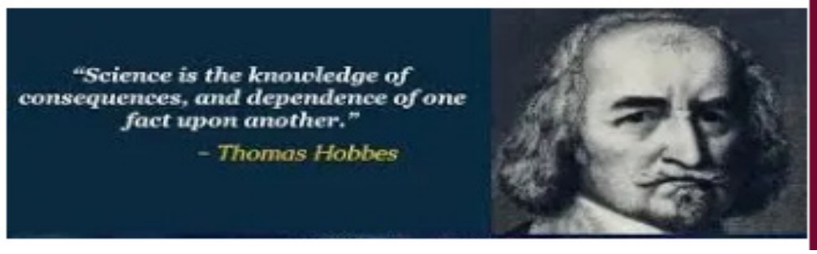
"

The purpose of education is to replace an empty mind with an open one.

"

- Malcolm Forbes



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CONTENTS

A STUDY ON COMPARATIVE ANALYSIS OFPRIVATE SECTOR AND PUBLIC SECTOR BANKSSTOCK IN INDIA DURING FINANCIAL CRISIS

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ABSTRACT

A study understanding stock investments in both public and private sector banks was the goal of the study. People typically seek for significant returns on their stock investments. They don't know how risky the stocks are variety of causes and market participants, volatility estimation is significant. The average volatility and daily average return help investors, regulators, market players, and policy makers make informed decisions. Many financial assets have seen a notable increase in return volatility in recent years, piqueing the interest of investors, regulators, and scholars.The study focuses on the bank stocks' volatility and return. The National Stock Exchange's listed bank stocks, both public and private, are examined in this context for their performance. The examination of bank stocks in the public and private sectors provides insight into the financial performance of the equities in terms of return and volatility.

Key Words: stock market, volatility, share, stock, piqueing.

INTRODUCTION

Finance is regarded as the oxygen of trade and industry. Before the establishment of banks, the financial activities were handled by money lenders and individuals the interest rates were very high during the time. There were no security for public savings and no uniformity regarding loans. To overcome such problems the organised banking sector was established in the

year 1786, which was fully regulated by the government.The health and efficiency of the financial sector are crucial to economic growth of a country because of the pace of economic growth. A balanced capital market, an efficient flow of fund between savers and investors cannot be preserved without a sound financial sector. Modern trade and commerce would not be possible without theavailabilityof suitable banking services. Banks are a subset of the financial service industry. As a result, the performance of the banking sector has a direct correlation with the entire financial sector andeconomyof our country. In every country, the banking sector is the most important mechanism for performing a lot of tasks related to deposit mobilization, credit evaluation and monitoring, providing access to a payments system and to a clearing house for transactions. It is the system by which a country's most profitable and efficient projects are systematically and continuously funded, and thus it is the mechanism, which ensures that resources are directed to the most productive sources of the future growth. The system not only transfers funds from savers to investors, it selects projects which will yield the highest returns, accumulate sufficient quantities of capital to fund the range of investment projects across economic activities, account for price risks across assets, monitor performance, and enforce contracts. A banking system also referred as a system provided by the bank which offers cash management services for customers, reporting the transactions of their accounts and portfolios, throughout the day. Thus, their performance and outcomes have a major. Impact on the financial health of our country. Financial system of India is also witnessing startling changes, especially in the financial institutions. The Indian Financial System has four pillars: these are financial institutions, the financial market, financial instruments, and regulatory bodies. Among all, the banking industry is one of the most integral parts of the Indian Financial System. The banking sector just acts as a mirror by which the financial health of that country can be predicted, and India is no exception.In India, the public sector banks account for more than 70% of the assets of the total banking industry. Almost 80% of the businesses are still controlled by Public Sector Banks (PSBs). PSBs are still dominating the commercial banking system. Shares of the leadingPSBs are already listed on the stock exchanges.Public Sector Banks had, in the past,

relied on government support for capital augmentation. However, with the government making a conscious decision to reduce it's holding in banks, most of the banks have approached the capital market for raising resources. During the post nationalization era, this sector had phenomenal growth and thus a study of banks stock functioning is of paramount importance. The effect of banking reforms processes have been reflected in the bank stocks. Banking sector exhibited growth trend in market capitalization among computer software, pharmaceuticals, and automobiles. Volatility estimation is important for several reasons and for different people in the market. The daily average return and average volatility are useful to the policy makers, regulators, market participants and even investors to take proper decision. In recent years there has been a significant increase in the volatility of returns of many financial assets which has attracted the interest of participants, regulatorsandacademics.

The study focuses on the return, and volatility of the bank stocks. In this context the performance of both private and public bank stocks that are listed in the National Stock Exchange are analysed. The analysis of private and public sector bank stocks throws light on financial performance in terms of return of volatility of bank stocks.

Objectives of The Study

- To examine the returns of the public and private sector banks stock.
- To examine the impact of global financial crisis on public and private sector banks stock.
- To analyse the trend of the volatility of the public and private sector banks stock.

Limitations of the Study

The study is entirely based on the secondary data. Hence, the bias in the data itself may affect the accuracy of the result of the study. The analysis is confined to the selected private and the public sector banks stock and not the foreign banks stock.

Review of literature

SLGupta, ArunMittal(2008) concluded that public sector is more reliable but it was not so good inequality and innovativeness, a private sector bank was not so reliable but they are better in services quality and innovation.

Laxman,Deen and Badiger (2008) examined that Banking Industry is undergoing paradigm shift in scope, content, structure, functions and governance. The information and communication technology revolution is radically perceptible changing the operational environment of the banks. Singla (2008) examined that how financial management plays a crucial role in the growth of banking industry. He examined the profitability position of selected sixteen banks of banker index for a period of six years (2001-2006) the study revealed that the profitability position was reasonable during the period of study when compared with the previous year.

Methodology

- Calculation of return
- Close to close volatility
- Open to open volatility

Hypotheses

Following null hypotheses have been formulated for testing.

- Null Hypothesis (Ho): The US financial crisis had no impact on the banks stock return.
- Alternative hypothesis (H1): The US financial crisis had a negative impact on the banks stock return.

Table 1

Year wise Mean Return of Kotak Mahindra Bank and Axis bank stock 2005-2015 (percentage)

Year	Kotak Mahindra Bank		Axis bank	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**
2005-06	-0.077	5.871	0.160	2.376
2006-07	0.210	3.290	0.123	4.041
2007-08	0.124	3.781	0.216	2.992

2008-09	-0.339	4.718	-0.228	4.630
2009-10	0.376	3.442	0.426	3.029
2010-11	-0. 193	4.487	0.070	2.004
2011-12	0.075	2.065	-0.090	2.475
2012-13	0.064	1.459	0.047	1.817
2013-14	0.072	2.063	0.042	2.71 1
2014-15	0.224	1.640	-0.397	10.58

Table 2

Year wise Mean Return of SBI Bank and Canara Bank stock 2005-2015 (percentage)

Year	**SBI Bank**		**Canara Bank**	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**
2005-06	0.147	1.610	0.104	2.387
2006-07	0.004	2.264	-0.131	3.165
2007-08	0.216	2.738	0.082	3.396
2008-09	-0.173	3.669	-0.114	3.399
2009-10	0.270	2.758	0.378	2.777
2010-11	0.108	1.935	0.164	2.241
2011-12	-0.103	2.239	-0.111	2.348
2012-13	-0.011	1.799	-0.080	2.145
2013-14	-0.034	2.015	-0.155	3.125
2014-15	-0.809	14.814	0.141	2.794

The mean return for Kotak Mahindra Bank stock was very high in the year 2009 – 2010 (0.3768). The bank suffered heavy loss in the year 2008-09 (-0.3398), due to global financial crisis. During the year the dividend was tumbled to 7.50%.

In Axis Bank the return was very high in the year 2009-10 (0.4262). During the year 2014-15, it has suffered loss (0.397) because the share price was split from Rs.10 to Rs.2 per share. Kotak MahindraBank and Axis Bank enjoyed high return in the year 2009-10.

The year wise mean return of SBI Bank was peak in the year 2009-10 (0.2703). In the year2008-09 dividend rate was Rs.21.50 but in the year 2009-10 the dividend was increased to Rs.29 per share.

The SBI Bank suffered loss for four consecutive years from 2011-12 to2014-15, because the share price has decreased from Rs.30 per share to Rs.15 per share. In 2014-15 return was negative (-0.8094) because share value was split from Rs. 10 to Rs.1 per share. In the Canara Bank the return was very high in the year 2009-10 (0.3789).

It suffered loss for three consecutive years from 2011-12 to 2013-14, because of the share price was tumbled to Rs.4.50 per share. In the year 2013-14, it suffered heavy loss because the share price was decreased from Rs.13 to Rs.4.50 per share. Both SBI Bank and Canara Bank earned positive return in the year 2009-2010, because the share price was increased.

Table 3

The result of the Binary Variable Regression for Private Sectors bank

	Parameter Estimate	Standard Error	t-Value
Kotak Mahindra Bank N- 992, R-sq=0.001			
Intercept	0.001	0.002	0.611
Event dummy	-0.003	0.003	-1.807
Axis Bank			

N-992,R-sq=0.001			
Intercept	0.002	0.001	1.213
Event dummy	-0.003	0.003	-1.087

Table 4

The result of the Binary Variable Regression for Public Sectors bank

SBI Bank N=993, R-sq=0.002	Parameter Estimate	Standard Error	t-Value
Intercept	0.001	0.001	1.319
Event dumtny	-0.002	0.002	-1.376
Canara Bank N=991, R-sq=0.001			
Intercept	0.000	0.001	0.226
Event dummy	-0.001	().()02	-0.582

In the year 2008-2009 both private and public sector banks suffered glasses because of the global financial crisis the Kotak Mahindra Bank suffered heavy loss. After the crisis in 2009 to 10 all the banks enjoyed profit. Among all the banks SBI suffered losses for the four consecutive years from 2011 -12to 2014 - 15

Because of reduction in the share value. The result of the regression Prove that the banks stock return is not affected by the global financial crisis global financial crisis had it is impact only in the year 2008 to 9 all the main result proves that investing money in private sector bank is more beneficial.

Introduction on Volatility

Volatility is the most basic statistical measure. It can be used to measure the market risk of a single instrument or an entire portfolio of instruments. While volatility can be express differentways,statistically, volatility of a random variable is its standard deviation. In day -to – day practice, volatility is calculated for all sorts of random financial variablesuch as stock return, interest rate, the market value of portfolio etc ., stock return volatility measure the random variability of the stock returns.

Simply put, stock return volatility is the variation of the stock return in time. More specifically, it is the standard deviation of the daily stock return around the mean value and the stock market volatility is the return volatility of the aggregate market portfolio.

Types of Volatility

There are several types of volatility. The first is the actual volatility of the stock. It includes the intraday data but most often is calculated from one day's closing price to the next. Volatility, of course, is a measure of uncertainty. A high – volatility stock has a greater potential range than a low – volatility stock.

Table 5

Close to close and open to open volatility Kotak Mahindra Bank and Axis Bank (2005-2015)

Year	Kotak Mahindra Bank		Axis Bank	
	Close -Close	Open-Open	Open- Open	Close -Close
2005-06	5.871	6.416	2.836	2376
2006-07	3.290	3.762	3.459	3.031
2007-08	3.781	5.018	3.685	2.992
2008-09	4.718	5.709	6.014	4.630
2009-10	3.442	4.007	3.656	3.029
2010-11	4.487	4.671	2.177	2.004

2011-12	2.065	2.281	2.407	2.475
2012-13	1.459	1.642	1.985	1.817
2013-14	2.063	2.1 16	2.931	2.711
2014-15	1.640	1.821	10.51	10.58

Table 6

Close to close and open to open volatility SBI Bank and Canara Bank (2005-2015)

Year	**SBI Bank**		**Canara Bank**	
	Open -Open	**Close -Close**	**Open-Open**	**Close -Close**
2005-06	2.404	1.610	2.809	2.387
2006-07	2.791	2.264	3.628	3.165
2007-08	3.788	2.738	3.785	3.396
2008-09	4.153	3.669	4.796	3.399
2009-10	2.304	2.758	3.074	2.777
2010-11	2276	1.935	2.526	2.241
2011-12	2.395	2.239	2.507	2.348
2012-13	1.989	1.799	2.294	2.145
2013-14	2.215	2.015	3.494	3.125
2014-15	14.98	14.81	3.048	2.794

Table 5 and 6 exhibit the inter day volatility for private sector banks and public sector banks. In the private sector banks open to open volatility was higher than close to close volatility. The Kotak Mahindra Bank has high open to open volatility in the year 2005-06 (6.416), because the

dividend was low 12.5 per cent. It has low volatility in the year 201213 (1.642) during the year the dividend was tumbled to Rs.50 per share. In Axis Bank volatility was very high in the year 2014-15. In the year the face value of the share reduced from Rs. 10 to Rs.2 per share.

In the year 2008-09, Canara Bank volatility was high, because of high dividend. In SBI Bank the volatility was high in the year 2014-15, because the dividend rate was reduced from Rs.41.50 to Rs.15 per share.

Among all the private sector banks Axis Bank has high volatility in the year 2014IS (10.514). The inter day volatility was very high in the year 2014-15, for SBI Bank.

Summary Findings and Conclusion

Introduction

The importance of the private and public sector banks stock in promoting the growth of an economy is well recognised. A well developed and efficient banks stock is dynamic in introducing new products and services. NSE provides nation wide screen based banks stock system with the high degree of transparency and equal access to investor's irrespectiveofbanks position. The National Stock exchange of India Limited (NSEIL), India's leading stock exchange across the country has played a vital role in restructuring the Indian Banks stock in terms of Deposits, Advances and Non-performing Asset (NAP).

In a dynamic economic environment, knowledge of the Indian banks stock structure is important for both investors and portfolio managers. Various theories in finance, suggest that individual and foreign and government investors should hold a well -diversified portfolio to reduce risk. From the perspective of an investor who is willing to make portfolio investments in different banks stock, it is important to know if diversification can give some gain or loss. Banks stock diversification is sought due to differences in the levels of economic growth and timing of business cycles move together, then investing in different banks stock would not generate any long-term gain to portfolio diversification. Earlier, Banks stock diversification was

recommended on the assumption of low return among different Banks stock. But due to growing banks stock investment flows, deregulation of the financial system and growth in capital flows, national economies have become more closely linked. It has created a level of return among banks stocks. In this research the following objectives have been analysed.

To examine the returns of the private and public sector banks.

To analyse the volatility of the private and public sector banks.

Data

The empirical work is based on daily closing prices of the banks stock indices. Only secondary data were used for this study. To analyse the banks stock, daily closing values ofKotak Mahindra Bank, Axis Bank, SBI Bank, Canara Bank, The daily data on banks stock indices were downloaded from nseindia.in.

SUMMARY OF FINDINGS

Return

Return is the motivating factor that induces the investors to invest money in shares. Return means the profit earned as a result of rise in share prices. Return helps the investor to compare the benefits available in the alternative investment avenue. Descriptive statistics were used to know the properties of the series. Among all the banks return was peak in the year 2009-10.

All the banks taken for study yielded a negative return in 2008-2009.

All the mean return results prove that investing money in private sector bank is more beneficial.

The selected banks stock was not affected by the global financial crisis in the long run.

Volatility

In India, open to open and close to close volatility appears to be neck to neck. Among all the banks the SBI Bank was high inter day volatility in the year 2014-2015.

In all the banks the Corporation Bank volatility was very low in the year 2012-13. The intraday volatility was moved in tandem.

Among all the banks the Kotak Mahindra Bank intraday volatility was peak in the year2008-09.

CONCLUSION

To conclude, the private sector banks stock outperformed public sector banks stock. The investor can invest money in the private sector banks stock. Public sector bank is more reliable but it has low return. The investors can get more return in the private sector banks but it is highly risky. Investing money in public sector bank is safe but the investor can get low return.

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PHYTOCHEMICAL ANALYSIS AND ANTIMICROBIAL ACTIVITY OF GREEN SYNTHESIZED ZnO-NPs USING *HIBISCUS CALYPHYLLUS* (FLOWER) EXTRACT

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ABSTRACT

Medicinal plants used in different diseases and ailments are the richest bio reservoirs of various phytochemical . The plant possesses rich genetic variability with respect to number of bio molecules and metabolites like flavonoids, terpenoids, polyphenols, alkaloids, phenolic acid, coenzymes, carbohydrates, etc [1]. ZnO-NPs was synthesised using Hibiscus calyphyllus flower extract and have been characterized by UV-Vis., FT-IR, XRD and SEM analysis. Phytochemical studies and antimicrobial activity of the synthesized ZnO-NPs were carried out.

