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8. Urban Air Pollution and Health

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Abstract

The environment and health are closely linked. Environmental factors like air and water pollution, exposure to toxic substances, and climate change can significantly impact human health. Air pollution is a major environmental risk factor for various diseases, including respiratory, cardiovascular, and neurodegenerative disorders. To review the current evidence on the association between air pollution and health, and to quantify the burden of air pollution on disease incidence and mortality. We conducted a systematic review of epidemiological studies on air pollution and disease, focusing on particulate matter (PM), nitrogen dioxide (NO2), and ozone (O3). We found consistent evidence that exposure to PM, NO2, and O3 is associated with increased risk of respiratory diseases, such as asthma and chronic obstructive pulmonary disease (COPD), as well as cardiovascular diseases, including myocardial infarction and stroke. Additionally, we found evidence linking air pollution to neurodegenerative diseases, such as Alzheimer's and Parkinson's. Our review highlights the significant burden of air pollution on disease incidence and mortality, emphasizing the need for urgent action to reduce air pollution levels and mitigate its health impacts. Policy interventions, such as transitioning to clean energy sources and implementing emission controls, are critical to protecting public health.

Key words: Urban, Air Pollution, and Health

Introduction

The environmental quality is an important determinant of human health. Deterioration of environmental quality severely impacts quality of life and compromises the objective of sustainable development (World Health Organization, 2017). The exploitation of natural resources, beyond their carrying capacity, to fulfill human greed has curtailed essential ecosystems functions such as availability of oxygen, water, soil nutrient, pristine biodiversity, etc. With world population projected to be 9 billion by 2050, from the current 6 billion, the potential environmental damage is obvious and hence, needs urgent attention.

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Air pollution is a form of environmental deterioration and is defined as an undesirable state of the natural air, contaminated with harmful substances as a consequence of human activities. It is a public bad that results from emission generated by manufacturing process, associated with production and consumption of natural goods (Cropper and Oates, 2021). In economic parlance, there will be an uncompensated human welfare loss in the form of an external cost (i.e. health damage, mortality, morbidity etc) due to increasing exposure to toxic air emissions. But these costs are not accounted in the existing market system and results in market failure or missing market for environmental goods. The economists attribute the problem of environmental degradation to the presence of externality caused due to market failure.

Air pollution imposes social cost, which is an additional cost of pollution prevention and mitigation. Apart from the polluter, the society undertakes measures to mitigate the negative impact of air pollution individually and collectively. However, inspite of collective action, society has to incur social and private costs to reduce the impact of air pollution. Therefore, the social cost borne by the individual households and the society have to be estimated. Hence, it is necessary to evolve a detailed framework for analyzing the negative externality caused by urban air pollution in terms of health effects.

The urban air pollution is the byproduct of rapid urbanization, high demand for fossil fuel and exponential growth of vehicles. The United Nations Environment Programme (UNEP) has estimated that globally 1.1 billion people breathe unhealthy air (UNEP 2022). Epidemiological studies also show that, the concentration of pollutants like Particulate matter (PM), oxides of nitrogen (NOx), ozone (O3) etc., are associated with a wide range of health effects on human, especially on the cardio respiratory system. The urban air pollution is responsible for 800,000 deaths and 4.6 million losses of life years each year around the globe (WHO, 2020). The burden of disease attributable to outdoor air pollution causes 39 percent of loss of life years in South-East Asia and 20 percent in other Asian countries (WHO, 2014).

Research Methodology

In the present study, the researcher was used secondary sources for the collection of data. Secondary data was collected from the Govt. publications, monthly journals, books, reports and Internet sources. Descriptive method has been adopted in the present work which is related to review the current evidence on the association between air pollution and health, and to quantify the burden of air pollution on disease incidence and mortality.

Environmental and Health

Environmental health is the branch of public health that focuses on the relationships between people and their environment; promotes human health and well-being; and fosters healthy and safe communities. Environmental health is a key part of any comprehensive public health system. A number of specific environmental issues can impede human health and wellness. These issues include chemical pollution, air pollution, climate change, disease-causing microbes, lack of access to health care, poor infrastructure, and poor water quality.

The environment refers to the surroundings in which we live, including the natural world and the physical, chemical, and biological factors that affect us. The environment plays a vital role in shaping our experiences, behaviors, and well-being. By understanding and addressing environmental factors, we can promote a healthier, more sustainable, and equitable world.

Environment pollution and diseases are closely linked. Environmental pollution can cause a wide range of health problems. It's essential to address environmental pollution to prevent and mitigate these health impacts. By reducing pollution, we can create a healthier environment and reduce the burden of diseases.

Health

Health is a state of complete physical, mental, and social well-being, not merely the absence of disease or infirmity. The range of personal, social, economic, and environmental factors that influence health status are known as *determinants of health.* Health is influenced by many factors, which may generally be organized into six broad categories known as determinants of health: genetics, behavior, environmental and physical influences, medical care and social factors. Health is a holistic concept that extends beyond just physical wellness. By addressing these various aspects, individuals can cultivate overall well-being and quality of life.

Health problem associated with urban air pollution are measured to guide policies and strategies both in health and the environmental sector. This will help to monitor health risks and to analyze the cost-effectiveness of policy interventions. The quantification of health impact of urban air pollution is to establish the magnitude of the disease problem, define causal factors, explore potential solutions and determine the impact of intervention by assessing their coverage and quality. The World Health Organization (WHO) has estimated that 13 million deaths (1.8 percent) annually can be attributed to preventable environmental causes. Further, the report reveals that 24 percent of the global disease burden (healthy life years lost) and 23 percent of all

deaths (premature mortality) are attributable to environmental factors. The EBD is 15 times higher in developing countries than in developed countries, due to differences in exposure to environmental risks and access to healthcare facilities. The 10 leading air pollutants and their impact on health factors are summarized in below table:

Major air Pollutants, their Sources and Health Effects

Air Pollutants	Sources	Health Impact
Carbon dioxide (CO2)	Burning of fossil fuels (coal, oil etc) in furnaces of thermal power plants, industries, etc	Respiratory problems, greenhouse effect, global warming.
Carbon monoxide (CO)	Automobile, industrial furnaces, open fires, forest fires and combustion of Domestic fuel.	Difficulty in breathing, headache and irritation of mucous membranes and Death.
Sulphur dioxide (SO2)	Burning of fossil fuels, industries and automobile.	Aggravates existing lung diseases like bronchitis, wheezing, shortness of breath, and coughing.
Hydrogen sulphide (H2S)	Decaying vegetation and animal matter. Sulphur springs, volcanic eruptions and sewage treatment plants etc.	Headache, nausea, collapse, coma and even death.
Nitrogen oxides (NOx)	Industries manufacturing HNO3 and other chemicals & automobile exhaust.	Irritation of alveoli, lung and respiratory infections and death.
Ozone (O3)	Automobile, specific industrial operations.	Temperature changes and increases UV radiation, which causes cancer relating to skin, cataracts,destruction of aquatic life and loss of vegetation and loss of immunity.
Particulate	Fuel combustion and	Respiratory diseases such as tuberculosis

matter (PM-TSPM, RSPM) PM10 & PM2.5	industrial operations, nonindustrial fugitive emission like road dust, agricultural, construction, and transportations.	and cancer, decreased lungfunction, cardiac problem, heart attacks, and premature death.
Lead	Industrial operations	Damage to brain and other parts of the nervous system.
Hydrocarbons (HC)	Motor vehicles, industrial operations.	Carcinogen effect on lung. Causes irritation of eyes, nose and throat and respiratory distress.
Benzene	Vehicles and industrial operations.	Drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation, disorder of blood, bone marrow, anemia and reduced ability of blood to clot, damage to immune system.

