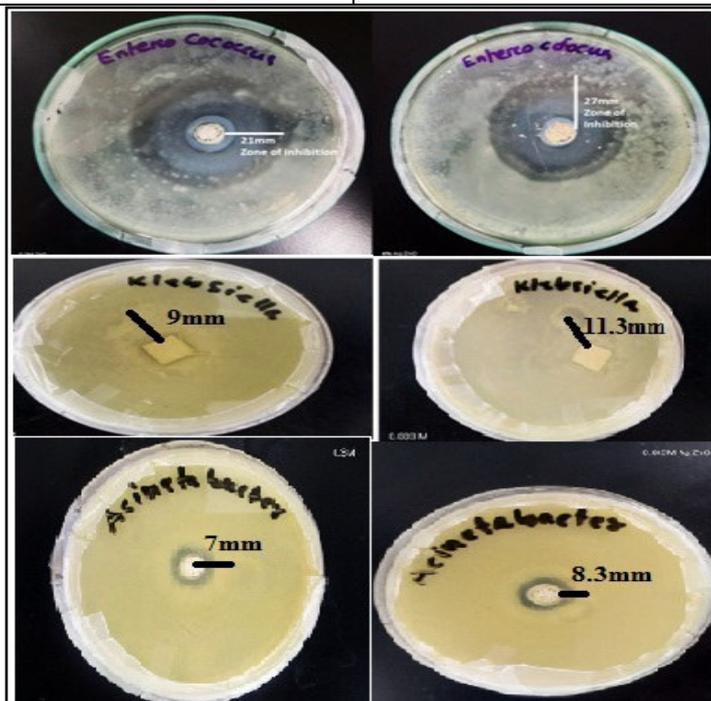


Figure-4: Antibacterial activity and zone of inhibition for undoped and Ag doped ZnO against different bacterial strains.





## Study on Crystallographic and Electronic Band Structure of Wurtzite ZnO

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### ABSTRACT

The present study proposed the theoretical analysis of crystallographic structure and stability of the polar surfaces of wurtzite ZnO. Effort has been devoted in calculating the surface energy of ZnO (0001)-Zn and Zn (0001 □)-O surfaces which are treated to be polar in nature. Density-Functional Theory (DFT) method has been adopted to determine the band gap structure and predicts that the terminal ZnO (0001 □)-O position is more stable than the terminal ZnO(0001)-Zn position. The O<sup>-2</sup> surface is regarded to have high polarizability in comparison to Zn<sup>+2</sup> surfaces which is the reason behind the above observation. The crystal structure of the proposed surface has also been analyzed. The X-Ray analysis shows the crystallinity along [111] direction with lattice parameter well matched with experimental result. The density of states shows the surfaces of ZnO-O are better than that of the surface in bulk makes ZnO qualified in the field of catalysis

**Keywords:** Band structure, Density of State, XRD, Zinc oxide

### INTRODUCTION

Metal oxide semiconducting materials show very interesting properties. Many of these materials are n-type semiconductors and some show p-type conduction also. Metal oxide like ZnO shows both p-type and n-type conduction upon selective doping of impurities. ZnO is regarded as a functional material which exhibit exceptional quality and new properties in the field of material science. Structural, electrical, optical, magnetic and biological properties of ZnO are too much interesting to study as it finds many applications in different industry. So, new interest to study different properties of ZnO, especially its structure and morphology has been developed using different theoretical and experimental techniques. ZnO crystal shows hexagonal wurtzite structure. It crystal comprises of different polar and non polar surfaces but these polar surfaces have received more attention due to their higher activity. This type of activity of polar surfaces is basically shown in catalytic, photo-catalytic and gas sensing features than the non-polar ones. Zinc Oxide (ZnO) crystallizes in the hexagonal wurtzite structure P63mc. ZnO is a

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group (II-VI) wide band gap semiconductor (3.37 eV) material with numerous application in the field of optoelectronic due to high chemical stability, high order transmittance and piezoelectric properties plane [1]. ZnO is nontoxic, cost effective, environmental friendly and biocompatible material, and can be used for biomedical application [2]. Several typical surface orientations have been shown by ZnO crystals. Some of the prime surfaces are the (0001) basal plane and (0001  $\bar{1}$ ), (1010  $\bar{1}$ ) and (1120  $\bar{1}$ ) (prism planes) and (1121  $\bar{1}$ ) (pyramidal plane) crystal faces. In theory, the (0001) planes are terminated by Zn atoms only, and the (0001  $\bar{1}$ ) planes are terminated by O. The energy between the surface with and without hydrogen passivation is estimated from the calculated surface energy. The surface energies of ZnO polar surfaces are essential to be calculated using theoretical techniques which will be more direct. There exist a difference in energy between the bulk and the surface around one unit area and this is defined as the surface energy theoretically. The surface energy can be calculated conveniently by the *ab initio* calculation method.

## METHODOLOGY AND COMPUTATIONAL DETAILS

The present calculations are based on DFT by using material studio, Biovia software. The band gap energy and density of state was determined from the CASTEP module of material studio tool. The diffraction pattern was obtained from the REFLEX module of material studio. A cutoff energy of 200 eV has been possessed by the calculate basis. The lattice parameters of bulk wurtzite ZnO structure are  $a=b=3.284 \text{ \AA}$ ,  $c=5.33 \text{ \AA}$  with lattice plane [101] which has been optimized. The value of these lattice parameters closely matches with the experimental values obtained as  $a=3.2496 \text{ \AA}$  and  $c=5.2042 \text{ \AA}$  [3]. The surface energy was calculated from the computational tool. The energy per unit area required to create a surface is termed as the surface energy ( $E_{\text{surf}}$ ) of a material [4].

## RESULTS AND DISCUSSION

### Unit cell structure

The unit cell structure ZnO has been depicted in Figure-1. This is a stable (B4) structure which constitutes of a hexagonal unit cell which is primitive in nature and having space group C46v P63mc. There are four atoms in one unit cell of ZnO which is regarded as primitive. Out of the four, two zinc atoms are placed at positions (1/3, 2/3, 0), (1/3, 2/3, 1/2). But, the oxygen atoms find themselves at (1/3, 2/3,  $\mu$ ), (1/3, 2/3,  $\mu+1/2$ ) positions. The lattice parameters of ZnO in bulk form are calculated and given as,  $a=3.281 \text{ \AA}$ ,  $c=5.321 \text{ \AA}$  and  $E_g=0.529 \text{ eV}$ . These values closely matches with the values obtained from the previous DFT calculation which are  $a=3.283 \text{ \AA}$ ,  $c=5.289 \text{ \AA}$  [5]. The lattice parameters such as;  $a$ ,  $c$ ,  $c/a$  and band gap ( $E_g$ ) have been summarized in Table-1. Our result obtained from the theoretical calculations using the Biovia software (Material Studio) is in good agreement with the values reported earlier [6-7]. These values are lower than the experimental values for band gap. Surface energy (J/m<sup>2</sup>) was found to be 2.83 and 3.21 for ZnO: Zn-polar (0001) and ZnO:O (0001) layers respectively for 4 layers. Fig.2 shows the XRD pattern of ZnO on [101] plane and predicts the crystalline structure of the proposed wurtzite ZnO by Biovia tools.

### Band structure and density of states

By using the calculated lattice parameters ( $a=3.284 \text{ \AA}$ ,  $c=5.33 \text{ \AA}$ ), the band structure of wurtzite ZnO is evaluated. The band structure has been illustrated in Figure-3. From the figure, it is clear that the valence band maximum and conduction band minimum lie on the same point which indicates the existence of direct band. The values of band gap obtained from this theoretical calculation with material studio are quite lower than the values obtained from experiment. This indicates that consistent results for band gap energy similar to other forms LDA may not be obtained using the above tool. The calculated value of band gap for wurtzite ZnO is about 70.00% less than the value obtained from experiment [8].



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The electronic structures of the ZnO-Zn and ZnO-O surfaces of the semiconductor material are usually influenced by surface termination. The surfaces which are regarded as polar in nature have different atomic compositions and different surface morphologies but have the same bulk structure. The electronic states arising out of the surfaces of a material are called as surface states. These are originated from the sharp transition from solid, semiconducting or crystalline material.

This transition ends with a surface and is found only at the atomic layers nearer to the surface. So the termination of a material near the surface leads to the alteration of the electronic band structure from the bulk material to the vacuum. In our study, the nature of surface states has been investigated by comparing the surface band structures with pseudo hydrogen saturation. So to study the exact surface state either the ZnO-Zn surface or ZnO-O surface is passivity at a time in order to have a exact positions of the ZnO-Zn and ZnO-O surface states. The position of ZnO-O and ZnO-Zn surface states are at the top of the valence band and the bottom of the conduction band respectively. The ZnO-Zn surface declines a lot as a whole relative to the Fermi level and the ZnO-Zn surface states become steeper.

It is also observed that the inclusion of Fermi level is deeper into the conduction band and the position of partial surface states is below the Fermi level. Therefore, n-type conduction is shown by the ZnO-Zn surface. The ZnO-O surface has characteristic which is completely different from the ZnO-Zn surface. It has a surface band gap about 0.6 eV, and the Fermi level transfers into the valence band. This leads to the p-type conduction behavior of ZnO-O. Fig. 5 shows the density of states of ZnO at one layer. At the bottom part of the figure, it has been shown that the highest density peak at Fermi level lies nearer 2.5 states/eV which is characterized by the presence of densities of our study compared to the solid state surface. In general, the case density of the three surfaces is more chemically active than the surface state in its solid state, in both the valence ring and the conduction ring, and that the increase in the value of the density relates to the number of layers formed for the surface, in other words, there is a positive relationship to the density of cases with the number of layers formed for the latter. The densest surfaces are the most stimulating surfaces.

## CONCLUSION

In the present study, study on the structural property of hexagonal wurtzite phased ZnO has been carried out. The band gap structure and density of state for ZnO at different planes have been estimated. Theoretical simulative methods have been adapted to calculate and determine different properties of ZnO surfaces. The energy  $e$  of Zn-polar (0001) surface is bigger than that of O-polar (0001  $\bar{1}$ ) indicating ZnO-O surface is more stable than the ZnO-Zn surface. ZnO in wurtzite phases is a direct band gap semiconductor. The three surfaces of ZnO-O are better than that of the surface in bulk which makes ZnO suitable in the field of catalysis.

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Table-1: The lattice parameters of ZnO in phase (wurtzite) with theoretical calculated values

	a(A <sup>o</sup> )	c(A <sup>o</sup> )	c/a	Band gap( eV )
ZnO	3.281	5.321	1.621	0.529
[6]	3.288	5.27	1.603	1.02
[7]	3.3	5.346	1.62	0.69

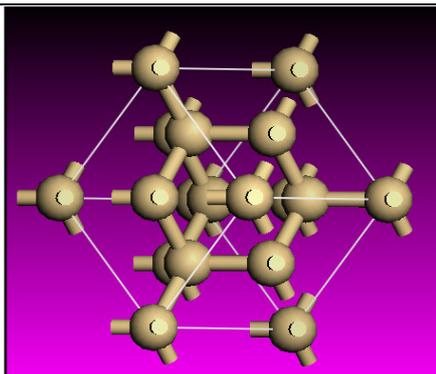


Figure-1: Crystal lattice structure of hexagonal wurtzite ZnO.

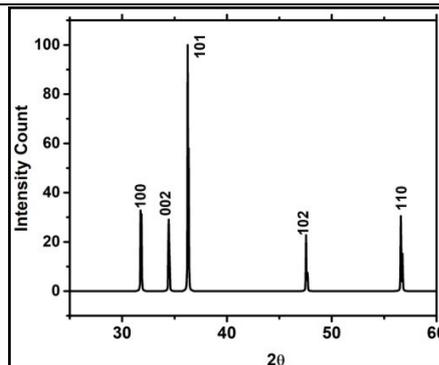


Figure-2: XRD pattern of ZnO obtained from Reflex module of Material studio.

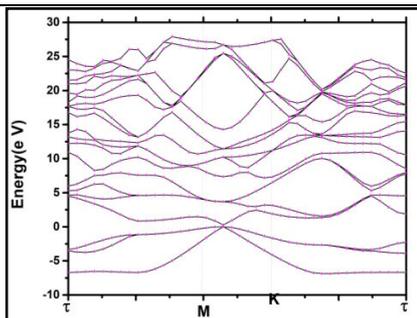


Figure-3: Band structure of 4 layers ZnO (0001)-Zn surface and ZnO(0001̄)-O surface.

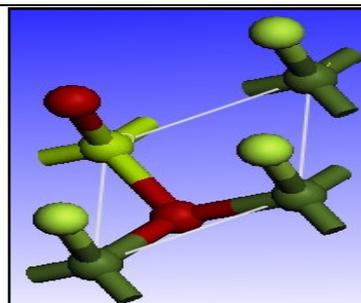


Figure-4: Position of ZnO-Zn and ZnO-O surfaces

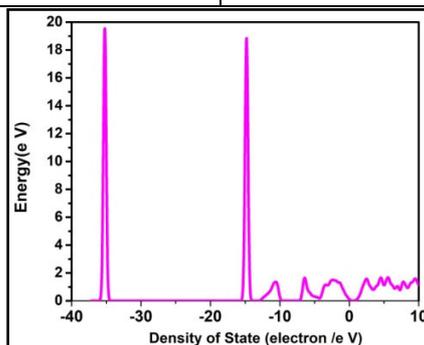


Figure-5: Density of states of ZnO on (0001) surface





## RESEARCH ARTICLE

## Study on the Electronic Band Structure and Optical Property of Semiconducting TiO<sub>2</sub> Nanoparticles

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### ABSTRACT

Titanium dioxide (TiO<sub>2</sub>) nanoparticles were synthesized via modified so-gel technique taking titanium isopropoxide as the precursor material. The nanopowder was characterized by using X-ray diffraction (XRD) and UV-VIS spectroscopy to structural and optical properties. The XRD diffraction study of the synthesized TiO<sub>2</sub> nanoparticles reveals the formation of rutile structure. Electronic band structure of TiO<sub>2</sub> was also been studied theoretically using simulation techniques by the help of *Material Studio* tool. The band structure and the density of states were studied and analyzed which corroborated the XRD data. The UV-VIS absorbance spectrum of TiO<sub>2</sub> shows the peak around 376 nm. The optical band gap of TiO<sub>2</sub> was obtained from the Tauc plot which was found to be 3.18 eV. TiO<sub>2</sub> nanoparticles exhibit enhanced UV absorbance leading to various optoelectronic applications.

**Keywords:** TiO<sub>2</sub>, Band Structure, X-Ray Diffraction, Density of state

### INTRODUCTION

Nanostructures of semiconducting materials are considered to have unique physical, chemical, optical, electronic and catalytic properties which significantly alter from the properties shown in bulk form. This is the reason why more and more research has been invested to study nano structured materials based wide band gap semiconductor. Metal oxides nanomaterials have displayed novel properties which find application in all branches of science such as physics, physics, chemistry, and materials science. These metal oxides possess unique characteristic attributes which make them a functional class of materials widely admired by material scientists and solid-state physicists [1]. Titanium oxide is a high band gap material having band gap  $E_g=3.2$  eV at 27 °C and also shows dielectric property. Out of the three structural phases, TiO<sub>2</sub> exists in rutile (tetragonal) phase generally. TiO<sub>2</sub> owes its application for its high oxidizing effect which makes it suitable for decomposition of organic and inorganic compounds. TiO<sub>2</sub> is also non-toxic and highly abundant and has a high chemical and optical stability [2, 3]. It is an n-type semiconductor

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which exists in both amorphous and crystalline phases. Also, known as Titania,  $\text{TiO}_2$ , consists of oxygen ( $\text{O}^{2-}$ ) and Titanium ( $\text{Ti}^{4+}$ ) ions arranged in a way that one  $\text{Ti}^{4+}$  ion is surrounded by six  $\text{O}^{2-}$  ions bonded to create a distorted structure with majority carriers being electrons. There are three  $\text{TiO}_2$  polymorphs, that is; rutile, brookite, and anatase. Rutile is the most stable and available polymorph [4]. Crystal structures of anatase and rutile phases have tetragonal structures although the octahedron in rutile is slightly distorted than that for anatase. Brookite shows an orthorhombic structure [5]. It is highly bright in powder form with a high refractive index. Usually, it is also the most preferred semiconductor for application in photocatalytic processes such as self-cleaning, air-purification and waste-water treatment since it is non-toxic, highly abundant and has a high thermal and chemical stability.

Anatase form exhibits a high photocatalytic activity. Structural and electronic properties of  $\text{TiO}_2$  have been rigorously studied basing on both experimental and theoretical calculations but these all are in debate till date. The main difference between the theoretical and experimental correlation is due to the difference arising in the value of the observed band gap. Since, the band gap of a nano semiconducting material has a significant role in explaining the optical and catalytic properties, it is necessary to calculate the band gap by theoretical method. The (110) and (100) surfaces of  $\text{TiO}_2$  have electronic structures which are similar to the bulk phase. This is the reason why the value of the band gap is close for (110) surface as compared to the bulk [5-7]. Therefore, a clear study on the electronic band structure of  $\text{TiO}_2$  is required based on both theoretical and experimental result to draw any conclusion. Our, present study is comprised of structural and optical investigations on  $\text{TiO}_2$  using experiment and theory.

## MATERIALS AND METHOD

### Synthesis of $\text{TiO}_2$ nanopowder

Sodium hydroxide was used as a precipitating agent and isopropyl alcohol was as a solvent for all the experiments. Titanium isopropoxide was taken as Titanium precursor while sodium hydroxide used for adjusting pH. 5g of titanium (IV) isopropoxide were dissolved in 50 ml of isopropyl alcohol and the mixture stirred for 1 h. Sodium hydroxide was then added drop wise to form a solution of pH ranging 2-3 and then further stirred for 1hr. 0.5 M nitric acid solution was added to the  $\text{Ti}(\text{OH})_4$  gel formed and stirred for 1 h after which the pH was adjusted to between 6 and 7. The sol was stirred for 5 h above 70 °C to form a  $\text{Ti}(\text{OH})_4$  slurry which was aged for 24 h. Subsequently, the slurry was filtered and washed with sufficient amounts of de-ionized water, dried at 100 °C for 24 h and calcined at 500 °C for 2 h.

### Experimental characterization method

All the analysis was carried out on the calcined samples of  $\text{TiO}_2$ . X-ray diffraction (Perkin Elmer) was used to investigate the structural orientation, crystallite size and phase analysis. UV-Vis spectroscopy was carried out to investigate the optical properties and record the absorbance spectra from 200 to 700 nm by a EI, UV-2600.

### Computational methods

For computational analysis of electronic band structure and density of states of  $\text{TiO}_2$ , the *Material Studio* of *Biovia* software was utilized. The CASTEP module with analysis part was used to predict the band structure of rutile phase. Density functional theory (DFT) within the local density approximation (LDA) was adopted to predict the band gap of rutile  $\text{TiO}_2$  which has been found to be 2.0 eV. This value is found to be 30 % lesser than the value (3.0 eV) obtained from experiment. Localized atomic orbital basis set embedded CASTEP module was utilized to perform these calculations. The cut off value and threshold energy set was at  $10^{-6}$  au and  $10^{-6}$  respectively. The lattice parameter was  $a=3.776 \text{ \AA}$  and  $c=9.486 \text{ \AA}$ ,  $\alpha=\beta=\gamma=90^\circ$ . In this crystal structure phase the orientation were along Z and B in YZ plane.





## RESULT DISCUSSION

### XRD analysis

X-ray diffraction (XRD) study of the synthesized TiO<sub>2</sub> nanopowders has been carried out and the pattern has been illustrated in Fig.1. Seven diffraction peaks are observed to appear at different 2θ values such as 27.29°, 36.69°, 39.29°, 41.15°, 44.11°, 54.239° and 56.01° which have been ascribed to (101), (004), (011), (111), (105), (211) and (220) crystal planes of TiO<sub>2</sub>. This has been matched with the standard pattern (JCPDS Card No.21-1272) of TiO<sub>2</sub> and indexed accordingly. So, XRD study confirms the formation of rutile TiO<sub>2</sub> nanoparticles. The dominant diffraction peak (101) was found in between the 2θ angle of 25 - 30°. There are no impurity peaks observed from the XRD pattern meaning that the synthesized samples are pure. The prepared nano TiO<sub>2</sub> is crystalline in nature and the crystallite size has been calculated by the Debye-scherrer equation as given below.

$$D = k\lambda / \beta \cos\theta$$

In the above equation, D, k, λ, β and θ are the crystallite size (nm), Scherrer constant =0.94, the wavelength of the incident CuKα radiation (1.54059 Å), the line broadening at half maximum (FWHM) and Bragg's diffraction angle respectively. The particle size and strain was found to be 22 nm and 0.00121 which are extracted from the y-intercept and slope respectively. The equation  $\epsilon = \beta / 4 \tan\theta$  was used for calculating the strain which arises after the synthesis of nanopowder where ε is the strain. This has been calculated from XRD data and shown in the Fig 2. The plot has been obtained by plotting 4sinθ on x-axis and βcosθ on the y-axis (in radians). A linear fit gives the y-intercept and slope of which the particle size and strain are estimated respectively. And it was found that the prepared titanium dioxide nanopowder have minimum strain as compared to other reported value.