Keywords: *Hibiscus calyphyllus* flower, *green synthesis, phytochemical studies and antimicrobial activity*

1. INTRODUCTION

Nanotechnology is a field of science where phenomena that take place at dimensions in the nanometre scale are utilised in the design, characterisation, production and application of materials, structure, devices and systems [1]. ZnO is a multi–tasking metal oxide, is considered to be one of the best metal oxide that can be used at a nanoscale due to its unique optical and electrical properties. ZnO-NPs have superior antibacterial, antimicrobial properties against human pathogenic E.coli, Staph aureus and Candida albicans etc [2]. The ability of plant extracts can act as both reducing and capping agents, thus reducing particle size and improving reactivity.

The plant metabolites contains hydroxyl, carbonyl and amine functional groups that react with metal ions to reduce their size in to nano range and supporting their subsequent stability [3]. ZnO-NPs was synthesised using *Hibiscus calyphyllus* flower extract and have been characterized by UV-Vis., FT-IR, XRD, SEM analysis and the phytochemical studies and antimicrobial activity were carried out.

2. EXPERIMENTAL METHODS

2.1 Preparation of *Hibiscus calyphyllus* (flower) extract

Fresh *Hibiscus calyphyllus* (flower) was collected from our college campus and nearby area. 15 grams of collected *Hibiscus calyphyllus* (flower) was accurately weighed and thoroughly washed with tap water and then distilled water to remove dust particles. *Hibiscus calyphyllus* (flower) is boiled with 150 ml of de-ionized water for 45 minutes under the reflux

***Hibiscus Calyphyllus* (Flower)** **Under Reflux** **H.C. Flower Extract**

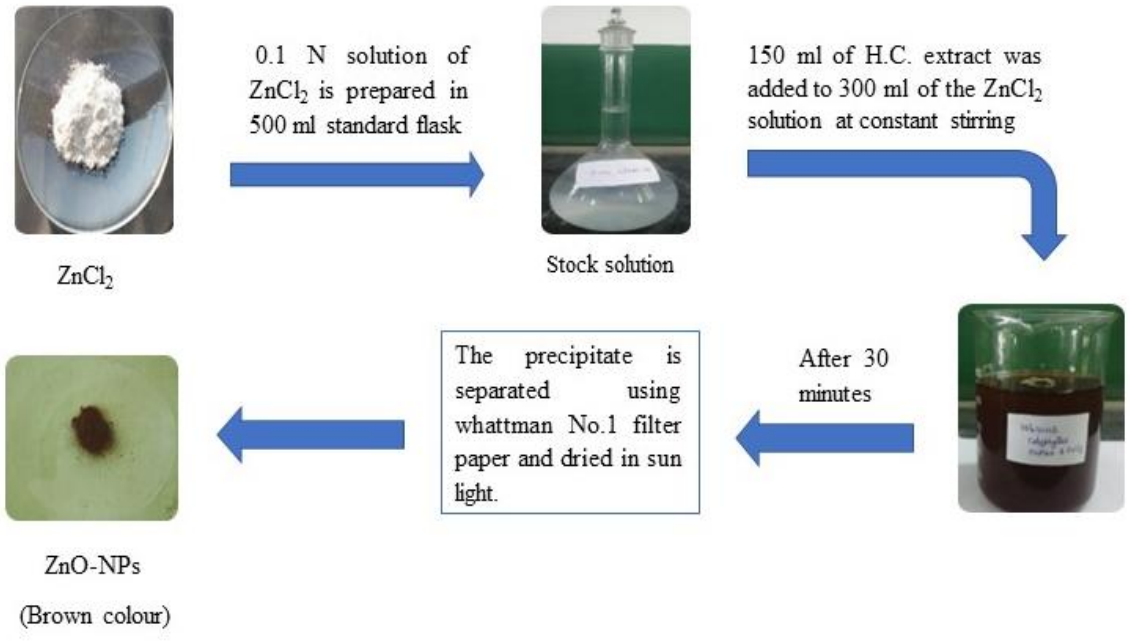
method. The extract was filtered using whattmann No.1 filter paper and stored at room temperature. Then the filtrates is used for the synthesis of ZnO-NPs.

2.2 Preparation of stock solution

A stock solution of 0.1 N Zinc Chloride was prepared by dissolving 2.04 g of Zinc chloride in 500 ml of de-ionized water.

2.3 Synthesis of ZnO-NPs using *Hibiscus calyphyllus* (flower) extract

For the preparation of ZnO-NPs, 150 ml of the *Hibiscus calyphyllus* (flower) extract was added to 300 ml of the $ZnCl_2$ solution and kept in a magnetic stirrer for 30 minutes. The precipitate formed was separated by using whattman No.1 filter paper and dried to get a fine powder. The synthesized ZnO-NPs powder is in brown colour.



3. RESULTS AND DISCUSSION

"Infrared (IR), Ultraviolet (UV), X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM) were used to characterize impurities, optical properties, the crystal structure and morphologies of ZnO Nanostructure.

3.1 UV-Visible Spectroscopy

The biosynthesized ZnO-NPs were characterized by spectrophotometric analysis. The presence of ZnO-NPs was confirmed by UV–Vis spectroscopy. UV-Visible spectroscopy analysis showed that the wave length of ZnO-NPs synthesized using *Hibiscus Calyphyllus (Flower)* extract. In these spectra for ZnO-NPs is observed at **370 nm** [4], [5]. This indicates the absorption shift towards the shorter wavelength, because of particles size reduction.

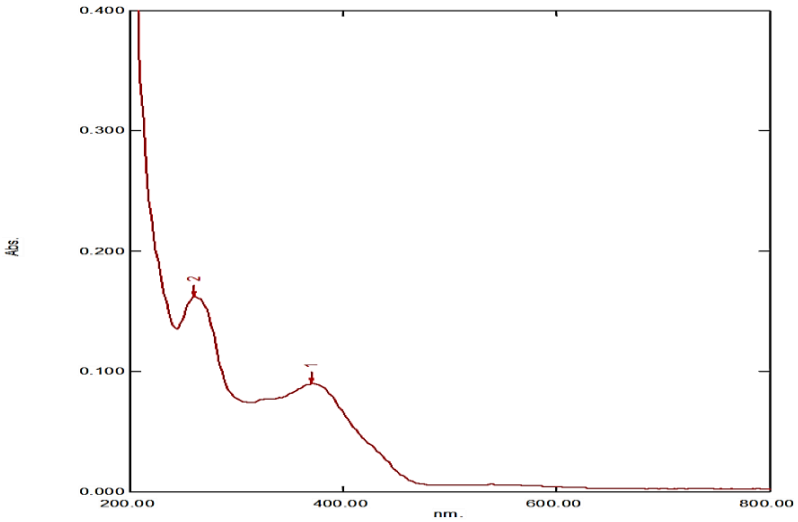


Fig 3.1 UV-Vis. Spectrum of ZnO-NPs using *Hibiscus Calyphyllus (flower)* extract

3.2 FT-IR Spectroscopy

FT-IR Spectra of metal sample show specific stretching vibrations for the differentstructural forms of metal. The specific metal oxide and their IR vibrational frequencies are given below. The stretching frequency of ZnO-NPs synthesised from *Hibiscus Calyphyllus (flower)* extract is **580.87 cm^{-1}** showing IR absorption due to the various vibration involved.

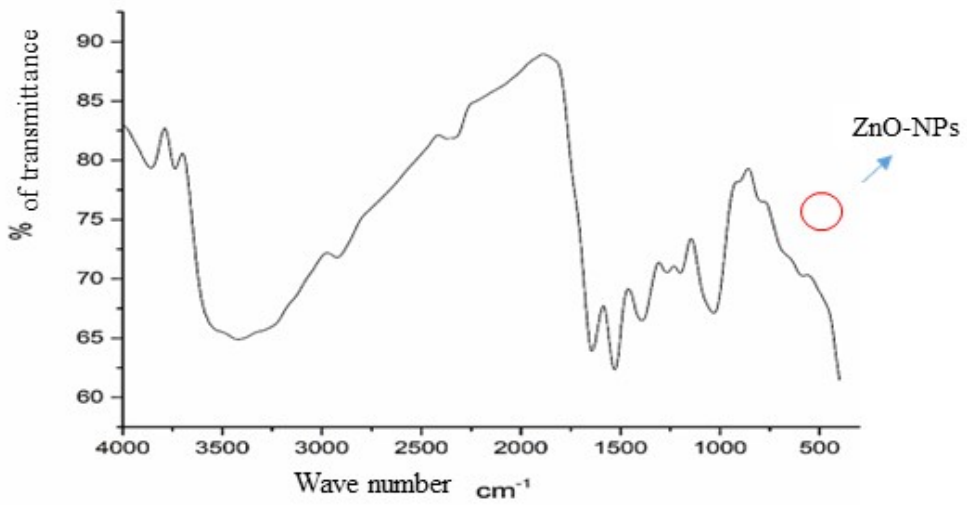


Fig 3.2 FT-IR spectrum of ZnO-NPs using *Hibiscus Calyphyllus (flower)* extract

IR spectrum of ZnO-NPs using *Hibiscus Calyphyllus (flower)* extract showed the distinct peaks in the range of 3856.73, 3736.18, 3419.85, 2924.13, 2371.52, 1643.38, 1528.61, 1393.59, 1266.29, 1199.74, 1030.01 cm−1. The peak observed at 3856.73 and 3736.18 cm^{-1} are attributed to be the OH group and O-H Stretching respectively. A peak observed at 3419.85 cm^{-1} were due to stretching vibrations of N-H (Amine) bond**.**

3.3 X-ray powder diffraction (XRD)

The prepared samples were analysed using XRD (X-ray Diffraction) technique. The Scherrer's formula can be used to calculate the particle size [6].

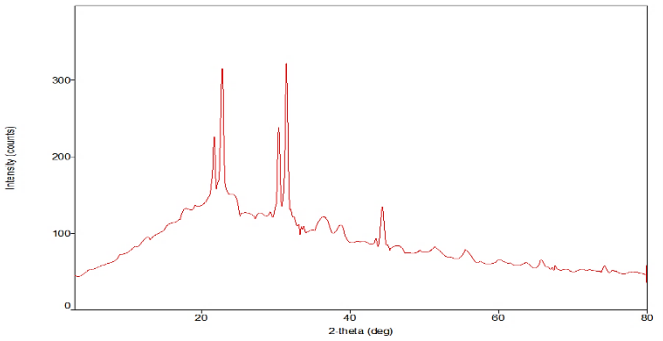


Fig 3.3 XRD spectrum of ZnO-NPs using *Hibiscus Calyphyllus (flower)* extract

This XRD value confirms that the synthesized particles were nanometric in size. The size of the ZnO-NPs thus estimated was found to be **1.26 nm**.

3.4 Scanning Electron Microscopy (SEM)

The surface morphology and size of the zinc oxide nanoparticles was identified by Scanning Electron Microscope. SEM image had shown shape and size of the zinc oxide nanoparticles synthesized by using extract of *Hibiscus Calyphyllus* (flower) and shows the surface morphology of the zinc oxide nanoparticles synthesized by using Hibiscus Calyphyllus (flower) extract recorded under different magnifications. The SEM image showed that most of the ZnO-NPs are formed in **partial spherical aggregates** shape [7].

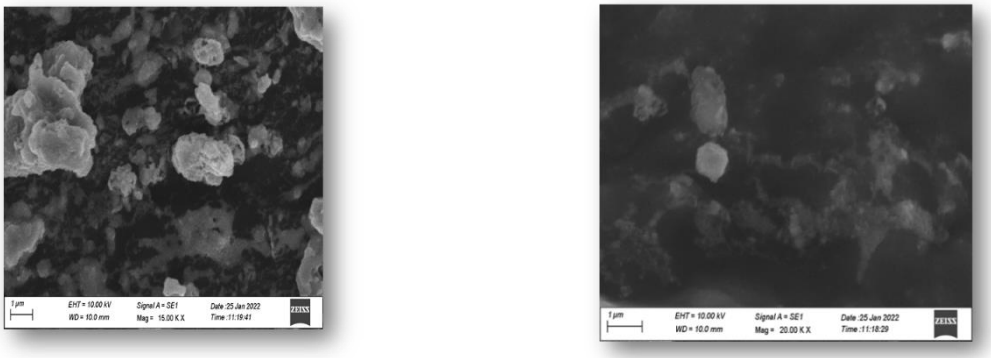


Fig.3.4 SEM image of ZnO-NPs

3.5 Phytochemical Studies

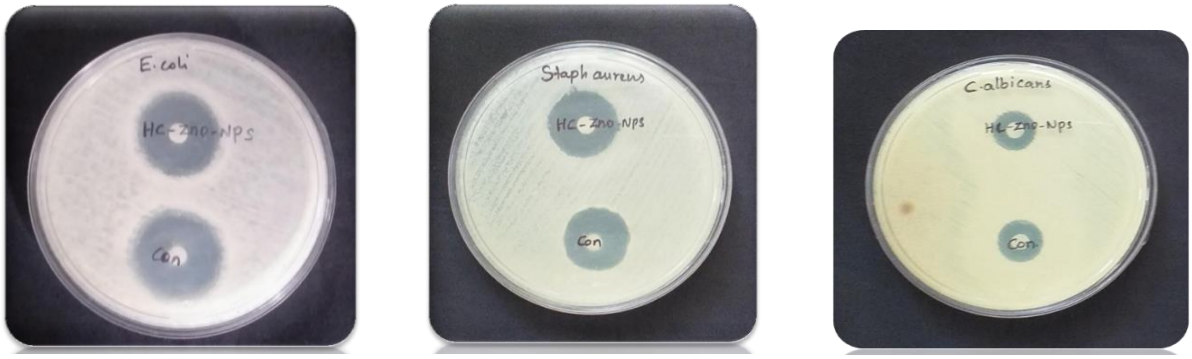
In plants, the naturally occurring chemical compounds are called phytochemical. They give organoleptic properties and color to the plant. Phytochemicals are beneficial to boost up immunolatory responses and also provide immunity against many diseases. Some phytochemical are known to reveal medicinal and physiological activities which are phenols, tannins, flavonoids, saponins, carbohydrates, alkaloids, phytosterols etc [8,9]. Therapeutic or curing activities of plants were conventionally proclaimed to have medicinal properties by small researchers. *Hibiscus calyphyllus* (flower) extract contains 103 compounds. Including phenolic compounds, flavonoids and anthocyanins.

3.6 Antibacterial and antifungal activities

The *hibiscus calyphyllus* extract have the highest antimicrobial activities. ZnO-NPs have superior antibacterial, antimicrobial activity. Synthesized nanoparticles were tested for antimicrobial activity against human pathogenic E.Coli, Staph aureus and Candida albicans.

Interpretaion

Each zone size is interpreted according to the organism by reference to the tables 3.6



Antibacterial and anti-fungal activities of ZnO-NPs synthesised from *Hibiscus calyphyllus* (flower) extract

Bacteria	**HC- ZnO-NPs**	**Control (Amikacin) Standard sample**
1. E. coli	25 mm	28 mm
2. Staph aureus	23 mm	22 mm
Fungus	**HC- ZnO-NPs**	**Control (Nystatin) Standard sample**
1. Candida albicans	16 mm	15 mm

Table 3.6 Zone inhibition of synthesised ZnO-NPs

The antimicrobial activity of ZnO-NPs is greater than the standard drug. The ZnO-NPs have better antibacterial activity against Staph aureus gram-positive bacteria compared to that of E. coli gram-negative bacteria. The ZnO-NPs have better antifungal activity against Candida albicans fungus.

CONCLUSION

Green approach is the best method due to its eco-friendly and cost-effective for the synthesis of ZnO-NPs with potential antimicrobial activity using the extract of *Hibiscus calyphyllus* (flower). The synthesized ZnO NPs was characterized by UV-Vis., FTIR, XRD and SEM analysis. The formation of ZnO-NPs was confirmed by UV-Vis. spectrum showed a absorption peak at **370 nm.** The formation of ZnO-NPs was confirmed by FT-IR spectrum showed a absorption peak at **580.87 cm^{-1}.** XRD spectrum revealed that the resultant ZnO-NPs size was found to be **1.26 nm**. The ZnO-NPs has been distributed well within the range of 100 nm. The image obtained by SEM of sample shows **partial spherical aggregates** structure. The phytochemical studies were confirmed by the presence of active compounds such as carbohydrates, reducing sugar, flavonoids, phenols and tannins are present in the *Hibiscus calyphyllus* (flower) plant extract. The synthesized ZnO-NPs was tested for the antimicrobial activity against human pathogenic such as E. coli, Staph aureus and Candida albicans. The antimicrobial activity of ZnO-NPs is greater than the standard drugs Nystatin, Amikacin. This research work has a great social relevance due to its non-toxic and inexpensive material which is suitable for environment and health related applications.