Urban Air Pollution

Urban air pollution is a significant environmental and public health concern in India, particularly in densely populated cities like Delhi, Mumbai, Bangalore and Kolkata. Urban air pollution has significant impacts on human health, particularly in densely populated cities.

The Health Effects of Urban Air Pollution

1. Respiratory Problems

Air pollution can irritate the lungs, exacerbate conditions like asthma, and increase the risk of respiratory infections.

2. Cardiovascular Diseases

Exposure to poor air quality can increase the risk of heart attacks, strokes, and other cardiovascular events.

3. Neurological Issues

Air pollution has been linked to cognitive impairment, neuroinflammation, and neurodegenerative diseases like Alzheimer's and Parkinson's.

4. Cancer

Long-term exposure to certain air pollutants can increase the risk of lung cancer and other types of cancer.

5. Premature Mortality

Air pollution can shorten life expectancy and increase the risk of premature death.

6. Birth and Developmental Effects

Exposure to poor air quality during pregnancy can increase the risk of low birth weight, premature birth, and developmental delays.

7. Mental Health

Air pollution has been linked to increased symptoms of depression, anxiety, and other mental health concerns.

8. Lung Development

Children's lung development can be impaired by long-term exposure to poor air quality.

9. Inflammatory Responses

Air pollution can trigger inflammatory responses in the body, exacerbating conditions like arthritis and other inflammatory diseases.

10. Immune System Suppression

Long-term exposure to poor air quality can weaken the immune system, making individuals more susceptible to infections.

It's essential to address urban air pollution to protect public health, particularly in vulnerable populations like children, the elderly, and those with pre-existing medical conditions.

Sources of urban air pollution in India

1. Vehicular Emissions

Emissions from cars, trucks, buses, and two-wheelers are a significant contributor to air pollution in Indian cities.

2. Industrial Activities

Small and large-scale industries, such as power plants, cement factories, and textile mills, release harmful pollutants into the air.

3. Construction and Demolition

Dust and debris from construction and demolition activities contribute to particulate matter (PM) pollution.

4. Waste Burning

Open burning of waste, including plastic and rubber, releases toxic pollutants into the air.

5. Domestic Fuel Combustion

Burning of fossil fuels like coal, wood, and kerosene for cooking and heating releases harmful pollutants.

6. Agricultural Activities

Crop burning, tractor emissions, and other agricultural activities contribute to air pollution.

7. Natural Sources

Dust storms, wildfires, and other natural sources also contribute to air pollution in India.

8. Waste Management

Inadequate waste management practices, including open dumping and burning, contribute to air pollution.

9. Industrial Waste

Improper disposal of industrial waste, including hazardous chemicals, contributes to air pollution.

10. Climate Change

Climate change can exacerbate air pollution by increasing temperatures, changing precipitation patterns, and enhancing the formation of ground-level ozone.

It's important to note that these sources can vary by city and region, and addressing air pollution in India will require a multi-faceted approach that involves both policy changes and Individual actions.

Government has Implemented Various Measures

Public Health is a State subject; hence, the responsibility of providing medical assistance to patients of all income group is of respective State/ UT Governments. However, National Health Mission (NHM) – a flagship programme of the Ministry with its two Sub-Missions, National Rural Health Mission (NRHM) and National Urban Health Mission (NUHM), supports States /UTs to strengthen their health care systems so as to provide universal access to equitable, affordable and quality health care services.

The Indian government has implemented various measures to address urban air pollution, including: National Clean Air Programme (NCAP), Air Quality Index (AQI), Emissions

standards for industries and vehicles, Promotion of clean energy sources and Waste management initiatives. However, more needs to be done to effectively mitigate urban air pollution in India. This requires a multi-faceted approach involving government policies, public awareness, and individual actions.

Some Potential Solutions

1. Increasing the use of public transportation and non-motorized transport
2. Encouraging the use of clean energy sources like solar and wind power
3. Implementing strict emissions standards for industries and vehicles
4. Improving waste management practices
5. Promoting sustainable urban planning and development

By working together, we can reduce urban air pollution in India and create a healthier environment for all.

Conclusion

Urban air pollution has emerged as a significant environmental and public health concern, particularly in densely populated cities. This review aims to summarize the current state of knowledge on the health impacts of urban air pollution, with a focus on the epidemiological evidence, toxicological mechanisms, and vulnerable populations. We examined the associations between urban air pollution and various health outcomes, including respiratory, cardiovascular, neurological, and cancer-related effects. The evidence consistently shows that exposure to poor air quality is linked to increased morbidity and mortality, with certain populations, such as children, older adults, and those with pre-existing conditions, being disproportionately affected.

We also explored the toxicological mechanisms underlying the health effects of urban air pollution, including oxidative stress, inflammation, and immune system dysfunction. Additionally, we discussed the sources and characteristics of urban air pollution, including vehicular emissions, industrial activities, and fuel combustion. Our review highlights the need for urgent action to mitigate urban air pollution and protect public health. We recommend policy interventions, such as promoting clean energy sources, improving vehicle emissions standards, and enhancing urban planning and green spaces. Furthermore, we emphasize the importance of continued research and surveillance to better understand the health impacts of urban air pollution and inform effective interventions. Overall, this review underscores the critical importance of

addressing urban air pollution as a public health priority, particularly in the context of rapidly urbanizing populations and climate change.