### UV-visible spectral analysis

UV-Visible spectroscopy is an innovative tool to study the optical properties of nanoparticles and many parameters linked with the characteristic property of the concerned material can be found out from this. Accordingly, we recorded the optical absorption spectrum of TiO<sub>2</sub> which has been depicted in Fig.3a. The absorption band is found to appear at 376 nm for the TiO<sub>2</sub> nanoparticles. To calculate the band gap energy (E<sub>g</sub>), the Tauc plot for the synthesized nano TiO<sub>2</sub> was plotted. This has been illustrated in Fig.3b. To determine the optical band gap of semiconductors, the method of Tauc plot is adopted. The photon energy is plotted versus square root of the product of the absorption coefficient and photon energy. The section of straight line from the curve touching the x-axis gives the value of band gap. The value of band gap energy is found to be 3.18 eV from this spectrum which is the gap between the conduction band and valence band.

### Electronic band structure and density of state

The density of state and band structure has given in Fig. 4 having of rutile phase for δ = 13%. For the O2s states, the calculated bandwidth of 2.11 eV is consistent with the experimental value of 1.81 eV, having lattice parameter= 4.594 Å and c= 2.958 Å. For the upper valence band, the band width of 6.5 eV agrees with the range of 5-6 eV for reported data [8-10]. The conduction band can be divided into two sets which are mainly linked with t<sub>2g</sub> and e<sub>g</sub> symmetries and the energy difference between the average energies of two sets is roughly about 3.0 eV. The band gap energy was obtained 0.067Ha (2.33-3.0 eV experimental value) [11-13]. The crystal lattice structure has been depicted in Figure-5 below.

## CONCLUSION

Nanosized TiO<sub>2</sub> was successfully prepared by sol-gel method and characterized by XRD, UV-Visible spectral studies. The X-ray diffraction (XRD) analysis confirms the presence of rutile phased TiO<sub>2</sub> nanocrystallites. The calculated grain size of nano TiO<sub>2</sub> was ~22 nm and the preferred orientation plane was (101). The band gap energy (E<sub>g</sub>) value





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calculated from the UV-Visible spectral studies was 3.18 eV. The band structure and density of state was theoretically analyzed the value was found to be 30 % less as compare the experimental value reported.

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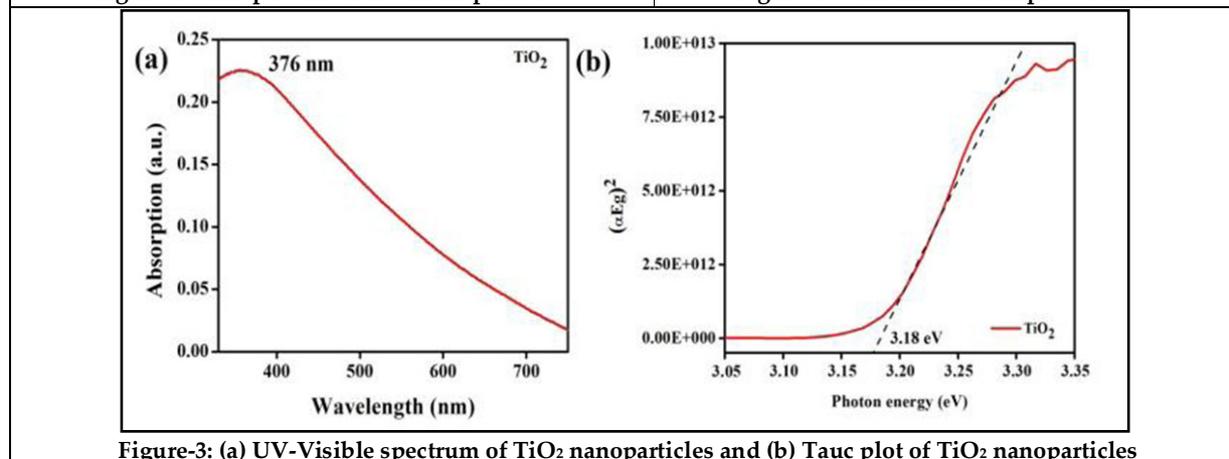
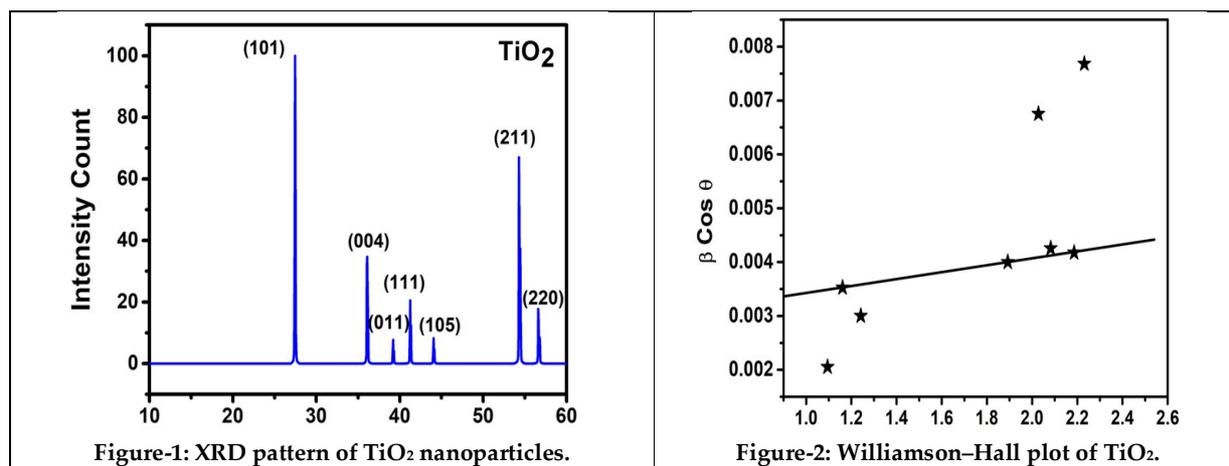


Figure-3: (a) UV-Visible spectrum of TiO<sub>2</sub> nanoparticles and (b) Tauc plot of TiO<sub>2</sub> nanoparticles



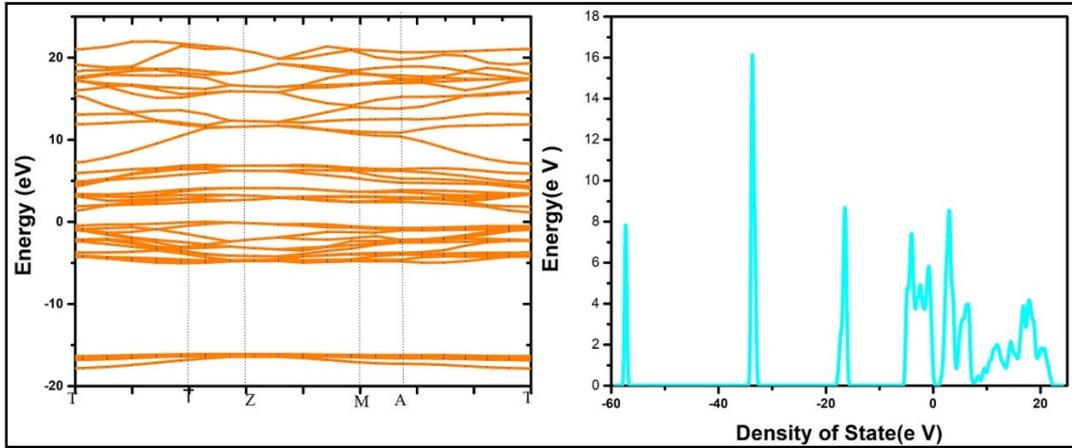


Figure-4: Band structure and density of states plot for TiO<sub>2</sub>

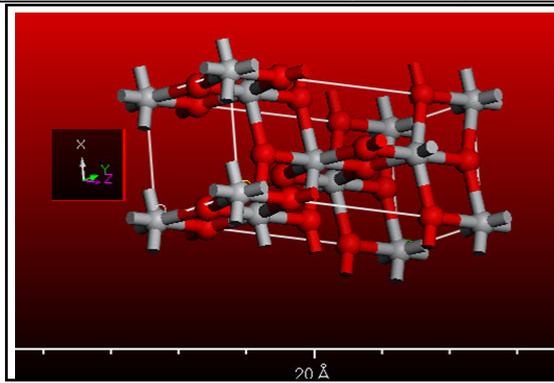


Figure-5: Crystal lattice structure of TiO<sub>2</sub>





## *In silico* Study of Band Gap Modulation for SnO<sub>2</sub> Systems

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### ABSTRACT

In this present study CASTEP module of Material Studio method was used the energy band structure of stannic oxide. The electronic band structures along with total energy of the build SnO<sub>2</sub> layer have been analysed using DFT within the local density approximation(LDA) method .It has been found that by manipulating the interatomic distances between Sn and O along with relative positions of atoms leads to change in band-gap energy of SnO<sub>2</sub> semiconductors

**Keywords:** Band Structure, DFT, Density of State, SnO<sub>2</sub>

## INTRODUCTION

Tin dioxide (SnO<sub>2</sub>) is considered as one of the most promising and used materials for the fabrication of solid state gas sensors, transparent conductors, and catalysts [1]. Tin dioxide (SnO<sub>2</sub>) as gained wide attention of researchers over the last decades due to its excellent optoelectronic properties, for potential applications in solar cells and flat panel displays[2-6]. SnO<sub>2</sub>(110) surface is one of the most studied surface in both theoretically and experimentally due all the defects and oxygen absorption site[7-8] .So the two surface (110) and (101) are of widely simulated for its application towards catalyst and other optical application [9-10]. Bulk and surface oxygen vacancies are extremely important for determining the electrical conductivity of tin dioxide [11] . Moreover, they are also responsible for a very efficient luminescence activity of SnO<sub>2</sub> nanobelts. The interstitial tin and oxygen vacancies can be known from first-principles calculations have a low formation energy [12-15]. Stannic oxide exhibits the rutile structure having space group P4<sub>2</sub>mm. SnO<sub>2</sub> crystal structure contain tetragonal unit cell , with a c/a ratio of 0.673, and having six atoms, two tin and four oxygen (Fig. 1).The prime objective of this work is to analyze the structural ,optical and electronic properties.

## COMPUTATIONAL METHOD

First principles methods using CASTEP of material studio has been used for the analysis of band structure and density of state .The module of CASTEP for the calculating the band structure with the following .In general at

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ambient conditions, SnO<sub>2</sub> molecule crystallizes in the rutile-type structure with P4<sub>2</sub>/mmn, space group. It is a 3D rutile structure where all structures are arranged with periodic boundary conditions in the x-, y-direction to simulate an infinite plane. Total number of ions, species in cell are 6 and 2 respectively.

Atomic calculation performed for Sn:

1s<sup>2</sup> 2s<sup>2</sup> 2p<sup>6</sup> 3s<sup>2</sup> 3p<sup>6</sup> 3d<sup>10</sup> 4s<sup>2</sup> 4p<sup>6</sup> 4d<sup>10</sup> 5s<sup>2</sup> 5p<sup>2</sup>

Converged in 78 iterations to an energy of -168090.064 eV,

Identity difference: 3.24E-03, Maximum eigen value error: 1.68E-04

Derived cutoff energies: C= 6 M= 9 F= 9 E= 12

Real Lattice (A)			Reciprocal Lattice (1/A)		
4.7372700	0.0000000	0.0000000	1.326330420	0.000000000	0.000000000
0.0000000	4.7372700	0.0000000	0.000000000	1.326330420	0.000000000
0.0000000	0.0000000	3.1863830	0.000000000	0.000000000	1.971886401

Lattice parameters (A)		Cell Angles	
a =	4.737270	alpha =	90.000000
b =	4.737270	beta =	90.000000
c =	3.186383	gamma =	90.000000

Current cell volume =	71.507938	A**3
Density	=	4.215163 AMU/A**3
	=	6.999442 g/cm <sup>3</sup>

The above are the detail setup parameter for CASTEP modules in order to predict the band structure using 1<sup>st</sup> principle calculation and LDA model.

Parameters for generating k-points: 3 3 4 0.00 0.00 0.00 36  
 Total number of symmetry-unique k points: 6  
 Total number of symmetry-unique tetrahedra: 43

The optimized (a) unit cell and (b) 1 layer of SnO<sub>2</sub> in the rutile-type structure are displayed in Fig. 1.

## RESULTS AND DISCUSSION

The structures optimizations for SnO<sub>2</sub> layers have been done according to three different methods i.e. by fixing the lattice parameter a and a/c ratio one by one. Minimal energies are calculated for the equilibrium parameters for each cases where a, c and c/a parameter varied one by one. So the optimized parameters "a, c" and "c/a" of the layers are lower than those of SnO<sub>2</sub> bulk and increase by increasing the numbers of layers from second layer to multilayers of SnO<sub>2</sub> [14]. Electronic structure calculations of multilayer SnO<sub>2</sub> materials, based on the detail understanding of electronic properties of bulk SnO<sub>2</sub>. In this respect, the total density of state and partial density of state of the electronic level of SnO<sub>2</sub> have been calculated ( Fig. 3.) The electronic structure of the rutile SnO<sub>2</sub> with a band gap equal to 2.30eV calculated by the CASTEP-LDA method (Fig.3), which is smaller than the experimental value 3.40eV [16]. Due to the first principles calculations both the theoretical and experimental value was found to be different based on the density functional theory which may be due to the errors in the estimation of the band-gap from CASTEP Material studio. Again it was seen that the valence band of SnO<sub>2</sub> consists mainly of O-2p states with 5p states of Sn. This can be observed by decrease /increase of the band gap energy by CASTEP calculation. It follows





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that the SnO<sub>2</sub> layer exhibit a semiconductor character like the bulk SnO<sub>2</sub> and contain a direct band gaps at the  $\Gamma$  point. In rutile SnO<sub>2</sub>, band gaps for layer structure are bigger as compare to bulk. Also it decreases with increasing the layer thickness. This should probably may due to the fact that with increasing of the layer thickness, the electrons in the layers are confined less. Consequently, the confinement effects in the layer become weaker with decrease in the bandgap. It was reported that the band structure of SnO<sub>2</sub> semiconductors could be modified by the inter atomic distances and relative positions of atom, and the epitaxial along "c-axis" is more efficient than the epitaxial along "a-" or "b-axis" for tuning the band gap of SnO<sub>2</sub>.

## CONCLUSION

Band gap engineering is an important tool for the design of new semiconductor materials and devices. In this study it has been seen that the bulk SnO<sub>2</sub> band gap was found to 0.634 which is lower than experimental value .The band structure and density of state

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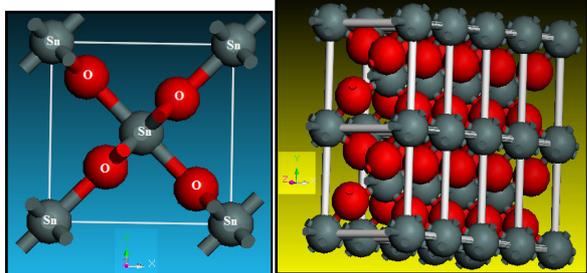


Fig. 1. Optimized stable (a) unit cell and (b)1 layer of SnO<sub>2</sub>

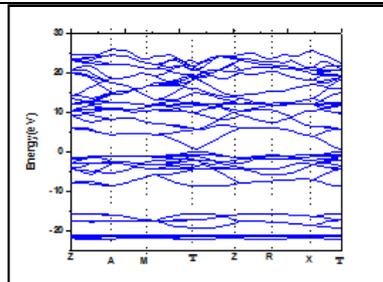


Fig.2. Band structure of SnO<sub>2</sub>

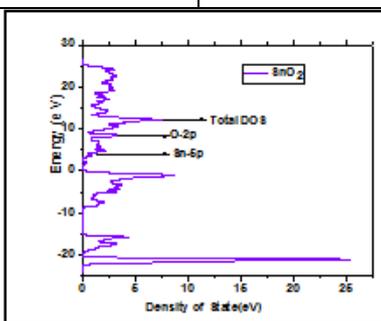


Fig.3. The total and partial DOS for the bulk rutile SnO<sub>2</sub>





## Extraction and Characterization of Clove Oil from Buds and Effect of the Residue on Soil Fertility

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### ABSTRACT

Clove (*Syzygium aromaticum*) is one among the mostly used spices in India that generally used as food preservative and lots of medicinal purposes. This spice should deserve a special attention due to its antioxidant and antimicrobial activity as compared to other spices used in India. The objective of the study is to extract clove oil from clove powder by using ethanol and water as solvent and to see the efficient solvent that gives maximum effective result. The oil was extracted from 50gm of clove with 250ml. of above solvents at their boiling temperature in soxhlation. The amount of solvent present along with it was separated by rotary evaporator. The oil so obtained was characterized by UV-Visible, FT-IR analysis. Finally it was concluded that the clove oil produced by using ethanol as solvent is most effective and we use the clove powdered residue (waste powder produced after preparing clove oil) on soil to see their effect. As we can't use those clove residue efficiently at our daily life so we may throw it out. So in this study, those clove residue waste powder was added to the garden soil and both initial and final physicochemical parameters and elemental contents of soil were examined. So clove waste can be recommended as the pesticide and organic fertilizer which can boost the nutrient level of soil and increase the soil fertility.

**Keywords:** Clove (*Syzygium aromaticum*), UV-Visible, FT-IR, residue, soil fertility.

### INTRODUCTION

Clove (*Syzygium aromaticum*) is an aromatic flower bud of a tree belongs to the family of *Myrtaceae*. Clove is usually found in the aromatherapy section of health, food storage and is employed in the flavoring of medicines. Madagascar and Indonesia are the most common producers of oil of cloves. Due to anti-oxidant property it helps in the prevention of cancer. Oral problems like dry socket following tooth extraction, pain and swelling of the mouth and throat can be relieved by using it [1]. Roughly, clove essential oil consists of 89% eugenol and 5% to 15% eugenol



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acetate and  $\beta$ -caryophyllene, 2.1% of  $\alpha$ -humulene. Other volatile compounds present in lower concentrations in clove oil are  $\beta$ -pinene, limonene, farnesol, benzaldehyde, 2-heptanone and ethyl hexanoate [2]. Generally the most important component eugenol may be a colorless to pale yellow, aromatic oily liquid extracted from certain essential oils especially from clove oil [3]. It is present in concentration of 80-90% in clove bud oil and at 82-88% in clove leaf oil [4]. Eugenol has a pleasant, spicy, clove-like scent [5]. Chemical formula of eugenol is  $C_{10}H_{12}O_2$ . Eugenol is employed in perfumes, flavorings and essential oils. Essential oils have high antioxidant so they participate in destruction mechanism against pathogens, viruses, microbes and bacteria [6]. Eugenol is used in perfumes, flavorings, essential oils and also used as a local antiseptic and anesthetic [7]. Eugenol is often combined with zinc oxide to form zinc oxide eugenol which has restorative and prosthodontic application in dentistry.

For persons with an alveolar osteitis as a complication of tooth extraction, packing the alveolar osteitis with eugenol-zinc oxide paste on iodo form gauze is effective for reducing acute pain [8]. Eugenol-zinc oxide paste is also used for root canal sealing [9]. In India we used clove in almost all spicy rich dishes to enhance the taste and as one of the home remedy. But at Indonesia clove used to make cigarettes by adding clove and tobacco in 1:2 ratios respectively [10]. Some of the literature study cited as Clove powder soaked with distilled water and ethanol to have respective extract, then it was mixed on a rotary system and filtered. The samples were processed until dry through a special lyophilizing flask that connected to a vacuum pump [11]. Clove extract was found to be effective against almost all of the food borne microbes but it was most effective against *Staphylococcus aureus*. And clove oil was mostly effective against common food spoilage fungi on SDA medium. Clove oil shows better result in vitro antibacterial and antifungal activity than its extract and sodium propionate [12]. It has been shown that clove oil was very effective against *Sphingobium indicum*, *Escherichia coli*, *Staphylococcus aureus* and *Bacillus subtilis*. This oil created a halo or zone of inhibition shown by *Bacillus* (halo area 7.543  $cm^2$ ) was more as compared to *E. coli*(halo area 5.144  $cm^2$ ) [13].

Depends on the chemical composition of the clove oil for analysis of medicinal values, the essential constituents are m-eugenol i.e. 3-allyl-6-methoxyphenol (69.43%), eugenol acetate (10.78%), caryophyllene (6.80%), 2-pentanone (7.78%) etc. [14]. Essential oil like clove oil can be used as reduction of fungal spoilage in *in vitro* systems and in bread system [15]. Clove oil can also eliminate the growth of *R. solanacearum* in overspread soil. Also depending on concentration used, clove oil could protect tomato and geranium plants from bacterial infection. It has been shown that clove oil and other essential oils possess wide activity against plant pathogens [16]. A study based on phytotoxicity of clove oil to vegetable crop seedlings and nematotoxicity to root-knot nematodes examined that in the case of cucumber phytotoxicity observed at lowest clove oil concentration. It was shown that the clove oil formulation was not effective on decreasing nematode population on cucumber [17]. Organic wastes may improve soil physicochemical properties, soil biological activity and also it helps to sustain soil health.

They also help in increase of plant nutrient and maintain soil fertility, by which crop growth and yield also increases [18]. Generally increase in potassium uptake and decrease in sodium uptake reinforces by addition of nano silicon that derived from  $SiO_2$  was the major mechanism responsible for more growth of plants under salinity [19]. According to previous researches the concentrations of soil nutrient are good indicators of soil quality and productivity due to their favorable effects on the physicochemical and biological properties of soil [20]. Soil pH affects the chemical reactions occur in soil [21]. Effect of clove bud residue on soil fertility after oil extraction has been rarely reported anywhere in the literature. So in the present research work we have extracted clove oil from the bud powder and study the effects of the residue on soil fertility.

**Experimental****MATERIALS**

The main ingredient Clove was purchased from a local grocery shop at Cuttack. Then those raw cloves were thoroughly washed with tap water and air dried. Then half of the cloves were kept aside and other half were



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powdered by using an electric blender and finely clove powdered sample was prepared. Then ethanol and distilled water was purchased from a local chemical store.