Acknowledgement

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FUZZY ECONOMIC PRODUCTION QUANTITY MODEL FOR SMART AND CONNECTED PRODUCTS

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ABSTRACT

Technology is the application of knowledge of achieving practical goals in a reproducible way. At present, digitalization occurs on every level and smart products are becoming increasingly more popular. This paper develops a fuzzy economic production quantity model for smart and connected products incorporating fuzziness in the holding cost. The optimal solution of the inventory model is evaluated under fuzzy environments by considering triangular fuzzy number. Centroid method is used for defuzzification. This model is supported with a numerical example and sensitivity analysis of the parameter is done to examine the effect of changes in the values of the parameter on the optimal inventory policies.

Keywords : *EPQ Inventory Model, Fuzzy Number, Smart and Connected Products, Triangular Fuzzy Number, Centroid Method.*

1. INTRODUCTION

In reality, it is not always possible to obtain the exact input values of the parameters of an inventory model. To study the effect of uncertainties on inventory decisions, the crisp model is analyzed in a fuzzy environment. Owing to the unstable environments it would not be easy for the decision maker to determine the exact value of the holding cost. So the focus is on the holding cost and is fuzzified using triangular fuzzy number. The optimal values are obtained with the main aim to maximize the total profit function. Centroid method is adopted for

defuzzification in the model owing to its efficiency. A numerical example is given to analyze the effectiveness.

2. LITERATURE REVIEW

In this real-world, smart products have fixed lifetimes. An effective inventory management of such products increases the cost of the system. So many researchers have worked on such inventory models. In today's competitive global market, it is not easy to get the realistic results. Hence to take decisions based on realistic situation approach, fuzziness is the best approach.

The investigation of Zadeh (1965) in fuzzy set theory has drawn the attention of many researchers to work on different areas including inventory control problems. In (1983) Zimmerman attempted the introduction of fuzzy sets in operation research. Extensive research work has been done on defuzzification of fuzzy numbers. Study shows that among the various methods, the Signed Distance Method by J.S. Yao and J. Chiang (2003) is better for defuzzification.

Goyal (1985) explored a single item Economic Order Quantity model where the suppliers provided permissible delay in payments to the customers. Syed and Aziz (2007) applied fuzziness in inventory models without shortages and also used signed distance method for defuzzification.

Rawat (2011) investigated a fuzzy inventory model without shortages using triangular fuzzy number. Chandrasiri (2016) applied fuzziness in inventory models using triangular fuzzy number and used signed distance method for defuzzification. Nandya Shafira Pramesti (2021) presented the model of Economic Production Quantity model for Smart and Connected Products with upstream and downstream trade credit.

The focus of this article is on fuzzifying the holding cost of an EPQ model for smart and connected products. This paper is designed as follows. Section 3 consists of some notations and assumptions to be used throughout the paper. Section 4 deals with the EPQ model for smart and

connected products. Section 5 deals with the EPQ model under fuzziness. In Section 6, a numerical example is provided for triangular fuzzy number. In Section 7, sensitivity analysis is carried out to examine the effects of changes in the values of the parameter. The proposed model is to analyze the effectiveness of optimal values under fuzzy environment.

3. NOTATIONS

Decision variables

T^* Manufacturer's optimal production cycle time (years)

S^* Manufacturer's optimal number of sensors (number/product)

P^* Manufacturer's optimal selling price ($/product)

Parameters

a Price coefficient on demand

b Number of sensors coefficient on demand

c Product component cost ($/product)

c_s Cost of sensors ($/sensor level)

d Manufacturer's downstream credit period to customer (years)

u Manufacturer's upstream credit period from the supplier (years)

$\tilde{h}$ Fuzzy inventory holding cost ($/units/years)

p Annual production rate that is larger than the annual demand rate (units)

X_e Interest rate earned ($/year)

X_c Interest rate charged ($/year)

K Maximum number of potential customers with $p \geq K$

o Setup cost ($/production rate)

Functions

$D(P,S)$ Annual demand rate as a function of unit selling price P and number of sensors S (units)

Q Manufacturer's production lot size $Q = D(P,S)$(units)

$\prod(\widetilde{P,S},T)$ Manufacturer's fuzzy profit function ($/year)

4. MATHEMATICAL MODEL

The inventory model discussed in Nandya Shafira Pramesti and Iwan Vanany (2021) is considered. The manufacturer's total profit function in crisp sense is

$\prod(P,S,T) =$ Sales revenue(SR) – Production cost (PC) - Setup cost (SC) - Holding cost (HC) – Interest charged (IC) – Interest earned (IE)

Hence, for

Case 1: $u \geq d$ and $u \leq T + d$

Case 2: $u \geq d$ and $u \geq T + d$

Case 3: $u \geq d$

Manufacturer's annual profit is

$$\Pi_1(P,S,T) = PD - (c + c_s S)D - \frac{o}{T} - \frac{hDT}{2}\left(1 - \frac{D}{P}\right) - \frac{1}{2T}(c + c_s S)DX_c(T + d - u)^2 + \frac{1}{2T}PDX_e(u - d)^2 \quad (1)$$

$$\Pi_2(P,S,T) = PD - (c + c_s S)D - \frac{o}{T} - \frac{hDT}{2}\left(1 - \frac{D}{P}\right) + PDX_e(u - d - \frac{T}{2}) \quad (2)$$

$$\Pi_3(P,S,T) = PD - (c + c_s S)D - \frac{o}{T} - \frac{hDT}{2}\left(1 - \frac{D}{P}\right) - (c + c_s S)DX_c(d - u + \frac{T}{2}) \quad (3)$$

5. INVENTORY MODEL IN FUZZY SENSE

To get more realistic results, the parameter h is fuzzified using triangular fuzzy number.

$$\Pi_1(\widetilde{P,S,T}) = PD - (c + c_sS)D - \frac{o}{T} - \frac{\tilde{h}DT}{2}\left(1 - \frac{D}{P}\right) - \frac{1}{2T}(c + c_sS)DX_c(T + d - u)^2 + \frac{1}{2T}PDX_e(u - d)^2$$

$$\Pi_2(\widetilde{P,S,T}) = PD - (c + c_sS)D - \frac{o}{T} - \frac{\tilde{h}DT}{2}\left(1 - \frac{D}{P}\right) + PDX_e\left(u - d - \frac{T}{2}\right)$$

$$\Pi_3(\widetilde{P,S,T}) = PD - (c + c_sS)D - \frac{o}{T} - \frac{\tilde{h}DT}{2}\left(1 - \frac{D}{P}\right) - (c + c_sS)DX_c(d - u + \frac{T}{2})$$

5.1 Triangular Fuzzy Number

Let $\tilde{h} = (h_1, h_2, h_3)$ then we have

$$\Pi_1(\widetilde{P,S,T}) = PD - (c + c_sS)D - \frac{o}{T} - \frac{(h_1,h_2,h_3)DT}{2}\left(1 - \frac{D}{P}\right) - \frac{1}{2T}(c + c_sS)DX_c(T + d - u)^2 + \frac{1}{2T}PDX_e(u - d)^2$$

$$\Pi_1(\widetilde{P,S,T}) = \{PD - (c + c_sS)D - \frac{o}{T} - \frac{h_1DT}{2}\left(1 - \frac{D}{P}\right) - \frac{1}{2T}(c + c_sS)DX_c(T + d - u)^2 + \frac{1}{2T}PDX_e(u - d)^2,$$

$$PD - (c + c_sS)D - \frac{o}{T} - \frac{h_2DT}{2}\left(1 - \frac{D}{P}\right) - \frac{1}{2T}(c + c_sS)DX_c(T + d - u)^2 + \frac{1}{2T}PDX_e(u - d)^2,$$

$$PD - (c + c_sS)D - \frac{o}{T} - \frac{h_3DT}{2}\left(1 - \frac{D}{P}\right) - \frac{1}{2T}(c + c_sS)DX_c(T + d - u)^2 + \frac{1}{2T}PDX_e(u - d)^2\}$$

Similarly, for case 2 and 3 we get

$$\Pi_2(\widetilde{P,S,T}) = PD - (c + c_sS)D - \frac{o}{T} - \frac{(h_1+h_2+h_3)DT}{6}\left(1 - \frac{D}{P}\right) + PDX_e(u - d - \frac{T}{2})$$

$$\Pi_3(\widetilde{P,S,T}) = PD - (c + c_sS)D - \frac{o}{T} - \frac{(h_1+h_2+h_3)DT}{6}\left(1 - \frac{D}{P}\right) -$$

$$(c + c_sS)DX_c(d - u + \frac{T}{2})$$

Then the centroid method is used to defuzzify the total profit function $\Pi_1(\widetilde{P,S,T})$

$$d_F(\Pi_1(\widetilde{P,S,T}),0) = [\frac{PD}{3} - \frac{(c+c_sS)D}{3} - \frac{o}{3T} - \frac{h_1DT}{6}\left(1 - \frac{D}{P}\right) - \frac{1}{6T}(c + c_sS)DX_c(T + d - u)^2 + \frac{1}{6T}PDX_e(u - d)^2] + [\frac{PD}{3} - \frac{(c+c_sS)D}{3} - \frac{o}{3T} - \frac{h_2DT}{6}\left(1 - \frac{D}{P}\right) - \frac{1}{6T}(c + c_sS)DX_c(T + d - u)^2 + \frac{1}{6T}PDX_e(u - d)^2] + [\frac{PD}{3} - \frac{(c+c_sS)D}{3} - \frac{o}{3T} - \frac{h_3DT}{6}\left(1 - \frac{D}{P}\right) - \frac{1}{6T}(c + c_sS)DX_c(T + d - u)^2 + \frac{1}{6T}PDX_e(u - d)^2]$$

Then we get

$$d_F(\Pi_1(\widetilde{P,S,T}),0) = PD - (c + c_sS)D - \frac{o}{T} - \frac{(h_1+h_2+h_3)DT}{6}\left(1 - \frac{D}{P}\right) - \frac{1}{2T}(c + c_sS)DX_c(T + d - u)^2 + \frac{1}{2T}PDX_e(u - d)^2$$

Using the necessary and sufficient conditions, the optimal values of the decision variables are obtained.

For any given Selling Price P and Number of Sensors S, the first and second order partial derivative of $\Pi_i(\widetilde{P,S,T}), i = 1,2,3$ with respect to T are:

$$\frac{\partial\Pi_1(\widetilde{P,S,T})}{\partial T} = -\frac{1}{2}D\left((h_1 + h_2 + h_3)\left(1 - \frac{D}{P}\right) + (c + c_sS)X_c\right) - \frac{1}{2T^2}[2o + D(u - d)^2(X_c(c + c_sS) - PX_e)] = 0$$

$$\frac{\partial^2\Pi_1(\widetilde{P,S,T})}{\partial T^2} = -\frac{1}{T^3}\left[2o + D(u - d)^2\left(PX_e - X_c(c + c_sS)\right)\right] < 0$$

$$\frac{\partial \Pi_2(\widetilde{P,S,T})}{\partial T} = \frac{o}{T^2} - \frac{(h_1+h_2+h_3)D}{6}\left(1-\frac{D}{p}\right) + PDX_e\left(u-d-\frac{1}{2}\right) = 0$$

$$\frac{\partial^2 \Pi_2(\widetilde{P,S,T})}{\partial T^2} = oT^{-2} = -2oT^{-3} = -\frac{2o}{T^3} < 0$$

$$\frac{\partial \Pi_3(\widetilde{P,S,T})}{\partial T} = \frac{o}{T^2} - \frac{(h_1+h_2+h_3)D}{6}\left(1-\frac{D}{p}\right) - (c+c_sS)DX_c\left(d-u+\frac{1}{2}\right) = 0$$

$$\frac{\partial^2 \Pi_3(\widetilde{P,S,T})}{\partial T^2} = oT^{-2} = -2oT^{-3} = -\frac{2o}{T^3} < 0$$

6. NUMERICAL EXAMPLE

Triangular Fuzzy Number

Component cost $c = \$35$ per unit, cost of sensor $c_s = \$\,20$, downstream trade credit period $d = 0.08$ years, upstream trade credit period $u = 0.25$ years, production rate $p = 5000$units.

Triangular fuzzy inventory holding costs $h_1 = \$8$, $h_2 = \$9$, $h_3 = \$10$ per unit, setup cost $o = \$20$ per order, interest earned $X_e = 0.03$ per year, interest charged $X_c = 0.05$ per year and demand rate $D(P,S) = 3000e^{-0.005P}S^{0.75}$ per year.

The optimal values of the decision variables are

$$P^* = 400, S^* = 0.25, T^* = 0.07752, D^* = 144, Q^* = 11.16 \; and \; \Pi^* = \$51762.25$$

7. SENSITIVITY ANALYSIS

%Changes	Parameter: Triangular fuzzy number	Changes in the values of parameters	Result $\Pi(\boldsymbol{P},\boldsymbol{S},\boldsymbol{T})$
-20	(h_1,h_2,h_3)	(6.4,7.2,8)	51783.64

-10	(h_1, h_2, h_3)	(7.2,8.1,9)	51772.94
10	(h_1, h_2, h_3)	(8.8,9.9,11)	51751.55
20	(h_1, h_2, h_3)	(9.6,10.8,12)	51740.85

Table 1 Triangular Fuzzy Number

The impact of the level of fuzziness in the cost components over the decision variables is analyzed. By changing the value of the key parameters one at a time and keeping the remaining parameters unchanged. The sensitivity analysis is performed by varying a particular parameter by -20%, -10%, 10%, 20% and keeping other parameters unchanged. The optimal total profit for the fuzzy model is given in Table 1. It is observed that as the value of the holding cost increases, there are slight variations in the total profit of the manufacturer.

CONCLUSION

An economic production quantity model for smart and connected products under fuzzy environment is developed by fuzzifying the holding cost. The objective was to analyze the effectiveness of the total profit function in fuzzy environment. This model is suitable for facing the uncertainties in the costs components. From the sensitivity analysis it is observed that there are only slight variations in the total profit. This result helps the manufacturer to decide the best approach to maximize the total profit. Further research could be extended by fuzzifying the other parameters and incorporating the factors suitable for the system to be ecofriendly.

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EDGE DOMINATION IN NEUTROSOPHICGRAPHS

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ABSTRACT

This paper investigates an edge domination in neutrosophic graphs. Some basic definitions on edge dominating set with suitable examples are introduced. Further some results on edge domination number are investigated and theorems on edge dominating set with a known parameter of a neutrosophic graph are established.

Keywords:

Neutrosophic set, neutrosophic graph, neutrosophic number, edge dominating set.

AMS Subject Classification: 05C69

1 INTRODUCTION

The study of dominating sets in graphs was started by Ore [29]. The domination number and the independent domination number were introduced by Cockayne and Hedetniemi [10]. Fuzzy relation was introduced by Zadeh [41] in his classical paper in 1965. Rosenfeld [34] introduced the notation of fuzzy graph and several fuzzy analogs of graph theoretic concepts such as paths, cycles and connectedness. Somasundaram and Somasundaram [39] discussed domination in fuzzy graphs. They defined domination using effective edges in fuzzy graphs. Nagoor Gani and Chandrasekaran [23] discussed

domination in fuzzy graph using strong arcs. Nagoor Gani and Vadivel [28] discussed domination, independent domination and irredundance in fuzzy graphs using strong arcs. Several advanced topics and different types of domination are listed in Haynes et al. [14,15]. In 1976, the idea of a connected domination graphs was introduced and studied by Sampathkumar and Walikar [36]. In 1977, the concept of edge domination was introduced by Mitchell and Hedetniemi [19] as an analogue of vertex domination. A subset X of D is called an edge dominating set of G if every edge not in X is adjacent to some edge in X. Arumugam and Velammal [3] introduced the concept of connected edge domination of a connected graph. They have shown that a characterization of graphs reaching the upper bounds. The edge domination number of connected graphs has been introduced by Chaemchan [8] which is based on [3]. In 2015, Puttaswamy and Alatif [33] was introduced the concept of the boundary of edge domination in graphs, and also they have obtained exact values of some standard graphs. The intuitionistic fuzzy set is introduced by Atanassov [4] as a generalization of fuzzy set [40], which have both membership grades and non-membership grades. As an application, he applied his idea into expert systems, pattern recognition and especially in decision making. As a new emerging study of an intuitionistic fuzzy graph (IFG) has been addressed in [37]. Chountas and Alzebdi [9] presented an intuitionistic fuzzy version of a tree in graph theory. Furthermore, the operations [31] and some particular case of intuitionistic fuzzy graphs [30] were done by Parvathy and Karunambigai. The domination of graph in an intuitionistic environment defined in [32]. Later, Nangoorgani and Prasanna Devi [27] proposed the idea of edge domination and independence in the fuzzy graph. In this research, inspired from [32] and [27] investigated the concept of edge dominating set in IFGs and proved some remarkable results on edge dominating set. Neutrosophic set proposed by Smarandache [12] is a powerful tool for dealing incomplete and indeterminate problems in the real world. It is the generalization of fuzzy sets [13] and intuitionistic fuzzy set [16,17]. Fuzzy graph and intuitionistic approaches are failed in some

applications when indeterminacy occurs. So Smarandache defined four main categories of neutrosophic graphs in [38]. M. Mullai (2019), introduced the concept of domination and various types of domination in neutrosophic graphs . In this proposed work, edge domination in neutrosophic graph are developed with suitable examples and some results and theorems are explored.