References

- Alberini, A.M. Cropper (1997), Valuing Health Effects of Air pollution in Developing Countries: The Case of Taiwan, Journal of Environmental Economics and Management , Vol 34, 107–126.
- Aunan, K. (2018), Health and Environmental Benefits from Air Pollution Reductions in Hungary, Science of the Total Environment, Vol 212, 245–268.
- Central Pollution Control Board (2022), Air Quality Standards In India, Central Pollution Control Board and Ministry of Environment and Forest, Government of India.
- Cropper and Oates (2021), Environmental Economics: A Survey, Journal of Environmental Economics and Management, Vol 30, 675-740.
- Furst, E. et al. (2010), Valuing the net Benefits of Air Pollution Control in Santiago, Chile, in Reitbergen, J. (ed.), Environmental Valuation:A Worldwide Compendium of Case Studies, EarthScan Publications, London.
- Giri D, Murthy V.K, Adhikary P.R, Khanal S.N (2017), Estimation of Number of Deaths Associated with Exposure to Excess Ambient PM 10 Air Pollution, International Journal for Environmental, Science & Technology, Vol 4(2), 183-188.
- Kunzli, N. et al. (2020), Public-Health Impact of Outdoor and Traffic-Related Air Pollution: A European Assessment, Lancet, Vol 356, 795–801.
- Mathews C D, Stein C, Ma Fat D, Rao C, Inoue M, Tomijima N, Berbard C, Lopez AD, Murry CJL, (2001), — Global Burden of Diseases 2000: Version 2 Methods and Resultsl World Health Organization, World Bank, Geneva.
- Murthy M.N, Gulati S.C and Banerjee A (2013), —Heath Benefits from Urban air Pollution Abatement in the Indian Subcontinent, Discussion paper No. 62/2013, Delhi, Institute of Economic Growth, IEF website.
- State of the Environment Report: Karnataka (2011 & 2021) Environment Management & Policy Research Institute Board and Department of Ecology & Environment.
- World Bank (2018), Pollution Prevention and Abatement Hand Book, Part I, II, and III, World Bank Group, Washington, DC.

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ARTIFICIAL INTELLIGENCE IN BUSINESS

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ABSTRACT:

For organizations, the development of new business models and competitive advantages through the integration of artificial intelligence (AI) in business and IT strategies holds considerable promise. The majority of businesses are finding it difficult to take advantage of the opportunities for value creation while other pioneers are successfully utilizing AI. On the basis of the research methodology of Webster and Watson (2020).According to the literature, the performance advantages, success criteria, and difficulties of adopting AI have been emphasized in prior research. The results of this review revealed the open issues and topics that call for further research/examination in order to develop AI capabilities and integrate them into business/IT strategies in order to enhance various business value streams. Organizations will only succeed in the digital transformation alignment of the present era by precisely adopting and implementing these new, cutting-edge technologies.

Keyword: artificial intelligence (AI); AI capability; business strategy; IT strategy; business value; digital transformation.

Introduction:

Artificial Intelligence (AI) is the branch of computer science which deals with intelligence of machines where an intelligent agent is a system that takes actions which maximize its chances of success. It is the study of ideas which enable computers to do the things that make people seem intelligent. The central principles of AI include such as reasoning, knowledge, planning, learning, communication, perception and the ability to move and manipulate objects. It is the science and engineering of making intelligent machines, especially intelligent computer programs.

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Research problem:

The concept artificial intelligence is biggest reform in technological sector. India has been taking small steps to meet its target in business by using artificial intelligence.

Objectives of the study:

This study is based on the following objectives.

- To study about the concepts of artificial intelligence
- To study about the benefits of the AI in business.
- To study understand how AI will work business community.
- To know the advantages and challenges of AI in business

Research methodology:

Being an explanatory research it is based on secondary data collected from journals, articles, newspapers and magazines. Considering the objectives of the study descriptive type research design is adopted to have more accuracy and rigorous analysis of research study. The accessible secondary data is intensively used for research study.

Concept of artificial intelligence:

Today technology has becomes so advanced that computers can function like human and even achieve high success rate all these have been possible due to artificial intelligence. Artificial intelligence in technology enables machine to perform task that would otherwise require human intelligence to be automated. AI has a vast spectrum in computer science and is developed programmed through machine learning and deep learning.

Benefits of AI in business:

- To take best decision
- To manage efficiency and productivity gains
- To improve personalized customer services and experiences.
- To improve monitoring
- To improve quality and reduction of human error
- Helps to increased profitability

Advantages and challenges of AI in business: The advantages of Artificial intelligence applications are enormous and can revolutionize any professional sector. Let's see some of them

- **Reduction human error:** Artificial intelligence can significantly reduce error and increase accuracy and precision. The decision taken by AI in every step is decided by information previously gathered and certain set of algorithms.

- **Recruitment:** companies use Artificial Intelligence and Natural Language Processing (NLP) to filter through resumes and shortlist candidates who closely meet their needs. It is done by analyzing various characteristics like location, skill, education, etc. It also recommends other job positions for the candidates if they are eligible.

- **Market prediction:** Stock markets are one of the most popular and unpredictable markets due to their dynamic nature. Many people invest in the stock markets as they have also proved very profitable. But Artificial Intelligence has made it easy too. With techniques like Support Vector Machines (SVMs) and Artificial Neural Networks (ANNs), which are types of machine learning, patterns are learned and predicted. This technical analysis is very important in predicting the financial markets and providing successful result.

- **Customer analysis:** Today, artificial intelligence enables companies to conduct surveys that provide customer feedback that goes much deeper than just historical data analysis. It provides accurate data and helps strategize to facilitate better engagement and sales by providing a better customer experience. Therefore, AI helps make the business more customer-centric, which ultimately benefits the company.

- **Billing and invoicing:** Artificial Intelligence has made financial management easy and accurate by automating the process. There is much software available in the market for accounting and invoicing. For manual paper-based invoicing, these software provide features such as data extraction and segregation, which, once scanned and uploaded, can extract data from paper invoices and store them. The AI-powered accounting tools are very precise and systematic, making financial management a very easy task.

- **Available 24*7:** Average human will work for 4–6 hours a day excluding the breaks. Humans are built in such a way to get some time out for refreshing themselves and get ready for a new day of work and they even have weekly offed to stay intact with their work-life and personal life. But using AI we can make machines work 24x7 without any breaks and they don't even get bored, unlike humans.

Challenges of AI in business: As every bright side has a darker version in it. Artificial Intelligence also has some disadvantages. Let's see some of them.

- **High cost production:** As AI is updating every day the hardware and software need to get updated with time to meet the latest requirements. Machines need repairing and maintenance which need plenty of costs. Its creation requires huge costs as they are very complex machines.
- **Making humans lazy:** AI is making humans lazy with its applications automating the majority of the work. Humans tend to get addicted to these inventions which can cause a problem to future generations.
- **Unemployment:** As AI is replacing the majority of the repetitive tasks and other works with robots, human interference is becoming less which will cause a major problem in the employment standards. Every organization is looking to replace the minimum qualified individuals with AI robots which can do similar work with more efficiency.
- **No emotions:** There is no doubt that machines are much better when it comes to working efficiently but they cannot replace the human connection that makes the team. Machines cannot develop a bond with humans which is an essential attribute when comes to Team Management.
- **Lacking out of the box thinking:** Machines can perform only those tasks which they are designed or programmed to do, anything out of that they tend to crash or give irrelevant outputs which could be a major backdrop.