## METHODS

### Extraction of Clove Oil from bud powder

50gm. Of air dried clove powders were weighed by using digital weigh machine at laboratory. Then it was filled in soxhlet. And 250ml. of ethanol was taken as solvent. The solvent was heated to reflux. The solvent vapour travelled up a distillation arm and flooded into the chamber housing the thimble of solid. When the soxhlet chamber was almost full, the chamber was emptied by the siphon and the solvent was returned to the distillation flask. This cycle was allowed to repeat many times over days. After many cycles the specified compound is concentrated within the distillation flask. After extraction the solvent is removed by means of rotary evaporator, yielding the extracted compound. The non-soluble portion of the extracted solid remains within the thimble and is usually discarded. According to above process clove extract was also prepared by using 50gm. Of clove powder and 250ml. of distilled water as solvent. 85 mL clove oil was obtained using ethanol as solvent whereas 47 mL clove oil extracted by using distilled water as solvent from 50gm of clove powder.

### Soil Analysis by adding clove residue:

The residues obtained after extraction of oil was added to the soil in Centurion University of Technology and Management, Odisha (Bhubaneswar Campus) garden and after 15 days some of the soil sample was collected and various physicochemical properties like pH, E.C, Water holding capacity and Moisture content were determined and recorded in a table and compared with the soil in order to know the effect of the residues on its fertility. After this the XRF analysis was carried out to know the different types of elements present in initial garden soil, clove residue and garden soil with clove residue one and the results were noted as tabular form.

### Characterizations

UV-Vis absorption study of the oil extracted with ethanol and water were carried out by perkin- Elmer Lamda 25 spectrophotometer in a range of 200 to 800 nm. FT-IR Spectra of clove oils were recorded on a perkin Elmer spectrometer(Spectrum RX1,Perkin Elmer, Singapore) using KBr pellet technique, in the range 4000-500  $\text{cm}^{-1}$  with a resolution of 2 $\text{cm}^{-1}$  using 4 scans per sample. X-Ray Fluorescence of the Garden soil, clove residue and Garden soil mixed clove residue were done by Epselon-1 XRF Spectrophotometer from Malvern Panaytical, in the X-ray fluorescence range of elements Na-Am calibrated by LLD 1ppm-100% containing high resolution of 135v

## RESULT AND DISCUSSION

### FTIR analysis

The result of FTIR analysis showed a characteristic clear and high intensive band at 3336  $\text{cm}^{-1}$  corresponding to OH groups of extracts. The signals which appeared between 2972-2883  $\text{cm}^{-1}$  are caused by the group  $\text{CH}_3$  of the extract. The band at 1653  $\text{cm}^{-1}$  which is responsible for the presence of conjugated  $\text{C}=\text{C}$  group. The bands present at 1454  $\text{cm}^{-1}$  and 1416  $\text{cm}^{-1}$  represents the presence of  $\text{CH}_2$  group. Other strong band at 1045  $\text{cm}^{-1}$  and 1086  $\text{cm}^{-1}$  represents the presence of secondary cyclic alcohol of C-O group. Another moderate band at 803  $\text{cm}^{-1}$  and 879  $\text{cm}^{-1}$  represents the presence of  $\text{CH}_2$  in the extracts [22].

ethanol extract, the absorption at 252nm is due to  $n-\pi^*$  electronic transition OH group of ethanol bind that with aromatic ring. Also the absorption at 295 nm is due to electronic move of type  $n-\pi^*$  of group carbonyl bind with aromatic ring of quinone which reach up to 340nm and provide the yellow color of those compounds. Absorption at 360nm is belonging to the electronic moving of the type  $\pi-\pi^*$  of the group of ketone that bind with aromatic ring



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[22]. Distilled water extracted oil showed absorption at 218 nm and 254 nm is due to  $\pi$ - $\pi^*$  transition for benzene ring and allyl group of the eugenol.

**Effect of clove residue on garden soil**

Here, different physicochemical parameters like pH, Electrical conductivity(E.C), soil moisture content(%), water holding capacity (W.H.C) and different elements/compound contents of a garden soil and garden soil treated with clove residue were analyzed and compared in table-1 & 2. In this study the pH value of the garden soil was measured as 7.32. But the pH value of soil treated with clove residue was measured as 6.98. The pH was decreased after mixing the clove residue, so this residue can help to neutralize the pH which is more important for plants. As the clove residue mixed soil shows 6-7pH, which is the desirable pH range for optimum plant growth in India. Electrical conductivity of the initial soil was 0.75mho/cm. But after mixing with clove residue it was 0.79 mho/cm. Moisture content of the garden soil increased from 9.76% to 1.23%. Also the water holding capacity increased from 9.76ml/kg to 10.23ml/kg. By the help of XRF spectroscopy it has been shown that clove residue enriched with several elements and compounds that increase the nutrient level of garden soil. The concentration of different elements like  $K_2O$ ,  $CaO$ ,  $Cl$ ,  $SO_3$ ,  $P_2O_5$ ,  $SiO_2$ ,  $MnO$  and  $Fe_2O_3$  increased after addition of clove residue into the garden soil. These elements amplify the soil nutritional level.

**CONCLUSION**

Clove oil was prepared successfully. The clove oil prepared by using ethanol was more efficient than water. Also yield of this type of clove oil was more. It can be used as antibacterial or antifungal diseases. Eugenol can be extracted and used further. There was no more wastage, clove residue can be used as fertilizer due to the presence of different valuable macro and micro nutrient for plants and can also be used as pesticide due to the presence of eugenol. Clove residue may help certain crops to grow effectively. Depending on clove oil concentration clove oil could protect different crops from infection by the bacterium.

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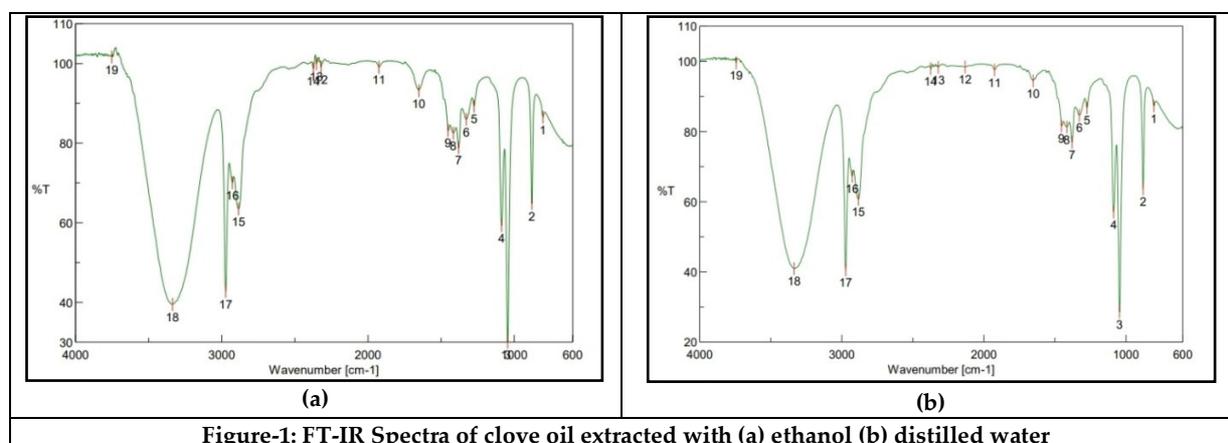
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**Table-1: Physicochemical properties comparison between garden soil and garden soil treated with clove residue**

Parameters	Unit	Garden Soil	Garden Soil Treated With Clove Residue
pH		7.32±0.068	6.98±0.005
E.C	mho/cm	0.754±0.003	0.798±0.002
Water holding capacity	ml/kg	149.937±1.532	151.213±0.528
Moisture content	%	9.76±0.315	10.233±0.062

**Table-2: Comparison of Elemental composition of garden soil, clove residue and garden soil mixed clove residue by XRF spectroscopy**

Elements	Unit	Garden soil	Clove residue	Garden soil mixed clove residue
SiO <sub>2</sub>	%	62.128±0.406	1.103±0.009	60.128±0.002
P <sub>2</sub> O <sub>5</sub>	%	2.432±0.012	2.673±0.001	3.292±0.050
SO <sub>3</sub>	%	0.468±0.022	2.887±0.462	1.926±0.586
Cl	%	0.373±0.034	3.442±0.035	1.828±0.001
K <sub>2</sub> O	%	0.182±0.002	27.303±0.566	3.287±0.054
CaO	%	4.016±0.004	15.602±0.321	6.008±0.045
TiO <sub>2</sub>	%	1.068±0.002	0.043±0.056	0.997±0.679
MnO	%	0.125±0.042	2.503±0.002	0.103±0.512
Fe <sub>2</sub> O <sub>3</sub>	%	5.828±0.080	1.563±0.589	5.032±0.006
ZnO	ppm	150.883±0.224	330.2±0.001	140.992±0.001
CuO	%	0.007±0.244	00	0.002±0.054
Rb <sub>2</sub> O	%	0.0193±0.211	0.018±0.005	0.020±0.004
SrO	%	0.0296±0.012	0.002±0.256	0.009±0.001
Y <sub>2</sub> O <sub>3</sub>	ppm	22.226±0.355	00	20.206±0.001
Eu <sub>2</sub> O <sub>3</sub>	ppm	587.732±1.123	555.205±0.489	503.281±0.052
Re	ppm	00	25.255±0.020	23.322±0.452
Ga <sub>2</sub> O <sub>3</sub>	ppm	29.023±0.032	00	25.102±0.246
As <sub>2</sub> O <sub>3</sub>	ppm	11.932±0.034	00	10.311±0.222
Nb <sub>2</sub> O <sub>5</sub>	ppm	30.712±1.915	00	24.192±0.002
SnO <sub>2</sub>	ppm	90.280±1.325	00	72.833±0.001



**Figure-1: FT-IR Spectra of clove oil extracted with (a) ethanol (b) distilled water**





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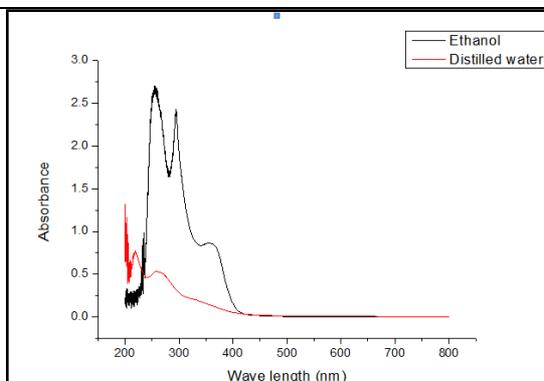


Figure-2: UV-Visible spectra of clove oil extracted from ethanol and distilled water





## Performance and Emission Analysis of Diesel Engine with Dual Biodiesel Blend of Castor and Mahua Oil

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### ABSTRACT

The depletion of petroleum fuels is a major concern now a day. The growth in automobile sector and population are the prime causes for it. Moreover the emission from vehicles that uses petroleum fuels such as petrol, diesel and kerosene possess a threat to the environment and mankind. The major gases coming out from the vehicle emission such as Carbon Monoxide (CO), Carbon Dioxide (CO<sub>2</sub>), Oxides of Nitrogen (NO<sub>x</sub>), Hydro Carbon (HC), Particulate Matter (PM) are polluting atmosphere to great extent. Many researchers have proposed several ways of reducing pollution by using alternate energy sources. Use of biodiesel as a liquid alternate fuel is one of the biggest achievement so far. As the name suggests, it can be produced from biofuels and has similar properties with conventional diesel fuel. The wide availability of plant such as karanja, Mahua, Sunflower, Kusuma, jatropha, Castor is favourable for biodiesel production. Researchers are going in favour of different non edible oil sources because they are non-consumable for human being. Characteristics of these oils need to be carefully studied before proceeding for biodiesel production. However the use of biodiesel as fuel for vehicles decreases the performance slightly due to less calorific value as compared to conventional diesel and petrol. But on the other hand, there is a significant reduction in pollution level as reported by different researchers. In this work, a mixed biodiesel blend of Mahua and castor has been prepared and used as an alternate fuel to run a diesel engine. The results obtained give comparable engine performances while there is a reduction in emission gases as compared to castor biodiesel of same blend.

**Key Words:** Diesel Engine, Performance test, biodiesel, blend of Mahua and castor Oil





## INTRODUCTION

The extensive use of petroleum fuels in automobile is the main reason behind air pollution in recent times. The emissions from the automobiles consisting of hazardous gases like Carbon Monoxide (CO), Carbon Dioxide (CO<sub>2</sub>), Oxides of Nitrogen (NO<sub>x</sub>), and Hydrocarbon (HC). This emission from automobiles is the reason behind global warming and possesses threat for the mankind. Hence use of alternate fuel is a wise option as the emission comes out as a result of burning these fuels is very less as compared to petroleum fuels. Biodiesel which is a liquid alternative fuel is an excellent option to be used as fuel in automobiles. It is alkyl esters of long chain fatty acid and having properties resembles with diesel. Moreover it can be used in automobile engines without or very little modification in engine. This biodiesel can be obtained from large variety of plants which are the sources of edible and non-edible oils. The non-edible oils, such as Jatropha, Microalgae, Neem, Karanja, Rubber seed, Mahua, Silk cotton tree, etc., are easily available in developing countries and are very economical comparable to edible oils. Castor oil is potential non edible oil which is prepared from castor beans. Castor oil has wide variety of industrial and medicinal use. Oil is extracted from castor beans as a result of crushing in mills. Mahua has a place to species of Sapotaceae. It is an Indian tropical tree found over the northern part. Mahua oil is acquired from the piece of mahua seed (*Madhuca Indica*) which have 50-55% oil. The oil contains unsaturated fats like those in cooking oils as oleic corrosive, Linoleic acid. Stearic corrosive and palmitic corrosive. The particular gravity of mahua oil is 9.11% higher than diesel.

The kinematic thickness of Mahua oil is 15.23 occasions more than diesel at temperature of 400 C. The kinematic consistency of mahua oil diminishes with increment in temperature upto 800 C and by expanding the proportion of diesel in fuel mixes. Numerous researchers and specialists had grown altogether different techniques for the creation of biodiesel from different feed supplies of vegetable oil and creature fats [1]. Produced biodiesel from transesterification procedure of Soya crude, with potassium hydroxide catalyzed methanol (KOH) [2]. Considered non-eatable separated (Jatropha Curcas, Karanja (*Pongamia pinnata*) and polanga (*Calophyllum inophyllum*) mono esters (biodiesel) dependent on oil delivered and mixed with diesel were tried for their utilization as elective energizers of diesel engine [3]. Examined the reasonability of creating biodiesel from three kinds of waste creature fats [4]. In his paper looked into production, characterization and current vegetable oil and biodiesel status. Ghaly et al. revealed that the exploration on the creation of biodiesel has expanded surprisingly lately as a result of the requirement for an elective fuel which invests with biodegradability, low harmfulness and sustainability [5].

Deepanraj et al. portrayed that the less mixes of biodiesel expanded the brake warm effectiveness and limited the fuel utilization. Moreover, biodiesel mixes produce lower motor emanation than diesel [6]. Biodiesel is delivered by means of the transesterification response among oils and liquor within the sight of a suitable impetus. All in all, either homogeneous or heterogeneous, and salt or acidic impetuses can be utilized in the transesterification response to boost transesterification response execution and upgrade biodiesel creation returns [7]. Transesterification process within the sight of salt impetuses is a general procedure for biodiesel creation, since this response within the sight of soluble base impetuses is around 4,000 overlap quicker than within the sight of acidic impetuses, making the procedure all the more monetarily feasible [8]. It has increased extraordinary arrangements of consideration on account of its biodegradability, biocompatibility, non-poisonousness, simple amalgamation, safe activity [9], high cetane number, natural lubricity, liberated from sulfur, and high glimmer point [10]. Notwithstanding the points of interest, the biodiesel has been perceived as a green fuel, since it restricts low measures of gases, for example, SO<sub>x</sub>, CO<sub>x</sub>, NO<sub>x</sub> and Suspension strong particles by burning [11]. Biodiesel is perceived like most plentiful accessible wellspring of fluid liquid which can be delivered from lipid material. On account of its comparative attributes to those of oil determined fills, biodiesel can be straightforwardly utilized in diesel motors. Biodiesels are predominantly created from sustainable materials, for example, vegetable oils, creature fats, squander oils, microalgae, and so on [12].



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Biodiesels creation from eatable oils builds the expense of biodiesel creation given that around 60-80% the all out expense of biodiesel creation is connected to crude material. In this way, it tends to be expressed that biodiesel creation from eatable oils is financially inefficacious as it offers ascend to an opposition between human utilization for such oils and of biodiesel creation advertise. As needs be, generally, the present and future biodiesel work creation is probably going to concentrate on biodiesel creation from minimal effort, non-eatable and natural sources is a plan to decrease the expense of biodiesel creation while securing the environment[13]. Utilization of biodiesel would make high openings for work in creating nations taking into account division of agribusiness where as of now level of business is low [14]. Castor oil is delivered by methods for extraction from castor bean. Castor oil is recognized by its high substance (over 85%) of ricinoleic corrosive.

No other vegetable oil has this high content an extent of greasy hydroxyl acids. Castor oil has a high quality sub-atomic weight (298), low dissolving point (50C) and low hardening point (- 120C to - 180C) that make it mechanically valuable, above all it is has the most noteworthy and most stable consistency of any vegetable oil[15]. The compound structure of castor oil is of incredible intrigue in view of the wide scope of responses it bears to the oleochemical business and the extraordinary synthetic concoctions that can be gotten from it. These subordinates are altogether better than petrochemical items Since they come from inexhaustible sources, bio-degradable and eco-accommodating. Ongoing examination had worries in the utilizing Of castor oil as a feedstock to manufacture biodiesel [16]. The mahua tree lasts for 8 to 15 years to get develop and can attract organic products as long as 60 years age.

As talked about it has profoundly spreaded roots which retains the dirt and all these occurs on squander land which encourages our rustic individuals to develop alongside national economy[17]. The monetary examination shows that karanja oil biodiesel can be utilized without rotating the current motor in a diesel motor to prompt employment creation and investment funds of crucial monetary standards. Discharges in the diesel, CO emanations were very higher for blends B20 and B40. HC discharges diminished to B20 and B40 pairs 12.8 percent not 2.85 percent dependent on Diesel with full load [18].For jatropha biodiesel blended in this was with diesel tentatively seen that a blend of half diesel traditional flammable with half jatropha biodiesel (B50) gives execution unadulterated diesel not as (D100) tantamount. A blend of 80% diesel customary and Jatropha biodiesel (B20) yields 20 percent a decent mechanical exhibition at full throttle [19].The greater part of the investigations depend on the consequences of the investigation of the biodiesel procedure. Supports the utilization of biodiesel to limit discharges of carbon monoxide.

The prevailing perspective is that HC outflows are decreased when biodiesel mixes are utilized rather than diesel. This decrease is because of the higher the oxygen level [20]. The oxidation soundness of mixes of biodiesel got From karanja, neem and jatropha oil and diesel minerals and finding the oxidation to steadiness of 10% mixed biodiesel is the most elevated among all the mixes. In any case, when the mixing rate builds, the oxidation dependability diminishes and at 20% mixing the oxidation strength of karanja oil decreases and doesn't fit the bill for the standard norms[21].In the present work we have synthesized bio diesel from Castor and Mahua oil mixture and perform various engine efficiency test with it.

## MATERIALS AND METHODS

### Materials

Castor and Mahua oils were purchased from local market and used directly without further purification.  $H_2SO_4$ , methanol, KOH were reagent grade chemicals and used with out purification.

### Methods

1 L of castor and Mahua oil mixture was heated at 110° C to remove moisture content .Then the oil was Cooled and 10g of  $H_2SO_4$  and 200 ml of methanol was added and mixed well. Then the Oil mixture was placed in the biodiesel



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reactor and heated for 3hr maintaining the temperature 60-64 °C. After 3hr the sample was cooled and collected in a separating Funnel then on the next day the sample was filtered and the unreacted methanol was Separated and the remaining product was transesterified. Esterification reaction is mostly used for reducing the FFA level of oil. The esterified product was blended in with 10g of KOH and 200 ml methanol arrangement. The blend was then warmed up to 3hr at 70°C in a biodiesel reactor with nonstop mixing . Then the example was cooled and kept in an isolating channel. At that point on the following day we seen that two layers were framed and the upper layer which is the methyl ester was isolated from the lower layer which is the glycerol. The methyl ester which is acquired is then water washed to evacuate the rest of the glycerol and debasements of arrangement. The methyl ester was blended in with water in 1:3 proportion and shaken well for 2 moment. At that point it was saved for 15 minutes. After that water was contracts debasements and the unadulterated methyl ester was gathered. This procedure was rehashed for 5-6 times. The gathered example after water wash was warmed at 1100C for 40-50 minutes then the biodiesel was gathered.

**Engine performance test set up**

A four-stroke single-tube shaped diesel motor (figure no.) with the current dynamometer in whirlpool was used for this test. The determinations of the motor are appeared in Table no. 2. The channel valve opens at 4.50 before top right on target and shuts down at 35.50 after base perfectly focused, the fumes valve opens 35.50 before base flawlessly focused and closes 4.50 after top flawlessly focused. The motor was tried with unadulterated diesel and arranged mixes of mahua and castor biodiesel at 25%, half, 75% and 100% stacking at a speed of 1500 rpm in particular. The motor was turned over with standard diesel fuel and heated up. The Heat Up periods closes Once temperature of the cooling water is is settled. The brake power, Explicit fuel utilization, brake warm proficiency and fumes gas temperature were estimated with various mixes of mahua and castor methyl ester.