2 Preliminaries:

Definition 2.1 An arc (v_i, v_j) is said to be a strong arc if $\mu_{2ij} \geq CONN_{\mu(G)}(v_i, v_j)$

and $\nu_{2ij} \leq CONN_{\nu(G)}(v_i, v_j)$ for every $v_i, v_j \in V$.

Definition 2.2 [32]

The strong neighbourhood of an edge e_i in a intuitionistic fuzzy graph G is
$N_s(e_i) = \{e_j \in E(G)/e_j$ is a strong arc in G and adjacent to $e_i\}$ *(S ⊆E(G))*

Definition 2.3 [32]

Let G = (V,E) be an IFG. Let e_i and e_j be two edges of G. We say that e_i dominates e_j, if e_i is a strong arc in G and adjacent to e_j.

Definition 2.4 [32]

Let D be a minimum dominating set of intuitionistic fuzzy graph G. If for every $e_j \in E(G) - D$, there exists $e_i \in D$ such that e_i dominates e_j, then D is called an edge dominating set of D. The minimum intuitionistic fuzzy cardinality of all edge dominating set of IFG G is known as edge dominating number and it is denoted by $\gamma_e(G)$.

Definition 2.5 [32]

Let G be an IFG and D be a subset of an edge set E. Then the node cover of D in G is defined as the set of all nodes incident to each edge in D.

Definition 2.6 [32]

Let IFG G=(V,E) and D is an edge dominating set in G.

(i) If the induced subgraph $< E - D >$ is disconnected. Then D is called split edge dominating set of G.

(ii) If the induced subgraph $< E - D >$ is connected. Then D is called a non-split edge dominating set of G.

(iii) If the induced subgraph $< E - D >$ is a path. Then D is called a path non-split edge dominating set of G.

(iv) If the induced subgraph $< E - D >$ is a cycle. Then D is called a cycle non-split edge dominating set of G.

Definition 2.7 [32]

Let e_i and e_j be any two edges of an intuitionistic fuzzy graph G. If $e_i \in \notin N_s(e_j)$ and $e_j \notin N_s(e_i)$, then e_i and e_j are called intuitionistic fuzzy independent. A set S E(G) is said to be an intuitionistic fuzzy edge independent set of an intuitionistic fuzzy graph G, if any two edges in S are intuitionistic fuzzy independent. The intuitionistic fuzzy edge independence number $\beta_e(G)$ is the maximum cardinality of all Intuitionistic fuzzy edge independent sets of G.

Definition 2.8 Let G = (A,B) be a single valued neutrosophic graph on the edge set E and Let $e_1, e_2 \in E$. e_1 dominates e_2 in G if

$T_A(e_1, e_2) = \min\{T_B(e_1), T_B(e_2)\}$, $I_A(e_1, e_2) = \min\{I_B(e_1), I_B(e_2)\}$ and

$F_A(e_1, e_2) = \min\{F_B(e_1), F_B(e_2)\}$.

Definition 2.9 A subset D^N of E is called an edge dominating set in G if for every edge $e_i \notin D^N$ there exists $e_j \in D^N$ such that e_j dominates e_i.

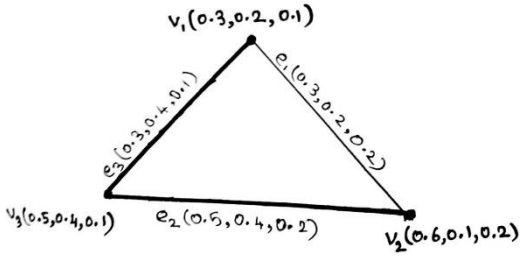
3 Edge Domination in Neutrosophic Graphs

Definition 3.1 The minimum cardinality of an edge dominating set in a neutrosophic graph G is called the edge dominating number of G and is denoted by $\gamma^N(G)$ or γ^N.

Example

Consider a figure 1,

Let $D^N = \{e_3\}$ is an edge dominating set and $E - D^N = \{e_1, e_2\}$. Edge domination



Figur

e 1:

number is $\gamma^N_e(G) = 0.4$.

Note:

(i) For any $e_i, e_j \in E$, if e_i dominates e_j in G then e_j dominates e_i and hencedomination is a symmetric relation on E.

(ii) For any e_i in E, $N(e_i)$ is the set of all edges which are dominated by e_i.

(iii) If $T_B(e_1, e_2) < \min\{T_B(e_1), T_B(e_2)\}$,

$I_B(e_1, e_2) < \max\{I_B(e_1), I_B(e_2)\}$ and

$F_B(e_1, e_2) < \max\{F_B(e_1), F_B(e_2)\}$, $\forall e_1, e_2 \in E$

then the only dominating set in G is E.

Definition 3.2 Let G be a neutrosophic graph and D^N is an edge dominating set of

G. Then D^N is said to be a minimal edge dominating set if no proper subset of D^N is a edge dominating set of G.

Definition 3.3 An edge e_1 of a neutrosophic graph G is said to be an isolated edgeif

$T_B(e_1, e_2) < \min\{T_B(e_1), T_B(e_2)\}$,

$I_B(e_1, e_2) < \max\{I_B(e_1), I_B(e_2)\}$ and

$F_B(e_1, e_2) < \max\{F_B(e_1), F_B(e_2)\}$, $\forall e_2 \in E - \{e_1\}$

i.e, $N(e_1) = \Phi$

Definition 3.4 Let G be a neutrosophic graph. A set of edges D^N in a neutrosophic graph G is said to be independent if

$T_A(e_1, e_2) < \min\{T_A(e_1), T_A(e_2)\}$,

$I_A(e_1, e_2) < \max\{I_A(e_1), I_A(e_2)\}$ and

$F_A(e_1, e^2) < \max\{F^A(e^1), F^A(e^2)\}$, $\forall e_1, e_2 \in D^N$

Definition 3.5 Let G be a neutrosophic graph without isolated edges and E be an edge set of G. A subset D^N of E is said to be a total edge dominating set if every edge in E is dominated by an edge in D^N.

Definition 3.6 The minimum neutrosophic cardinality of a total edge dominating set is called total edge domination number of a neutrosophic graph G.

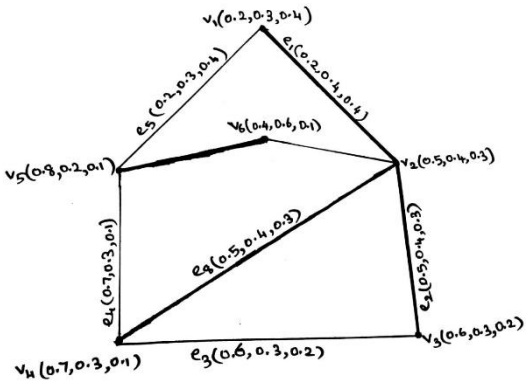
Definition 3.7 Let G be an neutrosophic Graph (NG) and D^N be a subset of an edge set E. Then, the node cover of D^N in G is defined as the set of all nodes incident to each edge in D^N.

Example

Consider a figure 2,

Let $D^N = \{e_6, e_8\}$ is an edge dominating set in NG and $E - D^N = \{e_1, e_2, e_3, e_4, e_5, e_7\}$.

Therefore, node cover of D^N is $\{v_5, v_2, v_6, v_4\}$.



Figur

e 2:

Definition 3.8 Let neutrosophic graph G and D^N is an edge dominating set in G.

(i) If the induced subgraph $< E - D^N >$ is a path. Then D^N is called a path non-split edge dominating set of G.

(ii) If the induced subgraph $< E - D^N >$ is a cycle. Then D^N is called a cyclenon-split edge dominating set of G.

Definition 3.9 Let e_i and e_j be any two edges of neutrosophic graph G. If $e_i \notin N_S(e_j)$ and $e_j \notin N_S(e_i)$, then e_i and e_j are called neutrosophic independent.

Definition 3.10 Let G be a neutrosophic graph. If any two edges of S^N are neutrosophic independent, then a set $S^N \subseteq E(G)$ is said to be a neutrosophic edge independent set

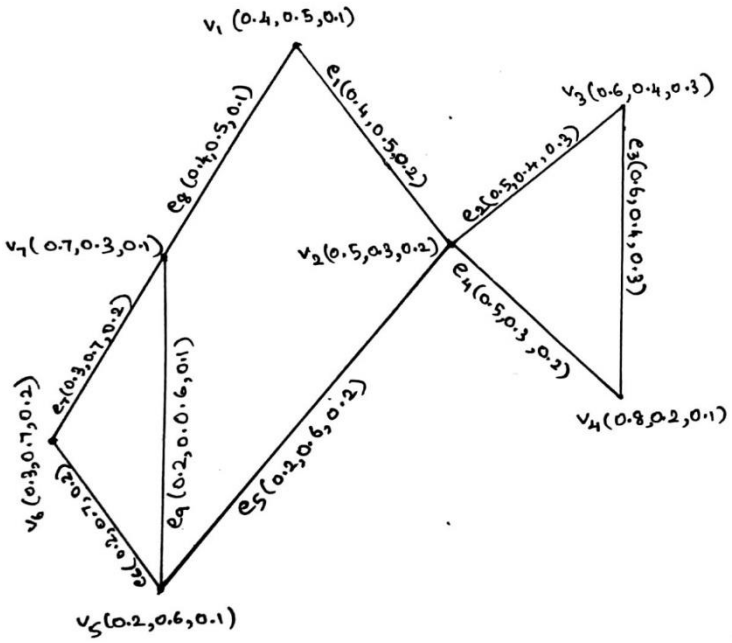
of G.

Definition 3.11 The neutrosophic edge independence number $\beta^N(G)$ is the maximum

cardinality of all neutrosophic edge independent set of G.

Example:

Consider the following figure ,



Here, $\{e_1\}$, $\{e_2\}$, $\{e_3\}$, $\{e_4\}$, $\{e_5\}$, $\{e_6\}$, $\{e_1, e_3, e_7\}$, $\{e_1, e_9, e_8\}$, $\{e_3, e_5, e_8\}$, $\{e_2, e_8, e_6\}$, $\{e_3, e_5, e_7\}$, $\{e_1, e_8\}$, $\{e_2, e_7\}$... etc

Theorem 3.12 Every edge dominating set D^N of an neutrosophic graph G containsat least one dominating set D'^N in G.

Proof:

Let D^N be an edge dominating set of neuutrosophic graph G.

Let us assume that the edge dominating set D^N of neutrosophic graph G contains no dominating set D'^N in D^N.

This implies any two nodes of D^N are independent and non-adjacent. Hence,

all $e's$ are not strong in D^N.

Therefore, for every $e_i \in E - D^N$, there exists no e_i in D^N, such that e_i will not dominate e_j that contradicts to D^N.

Therefore, D^N must contain at least one dominating set D'^N in G.

Theorem 3.13 Let D^N be a cycle non-split edge dominating set, if $< E - D^N >$ node cover includes all the nodes of G.

Proof:

We know that D^N is a cycle non-split edge dominating set of G

Assume that node cover of $< E-D^N >$ does not include all the nodes of G. Then $< E-D^N >$ may be connected (or) disconnected.

Case:1

If $< E-D^N >$ is connected, then any two edges of edge dominating set D^N of Gcontains no vertex in common and is disconnected.

Thisshows D^N is a non-split edge dominating set that contradicts our assumption that D^N is a cycle non-split edge dominating set of G.

Case:2

If $< E-D^N >$ is disconnected, then any two edges of edge dominating set D^N are non-adjacent and there exists independent vertices in D^N.

This implies edge dominating set D^N is a split dominating set that is a contradictionto our assumption.

Therefore, the node cover of $< E-D^N >$ must contain all the nodes of G from the above two cases. This completesthe proof.

Theorem 3.14 If D^N is an edge dominating set in neutrosophic graph G with end nodes, then at least one end node occur in D^N.

Proof:

Let D^N be an edge dominating set in neutrosophic graph G with end nodes.

Suppose there is no end node in D^N then some of the edges in edge dominating set D^N are independent and others are strong.

This implies for each $\forall e_j \in E - D^N \; \exists e_i \in D^N$ such that e_i dominates e_j but D^N will not be minimum.

Then it is contradicts to the definition.

Therefore, D^N contains at least one end node in G. This completes the proof.

Theorem 3.15 If D^N is an edge dominating set, then $\delta(G) \leq \gamma_e^N$.

Proof:

Let D^N be an edge dominating set of neutrosophic graph G.

By definition of edge dominating set, D^N must be minimum and most of the arcs should be strong. Minimum degree of G is nothing but minimum of degrees of all the vertices in G.

Since, degree of a vertex v is the sum of the weights of all strong arcs incident in v, implies cardinality of an edge dominating set D^N should be maximum.

Hence, the minimum degree of G is less than the cardinality of an edge dominating set D^N . Therefore, $\delta(G) \leq \gamma_e^N(G)$.

Theorem 3.16 Let G be a neutrosophic graph and G' the complement of G with the nodes and arcs as in G. If D^N is an edge dominating set of G, then D^N is anedge dominating set of G'.

Proof:

Let G and G' be a neutrosophic graph.

Let us assume that G' contains the nodes and arcs less than G.

Suppose any two edges e_i and e_j are adjacent in G may be adjacent (or) non-adjacentin G'.

Then, there exists distinct edge dominating sets in G' which does not equals D^N

which is a contradiction to the assumption that G' contains the edges and nodes less than G. Therefore, G and G' should contain equal number of nodes and arcs.

hence D^Noccurs both in G and G'.

Theorem 3.17 If D^N be an edge dominating set of complete neutrosophic graph G, then the edges of an edge dominating set D^N incident with the nodes containing maximum degree.

Proof: Let D^N be an edge dominating set in G.

Assume that edges of edge dominating set D^N is not incident with the nodes having maximum degree. Then arcs of edge dominating set D^N are strong, which are incident with the node containing minimum degree.

By definition of edge dominating set, for each $e_j \in E - D^N$ there exists $e_i \in D^N$ such that e_i dominates e_j.

Hence, edge dominating set D^n must contain more number of strong arcs.

This implies D^N is not minimum, then it leads to contradiction.

Hence, edges of edge dominating set D^N should incident with the nodes containing maximum degree.

Theorem 3.18 Let D_1^N and be an edge dominating set of neutrosophic graph G_1

and G_2 respectively. Then $D_1^N \times D_2^N$ is not an edge dominating set of $G_1 \times G_2$.

Proof:

Let D_1^N and D_2^N be an edge dominating set of neutrosophic graph G_1 and G_2 respectively.

Then $D_1{}^N \times D_2{}^N$ the connected neutrosophic graph. Most of the edges in $D_1^N \times D_2^N$ are strong edges.

Since, the connected graph, $D_1{}^N \times D_2{}^N$ is the part of the graph $G_1 \times G_2$, many of the edges of $G_1 \times G_2$ are non-adjacent to this connected graph $D_1{}^N \times D_2{}^N$.

Also some edges of $D_1{}^N \times D_2{}^N$ has common vertex with the edges of $G_1 \times G_2$.

This implies for each $e_j \in E - \{D_1^N \times D_2^N\}$ there exist $e_i \in \{D_1^N \times D_2^N\}$ such that e_i dominates e_j.

This is not true for all $e_j \in E - \{D_1{}^N \times D_2{}^N\}$, then it leads to contradiction.

Therefore, $D_1{}^N \times D_2{}^N$ cannot become as an edge dominating set of $G_1 \times G_2$.

Theorem 3.19 Let G be a complete neutrosophic graph with $n \geq 2$ vertices.If $S^N(G)$ is the size of edge dominating set D^N then

$$S_e^N(G)=\begin{cases}\frac{n-1}{2}, & n \text{ is odd}\\ \frac{n}{2}, & n \text{ is even}\end{cases}$$

Proof:

Let G be a complete neutrosophic graph with $n \geq 2$ vertices in G. Here no vertex is independent in G. This implies maximum arcs are strong arcs.

Otherwise, maximum number of end nodes will occur in G. Now we take some e_i's which are strong and non-adjacent in edge dominating set D^N . That is, they have no vertex in common. By definition of edge dominating set, D^N must be minimum.

Therefore, we select e_i's in such a way that for each $e_j \in E - D^N$ there exists $e_i \in D^N$ such that e_i dominates e_j which implies that, if n is even, then size of an edge dominating set $S_e{}^N(G)$ is $n/2$ such pairs and if n is odd, then there exist n-1/ 2 such pairs. This completes the proof..

Theorem 3.20 If D^N is an edge dominating set of G, then at least one edge dominating set D^N is itself an edge independent set.

Proof:

Let G be neutrosophic graph and D^N be an edge dominating set in G.