Conclusion:

Till now we have discussed in brief about Artificial Intelligence. We have discussed some of its benefit, advantages and challenges. The ultimate goal of institutions and scientists working on AI is to solve majority of the problems or to achieve the tasks which we humans directly can't accomplish. It is for sure that development in this field of computer science will change the complete scenario of the world now it is the responsibility of creamy layer of engineers to develop this field.

Reference:

- http://www.howstuffworks.com/arificialintelligence
- http://www.library.thinkquest.org
- https://www.educba.com/artificial-intelligence-techniques
- https://towardsdatascience.com/advantages-and-disadvantages-of-artificial-intelligence
- https://www.koenig-solutions.com/blog/top-benefits-of-artificial-intelligence

धरती आबा : आदिवासियों की संघर्ष गाथा

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"धरती आबा" हृषीकेश सुलभ द्वारा लिखित बिरस मुंडा के जीवन पर आधारित नाटक है। आदिवासी लोगों के साथ हुए, हो रहे अत्याचार को दर्शाने की कोशिश इस नाटक में की गयी है। अंग्रेज ही नहीं दिकुओं, महाजनों, बनियों तथा जमींदारों द्वारा निरंतर आदिवासी लोगों का शोषण हुआ है और आज भी हो रहा है। यह नाटक हमारे बर्बर इतिहास को हमारे सम्मुख रखता तथा आत्ममंथन के लिए मजबूर करता है। धर्म तथा वर्ग के नाम पर उनकी ठगी के खिलाफ़ आवाज़ ही 'धरती आबा' नाटक है।

नाटक का आरंभ गीत से होता है जिसमें वे धरती आबा का गुणगान करते नज़र आते हैं। मंच पर धानी का आगमन होता है। बिरसा द्वारा बदलाव का संकेत दिया जाता है। बिरसा के चित्रण के साथ ही हम देखते हैं कि उन लोगों के साथ हुए अनादर, अत्याचार, धर्म के नाम पर की गयी ठगी, उनके जंगलों पर किये गये अतिक्रमणों की एक-एक ज्यादतियों को बताया जाता है। मशीनरियों द्वारा उनका उपहास उड़ाया जाना, उन्हें भिखारी तथा विश्वासघाती कहना आदि बातें उन्हें भीतर तक छू जाती हैं। उनका खुद पर से विश्वास उठ जाता है। "फादर-----जैसा उजला कपड़ा है वैसा ही उजला मन होगा। पर नहीं ग़लत समझा था मैं। मैं तो चर्च, मिशन, क्रिस्तान और उनके प्रभु की प्रार्थनाओं पर विश्वास करता था.------वे मुझे पढ़ा रहे थे----ज्ञान दे रहे थे, इसलिए मैं उनके सामने झुका रहता था------पर उन्होंने मेरा भरोसा तोड़ दिया।"[1]

अपने सरदार मुंडाओं के प्रति अपनत्व का भाव भी इसमें दिखाई देता है। मुंडा तथा संथालों के साथ जो हुआ, बाहर के लोग आने के बाद वे किस प्रकार सिकुड़ते चले गये। यह अब उन्हें उनसे मुक्ति दिलाना चाहता है। इसीलिए वह कहता है- "ये जंगल हमारे हैं धानी।-----मैं दिलाऊँगा इन्हें वापस------मैं।"[2]

इसीलिए वह सभी को संगठित करता है। करमी-माँ की सोच से वह बिलकुल सहमत नहीं होता। "मैंने छोड़ दी ठाकुर की पूजा। अब मैं किसी को नहीं पूजनेवाला, न ठाकुर को और न मेरे सिंबोंडा को।"[3]

पुरानी मान्यताओं तथा सरकार, ठेकेदार तथा सहूकार के जुल्मों के खिलाफ़ सभी मुंडाओं को संगठित कर उनके खिलाफ़ लड़ने के लिए सभी को प्रेरित करता है। पहले पहल वह जंगल पर दावा की अर्जी कर अपने अधिकारों की स्वतंत्रता की बात करता है। बाबू के बुरे व्यवहार पर उसे मारने की धमकी भी देता है। इस प्रकार वह विद्रोह कर देता है।

माँ के कहने पर वह धरती का आबा बनकर मुंडाओं को स्वतंत्र करने उन्हें उनके अधिकार देने की ठान लेता है। बिरसा न की स्वतंत्रता की बात अपितु हैजा के संबंध में उन्हें जागृत करता है, इससे उसकी दवाईयों की समझ भी दिखाई देती है। बाहरी लोगों को जंगल से भगाने की बात करता है, उनके साथ लड़ने के

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लिए तैयार होता है तथा अपने मुंडाओं को भी लड़ने के लिए प्रेरित करता है। पर दोगले जमींदारों के चलते पकड़ा जाता है। कर्नल गौर्डन जब बिरसा को कहता है कि तुम मुंडाओं को भड़का रहे हो, तो वह बताता है – "मैंने हरदम जो सच है वही कहा है, मैं उन्हें धर्म की बात बताता हूँ। मैं उन्हें बताता हूँ कि धर्म का झूठ क्या है और सच क्या"[4] साथ ही "जब मुंडा मिशनवालों के पास जाते थे तो तुमने उनसे क्यों नहीं पूछा" में इनकी दोगली नीति की पिल भी खोल देता है। वह वकील भी नहीं चाहता क्योंकि उसे मालूम है कि वकील हो या न हो मुंडाओं को जेल होती ही है।

बिरसा को जेल होने के उपरांत मुंडाओं की अवस्था दयनीय होती है। बिरसा जेल से छूटकर आने के बाद अपने सभी मुंडाओं को सरकार से लड़ने के लिए फिर से संगठित करता कहता है – "हम सिर्फ़ दिकुओं, महाजनों, बनियों, जमींदारों को अपना दुश्मन मानते रहे।------वे हैं हमारे दुश्मन पर असली दुश्मन यह सरकार है। सरकार ने ही हमारी धरती को जमींदारों को सौंप दिया है।"5

इस लड़ाई को वह उपगुलाम का नाम देता है। संगठित होकर वे लड़ाई शुरू कर देते हैं। उधर सरकार की ज्यादती मुंडाओं की धरपकड़ शुरू हो जाती है। कई मुंडाओं को मार दिया जाता है। निरंतर खोजबीन के बाद भी बिरसा मुंडा सरकार के हाथ नहीं लगता तो फौरबेस लोगों को लालच देता है – "जो बिरसा को पहड़ेगा या पकड़वायेगा उसे पाँच सौ रुपये मिलेंगे।"[6]

अंग्रेजों के आतंक और भूख से बेहाल इनाम के लोभी बिरसा को पकड़ लेते हैं। शारीरिक रूप से बिरसा जेल में था पर मन उसका जंगल में ही था। लेखक कहते हैं – "हैजा हुआ-----नहीं मन नहीं मानता। तो फिर ? अंग्रेजों ने जहर दे दिए ? क्या पता दिया ही हो -----और 9 जून 1900 की सुबह बिरसा की मौत हो गयी।"[7]