**RESULT AND DISCUSSION**

Transient motors tests were done utilizing mixer of mahua and castor biodiesel with diesel so as to consider their impact on motor execution parameters at different burdens 2, 4, 6 and 8. The significant exhibition parameters of the motor, for example, BP, SFC and BTE acquired because of running the motor with biodiesel are contrasted and that of utilizing diesel fuel. The engine discharges is additionally estimated by methods for fumes gas analyser. A relative report is made on the sythesis of various gases, for example, CO, CO<sub>2</sub>, NO<sub>x</sub> and HC with the outcomes acquired by utilizing diesel and castor biodiesel.

**Engine Performance test**

The castor and mahua biodiesel blends are B10, B20, B30 i.e. 10% biodiesel in 90% diesel, 20% biodiesel in 80% diesel and 30% biodiesel with 70% diesel respectively and table 2 shows the BP of biodiesels against the loads and it's increasing with increase in loads. Here the BP of Diesel, castor and Mahua-Castor Mix slightly changed with respect to the load value. When the load increases the BP of Diesel, castor and the mahua- Castor mix is increasing and is clear from figure-1. The castor and mahua biodiesel blends are B10, B20, B30 i.e. 10% biodiesel in 90% diesel, 20% biodiesel in 80% diesel and 30% biodiesel with 70% diesel respectively. When the load increases the  $\eta_{bth}$  of Diesel, castor and the mahua- Castor mix is increasing. Here the  $\eta_{bth}$  of Diesel, castor and Mahua-Castor Mix slightly changed with respect to the load value as evidence from table-3 and figure-2.

The castor and mahua biodiesel blends are B10, B20, B30 i.e. 10% biodiesel in 90% diesel, 20% biodiesel in 80% diesel and 30% biodiesel with 70% diesel respectively and SFC of Diesel, castor and Mahua-Castor Mix slightly changed with respect to the load value. When the load decreases the SFC of Diesel, castor and the mahua- Castor mix is decreasing and the data were recorded in table-4. Figure-3 shows the variation of the SFC with respect to the load of the Diesel, castor and the Mahua- Castor mixer.



**Itishree Moharana and Chittaranjan Routray****Emission of CO (Carbon Monoxide)**

Analysis of Diesel, Castor B10 and Mahua-Castor Mix. The castor and mahua biodiesel blends are B10, B20, B30 i.e. 10% biodiesel in 90% diesel, 20% biodiesel in 80% diesel and 30% biodiesel with 70% diesel respectively. CO% of Diesel, Castor B10 and Mahua-Castor Mix Here the CO% of was Castor B10 and Mahua-Castor Mix slightly changed with respect to the load value. When the load increases the Co% of Diesel, castor B10 and the mahua- Castor mix is decreasing respectively as evidence from table-5 and figure-4.

**Emission with CO<sub>2</sub> (Carbon dioxide)**

Analysis of Diesel, Castor B10 and Mahua-Castor Mix. The castor and mahua biodiesel blends are B10, B20, B30 i.e. 10% biodiesel in 90% diesel, 20% biodiesel in 80% diesel and 30% biodiesel with 70% diesel respectively. CO<sub>2</sub>% of Diesel, Castor B10 and Mahua-Castor Mix Here the CO<sub>2</sub>% of was Castor B10 and Mahua-Castor Mix slightly changed with respect to the load value. When the load increases the CO<sub>2</sub>% of Diesel, castor B10 and the mahua- Castor mix is increasing respectively as shown in Table-6.

**Emission with HC (Hydrocarbon)**

Analysis of Diesel, Castor B10 and Mahua-Castor Mix. The castor and mahua biodiesel blends are B10, B20, B30 i.e. 10% biodiesel in 90% diesel, 20% biodiesel in 80% diesel and 30% biodiesel with 70% diesel respectively. HC% of Diesel, Castor B10 and Mahua-Castor Mix. Here the HC% of was Castor B10 and Mahua-Castor Mix slightly changed with respect to the load value. When the load increases the HC of Diesel, castor B10 and the mahua- Castor mix is increasing respectively as recorded in table-7 and analyzed in figure-6.

**Emission with NO<sub>x</sub> (Nitric Oxide)**

Analysis of Diesel, Castor B10 and Mahua-Castor Mix: The castor and mahua biodiesel blends are B10, B20, B30 i.e. 10% biodiesel in 90% diesel, 20% biodiesel in 80% diesel and 30% biodiesel with 70% diesel respectively. HC% of Diesel, Castor B10 and Mahua-Castor Mix. Here the HC% of was Castor B10 and Mahua-Castor Mix slightly changed with respect to the load value. When the load increases the HC of Diesel, castor B10 and the mahua- Castor mix is increasing respectively as given in table-8. Figure-7 shows the variation of the HC% with respect to the load of the Diesel, castor B10 and the Mahua- Castor mix.

**CONCLUSION**

Biodiesel has attracted considerable research due to its economic and environmental benefits and its renewable origin. Biodiesel produced from non-edible oil resources will defy the use of biodiesel production from edible oil. Consequently, its demand is gradually rising, and researchers are looking for possible newer sources of non-edible oil is a promising source that can sustain biodiesel growth. The performance and emissions tests were conducted with diesel, and blends of Castor oil biodiesel and Mahua oil biodiesel at different loads and constant speed (1500rpm). Double biodiesel from the experimental results obtained compared to smooth diesel service of Castor oil and Mahua oil. The engine output is comparable and emissions are slightly higher. All the dual biodiesels tested result in a slightly lower Thermal performance and increased levels of smoke, and CO. The biodiesel emission analysis and its blend yielded the best results compared to the single fuel. The existing engine could be operated on the dual biodiesel tested without any modification. India being an agricultural country, the energy from bio sectors will be highly beneficial for both plantation as well as transportation. Thus Castor oil biodiesel, Mahua oil biodiesel blended dual biodiesel will be a highly beneficial fuel in terms of both economy as well as fuel independence because this Castor oil, Mahua oil will be easily available as long as air and water are available in the earth. The results show that, dual blended biodiesel will be a good substitute and it could replace diesel in future.





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**Table-1: Engine specification**

Description	Value and unit
<b>BHP</b>	5
<b>Speed</b>	1500 rpm
<b>Number of cylinders</b>	ONE
<b>Compression ratio</b>	16.5:1
<b>Bore</b>	80mm
<b>Stroke</b>	110mm
<b>Orifice Diameter</b>	20mm
<b>Type of ignition</b>	Compression ignition
<b>Method of loading</b>	Eddy current dynamometer
<b>Method of starting</b>	Crank start

**Table 2: BP of Diesel, castor and Mahua-Castor Mix**

LOAD(kg)	BP DIESEL	BP Castor	BP Castor-Mahua Mix
2	0.71	0.57	0.61
4	1.17	1.15	1.18
6	1.78	1.77	1.79
8	2.33	2.29	2.31
10	2.76	2.68	2.71

**Table 3: □bth of Diesel, castor and Mahua-Castor Mix**

LOAD(kg)	□bth DIESEL	□bth Castor	□bth Castor-Mahua mix
2	12.48	10.56	11.78
4	16.84	16.3	16.45
6	21.92	21.62	21.76
8	25.08	24.8	24.92
10	28.75	28.44	28.56




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**Table 4: SFC of Diesel, castor and Mahua-Castor Mix**

LOAD (Kg)	SFC	SFC	SFC
	DIESEL	CASTOR	Castor-Mahua mix
2	0.7	0.94	0.92
4	0.51	0.57	0.56
6	0.39	0.41	0.4
8	0.34	0.37	0.35

**Table No. 5: The Changing of CO of Diesel, Castor B10 and Mahua-Castor Mix**

Load	CO	CO	CO
	Diesel	Castor B10	Mahua-Castor Mix
2	0.09	0.06	0.05
4	0.08	0.05	0.04
6	0.06	0.05	0.04
8	0.05	0.04	0.04

**Table-6: The Changing of Co2% of Diesel, Castor B10 and Mahua-Castor Mix**

LOAD	CO <sub>2</sub>	CO <sub>2</sub>	CO <sub>2</sub>
	Diesel	Castor B10	Castor -Mahua mix
2	2.7	2.6	2.7
4	3	2.9	3
6	3.5	3	3.2
8	3.7	3.1	3.4

**Table 7: The Changing of HC% of Diesel, Castor B10 and Mahua-Castor Mix**

Load	HC	HC	HC
	Diesel	Castor B10	Castor-Mahua mix
2	19	17	16
4	38	25	22
6	40	27	23
8	43	28	26

**Table -8: The Changing of HC% of Diesel, Castor B10 and Mahua-Castor Mix**

LOAD	NO <sub>x</sub>	NO <sub>x</sub>	NO <sub>x</sub>
	diesel	Castor B10	Mahua-Castor mix B10
2	37	45	48
4	107	118	120
6	156	160	161
8	201	216	218





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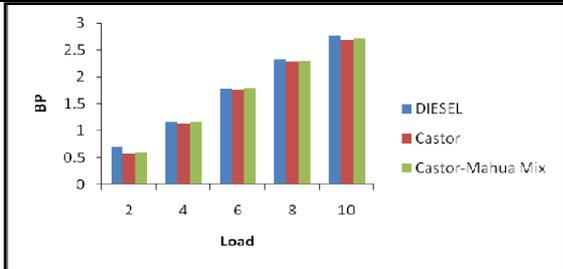


Figure-1: The Difference of the BP with respect to the load of the Diesel, castor and the Mahua- Castor mix.

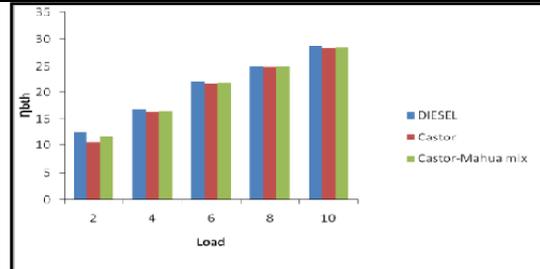


Figure-2: The variation of the  $\eta$  with respect to the load of the Diesel, castor and the Mahua- Castor mix.

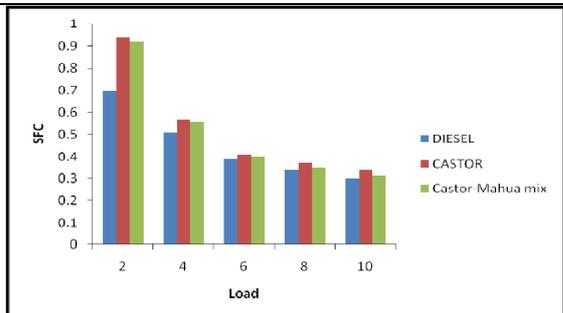


Figure-3: variation of the SFC with respect to the load of the Diesel, castor and the Mahua- Castor mix.

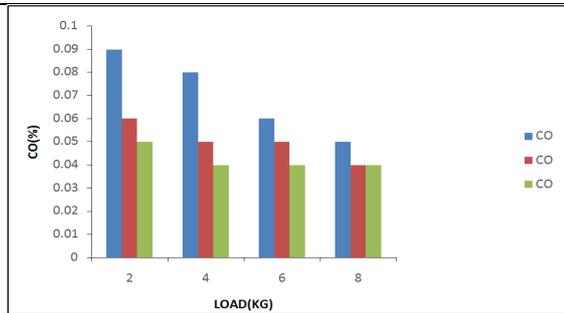


Figure-4: variation of the Co% with respect to the load Of the Diesel, castor B10 and the Mahua- Castor mix.

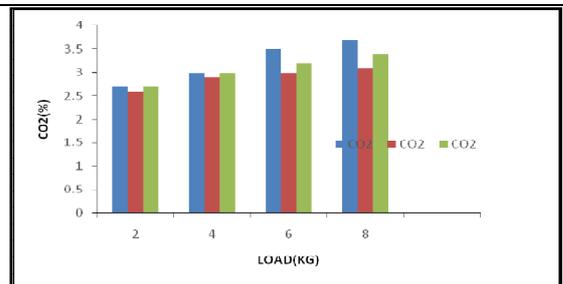


Figure -5: variation of the CO<sub>2</sub>% with respect to the load Of the Diesel, castor B10 and the Mahua- Castor mix.

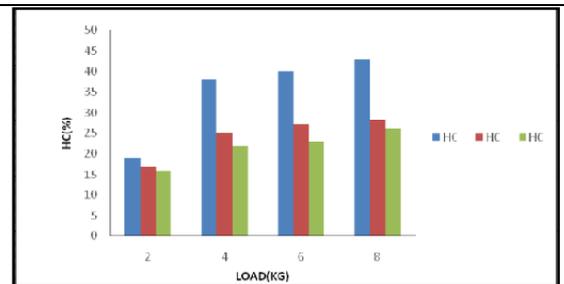


Figure-6: Graph represents the variation of the HC% with respect to the load of the Diesel, castor B10 and the Mahua- Castor mix.

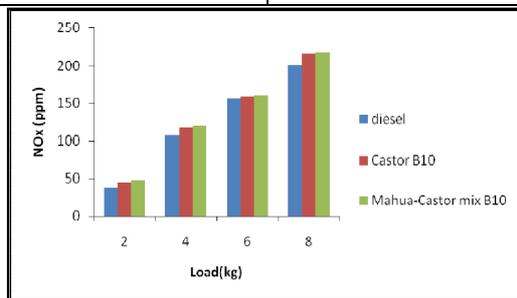


Figure-7: variation of the HC% with respect to the load of the Diesel, castor B10 and the Mahua- Castor mix.





## The Boundary Layer form of the Navier-Stokes Equations and their Treatments

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### ABSTRACT

The main purpose of this paper is to study of Navier stokes equations, Concept of boundary layer. Prandtl hypothesis & implications, Nal of Boundary layer equations, Solution techniques and then we Illustrate Biasus flow.

**Keywords:** Biasus flow, Navier stokes equations, prandtl boundary layer equation

## INTRODUCTION

We study the boundary layer formed near a rigid wall by a low-viscosity incompressible fluid that solves the Navier-Stokes equations (NSE) linearized around a smooth and stationary Euler flow. In exterior domains, such equations model the flow around an obstacle moving at constant velocity, the classical Oseen system, where the steady profile is also spatially homogeneous.

### Navier Stokes Equations

(For incompressible fluids)

$$\frac{Du}{Dt} = \bar{g} - \frac{1}{\rho} \nabla p + \nabla^2 \bar{u}$$

where  $\rho$  = density of fluid  
 $\nu$  = kinematic viscosity of fluid  
 $p$  = static pressure  
 $\bar{u}$  = velocity field





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$$\vec{g} = \text{body force per unit mass}$$

$$\frac{D}{Dt} = \frac{\partial}{\partial t} + u \frac{\partial}{\partial x} + v \frac{\partial}{\partial y} + w \frac{\partial}{\partial z}$$

substantial derivative

**Navier Stokes equations-features**

- Elliptic partial differential equations.
- Boundary conditions required on entire boundary.
- Difficult to get analytical solutions for the general case
- Simplifying assumptions and/or approximations required.

**Concept of boundary layer-Application**

- Wherever fluid flows near a solid surface of another stationary fluid.
- Ex. Fluid flow around submerged bodies in pipes, in jets etc.
- Boundary layer entirely accounts for the effects of fluid viscosity.
- Primarily useful for calculating shear stresses on the surface of the solid body and thus the total drag force on it due to the flowing fluid.
- Ex. Estimation of drag force on an airplane, the body of a swimmer, on a racing car, in wind tunnel testing etc. [1]
- Also useful for estimating other parameters such as entrance length in pipe flow, momentum transfer due to jet etc.

**Concept of boundary layer-Need**

- Away from solid boundaries effect of fluid viscosity negligible.
- Navier stokes equations reduced to Euler equations[2]

$$\frac{D\vec{u}}{Dt} = \vec{g} - \frac{1}{\rho} \nabla p$$

$\vec{u}$  = Velocity fluid

$\vec{g}$  = body force per unit volume

$\rho$  = density of fluid

P = static pressure

$$\frac{D}{Dt} = \text{substantial derivative}$$

- Euler’s equation is of first order
- Cannot satisfy both boundary conditions near solid surface.

$$u_n = 0 \quad (\text{no penetration condition})$$

$$u_t = 0 \quad (\text{no slip condition})$$

where  $u_n$  = velocity component normal to solid surface

$u_t$  = velocity component tangential to solid surface

- So it’s a good approximation near the surface
- On the surface of the solid boundary.





- $u = 0$  where  $u$  = component of velocity parallel to free stream velocity.
- In the free stream:  
 $u = U$ , where  $U$  = free stream velocity.

Boundary layer thickness defined as the thickness over the solid surface over which  $u$  varies from 0 to  $99U$ .

**Main Results**

**Prandtl hypothesis & implications**

The hypothesis:

For fluids of low viscosity, viscous forces significant only in a narrow region surrounding the solid boundary.

i.e.  $\delta \ll L$

where  $\delta$  = boundary layer thickness

$L$  = characteristic length of system

Implications of this hypothesis brought out by examining non-dimensional form of the Navier-Stokes and continuity equations.

Non-dimensional variables:[3]

$$u^* = \frac{u}{U_\infty}, v^* = \frac{v}{U_\infty}, p^* = \frac{p}{\rho U_\infty^2}, x^* = \frac{x}{L}, y^* = \frac{y}{L}$$

where  $U_\infty$  = free stream velocity

$\rho$  = density of fluid

$L$  = characteristic length of system

$u$  = velocity component parallel to  $U_\infty$

$v$  = velocity component normal to  $U_\infty$

$x$  = co-ordinate along the free stream velocity

$y$  = co-ordinate normal to the free stream velocity

$p$  = static pressure

Order of magnitude of boundary layer variables:

$$\partial u \sim U_\infty, \partial x \sim L, \partial y \sim \delta$$

$$\Rightarrow \partial u^* \sim 1, dx^* \sim 1, dy^* \sim \epsilon$$

$$\epsilon = \frac{\delta}{L} \ll 1$$

where

Non-dimensional form of governing equations (2-D steady flow continuity equation)

$$\frac{\partial u^*}{\partial x^*} + \frac{\partial v^*}{\partial y^*} = 0$$

$$\frac{1}{1} + \frac{?}{\epsilon} = 0$$

$$\Rightarrow \partial v^* \sim \epsilon$$

Order of magnitude of boundary layer variables:

$$v^*(x^*, y^*) = v^*(x^*, 0) + \left( \frac{\partial v^*}{\partial y^*} \right) \delta y^* \sim \epsilon$$





$$\Rightarrow v^* \approx (0) + (1)(\epsilon) \Rightarrow v^* \sim \epsilon$$

$$u^*(x^*, y^*) \approx u^*(x^*, \epsilon) + \frac{\partial u^*}{\partial y^*}(y^* - \epsilon)$$

$$\Rightarrow u^* \sim (1) + \left(\frac{\partial u^*}{\partial y^*}\right)(\epsilon - \epsilon) \Rightarrow u^* \sim 1$$

x-momentum (neglecting gravity effects):

$$u^* \frac{\partial u^*}{\partial x^*} + v^* \frac{\partial u^*}{\partial y^*} = -\frac{\partial p^*}{\partial x^*} + \frac{1}{\text{Re}} \left[ \frac{\partial^2 u^*}{\partial x^{*2}} + \frac{\partial^2 u^*}{\partial y^{*2}} \right]$$

$$(1) \frac{(1)}{(1)} + (\epsilon) \frac{(1)}{(\epsilon)} = ? + \frac{1}{\text{Re}} \left[ \frac{(1)}{(1)} + \frac{(1)}{(\epsilon^2)} \right]$$

$$\Rightarrow \frac{\partial p^*}{\partial x^*} - 1 \quad \& \quad \frac{\partial^2 u^*}{\partial x^{*2}} \square \frac{\partial^2 u^*}{\partial y^{*2}}$$

$$\Rightarrow \text{Re} - \frac{1}{\epsilon^2} \quad (\text{Re} = \text{Reynolds number})$$

Another way of showing  $\text{Re} \sim 1/\epsilon^2$

- Let  $L_1 =$  inertial force &  $V_1 =$  Viscous force in a high Re flow
- At  $y > \delta.1 \gg V_1$ , while at  $y = 0.1, f_1 = 0, V_1 \gg 1$
- Hence for  $0 < y < \delta.1$

$$u \frac{\partial u}{\partial x} \sim v \frac{\partial^2 u}{\partial y^2} \Rightarrow \frac{U_\infty^2}{L} - \frac{vU_\infty}{\delta^2}$$

$$\Rightarrow \frac{U_\infty L}{v} - \frac{L^2}{\delta^2} \Rightarrow \text{Re} - \frac{1}{\epsilon^2}$$

y-momentum equation (neglecting gravity effects):

$$u^* \frac{\partial v^*}{\partial x^*} + v^* \frac{\partial v^*}{\partial y^*} = \frac{\partial p^*}{\partial y^*} + \frac{1}{\text{Re}} \left[ \frac{\partial^2 v^*}{\partial x^{*2}} + \frac{\partial^2 v^*}{\partial y^{*2}} \right]$$

$$(1) \frac{(\epsilon)}{(1)} + (\epsilon) \frac{(\epsilon)}{(\epsilon)} = ? + (\epsilon) \left[ \frac{(\epsilon)}{(1)} + \frac{(\epsilon)}{(\epsilon^2)} \right]$$

$$\Rightarrow \frac{\partial p^*}{\partial y^*} \sim \epsilon \Rightarrow \frac{\partial p^*}{\partial y^*} \approx 0$$

Final form of the boundary layer equations;

$$\frac{\partial u^*}{\partial x^*} + \frac{\partial v^*}{\partial y^*} = 0 \Rightarrow \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

$$\frac{\partial p^*}{\partial y^*} = 0 \Rightarrow \frac{\partial p}{\partial y} = 0$$





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$$u^* \frac{\partial u^*}{\partial x^*} + v^* \frac{\partial u^*}{\partial y^*} = -\frac{dp^*}{dx^*} + \frac{1}{\text{Re}} \frac{\partial^2 u^*}{\partial y^{*2}} \Rightarrow u \frac{\partial u}{\partial x} + v \frac{\partial v}{\partial y} = -\frac{1}{\rho} \frac{dp}{dx} + \nu \frac{\partial^2 u}{\partial y^2}$$

Boundary conditions:

$$\text{at } y = 0, u = v = 0 \Rightarrow \text{at } y^* = 0, u^* = v^* = 0$$

$$\text{at } y = \delta, u = U_\infty \Rightarrow \text{at } y^* = \varepsilon, u^* = 1$$

To show that the boundary layer equations reduce to those for inviscid flow at the edge of the boundary layer: [4]

At  $y = \delta$  and beyond,  $u = U_\infty$  and

$$\frac{\partial u}{\partial y} = 0 \Rightarrow \frac{\partial^2 u}{\partial y^2} = 0$$

The x-momentum equation then reduces to:

$$u \frac{\partial u}{\partial x} + v(0) = -\frac{1}{\rho} \frac{dp}{dx} + v(0)$$

$$\Rightarrow U_\infty \frac{dU_\infty}{dx} + \frac{1}{\rho} \frac{dp}{dx} = 0$$

$$\Rightarrow p \frac{1}{2} \rho U_\infty^2, \frac{d}{dx} \left[ \left( \frac{1}{2} \rho v^2 + p \right) \right] = 0$$

= constant (Bernoulli equation)

### Physical significance of the terms

#### Continuity equations

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

- The continuity equation expresses the law of mass conservation for an incompressible fluid.
- The LHS is the divergence (in 2-D) of the velocity field which signifies the rate of mass production at a given point in the flow field.
- Since in the flow field considered there are no sources of mass production, it is identically equal to zero throughout the field.