Case:1

Let us assume that D^N contains an isolated edge e_i in G. By definition of a Neutrosophic edge independent set, every e_i is an edge independent set in G. Obviously D^N is an edge independent set.

Case:2

Suppose D^N is not a neutrosophic independent set in G. Then each edge e_i in G will be strong. Hence, we have G must be a neutrosophic graph with only strong arcs, which is a contradiction to our assumption.

Therefore, at least one edge dominating set must be an edge dominating set. This completes the proof .

Conclusion

This paper demonstrates an edge domination in neutrosophic graphs by introducing some definitions on edge dominating set with suitable examples. Further some results on edge domination number γ_e^N (G) are investigated and theorems on edge dominating set D^N with a known parameter of G are established. Using these concepts, this research could be expanded in the future to find the lower and upper bounds of edge domination number of a neutrosophic graph. Also, edge domination in neutrosophic graphs will be applied in traffic problems and look for possible relationships between edge domination number and other parameters.

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EFFECT OF MAGNETIC FIELD ON THE BINDING ENERGY AND DIAMAGNETIC SUSCEPTIBILITY OF A HYDROGENIC DONOR IN A ROSEN-MORSE QUANTUM WELL

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ABSTRACT

In the present work, a GaAs/$Ga_{1-x}Al_xAs$ semiconductor quantum well with Rosen-Morse potential is considered. Binding energy of a hydrogenic donor in Rosen-Morse quantum well (RMQW) are calculated for various well widths and barrier heights using the variational method. Effect of magnetic field on the binding energy of the donor in RMQW is also analyzed, by varying the strength of the magnetic field. Diamagnetic susceptibility of the hydrogenic donor in RMQW is also studied.

Keywords: Rosen-Morse potential, Semiconductors, Quantum wells, Binding energy, Magnetic field, Diamagnetic susceptibility.

1. INTRODUCTION

Low dimensional semiconductor systems (LDSS) exhibit new physicochemical properties not shown by the corresponding large scale structures of the same composition. Suitable control of the properties and responses of nanostructures can lead to new devices and technologies. Due to the advancements in the experimental techniques, it is possible to manufacture quantum nanostructures with varied potential profiles. Novel structures like Woods-Saxon, Poschl-Teller, Rosen-Morse quantum wells etc are studied with great interest in recent times, as they show greater possibility in tuning the shape of the wells and hence the properties of impurities in such wells.

Force experienced by nucleons in an atomic nucleus (shell model of nuclear structure) is modeled by a mean field potential called Rosen-Morse Potential. Such a potential profile is considered for a quantum well and studied by many authors [1-10], due to its flexibility in adjusting the profile according to the necessity of device applications. The effects of impurities and external applied fields on the properties of the low dimensional semiconductor structures are of great significance for their potential relevance in the design and manufacture of devices with magnetic field applications.

Effect of magnetic field on a material is widely used in Nuclear Magnetic Resonance to identify the chemical and geometrical structure. LDSS with applied magnetic field are analyzed intensively by many researchers worldwide [11-15]. Using a variational technique, Yesilgul et al. [11] estimated the intersubband transitions and impurity binding energy in different shaped semiconductor quantum wells under a magnetic field. Their computations have shown that a quantum well's electrical and optical properties are significantly influenced by the magnetic field's strength and the shape of the quantum well.

A large and tunable optical nonlinear figure of merit is possible, when the magnetic field is applied in the growth direction, according to Yildirim and Aslan's [12] study on the effects of magnetic field on the terahertz nonlinear optical properties in donor-doped GaAs/AlGaAs quantum wells and also the nonlinear susceptibility is also significantly affected by the magnetic field. Gonzalez et al. [13] calculated the donor binding energy under magnetic field in a cylindrical nanotube with two GaAs/GaAlAs quantum wells. They found that when the impurity is in QW1, increasing the magnetic field increases the binding energy; when the impurity is in QW2, the opposite happens.

Kalpana et al. [14] examined the effect of magnetic field on the donor impurity in $CdTe/Cd_{1-x}Mn_xTe$ quantum well wire and also calculated the spin polaronic shift. The effects of external electric and magnetic fields on the ground state binding energy of hydrogenic donor impurity are compared in square, V-shaped, and parabolic quantum wells, according to calculations made by Min Hu et al. [15]. The findings showed that in SQW, the binding energy changes fast as the well width increases.

Diamagnetic susceptibility is one of the important parameters to analyse the magnetic response of a material. Studies on diamagnetic susceptibility were also carried

out by many authors on all LDSS [16-23]. The diamagnetic susceptibility of a hydrogenic donor in a quantum dot was studied by Jasper et al. [16], they compared the donor's χ_{dia} in a spherical quantum dot for both infinite and finite barrier models. It was demonstrated that certain physical parameters, such as dielectric polarizability and diamagnetic susceptibility, exhibit catastrophic behavior during the transition.

The effects of position-dependent effective mass and dielectric screening on donor binding energies and diamagnetic susceptibility in a quantum well were investigated by Rajashabala and Navaneethakrishnan [17]. They observed that while the ionization energies increase with pressure, $|\chi_{\mathrm{dia}}|$ decreases with pressure. Peter and Ebenezer [18] computed the diamagnetic susceptibility of a confined donor in a quantum dot with different confinements and compared the eigenstates of a hydrogenic impurity in all the confinements of dots.

The influence of nitrogen on a donor's diamagnetic susceptibility in a $Ga_xIn_{1-x}N_yAs_{1-y}$ /GaAs quantum well under a magnetic field was computed by Kilicarslan et al. [19]. The findings demonstrated that the diamagnetic susceptibility and binding energy increased with an increase in the nitrogen mole fraction. Additionally, there is a smaller space between the electron and the impurity atom due to the donor electron's stronger confinement.

Khordad [20] examined the diamagnetic susceptibility of hydrogenic donor impurity in a V-groove GaAs/$Ga_{1-x}Al_xAs$ quantum wire and proved that the value of the diamagnetic susceptibility due to the non-parabolicity effect is higher than that of parabolicity effect. The diamagnetic susceptibility of hydrogenic donor in anisotropic quantum wells is essentially equal to the transverse diamagnetic susceptibility part when well widths are larger than L>100 Å and the impurity is located at the center, according to the research done by Akbas et al. [21] on the diamagnetic susceptibility of hydrogenic donor in two-dimensional semiconductors with anisotropic effective mass of carriers.

Safarpour et al. [22] investigated the binding energy and diamagnetic susceptibility of an on-center hydrogenic donor impurity in a spherical quantum dot placed at the center of a cylindrical nano-wire and found that the first excited state diamagnetic susceptibility increases as the wire radius increases. The temperature effect on the binding energy and diamagnetic susceptibility of a magneto-donor in a cylindrical quantum dot (GaAs/GaAlAs) was investigated by Janati Edrissi et al. [23]. The findings demonstrated that both the

binding energy and the absolute value of the diamagnetic susceptibility decreased with increasing temperature or magnetic field.

In the present paper, a GaAs/$Ga_{1-x}Al_xAs$ semiconductor quantum well with Rosen-Morse potential is considered. Hydrogenic donor binding energy in Rosen-Morse Quantum Well (RMQW) is calculated for various well widths and barrier heights using the variational method. Magnetic field effects on the binding energy of the donor in RMQW are also analyzed. Diamagnetic susceptibility of the hydrogenic donor in RMQW is also studied.

2. Theory

2.1 Rosen-Morse Quantum well (RMQW)

The Hamiltonian for the ground state energy level of an electron in bare RMQW is given by, $H = \frac{P^2}{2m^*} + V(z)$; In effective mass approximation, $H = -\frac{d^2}{dz^2} + V(z)$ (1)

The potential profile for RMQW [4,7,8] is chosen as,

$$V(z) = -V_1 sech^2 \eta z + V_2 tanh^2 \eta z; \qquad -\infty < z < \infty \tag{2}$$

where V_1 and V_2 are the depth parameters and η is the width parameter of RMQW.

The trial wave function for barewell states in RMQW is taken to be of the form,

$$\psi = Ne^{-\alpha^2 z^2} \qquad \infty < z < \infty \tag{3}$$

where N is the normalization constant. <H> is evaluated as a function of variational parameter 'α' using the Hamiltonian in (1) and the trial wave function in (3) as,

$$< H >= \frac{\int \psi^* H \psi dz}{\int \psi^* \psi dz} \tag{4}$$

The barewell states (E_o) is calculated as the minimized value of <H> with respect to α.

2.2 Rosen-Morse quantum well with hydrogenic donor and applied magnetic field

In the absence of magnetic field, the Hamiltonian of a hydrogenic donor is given by

$$H = \frac{P^2}{2m^*} + V(z) - \frac{e^2}{\varepsilon_0 r} \tag{5}$$

In the presence of magnetic field,

$$H = \frac{\left(\vec{P} + \frac{e\vec{A}}{c}\right)^2}{2m^*} + V(z) - \frac{e^2}{\varepsilon_0 r} \tag{6}$$

where $\vec{A}$ is the vector potential and $\vec{B} = \vec{\nabla} \times \vec{A}$. Using cylindrical coordinate system, the Hamiltonian can be written as,

$$H = \frac{p^2}{2m^*} + \frac{e^2A^2}{2m^*c^2} + \frac{2e}{2m^*c}\vec{p}.\vec{A} + V(z) - \frac{e^2}{\varepsilon_0 r} \quad (7)$$

$$H = \frac{-\hbar^2\nabla^2}{2m^*} + \frac{e^2B^2\rho^2}{8m^*c^2} + \frac{eBL_z}{2m^*c} + V(z) - \frac{e^2}{\varepsilon_0 r} \quad (8)$$

L_z = z - component of angular momentum (in units of $\hbar$), $L_z = -i\hbar\frac{\partial}{\partial z}$ (9)

The effective Rydberg R^* is taken as the unit of energy, $R^* = \frac{m^*e^4}{2\hbar^2\varepsilon_0{}^2}$ and the effective Bohr radius a^* is taken as the unit of length, $a^* = \frac{\hbar^2\varepsilon_0}{m^*e^2}$. In effective Rydbergs and effective Bohr radius, $H = -\nabla^2 + \frac{\gamma^2\rho^2}{4} + \gamma L_z + V(z) - \frac{2}{r}$ (10)

γ is the dimensionless measure of the magnetic field defined as, $\gamma = \frac{e\hbar B}{2m^*cR^*}$ and γ = 1 corresponds to B = 5.97 T.

The trial wavefunction of the hydrogenic donor with magnetic field is taken as,

$$\psi = Ne^{-\alpha^2z^2}e^{-ar}e^{-\lambda\rho^2} \quad ; \quad -\infty < z < \infty \quad (11)$$

where N is the Normalization constant, α, a, λ are the variational parameters. The expectation value of the Hamiltonian is given by,

$$< H >= \frac{\int \psi^* H \psi d\tau}{\int \psi * \psi d\tau} \quad (12)$$

Hydrogenic donor states with magnetic field is calculated as the minimized value of <H> with respect to the variational parameters α, a, λ.

2.3 Binding energy of the hydrogenic donor in RMQW with magnetic field

The donor binding energy of the ground state is calculated as,

$$E_B = E_o + \gamma - <H>_{min} \quad (13)$$

where E_o is the ground state energy level of an electron in bare RMQW, γ is the dimesionless magnetic field parameter and $<H>_{min}$ is the ground state energy of the hydrogenic donor in RMQW with applied magnetic field.

2.4 Diamagnetic susceptibility of the hydrogenic donor in RMQW

Diamagnetic susceptibility of the hydrogenic donor of a doped low-dimensional semiconductor in atomic unit is given by,

$$\chi = -\frac{e^2}{6m^*\varepsilon_o c^2} < \rho^2 > \quad (14)$$

Table – 1: Physical parameters used in the calculations

S.No.	Parameter	Description	Value
1.	c	Velocity of light	137 in a.u.
2.	e	Charge of an electron	1 in a.u.
3.	m*	Effective mass of an electron in GaAs	1 in a.u.
4.	ε_o	Static dielectric constant of GaAs	13.2

The expectation value for $<\rho^2>$ is given by, $< \rho^2 >= \frac{\int \psi^* \rho^2 \psi d\tau}{\int \psi^* \psi d\tau}$ (15)

Mathcad software is used for the calculations.

3. RESULTS AND DISCUSSION

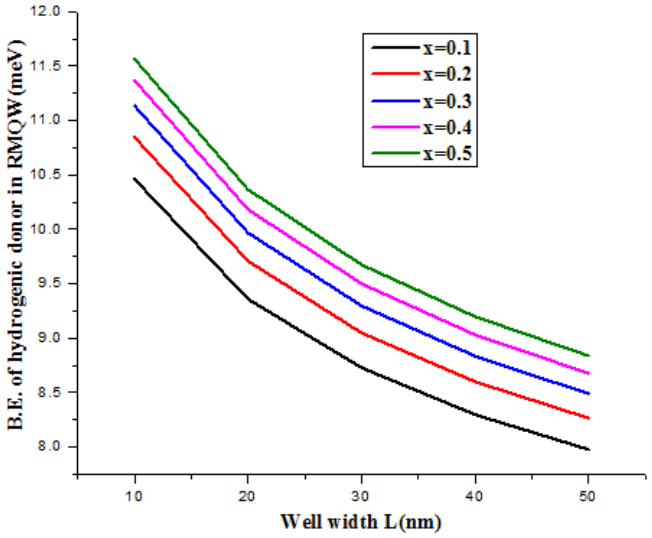

Figure 1. Variation of binding energy of a hydrogenic donor in RMQW as a function of well width for various Al compositions

Figure 1 shows the variation of the ground state hydrogenic donor binding energy as a function of well width (L) for different Al compositions (x). It is observed that for a fixed x, binding energy increases as well width decreases due to the compression of wavefunction

inside the well [18,23]. As x increases, the binding energy increases, as the barrier height increases with x. It is also observed that for a fixed L, the increase in binding energy decreases as Al composition increases.

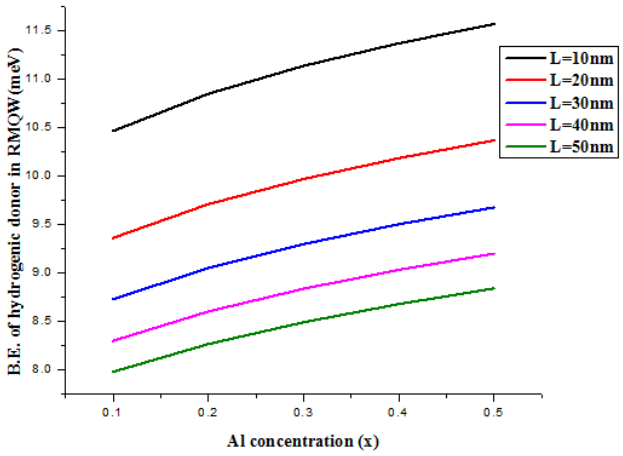

Figure 2. Variation of binding energy of a hydrogenic donor in RMQW as a function of Al composition for various well widths

Figure 2 shows the variation of the ground state hydrogenic donor binding energy as a function of Al composition (x) for various well widths (L). It is observed that for a fixed L, binding energy increases as Al composition increases due to the increase in barrier height which imposes more confinement on the donor [19,20]. It is also observed that for a fixed x, the decrease in binding energy decreases as well width increases.

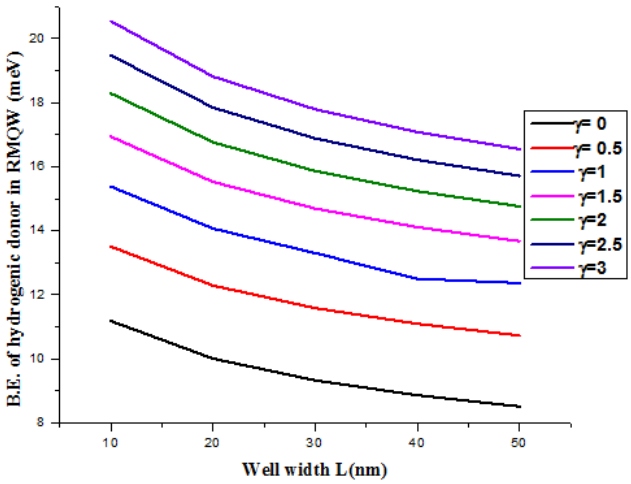

Figure 3. Variation of binding energy of a hydrogenic donor in RMQW as a function of well width for various magnetic field strengths and x=0.3

Figure 3 shows the variation of the ground state hydrogenic donor binding energy as a function of well width for various magnetic field strengths with x=0.3. It is observed that for a fixed L, binding energy increases as magnetic field strength increases due to the increase in confinement on the donor due to magnetic field [11,15,23]. It is also observed that for a fixed L, the increase in binding energy decreases as magnetic field strength increases.