मुंडाओं को इस पर विश्वास नहीं होता। बिरसा के अंतिम कथन के माध्यम से वह मुंडाओं को हौम्मत बनाये रखने, सही दुश्मन की पहचान देने, हथियारन छोड़ने, फिर वे वापस लौटने, इस लड़ाई को जारी रखने की बात करता उन्हें आश्वस्त करता है।

अंतिम गायन स्वर के माध्यम से लेखक ने आधुनिकता की आड़ में आदिवासियों पर हो रहे अत्याचार, अन्याय, दमन, शोषण के खिलाफ़ फिर से बिरसा मुंडा जैसे महान व्यक्तियों ने अवतरित होकर शोषण का समूल नाश करने का आह्वान करते हैं।

संदर्भ :-

1. सुलभ, हृषीकेश. (2010). *धरती आबा*. नई दिल्ली : राजकमल प्रकाशन. पृ. 22
2. सुलभ, हृषीकेश. (2010). *धरती आबा*. नई दिल्ली : राजकमल प्रकाशन. पृ. 23
3. सुलभ, हृषीकेश. (2010). *धरती आबा*. नई दिल्ली : राजकमल प्रकाशन. पृ. 34
4. सुलभ, हृषीकेश. (2010). *धरती आबा*. नई दिल्ली : राजकमल प्रकाशन. पृ. 49
5. सुलभ, हृषीकेश. (2010). *धरती आबा*. नई दिल्ली : राजकमल प्रकाशन. पृ. 68-69
6. सुलभ, हृषीकेश. (2010). *धरती आबा*. नई दिल्ली : राजकमल प्रकाशन. पृ. 93
7. सुलभ, हृषीकेश. (2010). *धरती आबा*. नई दिल्ली : राजकमल प्रकाशन. पृ. 94

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Evaluation of antioxidant and antibacterial activities of silver nanoparticles derived from *Limonia acidissima* L. fruit extract

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ABSTRACT

In the rapidly expanding field of nanoscience and research, AgNPs and their diverse by-products have been acknowledged as having a green approach. Fruit extract of *Limonia acidissima* L. is capable of bio-reducing $AgNO_3$ and stabilizing AgNPs. AgNPs distinctive absorption peak at 417 nm at pH 8 was visible on the UV-Vis spectrophotometer. The fruit extract contained bioactive chemicals, which may be the cause of the AgNPs bio-capping and stabilizing properties, according to Fourier transform infrared (FT-IR) spectroscopy. Using an X-ray diffractometer (XRD) examination, the AgNPs solid crystalline nature and size of 29.05 nm were investigated. Lastly, AFM and HR-TEM studies verified the AgNPs surface morphology, particularly their size and form. The DPPH assay method was used to measure the AgNPs capacity for radical scavenging. As compared to normal ascorbic acid and fruit extract (control), the AgNPs produced from the fruit extract demonstrated good antioxidant effectiveness. To evaluate the antibacterial activity of the AgNPs sample, it was additionally evaluated against *E. coli*, *S. typhi*, *V. cholera*, and *S. aureus*. With the greatest zone of inhibition and thus the strongest antibacterial activity, *S. aureus* (12.03 ± 0.043 mm) was the organism that displayed it. On the other hand, the least active strain was *V. cholera* (9.09 ± 0.013 mm). The data indicates that bio-fabricated silver nanoparticles (AgNPs) exhibited dose dependent inhibitory efficacy together with a notable zone of inhibition. Additionally, *S. aureus* was shown to be more effective than *V. cholera*. Future health and pharmaceutical fields may benefit from the biocompatible method of separating AgNPs from *L. acidissima* fruit extract.

1. Introduction

The search for new antimicrobial compounds with reduced toxic effects and high potency has led to the application of nanotechnology as a viable and effective route. Among numerous researched nanomaterials, silver nanoparticles (AgNPs) have become the most prominent ones due to their outstanding antimicrobial properties and wide range of applications including medicine, biotechnology and environmental remediation [1–3]. The synthesis of AgNPs from naturally occurring sources allows for an environmentally friendly and sustainable process that disregards the negative implications of traditional chemical methods [4]. *Limonia acidissima*, popularly known as wood apple or elephant apple, is a unique tropical fruit with a robust phytochemical composition that places it in the spotlight for AgNPs' fabrication. Nanoparticles are found in plants with therapeutic properties. They have a bioactivity because they are from phytoconstituents.

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Limonia acidissima, an originator of the family Rutaceae, is a famous traditional medicinal plant in many communities around the globe. The fruit extract of *Limonia acidissima* is full of bioactive compounds namely phenolics, flavonoids, tannins, and alkaloids which largely possess the antioxidant and antimicrobial properties [5,6]. Through exploiting the phytochemical composition of *Limonia acidissima*, it is feasible to use AgNPs for AgNPs synthesis, thereby applying the power of synergy to the existing nanotechnology and natural product advantages. The secondary metabolite conjugation with the surface of inorganic nanoparticles interferes directly with the biological activity of inorganic nanoparticles and not only may enhance the bioactivities of these inorganic nanoparticles but also may increase or decrease the inorganic nanoparticles side effects. This provides an opportunity for us to select a suitable natural resource for preparation of inorganic nanoparticles [7].

Determining the specific parameters of nanomaterials such as shape, size, dissolution, agglomeration state, chemical composition, specific surface area, crystal structure, surface morphology, surface energy, surface coating, and surface charge in current day research is of paramount importance. These parameters are crucial since they determine interactions, movement, and consequences of nanomaterials in biological systems. By specifying these factors, researchers provide an important basis for the interpretation of how nanomaterials behave in biological systems, opening up doors for both identifying their benefits and risks [8]. Antioxidants have been reported to counteract oxidative stress-driven damage by inhibiting free radicals and preventing lipid peroxidation, protein oxidation, or DNA damage, among others [8–11]. The search for antioxidant compounds with high efficacy has been very vigorous because of their relevance in the treatment of various diseases such as cardiovascular cases, neurodegenerative disorders, and cancer [12–16]. Silver nanoparticles produced using plant extracts have been documented to possess a potent antioxidant activity, with bioactive phytochemicals in the extract serving as the main contribution, which operate synergistically with silver ions to neutralize free radicals and reinforce the cellular defense mechanisms [17,18].

Apart from being antioxidants, these silver nanoparticles have also earned much appraise in their abetting anti-bacterial activity against microbes that can potentially bring a harmful impact to both human and environment [19]. There is a growing concern about the antimicrobial drug resistance problem as one of the major public health threats all over the world which calls for the search for other medicinal alternatives. The silver nanoparticles implemented antimicrobially through different mechanisms such as disturbance of bacterial cells membranes, hindering of enzymatic activities, and production of reactive oxygen species (ROS) [20]. Similarly, the concurrent device of silver nano-particles as well as of the phytochemical compounds presented in the plant extracts facilitates the increase of the antibacterial activity and at the same time prevents the development of the bacterial resistance [21]. Successively, apart from antioxidant and antimicrobial activities, silver nanoparticles exhibit various pharmaceutical and biological potential such as Analgesic activity [22], Antiviral activity [23], Anticoagulant activity [24], Anticancer activity [25], and Biofilm inhibitory activity [26].