#### y-momentum equation

$$\frac{\partial p}{\partial y} = 0$$

- Expresses the fact that there is no pressure variation along the direction normal to the solid surface.
- This means that the pressure at any location  $x$  in the boundary layer is same as that in the outer inviscid region.[5]
- The variation of pressure in the inviscid region can be calculated by solving the Euler equations for the external flow field and the same can be used inside the boundary layer.
- Thus pressure is not an unknown quantity in the boundary layer equations. It is simply imposed on it by the external inviscid flow.





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### Z-momentum equation

$$u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = -\frac{1}{\rho} \frac{dp}{dx} + \nu \frac{\partial^2 u}{\partial y^2}$$

- LHS denotes the inertial force on a fluid element.
- First term on RHS denotes the driving force for fluid flow in the boundary layer.
- It determines when separation of boundary layer from solid surface will occur.
- The last term accounts for the viscous shear stresses set up in the fluid due to the velocity gradient inside the boundary layer.
- Outside the boundary layer, it becomes negligible as the partial derivative goes to zero: hence the flow is essentially inviscid outside the boundary layer.
- Boundary layer equations are parabolic in nature.[6]
- Require only initial conditions.
- Solution progresses in flow direction by forward marching integration techniques.
- Based on the laws of similarity for boundary layer flows.
- u component of velocity with two velocity profiles of u(x,y) at different x locations differ only by scale factors in u & y.
- Hence, velocity profiles u(x, y) at all values of x can be made congruent if they are plotted in coordinate which have been made dimensionless with reference to the scale factors.
- Local free stream velocity  $U_\infty(x)$  at a section x obvious scale factor for u, because dimensionless  $U^*(X^*)$  varies from 0 to 1 with y at all sections.
- Scale factor for y, g(x) taken equal to local boundary layer thickness so that  $y^*$  itself varies between 0 to 1.

$$\frac{u \left[ x \left\{ y / g(x) \right\} \right]}{U_\infty(x)} = \frac{u \left[ x \left\{ y / g(x) \right\} \right]}{U_\infty(x)}$$

The underlying principle of the analytical solution by the similarity technique is to define a similarity variable, which is a function of coordinates. [7]

Dependent variables expressed as function of the similarity variable.

Then we try to reduce the boundary layer equations which are partial differential equations to ordinary differential equations in terms of functions of the similarity variable.

Successfully accomplishing this leads to an ordinary differential equation with boundary conditions in terms of the similarity variable which can be solved very easily.

As an illustration, consider fluid flow over a flat plate (Blasius flow)

Flow field unbounded above the plate.

Hence no pressure variation in direction of flow.

Flow incident on flat plate with an angle of incidence zero.

We assume fluid is incompressible & gravity effects negligible in the thin boundary layer.

Hence we may apply the boundary layer equations derived earlier.

### Illustration: Blasius Flow Governing equations

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

$$\frac{\partial p}{\partial y} = 0$$





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$$\frac{1}{\rho} \frac{dp}{dx} = -U_{\infty} \frac{dU_{\infty}}{dx} = 0$$

$$\Rightarrow u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = v \frac{\partial^2 u}{\partial y^2}$$

Boundary conditions:

At  $y = 0, u = v = 0$

At  $y = \infty, u = U_{\infty}$

Eliminate continuity equation using stream function

$$u = \frac{\partial \psi}{\partial y}, v = \frac{\partial \psi}{\partial x}$$

The boundary layer equation transforms to:

$$\frac{\partial \psi}{\partial y} \frac{\partial^2 \psi}{\partial x \partial y} - \frac{\partial \psi}{\partial x} \frac{\partial^2 \psi}{\partial y^2} = v \frac{\partial^2 \psi}{\partial y^2} \dots\dots\dots(*)$$

$$\frac{\partial \psi}{\partial y} = U_{\infty} \text{ as } y \rightarrow \infty$$

$$\frac{\partial \psi}{\partial x} = 0, \frac{\partial \psi}{\partial y} = 0 \text{ at } y = 0$$

In accordance with the law of similarity we define a similarity variable

$$\eta = Ax^2 \text{ so that } \psi = \psi(x, y) = \psi(\eta, x)$$

Using boundary condition

as  $y \rightarrow \infty, u \rightarrow U_{\infty}$

$$\Rightarrow u(x, \infty) = \frac{\partial \psi}{\partial y} \Big|_{y \rightarrow \infty} = \frac{\partial \psi}{\partial \eta} \Big|_{\eta \rightarrow \infty} \frac{\partial \eta}{\partial y} = U_{\infty}$$

$$\Rightarrow Ax^2 \frac{\partial \psi}{\partial \eta} \Big|_{\eta \rightarrow \infty} = U_{\infty}$$

RHS is constant, so to make LHS constant  $\psi$  must be of the form:

$$\psi = Bx^* f(\eta) \Rightarrow u(x, \infty) = ABf(\infty) = U_{\infty}$$

Let  $AB = U_{\infty}$

$$\therefore f(\infty) = 1$$

Using second boundary condition:

$$u(x, 0) = \frac{\partial \psi}{\partial y} \Big|_{x=0} = ABf'(\eta) \Big|_{\eta=0} = 0 \Rightarrow f'(0) = 0$$

Using third boundary condition:

$$v(x, 0) = -\frac{\partial \psi}{\partial x} \Big|_{x=0} = -Bbx^{b-1} (\eta f' - f) \Big|_{\eta=0} = 0 \Rightarrow f(0) = 0$$





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- Substitute  $\psi$  in forms of  $\eta$  in the differential equation (.)
- Choose the free constants A, B & b such that x & y do not appear in the final equation resulting in:[8]

$$A = \sqrt{\frac{U_\infty}{v}}, B = \sqrt{U_\infty v} \quad \& \quad b = -\frac{1}{2}$$

Giving:

$$f(\eta)f'(\eta) + 2f''(\eta) = 0$$

With the boundary conditions:

$$f(0) = f'(0) = 0 \quad \& \quad f'(\infty) = 1$$

$$\eta = y\sqrt{\frac{U_\infty}{vx}} = \frac{y}{x} \text{Re}, \quad \psi = \sqrt{vU_\infty} f(\eta)$$

$$u = \frac{\partial \psi}{\partial y} = U_\infty f'(\eta), \quad v = -\frac{\partial \psi}{\partial x} = \frac{1}{2} \sqrt{\frac{vU_\infty}{x}} (\eta f' - f)$$

$$r_w = \mu \left. \frac{\partial u}{\partial y} \right|_{y=0} = \mu U_\infty f'(\eta) \left. \frac{\partial \eta}{\partial y} \right|_{y=0} = \mu U_\infty \sqrt{\frac{U_\infty}{vx}} f'(0)$$

$$\text{Re} = \frac{U_\infty}{v} = \text{Reynolds number}$$

$r_w$  = wall shear stress

$\mu$  = dynamic viscosity

- Thus the original variables (x, y, u and  $\phi$ ) are replaced by the two variables  $f'(u/U_\infty)$  &  $\eta$  in the similarity technique.
- By the Blasius equation, those two variable will uniquely determine the velocity profile at any location.
- Values of  $G(\infty)$  estimated from G curves, as in upper graph.
- Calculate improved guess of  $H(0)$  by finding the value  $H(0)$ , at which the line a b in the lower graph crosses the line  $G(\infty)=1$ .
- Using similar triangles

$$\frac{H(0)_2 - H(0)_1}{1 - G(\infty)} = \frac{H(0)_2 - H(0)_1}{G(\infty) - G(\infty)}$$

- Solve for  $H(0)_1$
- Repeat whole procedure using  $H(0)_2$  and better of the two initial guesses  $H(0)_1$  &  $H(0)_2$
- Continue till satisfactory results are obtained.

$f(\eta), f'(\eta)$  &  $f''(\eta)$  in the boundary layer.

Boundary layer thickness ( $\delta$ ):

$$u = 0.99U_\infty \Rightarrow f'(\eta) = 0.99 \Rightarrow \eta = 5$$

$$\Rightarrow \delta = \frac{50}{\sqrt{\text{Re}}}$$





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Displacement thickness ( $\delta_0$ ):

$$\delta_0 = \int_0^{\infty} \left(1 - \frac{u}{U_{\infty}}\right) dy = \frac{1.73}{\sqrt{Re}}$$

Momentum thickness ( $\delta_m$ ):

$$\delta_m = \int_0^{\infty} \frac{u}{U_{\infty}} \left(1 - \frac{u}{U_{\infty}}\right) dy = \frac{1.328}{\sqrt{Re}}$$

Location skin friction coefficient

$$C_{\infty} = \frac{r_w(x)}{\frac{1}{2}\rho U_{\infty}^2} = \frac{0.664}{\sqrt{Re}}$$

This result experimentally confirmed by Liepmann & Dhawan (1951).

If F is the total frictional force per unit width on a plate of length L.

$$F = \int_0^L r_w dx$$

Average skin friction coefficient:

$$\bar{C}_1 = \frac{F}{\frac{1}{2}\rho U_{\infty}^2 L} = \frac{1.328}{\sqrt{Re}}$$

$$Re = \frac{U_{\infty} L}{\nu}$$

#### Conclusion

Boundary layer flows occur ubiquitously in nature, hence important topic of study.

Prandtl's hypothesis reduces the general Navier Stokes equation to the boundary layer equations which are easier to solve. Analytical approach based on laws of similarity.

As an illustration, Blasius flow (unbounded fluid flow over a flat plate) was solved analytically.

#### Appendix

An appendix, if needed, should appear before the acknowledgments.

#### ACKNOWLEDGMENTS

These should be brief and placed at the end of the text before the references.

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**Table 1**

$\eta$	$f$	$f'$	$f''$
0	0	0	0.332
1	0.166	0.330	0.323
2	0.650	0.630	0.267
3	1.397	0.846	0.161
4	2.306	0.956	0.0642
5	3.283	0.992	0.0159
6	4.280	0.999	0.024
$\infty$	$\infty$	1.000	0





## Effect of Different Parameters on Production of *Sorghum* Using Machine Learning

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### ABSTRACT

*Sorghum* production depends upon different parameters like longitude, latitude, Rain (Jan-Dec), Rain (Nov-May), Rain (June-Oct), Temperature (Jan-Dec), Temperature(Nov-May), and Temperature(June-Oct) etc. The effect of these parameters on production of *Sorghum* is studied. *Sorghum* is the fifth most important cereal in the world in terms of the cropped area. It is mainly grown for animals and it is also used in food industry. *Sorghum* grain is generally a rich source of antioxidants such as polyphenols and carotenoids. Some *Sorghum* types are suitable for sugar extraction for ethanol production and the Stover can be used for the manufacture of plastics. Pipeline pilot module of Biovia software (DassultSystem of France) is used for computation. The software provides different built –in mechanism to develop a machine learning model and use the model for calculation.

**Keywords:** Neural network, *Sorghum*, Latitude, Longitude, Rain, Temperature.

## INTRODUCTION

### Machine Learning

Machine learning is a sub area of artificial intelligence, where by the terms refers to the ability of IT systems to independently find all the solutions of the problem by recognizing patterns in database. In order to enable the software to independently generate solution, the required algorithm and data must be fed into the system in advance and the respective analysis rules for the reorganisation of pattern in data stock must be defined. The system can perform the following tasks by machine learning.





### **Sorghum Production**

*Sorghum* is truly a versatile crop that can be grown as a grain, forage or sweet crop. *Sorghum* is one of the top five cereal crops in the world [1]. *Sorghum* is used for food, fodder and alcoholic beverages. It is drought-tolerant and heat-tolerant. It is an important food crop in Africa, Central America, south Asia [3] while the grain of *Sorghum* is edible, its leaves can sometimes contain hydrogen cyanide that are toxic to humans and animals also. Identification of genes that control cyanide production and release could lead to the development of cyanide-free *Sorghum* plants. In the *Sorghum* growing regions of Africa and Asia the grain is made into flour by hand pounding. Traditionally, water was added to the grain by up to 30-40% and the grain was decorticated by hand pounding with wooden pestles in a mortar for 10-15 min. The products of *Sorghum* are- Breads from Anna original bread mix, Kellogg's special k gluten free touch of brown sugar cereal etc.

*Sorghum* is an important tropical crop for food, fodder [2]. Botanically *Sorghum* belongs to the genus *Sorghum* and family Gramineae. There are several types of *Sorghum* including grain *Sorghum*, grass *Sorghum*, sweet *Sorghum* and broom corn [4]. Among known species the genus, *Sorghum* bicolor (L) Moench is important. *Sorghum* contains hydrogen cyanide [5]. It can tolerate high temperature throughout its life cycle better than any other crop. The maximum temperature for good growth of *Sorghum* is 26-30°C and the minimum temperature is 7-10°C and seedling growth may result if planted before soil temperature reaches 35°C. For high production, a medium-to-late maturing *Sorghum* cultivar (maturity within 110 to 130 days) requires approximately 450 to 650 mm of water during the growing season, daily use is low approximately 1 to 2.5 mm per day.

### **Objectives**

Objective of the present study is to determine the effect of various parameters on production of *Sorghum* using machine learning. In this study we can determine the suitable condition where the rice grows in a manner that we can get maximum profit.

## **MATERIALS AND METHODS**

### **Software used**

"Pipeline Pilot module of Biovia software" (Dassault Systems of France) is used for analysis. The software provides different built-in components to develop a "machine learning model" and use the model for prediction.

### **Methodology**

#### **Collection of data**

Data was collected about Longitude, Latitude and considered as input while production of *Sorghum* is used as output parameter.

#### **Development of deep learning neural network model**

The dataset was read using "Delimited Text Reader" component of pipeline pilot. The component was connected to the "Learn R Deep Neural Net Model". The output of the model was displayed using "HTML Table Viewer" component. The parameters for the "Learn R Deep Neural Net Model" component is a set as shown in Figure 3. The setting for which the experimental output parameter and the predicted parameter were close to a 45°C line were considered for the final model.

#### **Study of effect of different input parameters on *Sorghum* production**

Text files were prepared where one parameter was varied within the range of data analyzed. All other parameters were kept constant at an average value.





## RESULTS AND DISCUSSION

*Sorghum* production varies due to different reasons. However, the relationships are difficult to predict. Thus, this study focuses on the effect of various input parameters on the *Sorghum* production.

### Prediction ability of the model

Figure: 4 (a) shows the model developed. Figure 4(b) shows that the prediction ability of the model was good and the predictions were close to the experimental values.

### Prediction by the model

Figure 5: shows that the *Sorghum* production in the particular area is gradually increasing after the longitude crossed above  $85^{\circ}E$ , while the production of *Sorghum* is minimum in between longitude  $85^{\circ}E$  to  $90^{\circ}E$ . The results showed that high value of longitude favoured rice production. Figure 6: shows that the production of *Sorghum* is gradually increasing if the latitude exceeds  $18^{\circ}N$ . The analysis shows that *Sorghum* production is high at around  $25^{\circ}N$ . Figure 7: indicates that the production of *Sorghum* gradually decreasing when the rain amount in the month June-October exceeds  $300\text{ mm}$ . The production of crop is minimum when the rain is in between around  $80 - 300\text{ mm}$ . The production of *Sorghum* is very low if the rainfall during June-October is high (around  $600\text{ mm}$ ). Figure 8: shows that the *Sorghum* production is gradually increasing in the month November-May when the rain amount exceeds  $120$  and the *Sorghum* production is in the pick if the rain amount is between  $0$  to  $120$ . Figure-9: shows that the production of *Sorghum* gradually decreasing at the temperature increases. We can say *Sorghum* production in (jan –dec) inversely proportional to temperature. Figure-10: shows that the production of *Sorghum* is gradually decreasing when the temperature is increasing in November-May and after the temperature exceeds upto  $25$  crop production decreases. Figure 11: indicates that the production of *Sorghum* is inversely proportional to the temperature in June-October i.e. the *Sorghum* production is gradually decreasing when the temperature is increasing in June-October. Figure [12] shows that the production of *Sorghum* is gradually decreasing if the rain is increasing in between January-December. The production of *Sorghum* is maximum when the amount of the rain is minimum in January-December.

## CONCLUSIONS

The effect of different parameters on *Sorghum* production has been studied using Pipeline pilot. In figure 5 the results showed that *Sorghum* production is high at high values of longitude (above  $85^{\circ}N$ ). In figure 6 the result showed that the effect of latitude on *Sorghum* production increases in between  $0-25^{\circ}N$ .