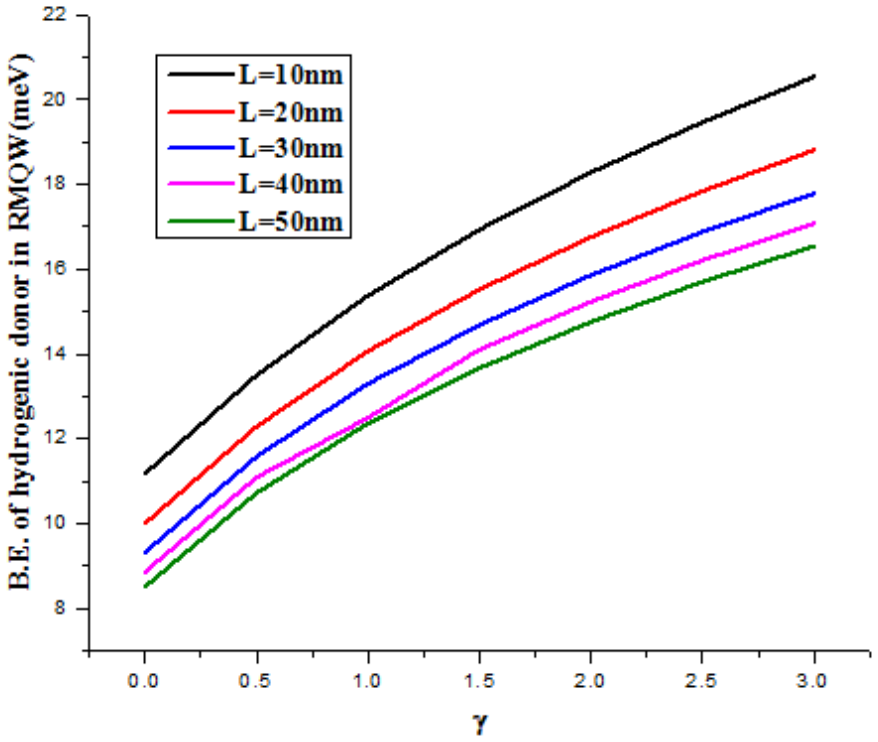

Figure 4. Variation of binding energy of a hydrogenic donor in RMQW as a function of magnetic field strength γ for various well widths and x=0.3

Figure 4 shows the variation of the ground state hydrogenic donor binding energy as a function of magnetic field strength for various well widths with x=0.3. It is observed that for a fixed γ, binding energy decreases as well width increases due to the decrease in confinement on the donor [15,23]. It is also observed that for a fixed γ, the decrease in binding energy decreases as well width increases.

Figure 5 shows the variation of the ground state hydrogenic donor binding energy as a function of Al composition for various magnetic field strengths with L=30nm. It is observed that for a fixed x, binding energy increases as magnetic field strength increases due to the

decrease in confinement on the donor. It is also observed that for a fixed x, the increase in binding energy decreases as magnetic field strength increases.

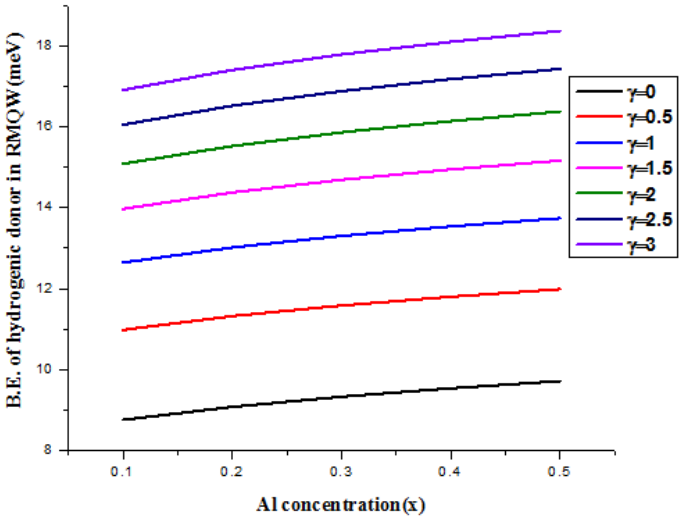

Figure 5. Variation of binding energy of a hydrogenic donor in RMQW as a function of Al composition for various magnetic field strengths with L=30nm

Figure 6 shows the variation of the ground state hydrogenic donor binding energy as a function of magnetic field strength for various Al composition and L=30nm. It is observed that for a fixed γ, binding energy increases as Al composition increases due to the increase in barrier height leading to increase in confinement on the donor. It is also observed that for a fixed γ, the increase in binding energy decreases as Al composition increases.

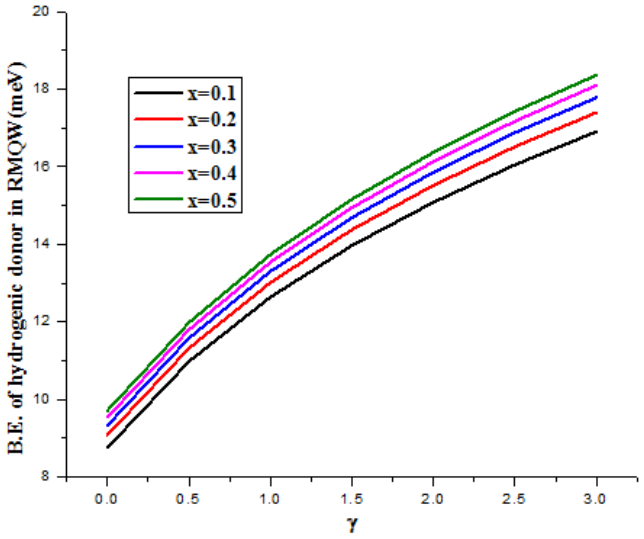

Figure 6. Variation of binding energy of a hydrogenic donor in RMQW as a function of magnetic field strength for various Al composition and L=30nm

Figure 7 shows the variation of diamagnetic susceptibility of a hydrogenic donor as a function of well width for various magnetic field strengths with x=0.3. It is observed that for a fixed γ, diamagnetic susceptibility decreases as well width increases [16,21,23] and the decrease is more prominent for low values of γ [17]. It is also observed that the increase in diamagnetic susceptibility decreases as well width decreases [19].

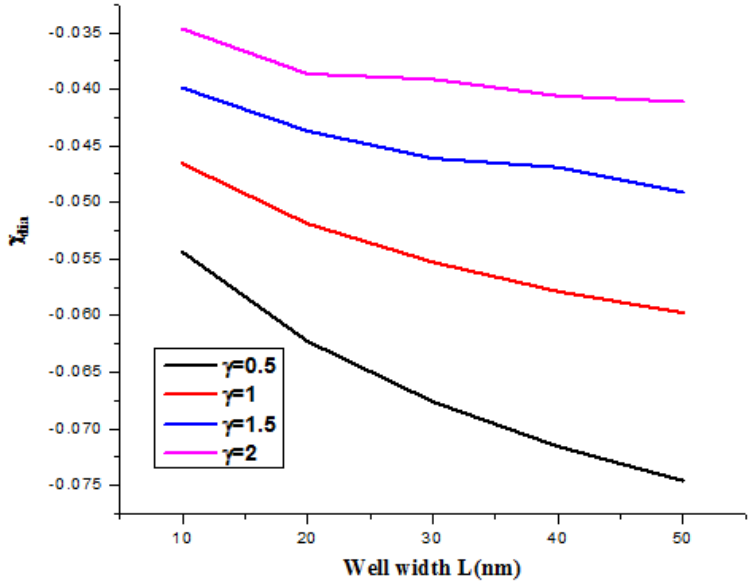

Figure 7. Variation of diamagnetic susceptibility of a hydrogenic donor in RMQW as a function of well width for various magnetic field strengths with x=0.3

Figure 8 depicts the variation of diamagnetic susceptibility of a hydrogenic donor as a function of Al composition for various magnetic field strengths with L=30nm. It is observed that the diamagnetic susceptibility of the donor increases as Al composition increases [16,19]. It decreases and the decrease becomes smaller, as magnetic field increases.

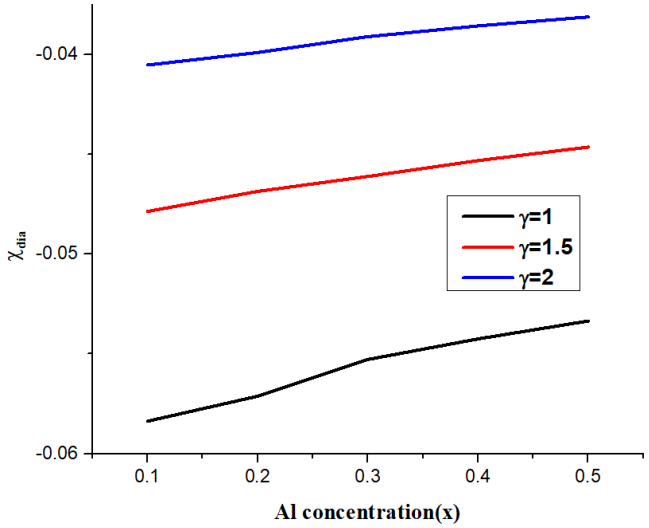

Figure 8. Variation of diamagnetic susceptibility of a hydrogenic donor in RMQW as a function of Al composition for various magnetic field strengths with L=30nm

4. Conclusions

Binding energy and diamagnetic susceptibility of a hydrogenic donor in a Rosen-Morse Quantum well (RMQW) formed by GaAs/$Ga_{1-x}Al_xA_s$ are calculated as a function of well width, Al composition and magnetic field using variational method. It is found that both the binding energy and diamagnetic susceptibility decreases as well width increases, increases as Al composition increases and increases as magnetic field strength increases. These results may find applications in the choice of well width, Al composition and magnetic field for the design of required devices. Optical and electrical properties of the hydrogenic donor in RMQW will be studied in future for the device applications in these areas.

Acknowledgement

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ASSESSMENT OF ANTI-CANCER ACTIVITY OF *MOLLUGO CERVIANA* (*L*). SER ON HEPATOCELLULAR CARCINOMA BY *INVITRO* AND *INSILICO* ANALYSIS

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ABSTRACT

Hepatocellular carcinoma (HCC) is one of the primary forms of malignancy that affects liver. The primary causes of HCC are believed to be the severe liver cirrhosis, continuous and prolonged exposure to viral infections. Though the time period for the survival of the patients has been increased by modern medicine, these treatments have many lethal side effects and emotional distress which is a great disadvantage. Hence Plants are considered to be the best alternative strategy. The present study is specifically designed to assess the invitro cytotoxicity of the ethanolic and methanolic extract of Mollugo cerviana against the HepG2 cell lines by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT). In silico approach technique molecular docking analysis is documented by using the bioactive compounds present in the plant Mollugo Cerviana with AKR1B10 protein target which is considered to be an important protein implicated in cancer pathology and it is proposed to be a suitable target for drug development. The findings clearly states that cell viability decreases from 98% to 44% with the increasing concentration of the extract. Docking analysis proves that the compound strongly binds to target and they have a very good binding affinity against the drug targets. In conclusion the study gives a good insight that the selected plant has a very good anticancer potential and they can serve as a promising therapeutic target for hepatocellular Carcinoma.

1. INTRODUCTION

Hepatocellular carcinoma (HCC) is one of the leading causes of cancer worldwide with an estimated incidence of >1 million cases by 2025 [1]. The main risk of developing HCC in majority of the patients is considered to be the infection of hepatitis B virus and hepatitis C virus. Though there are several treatment plans for HCC which includes curative resection, radiofrequency ablation and liver transplantation, the response of the patients to the drugs are still under development due the severe side effects of the drugs, and resistance of cancer cells to treatment [2]. The conventional and traditional anticancer medications induce a cascade of molecular events that can halt the proliferation of cancer cells which can also leads to intracellular damage that is highly detrimental to human health. An alternative strategy to modern medicine is Herbal medicine, and this is one of the promising and efficient approach in recent years in reducing the cancer symptoms and painful treatment. Herbal medicine plays a vital role in mitigating the side effects of synthetic drugs and also provides a persistent relief to the patients. Plants are regarded as a valuable source of medicinal compounds due to their ability to produce beneficial drugs. Plant sources are also rich in secondary metabolites which has an outstanding biological property and it is also proved that potent compounds in the plants helps in the inhibition of cell development, variation in cell differentiation and initiation of apoptosis [3]. Hence, they are considered as very good source of alternative to the synthetic drugs as they do not contribute any adverse side effects and they do not develop any drug resistance mechanism. The chosen plant Mollugo cerviana (L.) belonging to the family of Mollugnaceae is a common weed found in the southern parts of Tamil Nādu and it is an annual herb that grows up to 20 cm long with a straight slim and cylindrical stem often used as a traditional medicine in treating inflammation and Jaundice [4]. This Plant has scientifically been proved to have a good antimicrobial, antioxidant and anticancer properties making them as a valuable resource for therapeutic applications [5].

The effect of plant extracts on cell viability and proliferation can be assessed by various techniques and the most important technique that is widely used is 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide assay (MTT) assay. It is a calorimetric assay that measures the metabolic activity of the cells. MTT assay, is based

on the ability of a mitochondrial dehydrogenase enzyme of viable cells to cleave the tetrazolium rings of the pale yellow MTT and form a dark blue colored formazan crystals which is largely impermeable to cell membranes, thus resulting in its accumulation within healthy cells. Solubilization of cells by the addition of detergents Dimethyl sulfoxide (DMSO) results in the liberation of crystals which are solubilized. The intensity of the color produced is directly proportional to the number of viable cells in the sample. Therefore, MTT assay provides a quantitative measure of cell viability or cytotoxicity depending on experimental conditions [6].

Docking of plant extracts is a computational technique crucial in drug discovery, offering vital insights into the binding mode of phytochemicals on cells. It aids in predicting the interaction and affinity of small molecules, including those derived from plant extracts, with specific target proteins or receptors. This approach plays a pivotal role in understanding the molecular interactions and potential therapeutic applications of bioactive compounds present in the plant extract and specific protein targets associated with diseases, including cancer [7].

Additionally, docking analysis was conducted to assess the binding affinity of active compounds from the plant to the AKR1B10 protein, an important target in cancer therapy. Aldo-keto reductase family 1 member B 10 (AKR1B10), is associated with the development and progression of hepatocellular carcinoma. It was reported that AKR1B10 in hepatocarcinogens is via modulation of proliferation and apoptosis According to Wang et al., 2009, it was proved that inhibition of AKR1B10 results in apoptosis of tumor cells, in which cellular lipids, especially phospholipids, were decreased by over 50%. Thus, it was chosen as a target for in silico analysis.

Therefore, in the present study, the objective was to assess the anticancer potential of Mollugocerviana on HepG2 cells and unravel the underlying mechanism of its cytotoxicity through MTT assay. Additionally docking analysis was performed to evaluate the binding affinity of active compounds derived from the plant with the AKR1B10 protein, a significant target in cancer therapy.

MATERIALS AND METHODS

Selection of Cell lines:

Human liver cancer cells specifically Hep – G2 cell line was purchased from NCCS, Pune and were cultured in liquid medium (DMEM) supplemented with 10% Fetal Bovine Serum (FBS), 100 ug/ml penicillin and 100 µg/ml streptomycin, and maintained under an atmosphere of 5% CO_2 at 37ºC.

CYTOTOXICITY ASSAY

MIT ASSAY:

The methanolic extract of the Plant Mollugo cerviana (MEMC) was tested for in vitro cytotoxicity, using Hep-G2 cells by MTT assay. The sample was tested for in vitro cytotoxicity, using Hep-G2 cells by MTT assay. Briefly, the cultured Hep-G2 cells were harvested by trypsinization, pooled in a 15 ml tube. Then, the cells were plated at a density of 1×10^5 cells/ml cells/well (200 µL) into the 96-well tissue culture plate in DMEM medium containing 10 % FBS and 1% antibiotic solution for 24-48 hour at 37°C. The wells were washed with sterile PBS and treated with various concentrations of the sample in a serum free DMEM medium. Each sample was replicated three times and the cells were incubated at 37°C in a humidified 5% CO_2 incubator for 24 h. After the incubation period, MTT (20 µL of 5 mg/ml) was added into each well and the cells incubated for another 2-4 h until purple precipitates were clearly visible under an inverted microscope. Finally, the medium with MTT (220 µL) were aspirated off the wells and washed with 1X PBS (200 µl). Furthermore, to dissolve the formazan crystals, DMSO (100 µL) was added and the plate was shaken for 5 min. The absorbance for each well was measured at 570 nm using a micro plate reader (Thermo Fisher Scientific, USA) and the percentage cell viability and IC50 value was calculated using Graph Pad Prism 6.0 software (USA).

INSILICO ANALYSIS: The inhibitory activity was tested by Insilco analysis by following the docking protocol.