Nevertheless, studies and publications that are currently available are focused on various components of the antioxidant and antibacterial activities of silver nanoparticles synthesized from biological sources (Green Tea and Propolis) [27] consequently leading to an absence of scientific studies to a great extent that document the treatment potential of silver nanoparticles that are derived from the *Limonia acidissima* L. fruit extract (Table 1) There is a great insufficiency for the research pursuit in this area by brainstorming antioxidant and antibacterial properties of nanoparticles made by *Limonia acidissima* fruit extract. This can be achieved by deepening and sharing our knowledge of how these nanoparticles act, giving us a clear vision of where they can be used in developing medicines, cosmetics, and food packaging, and manufacturing equipment.

Table 1
Fabrication of Silver Nanoparticles using various botanical sources.

Sl No.	Material	Botanical Source	Studies	References
1	AgNPs	*Moringa oleifera* L. extract	Antibacterial activity	[28]
2	AgNPs	Weed (Dactyloctenium aegyptium)	Antibacterial activity	[29]
3	AgNPs	*Phlogacanthus thyrsiflorus*	Antioxidant and Antibacterial activity	[30]
4	AgNPs	*Aristolochia bracteolata* L. Extract	Antioxidant and Antibacterial activity	[31]
5	AgNPs	*Sambucus ebulus* L. Extract	Antioxidant and Antibacterial activity	[32]

2. Experimental

2.1. Materials and methods

Silver nitrate, DPPH, Methanol, 0.1 N NaOH, 0.1 N HCl, Muller Hinton media was purchased from Hi-media Laboratories, Mumbai (India). The aqueous precursors of absorption spectra of green AgNPs were characterized by UV-visible (UV) spectrometer (UV-1650PC-Shimadzu Europe). The photoluminescence absorption spectrum ranges between 200 and 800 nm wavelength with resolution of ±1 nm. The reaction mixture was centrifuged (Remi 8C-T-10 M) at 5000 rpm for 20 min. The centrifugation and dispersion process repeated thrice with 2.5 mL of distilled water. The supernatant was discarded and suspended purified particles were dried at 60 °C in an oven for 12 h to obtain solid crystalline particles. These crystalline particles were mixed with potassium bromide (KBr) to get into pellet form and subjected to FTIR (Bruker, Germany) measurements were recorded with range between 4000 and 500 cm^{-1} to identify functional compounds involved in bio-capping, stabilization, and formation of AgNPs. Further, dry powder of samples was determined with X-ray diffractometer (Rigaku Miniflex 600 Japan) to check phase purity and crystalline nature of AgNPs. The surface chemistry and size of the AgNPs was analyzed by atomic force microscopy (Nano Surf Flex AFM) and High-resolution transmission electron microscopy (Hitachi, Model: S-3400 N).

2.2. Plant material collection and fruit extract preparation

The fresh and healthy fruits of *L. acidissima* were harvested from Karnataka State Akkamahadevi Women's University campus, Vijayapur, Karnataka, India. The harvested ripen fruits were washed thrice with running tap-water and then with double distilled (DD) water to eradicate dirt and other contamination from the fruits. Further, the pulp was separated from the seeds. About 20 g of fruit pulp or flesh weighed and chopped into small pieces and added into 250 mL beaker containing 100 mL of deionized water and heated for about 20 min at 60 °C. Finally, the obtained fruit extract was filtered through Whatman No. 1 filter paper and supernatant was stored in freezer at 4 °C for further assessment.

2.3. Green synthesis of AgNPs

Freshly one mili molar (1 mM) silver nitrate ($AgNO_3$) was primed with double sterilized water in 250 mL of Erlenmeyer flask. About 10 mL of aqueous fruit extract was mixed to $AgNO_3$ (90 mL) and suspensions were constantly stirred with glass rod. After 15 min, the colloidal suspension was changed its color from light yellow to dark brown, suggesting that the formation of AgNPs. Which again attributes to the plasmonic resonance of the surface electrons of the nanoparticles on the surface [33–36].

2.4. Antioxidant assay

Using the DPPH (2, 2-diphenyl 1picrylhydrazyl)) test, evaluated the as-prepared AgNPs' capacity to scavenge radicals (Mensor et al., 2001). The ascorbic acid standard and fruit extract were used to determine the various amounts of as-synthesized AgNPs (i.e., 200, 400, 800, and 1000 μg/mL). Next, 4 mg of recently made DPPH was added to each test tube along with 100 mL of methanol (0.1 mM) to dissolve it. 2 mL of DPPH were combined with 1 mL of the sample and properly vortexed. After a final 30-min incubation period, the combination was kept at room temperature in the dark. The samples were then measured in a UV-visible spectrophotometer at 517 nm using standard ascorbic acid and methanol as a blank. Fruit extract and ascorbic acid equivalents per gram were used to quantify the antioxidant effectiveness of AgNPs (100 μL).

2.5. Antibacterial activity

The AgNPs derived from *L. acidissima* fruit extract were investigated for antibacterial activity was studied against *Escherichia coli* (MTCC 723, 1554), *Salamonela typhi* (MTCC3216), *Vibrio cholerae* (MTCC 3906) and *Staphylococcus aureus* (MTCC3160) by well diffusion method. The different concentrations of AgNPs (200, 400, 600, 800 and 1000 μL) and 250 μL of fruit extract (control) were used for the assessment. The prepared AgNPs solutions were filled in well with desired quantity. Thereafter, petri plates were incubated for 24 h at 37 °C. The growth of bacteria was scored by measuring diameter of zone of inhibition in milli meter (mm).

2.6. Statistical analysis

The data of antibacterial activity were measured thrice, and the results were expressed in Two-way ANOVA (Tukey test) using SPSS software 20 (IBM Armonk, NY, USA). The results were statistically significant $p<0.05$ against control.