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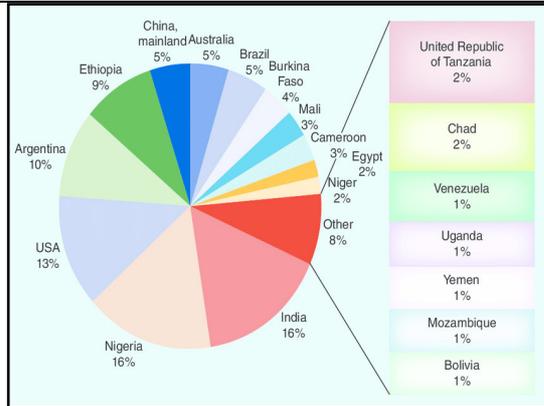


Figure 1: Sorghum production in different Country



Figure 2: Sorghum plant

Parameters	
LearnedProperty/Name	Predicted_Crop_Production
Name	sorghum
TypeOfProperty/IsLearn	Continuous
UseOfProperties	AllPropertiesOnFirstData
IOOutput	FitSummary   FitPlot
ML Options	
Method	net
ActivationFunction	sigm
HiddenLayers	5030
LearningRate	0.05
Momentum	0.9
NumEpochs	5000
MinibatchSize	2
HiddenDropoffFraction	0
VisibleDropoffFraction	0
Seed	12345
Learn Options	
Additional Options	

Figure 3.Parameters for the "Learn R Deep Neural Net Model" component

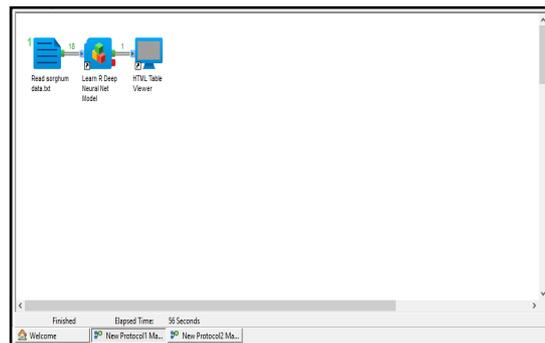


Figure 4 (a) Machine learning model

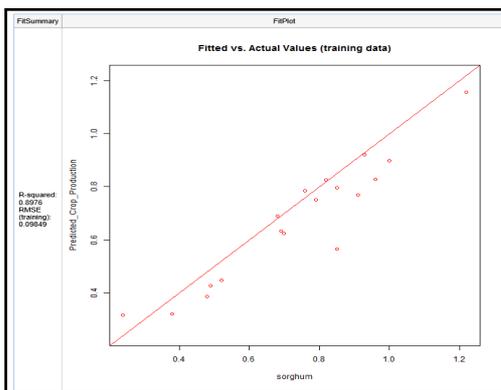


Figure 4 (b) Prediction capability of the model

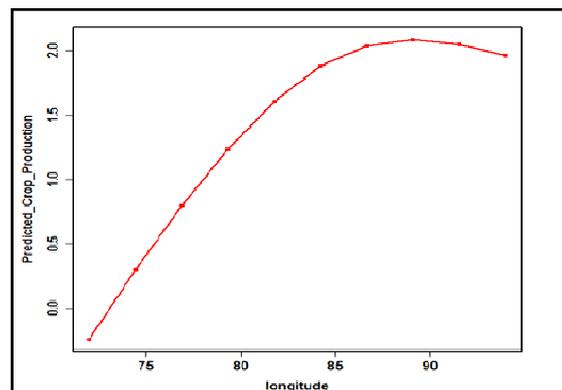


Figure 5: Effect of longitude in the production of Sorghum



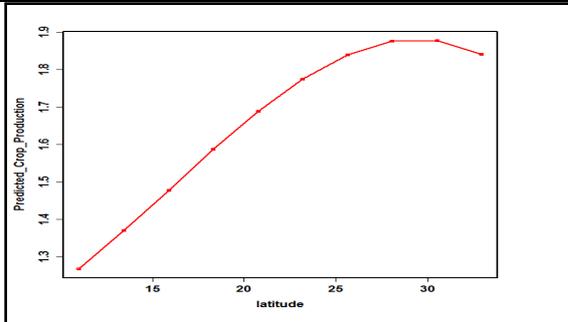


Figure 6: Effect of latitude on production of Sorghum

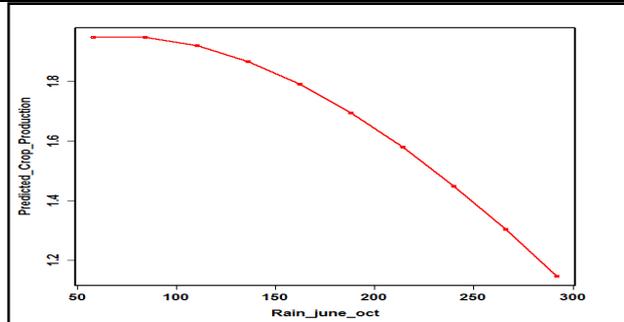


Figure 7: Effect of Rain on production of Sorghum

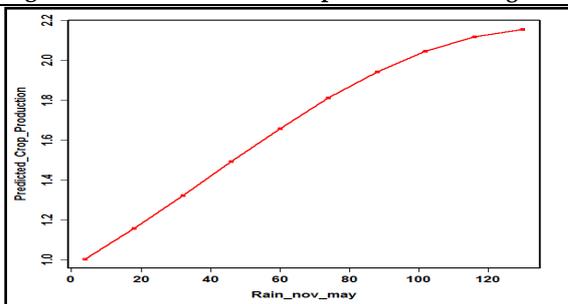


Figure-8: Effect of Rain in Nov-May in the production of Sorghum

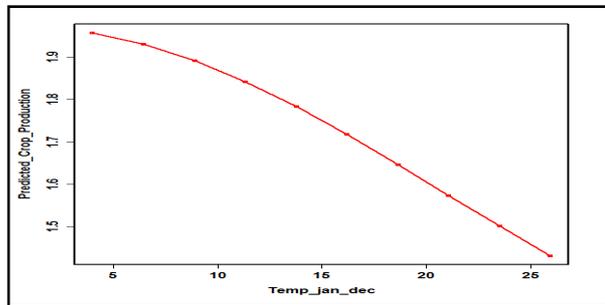


Figure 9: Effect of temp in Jan-Dec in the production of Sorghum

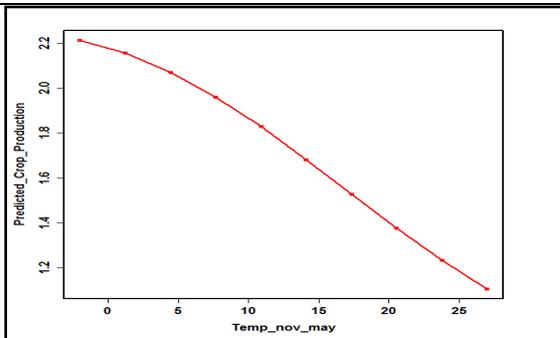


Fig 10: Effect of temperature in the month (Nov-May) on production of Sorghum

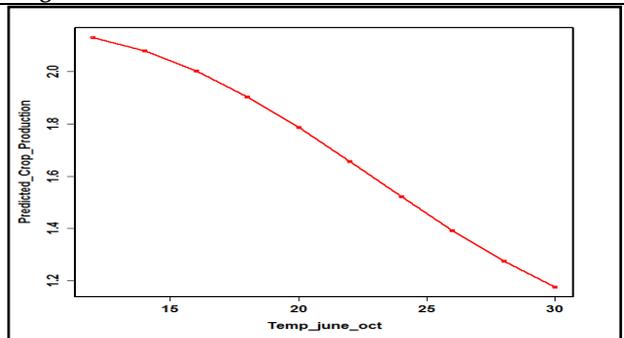


Figure 11: Effect of temperature in the month (June-Oct.) on production of Sorghum

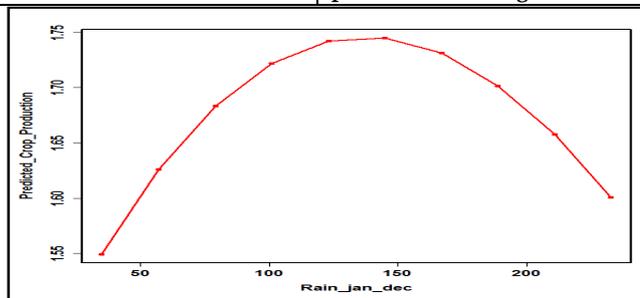


Fig 12: Effect of temperature in the month (Jan-Dce) on production of Sorghum





## Effect of Various Parameters on Stock Price of Axis Bank Using Machine Learning

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### ABSTRACT

The stock markets reflect to a large extent the economic development of a country. The banking industry has a strong grip on majority of shares in Indian stock trading market. The investors in the stock market use to bear certain risk for their predictable returns in the future. Investment decisions are usually taken by considering different fundamental factors both internal and external. Apart from fundamental factors which replicated in the security prices, there are numerous additional factors that can influence investment are stock prices, volume of trading, spread, turnover etc. The paper explores the effect of different variables on the high stock price of Axis Bank considering daily data over the period 4 Jan 2010 to 23 Apr 2020. For the study the “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization” were noted. High stock price was considered as output while other parameters were used as input. Pipeline Pilot module of Biovia software (Dassault Systemes of France) was used for analysis. The software provides different built-in components to develop a machine learning model and use the model for prediction.

**Keywords:** Bombay Stock Market, Axis Bank, High Stock Prices, WAP, Spread, Deliverable Quantity

## INTRODUCTION

### Background of the Study

Stock markets play a significant role in reflecting the monetary and economic condition of developing nations. Trading in the financial instruments like share, debenture and bonds of different companies used to be carried out in



**Mohammed Siddique and Pramod Kumar Patjoshi**

the capital market. The investors buy and sell on various financial instruments of different companies in the stocks market. As the demand and supply of different stocks in a specific time determines the stock prices, it varies in every minute. Thus, investments in the capital market involve risks as well as uncertainties associated with high level of instability or volatility. The investors in the stock market use to bear certain risk for their predictable returns in the future. As a result investments in stock market involve risk and returns (Savsani and Rathod, 2018).

While investing in the stock market, investors respond to the accessible data with them and take the decisions consequently based on their analysis. Investment decisions are usually taken by considering different variables like types of “investors, family back ground, age, occupation, sex, income, marital status, risk tolerance capacity, education, demographic environment and advice of financial expert and advisor” (Singh and Yadav, 2016). On the other hand, an investor considers internal factors (firm particulars) like company news and performance, industry performance, board structure, asset situation, dividends and earnings and external factors comprising of governmental policies, interest rates, economic outlook, inflation, business cycle, approach of investor, market environments and contingencies like strikes, lock outs etc. before making an investment decision (Graham and Dodd, 1934). Different theories indicate that apart from fundamental factors which replicated in the security prices, there are numerous additional factors that can influence investment are stock prices, volume of trading, spread, turnover etc. (Debasis, 2006).

Indian stock market has seen remarkable progress in last three decades in relations of contribution, volume of trade, financial instruments, procedures, dynamics and strategies of investment. The stock market is creating new record by achieving high market capitalisation in addition to incorporated with the international stock markets. Simultaneously, the various stock markets of different countries inside the economy are getting better (Ashraf and Baig, 2015). BSE has aided the development of the Indian company by contributing towards well-organized fund raising platform. Currently BSE delivers an effective and apparent market for buying and selling in equity, currencies, debt instruments, derivatives, mutual funds (bseindia.com).

**LITERATURE REVIEW**

DeBondt and Thaler (1985) examined the share prices by means of low long-term returns inclined to achieve higher expected returns. While Pesaran and Timmermann (1995), observed the strength of the indication on certainty of U.S. share prices returns and studied prediction of stock prices depends upon past trend oppressed by investors to earn profits in excess of a buy and hold strategy. Yartey (2008) investigated that the in developing countries the macro-economic issues like income level, gross domestic investment, banking sector development, private capital flows, and stock market liquidity are vital elements for the growth in stock market. The research also indicates that political risk, law and order, and bureaucratic quality are important elements of growth in stock market. Similarly, Hosseini, Ahmad and Lai (2011) observed the associations among stock market indices and four macro-economic elements, specifically crude oil price, money supply, industrial production as well as inflation rate in China and India. Aduda, Masila, and Onsongo (2012) examined the factors influencing the Nairobi Stock Exchange and brought out that, macro-economic features like stock market liquidity, institutional excellence, income per capita, domestic savings and bank growth are vital factors of growth in stock market. While Joshi (2013) in his research suggested that the foremost issues of accountable fluctuation in Indian stock market are investment of FIIs, political condition, growth of GDP, price level changes, liquidity and altered in interest rate. As indicated in the literature that performance of banking sector has an impact on stock market, an attempt is made to study the same.

**Indian Banking Industry**

India's banking sector is adequately capitalized by Reserve Bank of India (RBI) and well governed. RBI's new steps could go a long way in helping the domestic banking industry restructure. “The Indian banking system consists of 18 public sector banks, 22 private sector banks, 46 foreign banks, 53 regional rural banks, 1542 urban cooperative banks



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and 94384 rural cooperative banks as of September 2019. In FY2017-18, total lending increased at a CAGR of 10.94 per cent and total deposits increased at a CAGR of 11.66 per cent. India's retail credit market is the fourth largest in the emerging countries. It increased to US\$ 281 billion on December 2017 from US\$ 181 billion on December 2014" (www.ibef.org) Credit, market and liquidity risk studies suggest that Indian banks are generally resilient and have withstood the global downturn well. Indian banking industry has recently witnessed the roll out of innovative banking models like payments and small finance banks. The digital payments system in India has evolved in the last decade and with India's Immediate Payment Service (IMPS), being the only system at level 5, is the Faster Payments Innovation Index (FPII). Axis Bank is one of the pioneer public sector banks which are introducing innovative digital platforms for smooth running of the bank.

**MATERIALS AND METHODS****Software used**

Pipeline Pilot module of Biovia software (Dassault Systems of France) was used for analysis. The software provides different built-in components to develop a machine learning model and use the model for prediction.

**Methodology****Collection of data**

Data was collected from Bombay Stock Exchange on 23 Apr 2020 at around 9 PM for the period 4 Jan 2010 to 23 Apr 2020 for Axis Bank. Data for certain dates were not available. For each of the available dates weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close and the high stock price of the organization were noted. High stock price was considered as output while other parameters were used as input. In order to avoid numerical difficulties during computation and to prevent dominance of features with greater numerical ranges over smaller numerical ranges, normalization has been implemented during pre-processing stage. Here, normalization of data has been achieved by linearly scaling to [0, 1] using the following equation

$$NV_i = \frac{A_i - A_{min}}{A_{max} - A_{min}}, \text{ for } i = 1, 2, 3, \dots, l$$

where,  $A_i$  is the actual value of the  $i$ -th feature,  $l$  is the total number of data points available,  $A_{max}$  and  $A_{min}$  are the maximum and minimum values respectively, and  $NV_i$  is the corresponding normalized value

**Development of Deep Learning Neural Network Model**

The normalized dataset was read using "Delimited Text Reader" component of pipeline pilot. The component was connected to the "Learn R Deep Neural Net Model" component. The output of the model was displayed using "HTML Table Viewer" component. The parameters for the "Learn R Deep Neural Net Model" component were set as shown in Figure 1. The setting for which the experimental output parameter and the predicted parameter were close to a 45° line were considered for the final model.

**Study of effect of different input parameters on high stock price**

Text files were prepared where one parameter was varied within the range of 0 to 1. All other parameters were kept constant at 0.5. The 0.5 value was chosen arbitrarily for the normalized parameter value. Figure 2 shows a sample application developed for the purpose of studying the effect of parameter 1 (WAP) on high stock price.

**RESULTS AND DISCUSSION**

Stock prices vary every day due to different market forces. Share prices, on principle, change because of supply and demand. If more people want to buy a stock (demand) than sell it (supply), then the price moves up. On the other



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hand, if more people want to sell a stock than buy it, the price would fall. However, it is difficult to predict the factors what make people prefer a particular stock and dislike another stock. If an organization's earnings surprise (are better than expected), the stock price jumps up. If a company's results disappoint (are worse than expected), then the price falls. Apart from earnings, the sentiment towards a stock can control its price. The stock prices are volatile and can change due to number of parameters. However, the relationships are difficult to predict. Thus, this study focuses on the effect of various input parameters on the high stock price.

**Prediction ability of the model**

Figure 3 shows that the prediction ability of the model was good and the predictions were close to the experimental values.

**WAP**

A weighted average takes into account the number of shares purchased with each trade. It is important because it provides traders with insight into both the trend and value of a security. Institutions usually try to buy below the WAP, and sell above it. Thus, WAP controls the stock prices. As expected, Figure 4 shows that an increase in WAP increases the stock prices.

**Number of shares**

The principal theory is that the price movement of a stock indicates what investors feel about the worth of a company is worth. The number of shares a company holds controls the impression about the company. Thus, increase in number of shares increase the stock price (Figure 5).

**Number of Trades**

Every stock has a component of number of trades. Higher numbers of trades create a positive impression in the mind of the investors. Figure 6 shows that an increase in number of trades increases the stock price, as expected.

**Total turnover (in INR)**

In an emerging market, one of the noise indicators is turnover. Usually the investors use these noises to predict future prices of the stocks on a short-term time horizon. Turnover parameter is dynamic in nature and usually depends on the choice for the investors. For a rising market, a high turnover reflects the investors' affinity and is likely to increase the stock price. On the other hand, in falling market, usually high turnover accelerates fall in stock prices. Figure 7 shows that an increase in turnover decreases fall in stock prices indicating a possibility of a falling market.

**Deliverable Quantity**

Deliverable quantity is that portion of total traded quantity which actually drives a person taking delivery into Demat or selling from Demat. When the deliverable quantity increases and the stock price do not increase, then people are waiting for something nice to happen in the near future. This is a good indicator to hold the stock for a long term. Usually an increase in deliverable quantity should increase the stock price. Figure 8 shows that the stock price shows an increasing trend with the increase in the deliverable quantity.

**Percent deliverable quantity to traded quantity**

When the deliverable quantity percentage (with respect to total traded quantity) increases with increase in the stock price, then there is a bullish move on the stock. When the stock price decreases with increase in deliverable quantity percentage (with respect to total traded quantity), then there is a bearish move on the stock. Figure 9 shows that stock prices drop sharply after a slight hike with the increases in percent deliverable quantity to traded quantity.



**Mohammed Siddique and Pramod Kumar Patjoshi****Spread high and low**

One of the noise indicators is spread high and low. Usually the investors use these noises to predict future prices of the stocks on a short-term time horizon. The spread between high and low prices reflects the extremities of intra-day movement and it indicates boundaries of intra-day volatility. If the difference is high, the prices are susceptible to react more on instant market information. As this indicator is usually used under falling market condition, a hike in stock price with an increase in the spread high and low indicates good sign in the market for the investor (Figure 10).

**Spread open and close**

One of the noise indicators is spread open and close. Usually the investors use these noises to predict future prices of the stocks on a short-term basis. The spread between opening and previous closing prices is a differentially static price phenomenon. It shows the impulse of price movement during the period of no trading. Even if the nature of this noise is comparatively static, it can have a negative relationship with the stock price movements. Figure 11 also shows that increase in spread open and close negatively affects the stock price.

**CONCLUSIONS**

The fluctuation in the stock prices is effected by different fundamental factors both internal and external. Apart from fundamental factors which replicated in the security prices, there are numerous additional factors that can influence investment are stock prices, volume of trading, spread, turnover etc. This paper explores the effect of different variables on the high stock price of Axis Bank considering daily data over the period 4 Jan 2010 to 23 Apr 2020. Pipeline Pilot module of Biovia software (DassaultSystemes of France) was used for analysis. The software provides different built-in components to develop a machine learning model and use the model for prediction. The results show that WAP, number of shares, number of trades, deliverable quantity as well as spread high and low have similar effect on high price of Axis Bank during the study period. The increases in WAP, number of shares, number of trades, deliverable quantity as well as spread high and low increases the stock prices. On the contrary turnover as well as spread open and close have a reverse effect on high price of Axis Bank. And it is found that increase in turnover as well as spread open and closed decreases in stock prices indicating a possibility of a falling market. On the other hand stock prices drop sharply after a slight hike with the increases in percent of deliverable quantity of Axis Bank stock prices during the study period. Therefore, it can be concluded that relationship between WAP, number of shares, number of trades, deliverable quantity as well as spread high and low have significant effect on high price on stock of Axis Bank.

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Parameters	
LearnedPropertyName	Predicted_High_Price
Name	High_Price
TypeOfPropertyToLearn	Continuous
UseProperties	AllPropertiesOnFirstData
ROutput	FitSummary ; FitPlot
NN Options	
Method	nn
ActivationFunction	tanh
HiddenLayers	50 50
LearningRate	0.05
Momentum	0.6
NumEpochs	4000
MinibatchSize	150
HiddenDropoutFraction	0
VisibleDropoutFraction	0
Seed	123
Learn Options	
Numeric Distance Function	Euclidean
Fingerprint Distance Function	Tanimoto
Model Domain Fingerprint	FCFP_2
Additional Properties	
Additional Options	

Figure 1. Parameters for the "Learn R Deep Neural Net Model" component

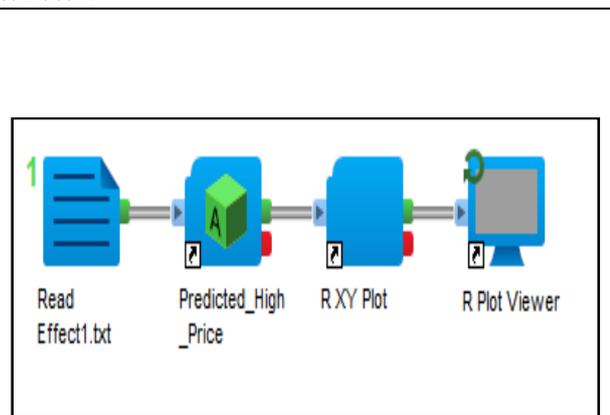


Figure 2. Use of trained model for prediction

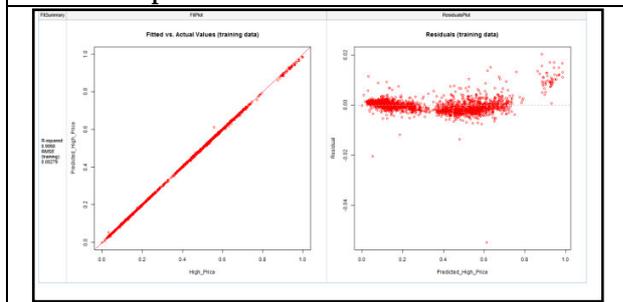


Figure 3. Prediction capability of the model

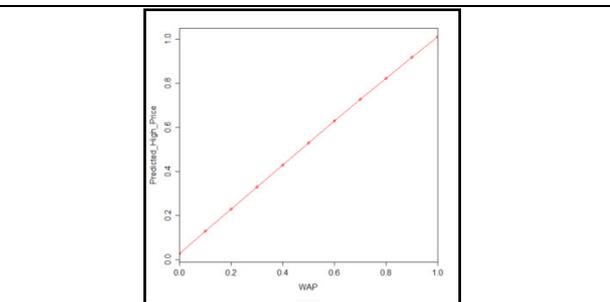


Figure 4. Effect of WAP on high stock price





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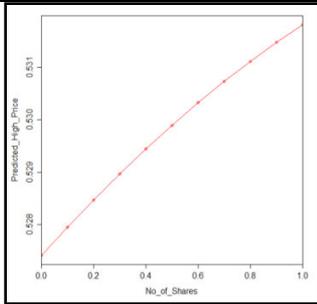


Figure 5. Effect of number of shares on high stock price

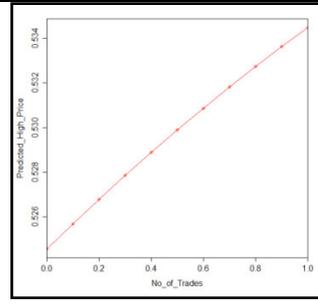


Figure 6. Effect of number of trades on high stock price

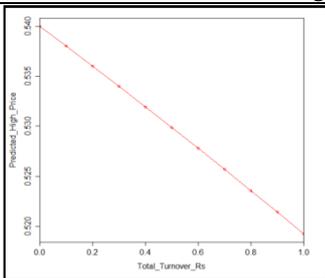


Figure 7. Effect of total turnover on high stock price

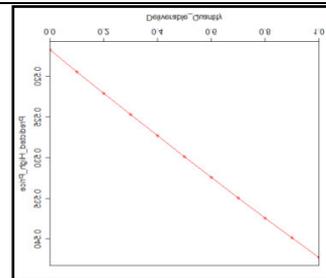


Figure 8. Effect of deliverable quantity on high stock price

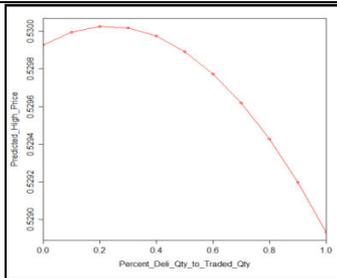


Figure 9. Effect of Percent deliverable quantity to traded quantity on high stock price

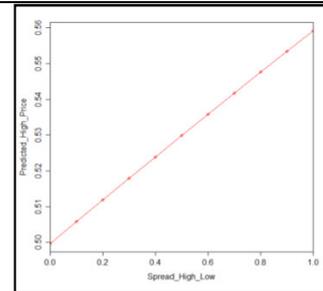


Figure 10. Effect of spread high and low on high stock price

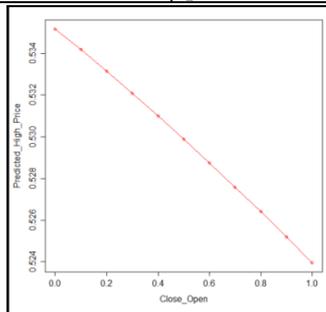


Figure 11. Effect of spread high and low on high stock price





## Impact of Various Parameters on Stock Price of State Bank of India Using Deep Learning Neural Network Model

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### ABSTRACT

The stock markets immensely contribute to the economic development of India. The banking industry has in its grip majority of shares in Indian stock trading market. The investors in the stock market use to bear certain risk for their predictable returns in the future. Investment decisions are usually taken by considering different fundamental factors both internal and external. Apart from fundamental factors which replicated in the security prices, there are numerous additional factors that can influence investment are stock prices, volume of trading, spread, turnover etc. The paper explores the effect of different variables on the high stock price of State Bank of India considering daily data over the period 4 Jan 2010 to 23 Apr 2020. For the study the “weighted average price (WAP), number of shares, number of trades, total turnover (in INR), deliverable quantity, percent deliverable quantity to traded quantity, spread high and low, spread open and close” and the high stock price of the organization were noted. High stock price was considered as output while other parameters were used as input. Pipeline Pilot module of Biovia software (Dassault Systemes of France) was used for analysis. The software provides different built-in components to develop a machine learning model and use the model for prediction.