PROTEIN PREPARATION: Three-dimensional structure of the enzyme AKR1B10

was retrieved from the PDB database using its id 4WEV. Protein was prepared by auto dock tools. The ligand and crystallographic water molecules were removed from the protein, and the chemistry of the protein was corrected for missing hydrogen. Crystallographic disorders and unfilled valence atoms were corrected using alternate conformations and valence monitor options. Following the above steps of presentation, the protein was subjected to energy minimization by applying kollman charges [8].

LIGAND PREPARATION:

The ligand molecule present in Mollugo cerviana was identified through literature search [9]. Three-dimensional structure of two phytocompounds orientin and vitexin was retrieved through pubchem text search and the structure was downloaded in .sdf format. The three- dimensional structure of phytocompound saved in .sdf format was converted to .pdb format using open babel 2.3.1. Ligands were prepared using MGL tools by adding hydrogen atom to check the valencies of the heavy atoms. Ligand was minimized by computing gustier chargesand saved in PDBQT.

DOCKING:

Docking program Autodock vina uses a grid-based method for energy evaluation of flexible ligand in complex with a rigid protein. Points on a 3D grid, are placed to cover the entire receptor. Docking was carried out using Autodock Vina with AMBER force field and Monte Carlo simulated annealing algorithm [10]. Throughout the docking studies the protein moleculewas kept as rigid and drug molecules as flexible.

RESULTS

In the present study the cytotoxic effects of the methanolic extract of Mollugo cerviana was analyzed on Hep G2 cells and the cell viability decreases from 97% to 33% with the increasing concentration of the extract (Table 1). The plant extract exhibited 50% cytotoxicity against HepG2 cells at the Inhibitory concentration (IC50) of 90.2µg/ml (Figure 1).

S.No	Tested sample concentration (µg/ml)	OD Values at 570 nm (Average Value in Triplicates)
1.	Control	0.466
2.	1 µg/ml	0.455
3.	5 µg/ml	0.424
4.	10 µg/ml	0.396
5.	15 µg/ml	0.3703
6.	50 µg/ml	0.344
7.	100 µg/ml	0.319
8.	200 µg/ml	0.311
9.	300 µg/ml	0.253
10.	400 µg/ml	0.205
11.	500 µg/ml	0.157

Table 1: OD values at 570nm arereplicated in triplicates and represented in Table 1

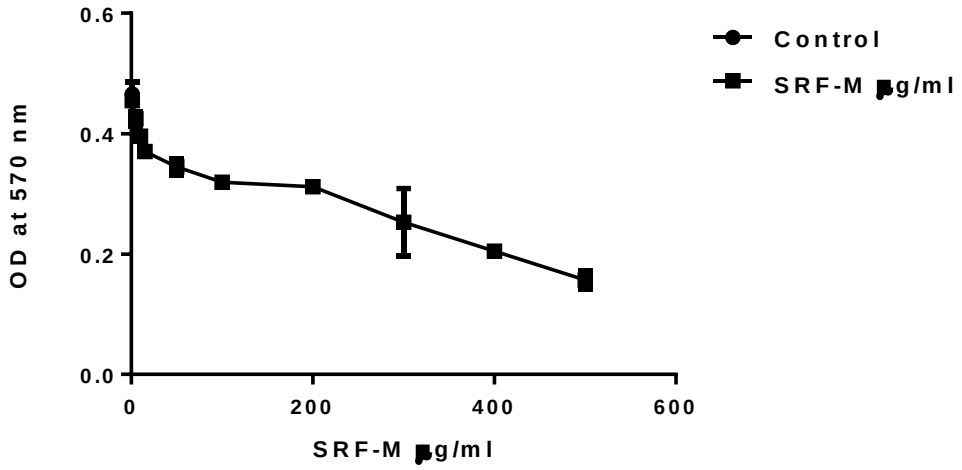
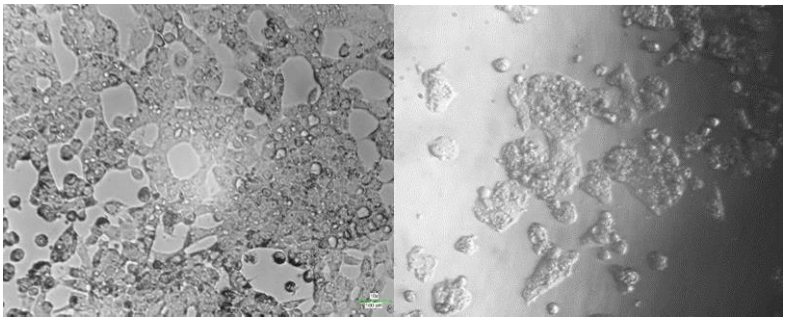
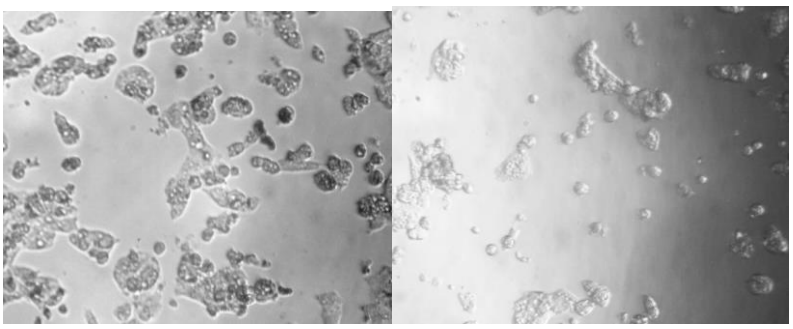


Figure 1: Graph representing the effect of plant extracts on the viability of Hep G2 cells based on MTT assay. The different absorbance levels of MEMC and their action on HepG2 cells.

The viability of cancer cells got decreased in treated cells when compared to the normal cells. With an increasing concentration of extract the viability gets decreased and this has a very good cytotoxic effect on Cancer cells which is depicted in Figure 2



Control cells **10 µg/ml on HepG2 cells**



100 µg/ml on HepG2 cells **500 µg/ml on HepG2 cells**

Figure 2 : MTT Assay Results Showing Cell Viability at Different Concentrations of Plant Extract on HepG2 Cells"

DOCKING ANALYSIS

The Molecular Docking analysis of the bioactive compounds orientin and vitexin in Mollugo cerviana (L.) SER with the protein target shows very good binding affinity (Table 2)

Table 2 : Molecular docking results of AKR1B10 with the selected compounds

S.NO	Compound Name	Binding Energy Kcal/mol
1	Vitexin	-8.9
2	Orientin	-8.5

Results of the present study clearly shows that both compounds have very good binding affinity score of about (-8.9 kcal/ mol and -8.5kcal/mol). The results of interaction between AKR1B10 with the phytocompound are shown in Figure 3. The green dotted line denotes the hydrogen bond. All the amino acid residues which involved in molecular interactions are displayed as lines and the ligand is displayed as sticks.

To visually represent and interpret the molecular interactions, the following figures were generated. Figure 3(A) represents interaction between AKR1B10 and orientin. Figure 3(B) represents the interactions between AKR1B10 and vitexin. The green dotted lines in the figure denote hydrogen bonds, indicating a specific and directional interaction between the hydrogen donor and acceptor groups.

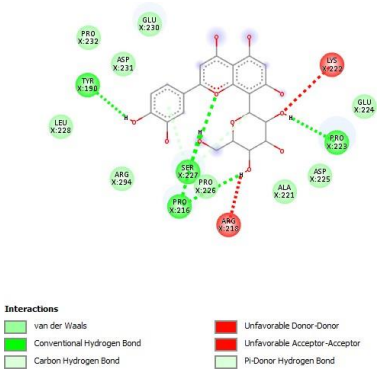


Fig 3(A): 2D images generated using discovery studio Visualizer showing amino acid residues involved in interactions between AKR1B10 and orientin

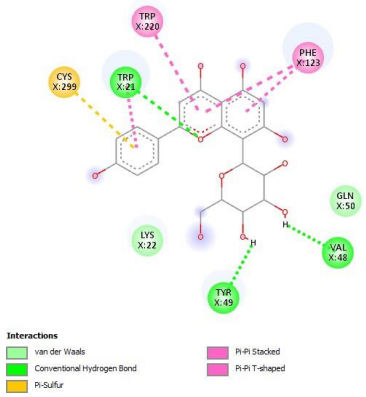


Fig 3 (B): 2D images generated using discovery studio Visualizer showing amino acid residues involved in interactions between AKR1B10 and Vitexin

DISCUSSION: The cytotoxic study clearly reveals that the plant extract has a good antitumor activity against the Hep G2 cells. The minimum inhibitory concentration is determined value is 90.22 µg/ml which clearly states that the plant extract stops the proliferation of cancer cells and inhibits its activity. With these promising results the study was further carried out to determine the active compounds in the plant that has a binding affinity towards a target protein.

In the present study docking studies was performed by using Auto dock vina. Binding affinity value was used to identify how the compound strongly binds to the target protein.

The present study utilizes Auto Dock Vina, for predicting the binding modes and affinities of small molecules to target proteins. The binding affinity values obtained from the docking simulations were utilized to evaluate how strongly the investigated compounds interact withthe target protein [11].

The results of the study indicate that both compounds exhibited favorable binding affinities with AKR1B10, as evidenced by the obtained scores of approximately -8.9 kcal/mol and -8.5 kcal/mol. These values suggest a strong binding interaction between the compounds and the target protein. In molecular docking studies, a lower binding affinity score generally corresponds to a stronger binding interaction.

Moreover, the figure displays the molecular structure of AKR1B10, represented as lines, and the ligands, represented as sticks. Each line in the figure corresponds to an amino acid residue from the AKR1B10 protein that is involved in molecular interactions with the ligand. The visualization of these interactions provides insights into the spatial arrangement and specific amino acid residues that contribute to the binding of the compounds to the target protein.

Overall, the study suggests that both compounds have a promising potential for binding to AKR1B10, supported by their favorable binding affinity scores and the observed molecular interactions depicted in Figure 3. These findings contribute valuable information for understanding the potential therapeutic or biological

effects of the investigated compounds onthe target protein.

CONCLUSION: The findings of this study suggest promising pharmaceutical potential for the plant extract in combating cancer cells, particularly due to the notable effectiveness of compounds such as vitexin and orientin, which exhibit strong binding affinity towards the target protein. However, further research is warranted to isolate these compounds biologically and validate their efficacy through in vivo experimentation. This step is crucial for confirming the therapeutic effectiveness of the plant extract and its constituents in a living organism, thereby advancing our understanding of their potential as cancer-fighting agents

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HISTORY OF PRIMARY HEALTH CENTRE IN INDIA WITH SPECIAL REFERENCE TO JANGALPATTY PHC IN THENI DISTRICT

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ABSTRACT

India's commitment to accessible and universal health services has driven the dynamic evolution of primary healthcare. Rooted in the Health Survey and Development Committee Report of 1946, emphasizing socially oriented medical practice, the journey spans colonial health focus to contemporary reforms. Key milestones include the Alma-Ata Declaration (1978) influencing India's first National Health Policy (1983) and subsequent adaptations. Examining India's healthcare structure, from Primary Health Centres (PHCs) to Patient Welfare Societies, born from the National Rural Health Mission, this exploration highlights a community-centric dimension. With regards to community-centric dimension it Focuses on Jangalpatty Primary Health Centre and the Patient Welfare Society's initiatives which showcases commitment to government standards, transparency, and modernized health services. The leadership structure emphasizes community representation, ensuring holistic healthcare governance. India's resolute commitment to comprehensive health services, despite challenges, is evident as initiatives like Patient Welfare Societies all around the country similar to the Jangalpatty Primary Health Centre contribute to healthcare improvements, steering India towards equitable primary healthcare access for all citizens, transcending socio-economic constraints.

Keywords: Primary Health Centre, Jangalpatty, Healthcare, Patient Welfare, Services

INTRODUCTION

The evolution of primary healthcare in India reflects a dynamic journey deeply embedded in the nation's commitment to providing accessible and universal health services.

India's healthcare principles emphasized socially oriented medical practice and active public involvement. This article navigates through historical milestones, from the colonial era's focus on British residents' health needs to contemporary healthcare reforms. Notably, the Jangalpatty Primary Health Centre (PHC) in Theni district emerges as a focal point, illustrating the tangible impact of India's commitment to healthcare accessibility from the grassroots. With an intricate structure encompassing Sub-Centers, Primary Health Centres, Community Health Centres, and more, the article explores the challenges, reforms, and initiatives that have shaped India's primary healthcare landscape. Patient Welfare Societies, born out of the National Rural Health Mission, add a community-centric dimension, contributing to improved infrastructure and healthcare delivery. This exploration aims to provide insights into India's ongoing efforts to achieve comprehensive and inclusive primary healthcare services.[i]

Recognizing the significance of primary healthcare well before the Alma-Ata Declaration of 1978, India has continually adapted and implemented various healthcare models. This essay explores the historical trajectory of primary healthcare in India, specifically delving into the initiatives undertaken at the Jangalpatty Primary Health Centre in the Theni district. The foundational principles of India's healthcare approach were laid out in the Health Survey and Development Committee Report of 1946, chaired by Sir Joseph Bhore. The subsequent decades witnessed the establishment of primary health centres (PHCs) and subcentres as part of the Community Development Programme initiated during the first five-year plan 1951-1955. Various committees, such as the Jungalwalla Committee in 1967 and the Kartar Singh Committee in 1973, advocated for the integration of health services at all levels, further strengthening India's resolve to provide comprehensive healthcare. The Alma-Ata Declaration in 1978 propelled the formulation of India's first National Health Policy in 1983, outlining the goal of delivering universal primary healthcare services. The subsequent policy in 2002 adjusted the framework to address evolving socio-economic circumstances, emphasizing increased sectoral allocation to primary healthcare.[ii]

HISTORICAL BACKGROUND OF PRIMARY HEALTHCARE IN INDIA

During the colonial era, public health systems primarily catered to the health needs of British residents in India. This period witnessed the establishment of research institutes, the enactment of public health legislation, and the formation of sanitation departments. It is noteworthy that, despite these developments, only 3% of Indian households had access to toilets during this time. Annual health reports were regularly published, emphasizing the prevention of contagious diseases. By the conclusion of the colonial period, there was a notable decline in death rates from infectious diseases like cholera, although other illnesses continued to prevail.

In contemporary India, the control of communicable diseases has significantly improved, with non-communicable diseases, particularly cardiovascular diseases, emerging as major causes of mortality. The impetus for healthcare reform dates back to the 1946 Bhore Committee Report, which advocated for a government-financed healthcare system. The inaugural National Health Policy (NHP) in 1983 aimed to establish a network of primary-care facilities and a referral system. The 2002 update of the NHP focused on enhancing the practicality and inclusivity of the healthcare system, integrating both private and public clinics.

In the current push for universal health coverage in India, there is a concerted effort to ensure that every citizen has equitable access to curative care without facing financial hardships. Additionally, there is a growing recognition of social determinants of health, emphasizing the need to incorporate a public health cadre within the existing healthcare system. This underscores the importance of distinguishing between the 'Public health' system and the 'Public' sector healthcare system, as the latter signifies the government's primary role rather than the broader concept of public health.

Public health funding has primarily been allocated to benefit the middle and upper classes, with a focus on creating more jobs for health professionals, expanding research institutions, and enhancing training opportunities. Unfortunately, this approach results in unequal access to healthcare for the lower classes, as they do not reap the advantages of this funding. Currently, states contribute approximately 75% to the public healthcare system, but the inadequacy of funding in certain states in India has led to a significant reliance on out-of-

pocket health expenditure by households, constituting 60.6% of India's total health expenditure. Consequently, a considerable number of households are being pushed below the poverty line each year.

The healthcare system is structured across primary, secondary, and tertiary levels. At the primary level, there are sub-centers and Primary Health Centers (PHCs). The secondary level includes Community Health Centers (CHCs) and smaller sub-district hospitals. The highest level of public care provided by the government is the tertiary level, comprising Medical Colleges and District/General Hospitals. While the number of Primary Health Centres , Community Health Center, sub-centers, and District Hospitals has increased in the past six years, not all of them meet the standards set by Indian Public Health standards.

Sub-Centers

Sub-Centers are strategically established to cater to highly rural areas, with the entire cost borne by the national government. Mandates stipulate that there must be a minimum of two health staff members (one male and one female) assigned to serve a population of 5000 people (or 3000 in remote or hilly areas). In addition to providing immediate healthcare services, Sub-Centers also actively engage in educating rural communities about healthy habits, aiming for a sustained and long-term impact on public health.

Primary Health Centres

Primary Health Centres are situated in relatively more developed rural areas with populations of 30,000 or more (20,000 in remote areas), functioning as comprehensive health clinics staffed with both doctors and paramedics. In cases of more complex health issues, patients may be referred from local sub-centers to Primary Health Centres (PHCs). Notably, unlike sub-centers, the funding for Primary Health Centres comes from the state government rather than the national government. Additionally, Primary Health Centres play a crucial role in enhancing health education, with a greater emphasis on preventative measures to promote community wellbeing.