3. Results and discussion

3.1. UV-visible analysis

To confirm that the fruit extract of *L. acidissima* forms AgNPs, an ultraviolet-visible spectrum analysis was conducted (Fig. 1). The fruit pulp extract that was obtained was added to a 1 mM $AgNO_3$ solution. AgNPs formation is affirmed by the samples' progressive change in color from light yellow to dark brown. Later, pH levels of suspended mixture were brought to 8, 9, and 10 upon adding appropriate basic solution. This pH effect on the characteristic absorption peak was conducted by the sense of quantifying the presence of AgNPs, pH 8 among the varied

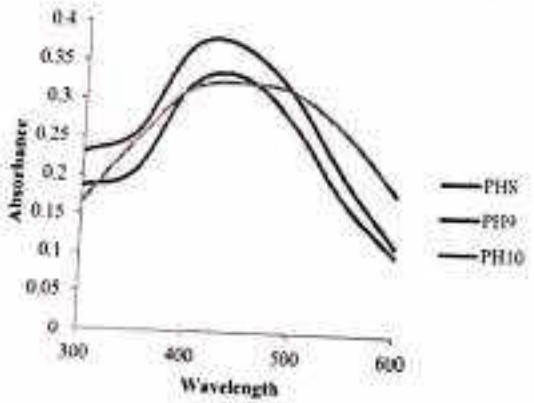

Fig. 1. UV-Visible spectra of as-synthesized AgNPs using *L. acidissima* fruit extract.

pH values showed a characteristic broad absorption peak at 417 nm [37]. Comparable outcomes regarding the production of AgNPs from the ethanolic extract of *Melissa officinalis* and the *Eugenia roxburghii* leaf extract have been documented [38]. According to Penga et al. (2010), the emergence of a broad SPR peak indicates that AgNPs have a high degree of size, shape, and crystallinity uniformity [39].

3.2. Infrared analysis

The relationship between secondary metabolites and AgNP reduction and bio-capping was shown by the FTIR data of fruit extract and AgNPs, which showed absorption peaks. The FTIR spectrum shows the principal matching bands at 3437.18, 2925.59, 2854.95, 1629.50, 1464.58, 1384.57, 1203.60, 1096.67, 661.98, and 599.79 cm^{-1} (Fig. 2 and Table 2). The fruit extract contains proteins, as indicated by the strong band 3437.18 3 cm^{-1}, which is attributed to N-H/O-H stretching. The methylene anti-symmetric and symmetric vibrational modes are shown by the peaks shift from 2925.59 cm^{-1} to 2854.95 cm^{-1} [40]. A weaker band at 1629.50 cm^{-1} has been linked to carbonyl stretching of aromatic alcohols, such as polyphenols, by amide bands [41]. The bands at 1464.58 cm^{-1} and 1384.57 cm^{-1}, respectively, are caused by the carboxylate groups' interaction and the -C-O- stretching of the carboxylation ions. According to Ghotekar et al. (2018), the intense bands 1096.67 and 1026.98 cm^{-1} correspond to the bending of the -C-O-H functional group and the C-N stretching of phenolic compounds [42]. Protein carboxyl groups' C−O stretching, aromatic rings, CH group, and bending vibrations of the substituted ethylene system are all responsible for the bands at 661.98 cm^{-1} and 599.79 cm^{-1}. Finally, FTIR data demonstrated the presence of secondary phyto-constituents involved in AgNPs bio-reduction, stability, and capping, such as flavonoids, tannins, phenolics, carboxylic groups, proteins, and saponins [43,44].

3.3. Powder XRD analysis

The X-ray diffraction analysis was used to analyze crystalline nature of the AgNPs synthesized by the fruit extract of *L. acidissima*. The 2θ values of diffraction peaks are 37.74°, 44.90°, 64.32°, and 77.31° which corresponds to the planes at (111), (200), (220) and (311) respectively (Fig. 3). The resultant data was matched with JCPDS file no. 04-0783. The value (111) shows full width half maximum (FWHM) which is used to estimate the utmost size of the AgNPs by the formula Debye-Scherrer's equation and it was found to be 29.05 nm. This result was very similar to the synthesis of AgNPs by leaf extract of *Averrhoa bilimbi* and *Nerium indicum* [45,46].

3.4. Surface morphology analysis

The surface chemistry (mainly size and shape) of the AgNPs was estimated by atomic force microscopy (AFM) measurements. The topographical 2D and 3D views have shown surface morphology, distribution of the AgNPs (Fig. 5A). However, the surface particle size of the AgNPs affirmed to be 78.4 nm with irregular and spherical shaped (Fig. 4A and B). Fig. 4C represents the distribution of AgNPs.

3.5. TEM analysis

The TEM and HR-TEM images of as-synthesized AgNPs using *L. acidissima* fruit extract are represented (Fig. 5). The crystalline AgNPs shows size which was ranged between 5 and 40 nm at pH 8. The spherical shaped AgNPs showed lattice fringes with minimum agglomeration which can be clearly seen and confirmed by the images. The obtained result corresponds to synthesis of AgNPs from *Rumex hymenosepalus* extracts [47].

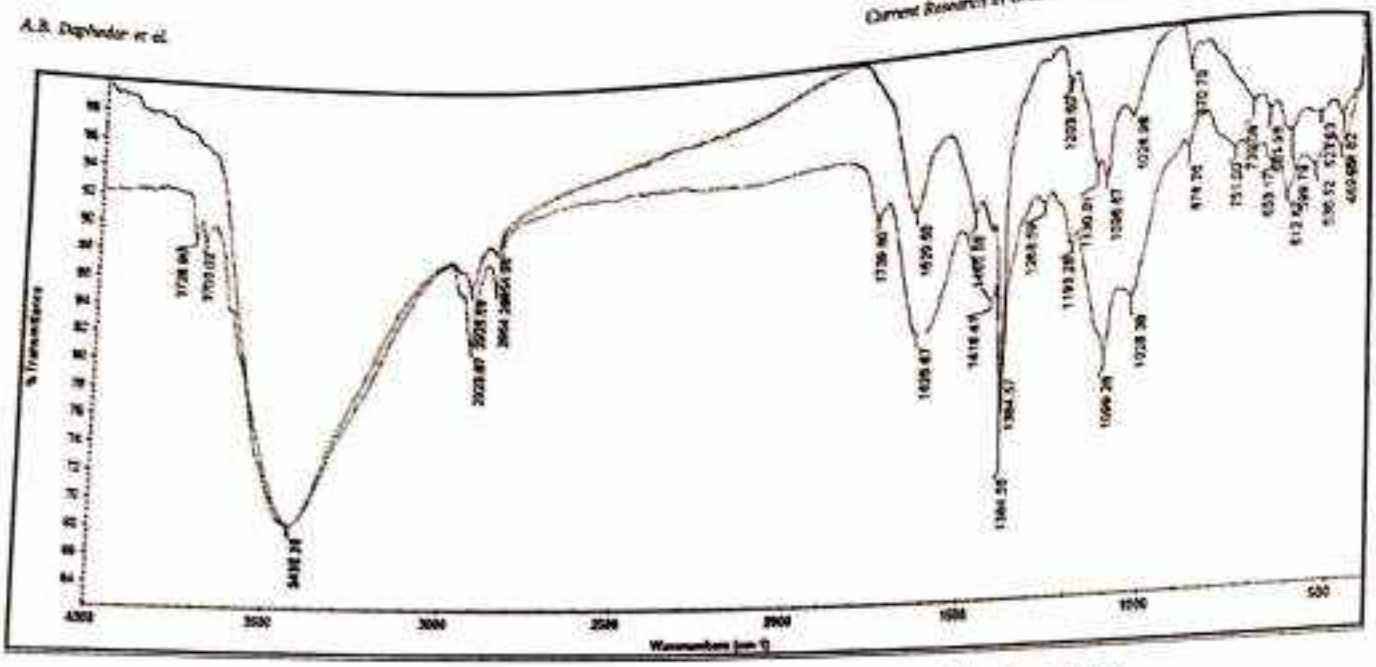

Fig. 2. FTIR analysis of fruit extract and bio-fabricated AgNPs (red color) of *L. acidissima* (green color).