**Keywords:** Bombay Stock Market, State Bank of India, High Stock Prices, WAP, Spread, Deliverable Quantity

### INTRODUCTION

Stock markets play a significant role in reflecting the monetary and economic condition of developing nations. Trading in the financial instruments like share, debenture and bonds of different companies used to be carried out in the capital market. The investors buy and sell on various financial instruments of different companies in the stocks

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market. As the demand and supply of different stocks in a specific time determines the stock prices, it varies in every minute. Thus, investments in the capital market involve risks as well as uncertainties associated with high level of instability or volatility. The investors in the stock market use to bear certain risk for their predictable returns in the future. As a result investments in stock market involve risk and returns (Savsani and Rathod, 2018).

While investing in the stock market, investors respond to the accessible data with them and take the decisions consequently based on their analysis. Investment decisions are usually taken by considering different variables like types of “investors, family back ground, age, occupation, sex, income, marital status, risk tolerance capacity, education, demographic environment and advice of financial expert and advisor” (Singh and Yadav, 2016). On the other hand, an investor considers internal factors (firm particulars) like company news and performance, industry performance, board structure, asset situation, dividends and earnings and external factors comprising of governmental policies, interest rates, economic outlook, inflation, business cycle, approach of investor, market environments and contingencies like strikes, lock outs etc. before making an investment decision (Graham and Dodd, 1934). Different theories indicate that apart from fundamental factors which replicated in the security prices, there are numerous additional factors that can influence investment are stock prices, volume of trading, spread, turnover etc. (Debasis, 2006).

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**Objective of the Study**

To analyse the effect of different variables on the high stock price of State Bank of India

**LITERATURE REVIEW**

DeBondt and Thaler (1985) examined the share prices by means of low long-term returns inclined to achieve higher expected returns. While Pesaran and Timmermann (1995), observed the strength of the indication on certainty of U.S. share prices returns and studied prediction of stock prices depends upon past trend oppressed by investors to earn profits in excess of a buy and hold strategy. Yartey (2008) investigated that the in developing countries the macro-economic issues like income level, gross domestic investment, banking sector development, private capital flows, and stock market liquidity are vital elements for the growth in stock market. The research also indicates that political risk, law and order, and bureaucratic quality are important elements of growth in stock market. Similarly, Hosseini, Ahmad and Lai (2011) observed the associations among stock market indices and four macro-economic elements, specifically crude oil price, money supply, industrial production as well as inflation rate in China and India. Aduda, Masila, and Onsongo (2012) examined the factors influencing the Nairobi Stock Exchange and brought out that, macro-economic features like stock market liquidity, institutional excellence, income per capita, domestic savings and bank growth are vital factors of growth in stock market. While Joshi (2013) in his research suggested that the foremost issues of accountable fluctuation in Indian stock market are investment of FIIs, political condition, growth of GDP, price level changes, liquidity and altered in interest rate. As indicated in the literature that performance of banking sector has an impact on stock market, an attempt is made to study the same.





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#### METHODOLOGY

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## RESULTS AND DISCUSSION

Stock prices vary every day due to different market forces. Share prices, on principle, change because of supply and demand. If more people want to buy a stock (demand) than sell it (supply), then the price moves up. On the other hand, if more people want to sell a stock than buy it, the price would fall. However, it is difficult to predict the factors what make people prefer a particular stock and dislike another stock. If an organization's earnings surprise (are better than expected), the stock price jumps up. If a company's results disappoint (are worse than expected), then the price falls. Apart from earnings, the sentiment towards a stock can control its price. The stock prices are volatile and can change due to number of parameters. However, the relationships are difficult to predict. Thus, this study focuses on the effect of various input parameters on the high stock price.

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**Pramod Kumar Patjoshi and Mohammed Siddique****Percent deliverable quantity to traded quantity**

When the deliverable quantity percentage (with respect to total traded quantity) increases with increase in the stock price, then there is a bullish move on the stock. When the stock price decreases with increase in deliverable quantity percentage (with respect to total traded quantity), then there is a bearish move on the stock. Figure 9 shows that there is a threshold below which there is interest in the stock and above which the investors lose interest in the stock.

**Spread high and low**

One of the noise indicators is spread high and low. Usually the investors use these noises to predict future prices of the stocks on a short-term time horizon. The spread between high and low prices reflects the extremities of intra-day movement and it indicates boundaries of intra-day volatility. If the difference is high, the prices are susceptible to react more on instant market information. As this indicator is usually used under falling market condition, a drop in stock price with an increase in the parameter indicates some issues in the market. In certain cases, spread of high and low may trigger selling (Figure 10).

**Spread open and close**

One of the noise indicators is spread open and close. Usually the investors use these noises to predict future prices of the stocks on a short-term basis. The spread between opening and previous closing prices is a differentially static price phenomenon. It shows the impulse of price movement during the period of no trading. Even if the nature of this noise is comparatively static, it can have a positive relationship with the stock price movements. Figure 11 also shows that above a threshold value it negatively affects the stock price.

**CONCLUSIONS**

The fluctuation in the stock prices is due to various fundamental internal and external factors. Apart from fundamental factors which replicated in the security prices, there are numerous additional factors that can influence investment are stock prices, volume of trading, spread, turnover etc. This paper explores the effect of different variables on the high stock price of State Bank of India considering daily data over the period 4 Jan 2010 to 23 Apr 2020. Pipeline Pilot module of Biovia software (Dassault Systems of France) was used for analysis. The software provides different built-in components to develop a machine learning model and use the model for prediction. The results show that WAP, number of shares and number of trades have similar effect on high price of State Bank of India during the study period. The increases in WAP, number of shares and number of trades increases the stock prices. On the contrary turnover have a reverse effect on high price of State Bank of India and found increase in turnover decreases in stock prices indicating a possibility of a falling market. On the other hand the percent deliverable quantities to traded quantity, deliverable quantity in addition to spread open and close have identical effect on State Bank of India stock prices during the study period. It found from the analysis that the percent deliverable quantities to traded quantity, deliverable quantity as well as spread open and close positive relationship with the stock price movements for a certain period and then shows above a threshold value it negatively affects the stock price. Therefore, it can conclude that relationship between WAP, number of shares, number of trades, percent deliverable quantities to traded quantity, deliverable quantity in addition to spread open and close have significant effect on high price on stock of State Bank of India.

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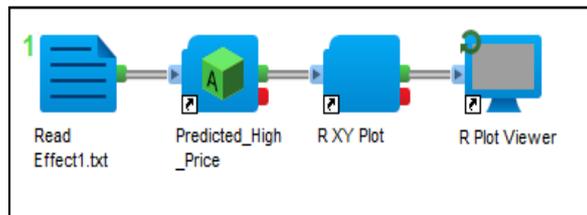


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Parameters	
LearnedPropertyName	Predicted_High_Price
Name	High_Price
TypeOfPropertyToLearn	Continuous
UseProperties	AllPropertiesOnFirstData
ROutput	FitSummary   FitPlot
NN Options	
Method	nn
ActivationFunction	tanh
HiddenLayers	50 50
LearningRate	0.05
Momentum	0.6
NumEpochs	4000
MinibatchSize	150
HiddenDropoutFraction	0
VisibleDropoutFraction	0
Seed	123
Learn Options	
Numeric Distance Function	Euclidean
Fingerprint Distance Function	Tanimoto
Model Domain Fingerprint	FCFP_2
Additional Properties	
Additional Options	

**Figure 1. Parameters for the "Learn R Deep Neural Net Model" component**



**Figure 2. Use of trained model for prediction**





Pramod Kumar Patjoshi and Mohammed Siddique

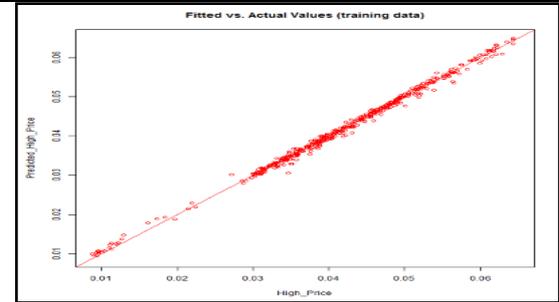


Figure 3. Prediction capability of the model

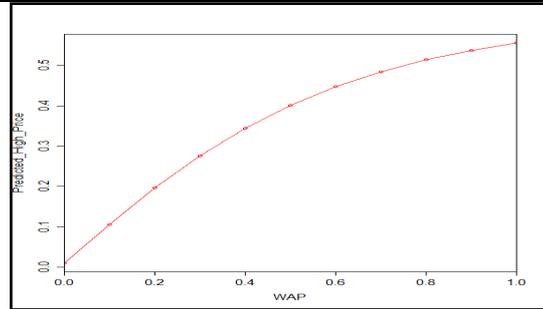


Figure 4. Effect of WAP on high stock price

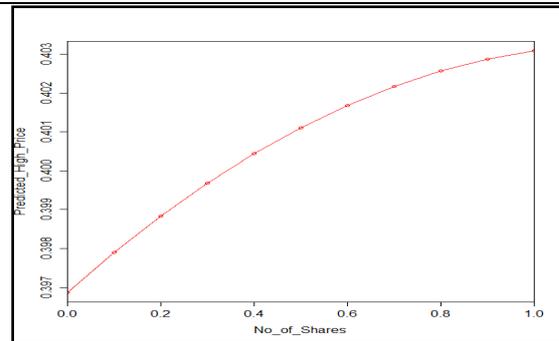


Figure 5. Effect of number of shares on high stock price

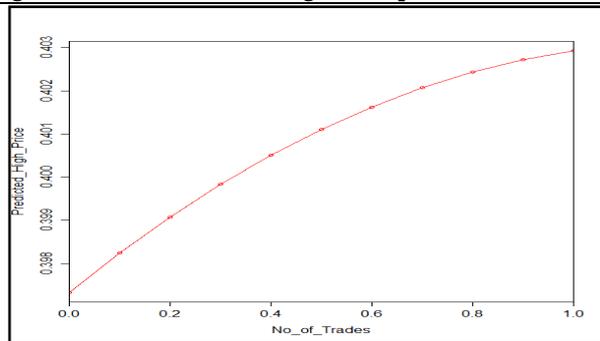


Figure 6. Effect of number of trades on high stock price

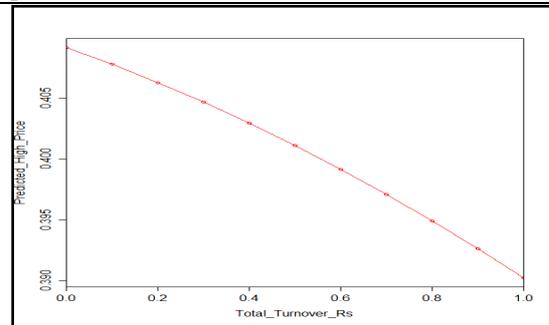


Figure 7. Effect of total turnover on high stock price

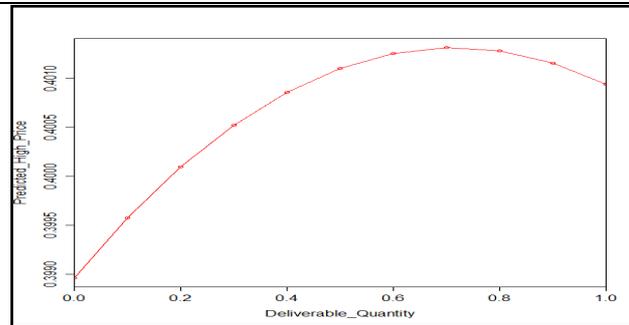


Figure 8. Effect of deliverable quantity on high stock price

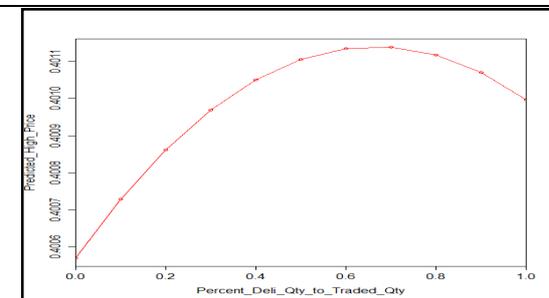


Figure 9. Effect of Percent deliverable quantity to traded quantity on high stock price

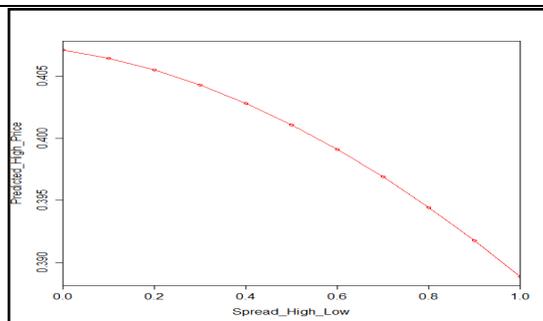


Figure 10. Effect of spread high and low on high stock price





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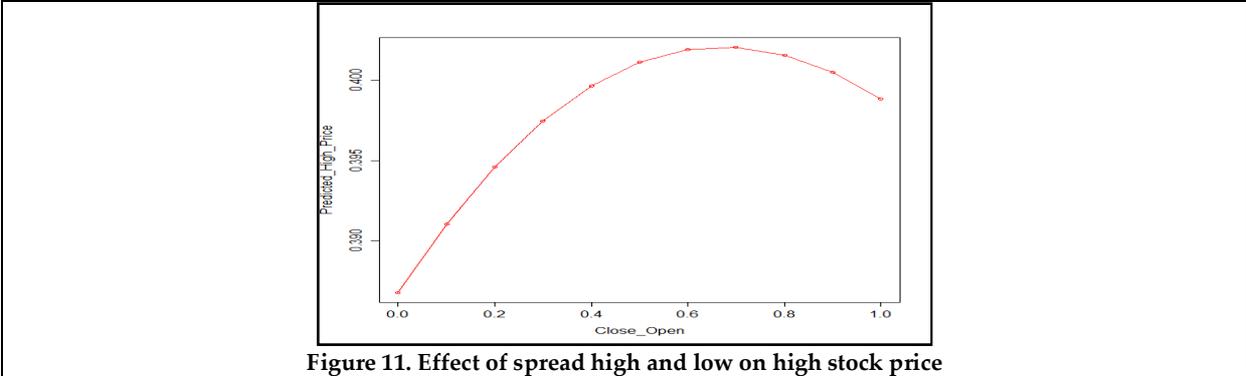


Figure 11. Effect of spread high and low on high stock price





## Role of Different Parameters on Production of Cotton using Machine Learning

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### ABSTRACT

Different parameters influence the production of cotton. For the study, the effects of longitude, latitude, Rain (Jan-Dec), Rain (Nov-May), Rain (June-Oct), Temperature (Jan-Dec), Temperature(Nov-May), and Temperature(June-Oct) on production of cotton was studied. "Pipeline Pilot module of Biovia software" (DassaultSystems of France) was used for analysis. The software provides different built-in components to develop a "machine learning model" and use the model for prediction.

**Keywords:**Neural network, Cotton, Latitude, Longitude, Rain, Temperature.

## INTRODUCTION

### Machine Learning

Machine learning is an software of synthetic intelligent (AI) that provide the system capacity to robotically research and improve from reveal in without being explicitly of programmed. Machine learning specialize in the development of laptop programmes that may access record and use it study for themselves. The system of getting to know being with observation or information such as example direct experience or instructions in order to search for styles in information and may better selection in the future based totally the example that we provide. The Primary aim is to allow the computer systems learn routinely without human intervention or assistant and alter movements accordingly.

### Cotton Production

Being a cash crop, cotton is known for it's intensive cultivation. Some Production Practice like wide plant to plant and row to row spacing. Nearly 65% cotton area is rainfed mainly in the central and southern states. Cotton crop is highly prons to pests and disease. Wide fluctuation in cotton prices, inadequate market infrastructure and cotton





export policy. Cotton is a semi-xerophyte is grown in tropical & subtropical conditions. A minimum temperature of 15°C is required for better germination at field conditions. The optimum temperature for vegetable growth is 21-27°C and it can tolerate temperature to the extent of 43°C but temperature below 21°C is detrimental to the crop warm days of cool nights with large diurnal variation during the period of fruiting are conducive to good boll and fiber development. Cotton is a kharif crop in the major parts of the country such as Rajasthan, Uttar Pradesh, Gujrat, Madhya Pradesh etc.

## REVIEW OF LITERATURE

Cotton is one of the most important cash crops in India. Every year the production of cotton is reducing due to the attack of the disease. Plant diseases are generally caused by pest insect and pathogens and decrease the productivity to large scale if not controlled within time. This paper presents a system for detection and controlling of disease on cotton leaf along with soil quality monitoring. The work proposes a support vector machine based regression system for identification and classification for five cotton leaf diseases i.e. Bacterial Blight, Alternaria, Gray Mildew, Cereospora, and Fusarium wilt. Cotton is one of the most important cash crops in India and affects India's economy in many ways. Large number of the population depends on cotton crop either for its cultivation or for the purpose of processing. It is observed that the development in agriculture is sluggish nowadays due to attack of disease.

P. R. Rothe, R. V. Kshirsagar[1] in "Cotton Leaf Disease Identification using Pattern Recognition Techniques" presents Active contour model is used for image segmentation and Hu's moments are extracted as features for the training of adaptive neuro-fuzzy inference system. Ratih Kartika Dewi, R. V. Hari Ginardi[3], in "Feature Extraction for Identification of Sugarcane Rust Disease" presents image pattern classification to identify rust disease in sugarcane leaf with a combination of texture and color feature extraction. Rajneet Kaur, Miss. Manjeet Kaur[2], in "A Brief Review on Plant Disease Detection using in Image Processing" presents identification of diseased part on the leaf and classify the disease using SVM classifier. [4] P. Revathi, M. Hemalatha, in "Advance Computing Enrichment Evaluation of Cotton Leaf Spot Disease Detection Using Image Edge detection" presents mobile captured symptoms of Cotton Leaf Spot images and categorize the diseases using neural network. The classifier is being trained to achieve intelligent farming, including early detection of disease in the groves, selective fungicide.

## Objectives

To determine the effect of parameters on production of Cotton using machine learning. In this study we can determine the suitable condition where the cotton grows in a manner that we can get maximum profit.

## MATERIALS AND METHODS

### Software used

"Pipeline Pilot module of Biovia software" (DassaultSystems of France) is used for analysis. The software provides different built-in components to develop a "machine learning model" and use the model for prediction.

### Methodology

#### Collection of data

Data was collected from website. Longitude, latitude, Temperature (Jan-Dec), Temperature (Nov-May), Temperature (June-Oct), Rain (Jan-Oct), Rain (Nov-May), Rain (June-Oct) were taken as input while production of cotton was used as output parameter.





### Development of deep learning neural network model

The dataset was read using "Delimited Text Reader" component of "pipeline pilot". The component was connected to the "Learn R Deep Neural Net Model" component. The output of the model was displayed using "HTML Table Viewer" component. The parameters for the "Learn R Deep Neural Net Model" component were set as shown in Figure 1. The setting for which the experimental output parameter and the predicted parameter were close to a 45° line were considered for the final model.

### Study of effect of different input parameters on cotton production

Text files were prepared where one parameter was varied within the range of data analyzed. All other parameters were kept constant at an average value.