Community Health Centre

A Community Health Centre, funded by state governments, accommodates patients referred from Primary Health Centres. It serves a population of 120,000 in urban areas or 80,000 in remote areas. Patients from these centres may be transferred to general hospitals for more extensive treatments. Consequently, Community Health Centres function as first referral units (FRUs), mandated to maintain obstetric care, newborn/childcare, and blood storage capacities around the clock, every day of the week.

Sub-District Hospitals

Sub-District Hospitals, also known as Sub-Divisional or Taluk Hospitals, are situated in sub-district or taluk headquarters and offer more specialized medical services compared to community health centres. Specifically, Taluk Hospitals, functioning as secondary healthcare centres, provide essential medical services such as paediatrics, obstetrics and gynaecology, dermatology, ophthalmology, dentistry, and psychiatry. Additionally, these hospitals are equipped with a laboratory and a pharmacy to deliver diagnostic and treatment services.

Operational 24/7, the emergency department at Taluk Hospitals ensures immediate medical attention for patients requiring urgent care. Taluk Hospitals can either be established by upgrading existing Community Health Centres (CHCs) or referred to as Sub-District (Sub-Divisional) Hospitals to align with the standardized guidelines of Indian Public Health Standards. Positioned between the district and block-level Community Health Centers, Taluk Hospitals play a crucial role in connecting Sub-Centres (SC), Public Health Centres (PHC), Community Health Centres (CHC), and District Hospitals. This arrangement helps alleviate the workload at the district hospital and reduces travel time for patients in need of emergency care. Sub-District Hospitals operate below the district level and above block-level Community Health Centers , serving as essential referral units for the population within their geographical location.[iii]

District Hospitals serve as the ultimate referral centres within the public health system, handling referrals from both primary and secondary levels. Ideally, every district in India should have at least one hospital; however, as of 2010, records indicate the existence of

only 605 hospitals for the 640 districts. These hospitals typically range in bed capacity from 75 to 500, depending on the demand driven by the local population. Unfortunately, many of these district hospitals face challenges as they often lack modern equipment and may have limited connections with local blood banks.

Medical Colleges and Research Institutions

The All India Institutes of Medical Sciences (AIIMS) are under the ownership and control of the central government. These institutes function as referral hospitals equipped with specialized facilities. Currently operational AIIMS facilities include those in New Delhi, Bhopal, Raipur, Patna, and Rishikesh. AIIMS is designed to provide holistic care for individuals across their entire lifespan, addressing health needs comprehensively rather than focusing solely on specific diseases. The concept of primary health care emphasizes the delivery of comprehensive services, spanning from health promotion and prevention to treatment, rehabilitation, and palliative care, all within the proximity of people's everyday environments.

Recognizing health as a crucial factor in social and economic development, the Government of India launched the National Rural Health Mission in 2005, focusing on rectifying the basic healthcare delivery system, particularly in rural areas. This mission aimed to improve access for vulnerable populations, including the poor, women, and children. The article then transitions to the specific context of the Jangalpatty Primary Health Centre in Theni district, exploring the initiatives undertaken by the Patient Welfare Society. Patient Welfare Societies, a product of the National Rural Health Mission, play a pivotal role in enhancing healthcare delivery by addressing challenges faced by patients, improving infrastructure and service quality, mobilizing resources, and fostering public-private partnerships.[iv]

The fundamental building block of public health services in developing nations is the Primary Health Center (PHC) or public healthcare center. Established to align with the Alma Ata Declaration of 1978 by member nations of the World Health Organization (WHO), these Primary Health Centres aim to deliver accessible, affordable, and available primary healthcare services. In India, Primary Health Centers are government-owned healthcare facilities, both in rural and urban areas, typically single-physician clinics equipped for minor

surgeries. They constitute the foundational units of the government-funded public health system, with a total of 30,045 Primary Health Centres in India as of March 31, 2019—24,855 in rural and 5,190 in urban areas. These centres serve as the frontline units offering primary health care services, theoretically catering to one Primary Health Centres for every 30,000 in population.

Primary healthcare stands as a crucial pillar in the delivery of health services, and India, being among the early adopters of this approach, recognized its merits well before the Alma-Ata Declaration. Rooted in the principles outlined in the Health Survey and Development Committee Report of 1946, chaired by Sir Joseph Bhore, India's commitment was to ensure that financial constraints would not hinder individuals from accessing healthcare. The emphasis was on a socially oriented medical practice with substantial public participation.

The initiation of health planning in India during the first five-year plan (1951-1955) led to the launch of the Community Development Programme in 1952. This comprehensive program aimed to cover health and sanitation by establishing primary health centres (PHCs) and sub centres. As health planning progressed, the Health Survey and Planning Committee (Mudaliar Committee) reviewed the sector's progress, recommending limiting Primary Health Centres populations for improved service quality and providing one basic health worker per 10,000 people. Subsequent committees, such as the Jungalwalla Committee in 1967 and the Kartar Singh Committee in 1973, stressed the integration of health services at all levels. The Shrivastav Committee in 1975 proposed the creation of para-professionals and semi-professional workers from within the community, promoting community participation.

The launch of the Rural Health Scheme in 1977 and the Alma-Ata Declaration in 1978 further solidified India's commitment to providing health for all. The Alma-Ata Declaration inspired India's first National Health Policy in 1983, aiming to deliver universal, comprehensive primary health services.[v] A subsequent policy in 2002 adjusted the framework to meet evolving socioeconomic circumstances, emphasizing an increased sectoral allocation to primary healthcare. Recognizing health's integral role in social and economic development, the Government of India initiated the National Rural Health Mission

in 2005. This mission aimed to rectify the basic healthcare delivery system, especially in rural areas, prioritizing improved access for the poor, women, and children.[vi]

Primary Health Centres Programmes are listed below:

- Delivering healthcare services
- Maternal and child health, encompassing family planning
- Ensuring safe water supply and fundamental sanitation
- Preventing and controlling locally endemic diseases
- Gathering and reporting vital statistics
- Providing health education
- Implementing relevant national health programs
- Offering referral services
- Training health guides, health workers, local dais, and health assistants
- Developing basic laboratory skills in workers

The National Rural Health Mission (NRHM), initiated in 2005, supports the establishment of patient welfare societies at district/taluk hospitals, Primary Health Centre (PHC)/Community Health Centre (CHC) levels, and village health, water, and sanitation committees at the health sub-centre level.[vii] These societies and committees are envisioned to operate "not as a government agency but as an NGO in terms of functionality." They are designed to consist of elected people's representatives, community representatives, civil society organizations, and government administrative/health officials. Furthermore, patient welfare societies may include individuals or institutions that contribute fixed amounts in donations.[viii] These entities are expected to fulfil various roles, such as addressing challenges faced by patients in accessing services, enhancing infrastructure and the quality of clinical and non-clinical services, mobilizing resources for the facility (which may involve levying user fees in the case of patient welfare societies), fostering public-private partnerships for service delivery, overseeing the implementation of national health programs, and reinforcing accountability to citizens.[ix]

Health and Family Welfare Department in Tamil Nadu

In adherence to national guidelines, the Tamil Nadu Health and Family Welfare Department issued directives between April 2006 and March 2007, focusing on the establishment of patient welfare societies/village health, water, and sanitation committees in district, taluk/non-taluk hospitals, primary health centres, and health sub-centres (3-6).[x] Fortunately, there was significant opposition in Tamil Nadu to the idea of permitting patient welfare societies to generate funds through imposing user fees, leasing government health facility infrastructure to private parties, and including private donors on the committee. Consequently, the Health and Family Welfare Department issued new governmental orders, amending the original ones to restrict such powers of the societies. Opposition to indirect privatization efforts emerged from various sources, including Left-leaning political parties, trade unions, a segment of public health professionals, and a portion of providers. Interestingly, Non-Governmental Organizations (NGOs) do not appear to have actively participated in these discussions.

Primary Health Centre in Jangalpatti

The society is established with the following goals and objectives, including ensuring adherence to government-issued minimal standards for facility and Primary Health Centres care, fostering accountability among public health providers, introducing transparency in fund management, enhancing and modernizing health services, overseeing the implementation of National Health Programmes, coordinating outreach services, and generating local resources. These objectives also include undertaking construction and expansion in the Primary Health Centres building, ensuring optimal use of Primary Health Centres land, enhancing society participation in Primary Health Centres management, ensuring proper training for doctors and staff, ensuring the scientific disposal of Primary Health Centres waste, guaranteeing proper use, timely maintenance, and repair of Primary Health Centres building equipment and machinery, and providing subsidized food, medicines, drinking water, and maintaining cleanliness for patients and their attendants.

To attain the aforementioned goals, the society will allocate its resources to engage in various activities and initiatives, including identifying challenges encountered by patients at the Urban Health Centre, procuring equipment, furniture, and ambulances through donations and funds, expanding the infrastructure of the Primary Health Centre (PHC),

organizing for the maintenance of the Primary Health Centres building, enhancing boarding/loading arrangements for patients and their attendants, fostering community involvement in the maintenance and preservation of the Primary Health Centres, advocating for resource conservation, embracing sustainable and environmentally friendly practices, and undertaking any additional activities necessary to accomplish the established objectives.

Governing Body's Inaugural Member: The following details pertain to the names, addresses, occupations, and designations of the initial members constituting the Governing Body of the Society. These individuals are entrusted with the management of the Society's affairs in accordance with the rules and regulations outlined in the Tamil Nadu Society Registration Act, 1975 (Tamil Nadu 1975), as mandated by section 6.[xi]

EXECUTIVE COMMITTTEE MEMBERS IN JANGALPATTY

SI.NO.	NAME AND ADDRESS	OCCUPATION	SATUS IN GOVERNING BODY
1	Dr. S. VANI M.B.B.S., Primary Health Centre, Jangalpatty.	Chair person	Medical Officer
2	A. SATHEESH. D.Pharm., Primary Health Centre, Jangalpatty	Member Secretary	Pharmacist
3	A. MURUGESAN, Primary Health Centre. Veerapandi	Executive Member	Block health supervisor
4	V. BALA SARASWATHI , Theni	Executive Member	C.D.P.O.
5	P.MANGALAMATHI, Primary Health Centre., Jangalpatty	Executive Member	S. H. N.
6	S. MARIMUTHU, Primary Health Centre, Veerapandi.	Executive Member	Health Inspector

7	PALAPANDIYAN Primary Health Centre, Veerapandi.	Executive Member	Block Health Statistician
8	R.JOTHI LAKSHMI Primary Health Centre, Veerapandi	Executive Member	Ophthalmic Assistant
9	S. RASEETHA , Primary Health Centres, Veerapandi	Executive Member	Lab Technician
10	V.SSETHA LAKSHMI Primary Health Centre, Jangalpatty	Executive Member	Village Health Nurse, Poomalaikundu
11	SUBATRA, Primary Health Centre, Jangalpatty	Executive Member	Senior Nurse
12	P.MUTHULAKSHMI Primary Health Centre, Veerapandi.	Executive Member	ICTC-Counsellor

Organization's Leadership:

The authorities of the Society comprises the following:

a. The Governing Body

b. The Executive Committee

c. The Monitoring Committee

d. Any additional authorities established by the Governing body

Governing Body Membership

The Governing Body of the Society consist of the following members

- The Chairperson, who shall be the Medical officer
- The Member Secretary and Convener, who shall be the Pharmacist of the Primary Health Centre
- Member of Parliament

- Member of Legislative Assembly
- Town Panchayat/Village Panchayat President of the area where the Primary Health Centre is located
- Two PRI members of the Primary Health Centre area (to be nominated by the Governing Body), with at least one woman
- Two SC/ST Representatives from Distant Villages/hamlets of the service area (nominated by the Governing Body
- Two patients or relatives randomly selected on the day of the meeting by the Chairperson, preferably one from the labor ward and one from OP
- Child Development Project officer
- Assistant Elementary Education officer
- Assistant Executive Engineer/Assistant Engineer, PWD (Buildings)
- Assistant Engineer, PWD (Electrical)
- ISM Medical Officer of the Primary Health Centre
- Medical Officer of the Primary Health Centre
- Community Health Nurse/Sector Health Nurse of the Primary Health Centre (to be nominated by the Medical officer)
- Block Health Supervisor
- Block Extension Educator
- Primary Health Centres Level Health Inspector
- Staff Nurse/ANM (to be nominated by the Medical officer)
- Pharmacist
- Lab Assistant
- VHN (nominated by the Medical Officer of the Primary Health Centre)
- Two representatives from industries, corporate sector, philanthropists (nominated by the Governing Body
- Two Representatives from local NGOs (nominated by the Governing Body
- Two eminent persons (nominated by the Governing Body)
- Three SHG Members (nominated by the Governing Body)
- District MCH Officer/Assistant Director, Statistical Assistant/Technical Personal Assistant, District Entomologist from the DDHS office

- Special Invitee
- Institutional members
- Associate members
- Additional members

Special Invitee

Special invitees can be called in as members from time to time. This decision is to be made by the Executive Committee prior to the Governing Body Meetings.

Institutional Members

Any institution that donates a specified amount of Rs. 1 Lakh or more, or adopts a ward of the Primary Health Centres and bears the cost of its maintenance, may be eligible to nominate a person from the institution as a member of the Governing Body of the society. The Associate Members are those who make a donation of a specified amount of Rs 25,000 or more.

Additional Members:

i. Representatives of professional associations (e.g., IMA, FOGSI, IAP, etc.) as may be nominated by the Governing Body from time to time
ii. Representatives of other organizations/individuals as may be determined by the Governing Body from time to time

Quorum: 1/3 Official Members.

1. The membership of an Executive Member, ex-officio member of the Society, and of the Governing Body shall terminate when he/she ceases to hold the office by virtue of which he/she is a member, and his/her successor shall become such a member
2. Non-official members of the Society will be nominated by the Chairperson in consultation with other members of the Governing Body. Nominated members shall hold office for a period of three years from the date of their nomination by the Chairperson. Such members will be eligible for re - nomination
3. The Society shall maintain a roll of members at its registered office, and every member shall sign the roll and state therein his/her rank or occupation and address.

No member shall be entitled to exercise the rights and privileges of a member unless he/she has signed the aforementioned roll

4. All members of the Governing Body shall cease to be members if they resign, become of unsound mind, become insolvent, or are convicted of a criminal offense involving moral turpitude or removal from the post by virtue of which he/she was holding the membership
5. Resignation of membership shall be tendered to the Governing Body in person to its Member Secretary and shall not take effect until it has been accepted on behalf of the Member Secretary by the chairperson
6. If a member of the Society changes his/her address, he/she shall notify his/her new address to the Member Secretary, who shall then enter his/her new address in the roll of the member. However, if a member fails to notify his/her new address, the address in the roll of members shall be deemed to be his/her address
7. Any vacancy in the Society or in the Governing Body shall be filled by the authority entitled to make such an appointment. No act or proceedings of the Society or of the Governing Body shall be invalid merely by reason of the existence of any vacancy therein or of any defect in the appointment of any of its members
8. No member of the Governing Body, except as appointed as per the rules, shall be entitled to any remuneration.[xii]

CONCLUSION

India's journey in establishing primary healthcare reflects a commitment to accessible and comprehensive health services. From the colonial era to contemporary times, the evolution has been marked by reforms, policy adaptations, and grassroots initiatives. The focus on Jangalpatty Primary Health Centre exhibit the tangible impact of these efforts at the local level. Despite challenges, the nation's commitment to universal health coverage and community participation remains unwavering. As Patient Welfare Societies contribute to healthcare improvements, India continues to navigate towards a future where every citizen, regardless of socio-economic constraints, has equitable access to primary healthcare services.

[i] Government Order(ms) No 310, Health and Family Welfare Department

[ii] Declaration of Alma-Ata International Conference on Primary Health Care, Alma-Ata, USSR, 6-12 September

1978

[iii] Government Order(2D) No 102 Health and Family Welfare Department dated,26-12-2011

[iv] Government Order(ms) No 310, Health and Family Welfare Department

[v] Declaration of Alma-Ata International Conference on Primary Health Care, Alma-Ata, USSR, 6-12

September 1978

[vi] Government Order(ms) No 310, Health and Family Welfare Department

[vii] Government Order(2D) No 102 Health and Family Welfare Department dated, 26-12-2011

[viii] Handbook, Health Society, Rural Health Mission, Tamil Nadu Government, 2005

[ix] Government Order (ms) No 310, Health and Family Welfare Department

[x] Government Order (2D) No 102 Health and Family Welfare Department dated, 26-12- 2011

[xi] Record, Primary Health Centre, Jangalpatti, Theni District,14-10-2014

[xii] Government Order (2D) No 104 Health and Family Welfare Department dated, 29-12- 2011