## RESULTS AND DISCUSSION

Cotton production varies due to different reasons. However, the relationships are difficult to predict. Thus, this study focuses on the effect of various input parameters on the cotton production. Figure 2 shows that cotton production in particular area is gradually decreasing till the longitude reaches around 85°E. The result shows that low value of longitude favored cotton production. Figure 3 shows that cotton production in the particular area is constantly decreasing when latitude varies from 0°N to 30°N. Figure 4 indicates that cotton production in particular area is gradually decreasing when the rainfall varies from 0 mm to 250 mm then it is increasing after crossing 300 mm. Figure 5 shows that cotton production in the particular area is gradually decreasing when the rainfall varies from 0 mm to 120 mm. Figure 6 represents that the cotton production in the particular area is gradually increasing when temperature increases from 0°C to 25°C. Figure 7 shows that the cotton production in the particular area is gradually decreasing with the variation in temperature from 0°C to 25°C. Figure 8 indicates that the cotton production in the particular area is gradually increasing when temperature increases from 0°C to 30°C. Figure 9 shows that cotton production in the particular area is gradually increasing from 0 mm to 100mm. Then it starts decreasing after crossed 100mm.

## CONCLUSIONS

The effects of different parameters on cotton production have been studied using Pipeline pilot. The results shown that cotton production is high around longitude 70°E, latitude (at 10°N), 600mm rain in June-Oct, below 20mm rain in Nov-May, 110mm rain in Jan-Dec, 30°C temperature in June-Oct, 10°C temperature in Nov-May and 30°C temperature in Jan-Dec.

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Parameters	
LearnedProperty/Name	Predicted_Crop_Production
Name	Cotton
TypeOfProperty/IsLearn	Continuous
UseProperties	AllPropertiesOfFirstData
ROOutput	FitSummary   FitPlot
MN Options	
Method	gsk
ActivationFunction	sign
HiddenLayers	1000
LearningRate	0.05
Momentum	0.9
NumEpochs	5000
MinibatchSize	2
HiddenDropoutFraction	0
VisibleDropoutFraction	0
Seed	12345
Learn Options	
Additional Options	

Figure 1. Parameters for the "Learn R Deep Neural Net Model" component

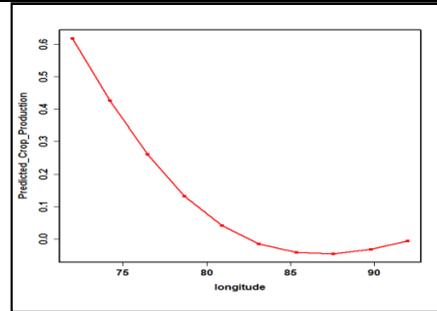


Figure 2: Effect of longitude in the production of Cotton

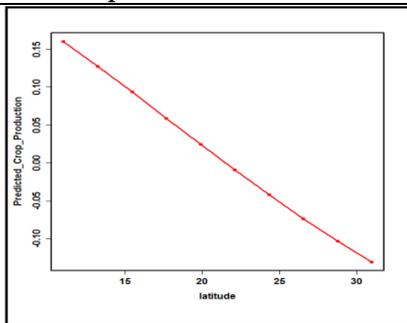


Figure 3: Effect of Latitude in the production of Cotton

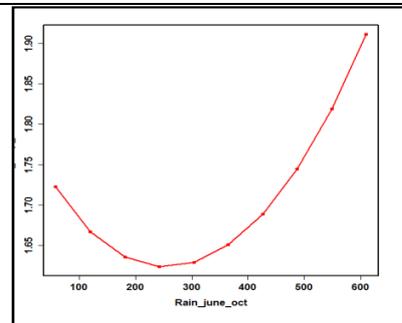


Figure 4: Effect of Rain in Jun-Oct in the production of Cotton

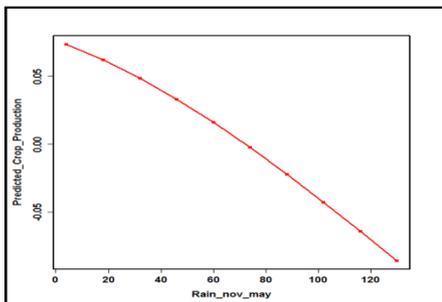


Figure 5: Effect of Rain in Nov-May in the production of Cotton

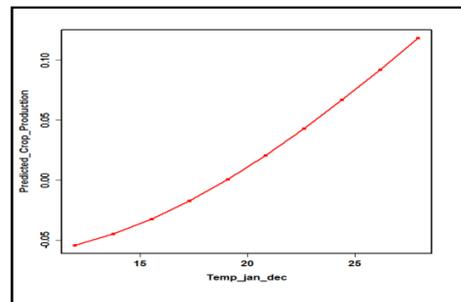


Figure 6: Effect of temperature in Jan-Dec in the production of Cotton

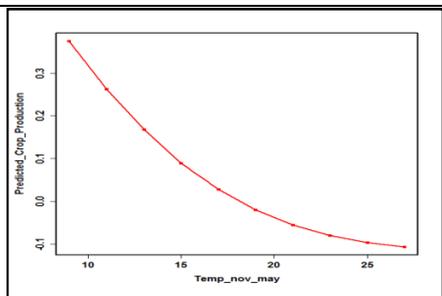


Figure 7: Effect of temperature in Jan-Dec in the production of Cotton

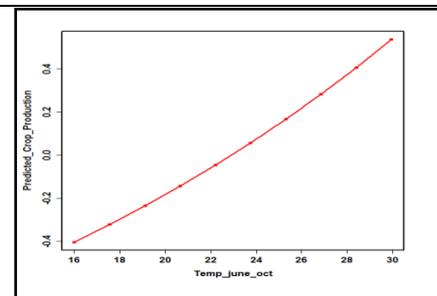
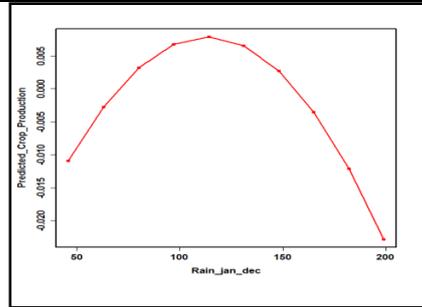


Figure 8: Effect of temp in June-Oct in the production of Cotton





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**Figure 9: Effect of rain in Jan-Dec in the production of Cotton**





## Pre-Engineered Building

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### ABSTRACT

The abstract is to be in fully-justified italicized text as it is here, below the author information. Use the word “Abstract” as the title, in 12-point Times New Roman, boldface type, centered relative to the column, initially capitalized. The abstract is to be in 11-point, single-spaced type, and may be up to 3 in. (18 picas or 7.62 cm) long. Leave two blank lines after the abstract, and then begin the main text. All manuscripts must be in English.

**Keywords:** Pre Engineered Buildings (PEB), Design of PEB

### INTRODUCTION

PEB is very versatile building systems and can be finished internally to serve any functions and accessorized externally to achieve attractive and unique designing styles. It is very advantageous over the conventional buildings and is really helpful in the low rise building design. Pre engineered buildings are generally low rise buildings however the maximum eave height can go up to 25 to 30 meters. Low rise buildings are ideal for offices, houses, showrooms, shop fronts etc. The application of pre engineered buildings concept to low raise buildings is very economical and speedy. The roof of low rise buildings may be flat or sloped. One such revolution was the Pre Engineered Buildings. Although PEB systems are extensively used in industrial and many other non residential constructions worldwide, it is relatively a new concept in India. As compared to other countries Indian codes for building design are stringent but safer in design of PEB.

Technological improvement over the years has contributed immensely to the enhancement of quality of life through various new products and services. One such revolution was the Pre Engineered Buildings. Although PEB systems are extensively used in industrial and many other non residential constructions worldwide, it is relatively a new



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concept in India. As compared to other countries Indian codes for building design are stringent but safer in design of PEB. Cold formed Z- and C-shaped members may be used as secondary structural elements to fasten and support the external cladding. Roll-formed profiled steel sheet, wood, tensioned fabric, precast concrete, masonry block, glass curtain wall or other materials may be used for the external cladding of the building. While pre-engineered buildings can be adapted to suit a wide variety of structural applications, the greatest economy will be realized when utilizing standard details. An efficiently designed pre-engineered building can be lighter than the conventional steel buildings by up to 30%. Lighter weight equates to less steel and a potential price savings in structural framework.

**Components of PEB Building****Main Frame**

Rigid steel frames of the building are mainly considered as the Main Frames of PEB. PEB rigid frame comprises of tapered columns and tapered rafters (the fabricated tapered sections are referred to as built-up members). The tapered sections are fabricated using the state of ART technology wherein the flanges are welded to the web. Splice plates are welded to the ends of the tapered sections. The frame is erected by bolting the splice plates of connecting sections together.

**Sheeting's and Insulation**

Panels used for sheeting purpose are generally of ribbed steel sheets used as roof and wall sheeting, roof and wall liners, partition and soffit sheeting. The steel sheets are generally produced from steel coils having thickness 0.5 mm to 0.7 mm high tensile stress. In present day scenario, newly developed type "S" panel, whose profile is designed to withstand heavy loads, such as roof snow loads and uplift loads resulting from high velocity (cyclonic) winds is widely prevalent.

**Paints and Finishes**

Normally the primary and secondary steel are coated with one coat (35 microns) of red oxide paint without any special treatment to steel. However, if some special paint has to be applied to steel in order to give better anti – corrosion properties, then the steel members have to be shot – blasted and then coated with the special paints. For houses; inside and outside painting on walls and false ceiling is to be provided.

**Doors and Windows**

Steel or aluminum framed doors and windows are fixed to the Purlins or the supporting profiled steel either by welding or bolted to the flanges already fixed to the Purlins. Proper flashings are applied wherever necessary.

**Ribbed Sheet Used for Roof and Wall Liners**

The other form of panels that are widely available is the G shaped panel. This deep – ribbed type 'G' panel is generally used as deck paneling for mezzanines and floor systems. Although exceptionally strong, 'G' shaped panel is used as shuttering for mezzanine reinforced concrete floors and panel is not a substitute for the reinforcement of mezzanine concrete slabs. The type 'G' panel is available only (unpainted) in 0.7 mm pre – galvanized coating over steel conforming to ASTM A653M SS Grade 550: Coating Z180.

**False Ceiling**

False ceiling is usually required for residential buildings or offices. A metal frame work is hung from the ceiling and false ceiling of rigid boards are either bolted or placed over the frame work.





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**Partition Walls**

Partition walls are usually required for residential building or offices. Partition wall comprises of two rigid having insulation sandwiched in between and fixed to the steel columns or supporting profiled steel and Purlins. Alternatively prefabricated sandwich panels can also be fixed to the columns and Purlins.

**Flooring**

Flooring is usually of conventional nature consisting of cement concrete. For intermediate floors metal decking sheet is fixed to Purlins and concrete poured over it.

**Columns and Rafters**

The most important parts of the Pre Engineered Building are Columns and Rafters which are otherwise called as Primary Structure. The major load of the building is being borne these members. Assembled Columns and Rafters make the frame of the buildings on which all other parts of the buildings are fixed. The design of this structure is done using advance software such as STAAD PRO, Tekla etc. The usual load considerations are Live Load, Dead Load, Wind load, Collateral Load etc. Once the designs of these are completed, detailed engineering and shop drawings will be prepared.

**Z-Purlin and C-Purlin**

Z-Purlin, Girts, Eave struts etc are secondary members of structural framing. Z-Purlins are cold formed from steel which has minimum yield strength of 345 MPa. Purlins and Girts shall be roll formed Z sections, 200 mm deep with 64mm flanges(depends). Purlins are used in all Pre Engineered building as a secondary load member.

**Hi-rib Roofing Sheets**

Trafford roof sheets come with various profiles and colors. These sheets are widely used for the Warehouses, Factory sheds etc. Trafford sheets are becoming more popular among residential building applications also these days. The various application include Warehouses, Garages, Community Halls, factory shed. A panel assembly used as covering and consists of an insulating core material with inner and outer skins.

**Curved Eaves**

Curved eaves are formed from color coated steel after crimping and curving. Crimping is done in order to give an aesthetic appearance to the building. Curved eaves are widely used in Pre Engineered buildings.

**Pre Engineered Buildings Vs Conventional Steel Buildings**

PROPERTY	PEB BUILDINGS	CONVENTIONAL STEEL BUILDINGS
<b>STRUCTURE WEIGHT</b>	Pre engineered buildings are on the average 30% lighter because of the efficient use of steel. Primary framing members are tapered built up section. With the large depths in areas of higher stress.	Primary steel members are selected hot rolled "T" sections. Which are, in many segments of the members heavier than what is actually required by design? Members have constant cross section regardless of the varying magnitude of the local stresses along the member length.
	Secondary members are light weight roll formed "Z" or "C" shaped members.	Secondary members are selected from standard hot rolled sections which are much heavier.
	Quick and efficient: since PEB's are mainly formed by standard sections and connections design, time is significantly reduced. Basic	Each conventional steel structure is designed from scratch with fewer design aids available to the engineer.




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<b>DESIGN</b>	design based on international design codes are used over and over.	
	Specialized computer analysis design programs optimize material required. Drafting is also computerized using standard details that minimize the use of project custom details.	Substantial engineering and detailing work is required from the very basic is required by the consultant with fewer design aids.
	Design shop detail sketches and erection drawings are supplied free of cost by the manufacturer. Approval drawing is usually prepared within in 2 weeks.	Extensive amount of consultant time is devoted to the alterations that have to be done.
	PEB designers design and detail PEB buildings almost every day of the year resulting in improving the quality of designs every time they work	As each project is a new project engineers need more time to develop the designs and details of the unique structure.
<b>FOUNDATIONS</b>	Simple design, easy to construct and light weight.	Extensive, heavy foundation required.
<b>DELIEVERY</b>	Average 6 to 8 weeks	Average 20 to 26 weeks
<b>SEISMIC RESISTANCE</b>	The low weight flexible frames offer higher resistance to seismic forces.	Rigid heavy frames do not perform well in seismic zones.

### Application

Applications of pre-engineered steel buildings include (but are not limited) to the following:

- Houses & Living Shelters
- Factories
- Warehouses
- Sport Halls
- Aircraft Hangers
- Supermarkets
- Workshops
- Distribution Centers
- Commercial Showrooms
- Office Buildings
- Labor Camps
- Petrol Pumps/Service Buildings
- Schools
- Community Centers
- Railway Stations
- Equipment housing/shelters
- Telecommunication shelters
- Restaurants

### Scope of Work

The major study of the project is on Moment Frame System and is explained in this work. Steel frames shall be so designed and detailed as to give them adequate strength and ductility to resist severe earthquakes in all zones classified. Frames, which form a part of the gravity load resisting system but are not intended to resist the lateral earthquake loads, need not satisfy the requirements of this section, provided they can accommodate the resulting deformation without premature failure.





### Types of lateral load resisting system

1. Braced Frame System
  - a. Ordinary Concentrically Braced Frame (OCBF)
  - b. Special Concentrically Braced Frame (SCBF)
  - c. Eccentrically Braced Frame (OCBF)
2. Moment Frame System
  - a. Normal Moment Resisting Frame (NMF)
  - b. Ordinary Moment Resisting Frame (OMF)
  - c. Special Moment Resisting Frame (SMF)

### Major Points Considered While Making the Model

- 1) Frames with same h/w ratio (0.2) and l/w (1.5) have been considered.
- 2) Supports are considered as pinned.
- 3) Member length has been maintained as 3 m for maximum members in the frame.
- 4) Columns depth is not varied along height as the moments will be high for frames with mezzanine floors.
- 5) Rafter and column depths are taken as tapered as per bending moment profile by not reducing the depth less than 50% than required.
- 6) The section properties of member has been calculated using following formulas taken from practice:
  1.  $d = \frac{\text{span}}{28}$
  2.  $\frac{d}{t_w} \leq \text{Max limit value for web section classification}$
  3. Width of flange =  $\frac{d}{5}$
  4.  $\frac{b}{t_f} \leq \text{Max limit value for flange section classification}$
  5. Overall section classification is the minimum of web and flange section classification.
- 7) Dimensions of steel members available in market
  1. Max length of any section available is 12m
  2. Thicknesses of web available are 4, 5, 6, 8, 10, 12, 14, 16, 20, 22, 24, 28, 32, 36, 40
  3. Widths of flange available are 130, 150, 180, 200, 225, 250, 275, 300, 325, 375, 400, 425, 450, 500
- 8) For each set of dimensions 3 different frames have been modeled
  1. Normal Moment Resisting Frame (NMF)
  2. Ordinary Moment Resisting Frame (OMF)
  3. Special Moment Resisting Frame (SMF)
- 9) For Normal and Ordinary Moment Resisting Frames:
  1. Column minimum as semi compact.
  2. Rafter minimum as Slender.
- 10) Load Combinations are taken from Table 1 of IS 800-2007 For Ordinary Moment Resisting Frame:
  1. Same member sections as considered as in Normal Moment resisting frame.
  2. Extra load combinations from Section 12.2.3 are considered along with Load Combinations from Table 4 of IS 800-2007 .
- 11) For Special Moment Resisting Frame:
  1. Column and Rafter minimum compact.
  2. Plastic potential zone is considered as 1.5 times depth required (d calculated above)
  3. In plastic potential zone the member is taken as plastic section.
  4. Plastic sections are considered at column-rafter junction and near support.





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12) Load Combinations are taken from Table 4 of IS800-2007

13) Deflection limit =  $\frac{Span}{180}$

By considering different frames (without cranes, with cranes and with mezzanine floors) with different dimensions given in following table, the results have been tabulated below.

Aspect Ratio: h/w = 0.2

Bay width = 7.5 m

Internal wind coefficient,  $C_{pi} = \pm 0.2$  as %opening is <5%

Wind Load Calculations done As per IS: 875-Part3

Sample STAAD frame models for an Ordinary Moment Resisting Frame, along with crane and with mezzanine are shown below

## CONCLUSIONS

By comparing different frames with and without section-12 load combinations state that there is no necessity of providing ductile sections or sections satisfying requirements of Section-12 of IS-800:2007. Compared to the previous code i.e. IS-800:1984, the weight of the structures is increasing when designed with the latest code, IS-800:2007. Therefore there is a increase in cost of the structure. But when observed, the section-12 load combinations are not governed for the same structure designed with new code. Hence the sections may be reduced by satisfying the minimum criteria as per the zone and type of structure through which weight of structure can be reduced which ultimately decreases the cost parameter.

## REFERENCES

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3. IS 800:2007, "Indian Standard General Construction In Steel Code Of Practice", ( Third Revision)
4. IS 1893 , "Indian Standard Criteria For Earthquake Resistant Design Of Structures", Part 1 General Provisions And Buildings ( Fifth Revision )
5. IS 875, "Indian Standard Code Of Practice For Design Loads (Other Than Earthquake) For Buildings And Structures", Part 3 (Wind Loads) ( Second Revision ).
6. ECCS Manual on "Design Of Steel Structures In Seismic Zones", First edi

**Table 1: Geometric properties of frame**

Height (m)	Width(m)	Length(m)
3	15	22.5
4	20	30
5	25	37.5
6	30	45
7	35	52.5





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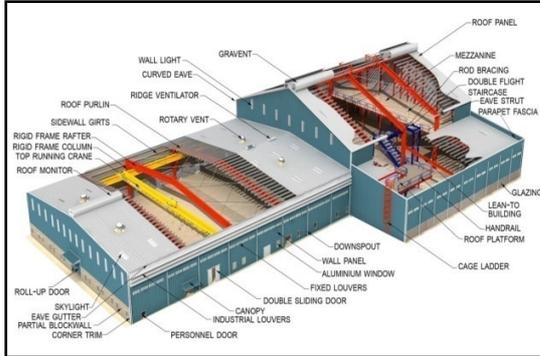


Figure 1.1: Components of PEB

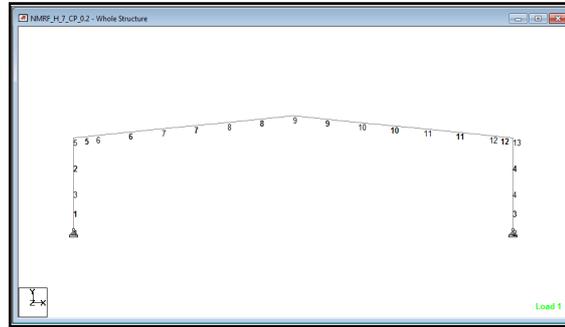


Figure 2: STAAD model for SMF without crane and without mezzanine

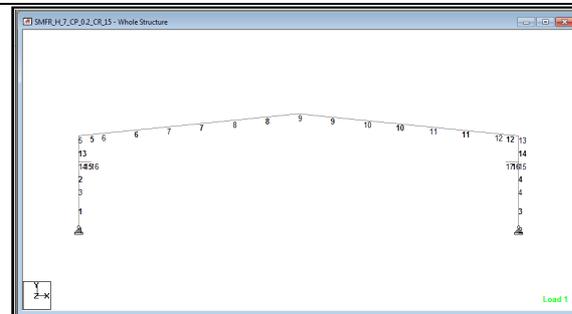


Figure 3. STAAD model for SMF with crane and without mezzanine

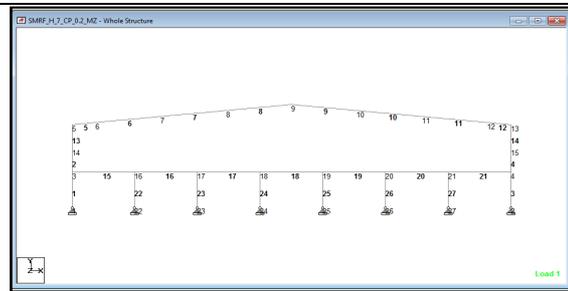


Figure 4: STAAD model for SMF without crane and with mezzanine