Table 2
Major and minor FTIR frequencies of fruit extract and as-synthesized AgNPs.

Sl. No	Fruit extract	AgNPs	Functional groups
1	3437.00	3437.19	Stretching of N-H/O-H
2	2923.87	2925.59	Anti-symmetric vibrational mode of methylene
3	2854.20	2854.95	symmetric vibrational mode of methylene
4	1625.67	1629.50	Stretching of amide band I/Carbonyl
5	1416.41	1464.58	Bending of silver ions with carboxylate groups
6	1384.55	1384.57	stretching of the carboxylation ions
7	1268.59	1203.60	Amide band III
8	1099.26	1096.67	-C-O-H bending
9	1028.38	1026.98	C-N stretching vibration of primary amines
10	612.67	599.79	C=C group/aromatic rings/C=O stretching in carbonyl groups of proteins

Table 3
Antibacterial activity of AgNPs by Fruit extract of *L. acidissima*.

Sl. No	Name of organisms	Different concentrations of AgNPs (µl)	Zone of inhibition (ZOI) mm
1	*E. coli*	Control	0.000 ± 0.000[d]
		25	0.000 ± 0.000[d]
		50	4.013 ± 0.019[c]
		100	6.054 ± 0.0077[b]
		250	8.030 ± 0.013
2	*S. typhi*	Control	0.000 ± 0.000
		25	0.000 ± 0.00
		50	7.033 ± 0.033
		100	9.066 ± 0.016
		250	11.025 ± 0.017
3	*V. cholera*	Control	0.000 ± 0.000
		25	0.000 ± 0.000
		50	0.000 ± 0.000
		100	3.000 ± 0.010
		250	5.033 ± 0.0044
4	*S. aureus*	Control	0.000 ± 0.000
		25	0.000 ± 0.000
		50	5.100 ± 0.057
		100	8.100 ± 0.067
		250	11.033 ± 0.033

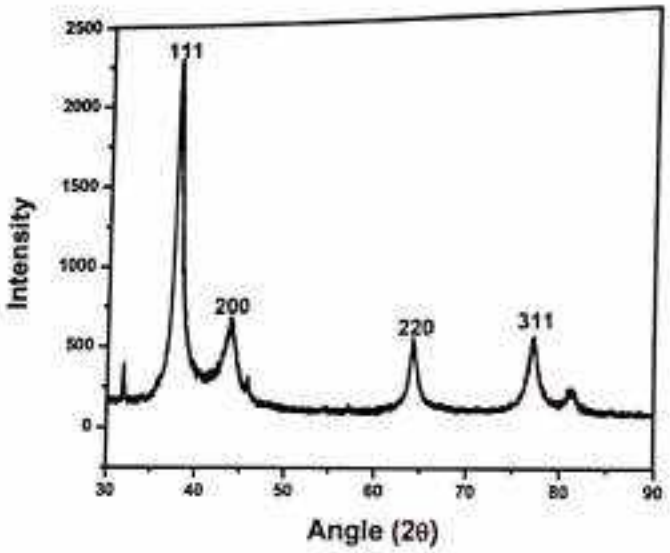

Fig. 3. XRD pattern of as-synthesized AgNPs.

3.6. Antioxidant investigation

The DPPH assay was used to conduct the experiment in order to determine the scavenging activity of the *L. acidissima* fruit extract and as-synthesized AgNPs (Fig. 6). Silver nanoparticles have the strongest antioxidant activity, as evidenced by their high EC50 value (EC50 = 442.16 µg/mL) when compared to conventional ascorbic acid (EC50 = 312.25 µg/mL) and fruit extract (EC50 = 261.08 µg/mL). The fruit extract of artificially generated AgNPs, which contains bio-effective phytochemicals such as tannins, phenolics, flavonoids, and saponins, is also in charge of the antioxidant activity and works well against radical scavengers.

3.7. Antibacterial activity

AgNPs derived from *L. acidissima* fruit extract were evaluated against three Gram negative and one Gram positive bacteria, namely *Salmonela typhi, Vibrio cholera, Staphylococcus aureus*, and *Escherichia coli*, respectively. Fruit extract was used as the control (Figs. 7 and 8). Using various

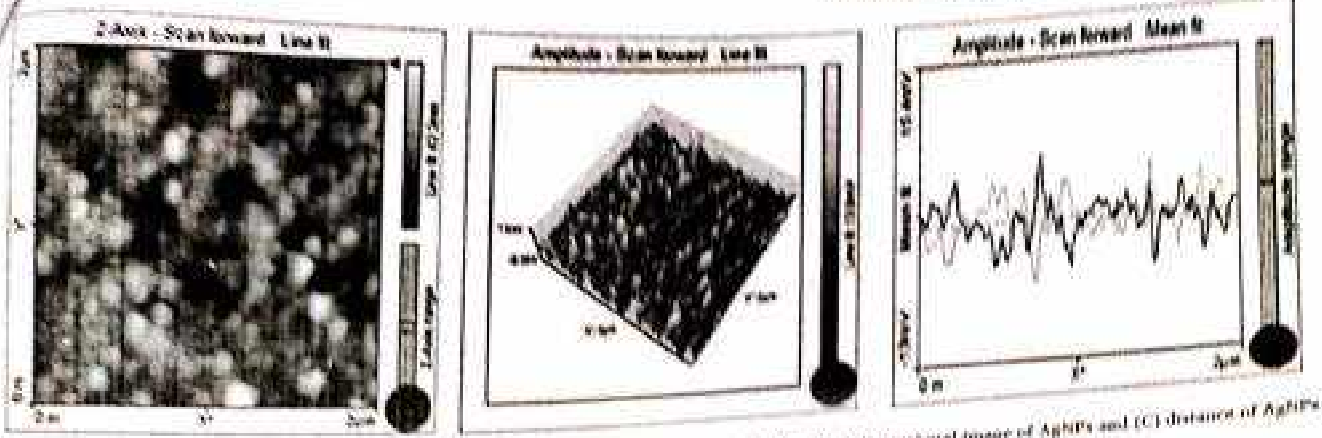

Fig. 4. AFM analysis of as-obtained AgNPs from fruit extract of L. acidissima (A) 2D image of AgNPs, (B) 3 dimensional image of AgNPs and (C) distance of AgNPs

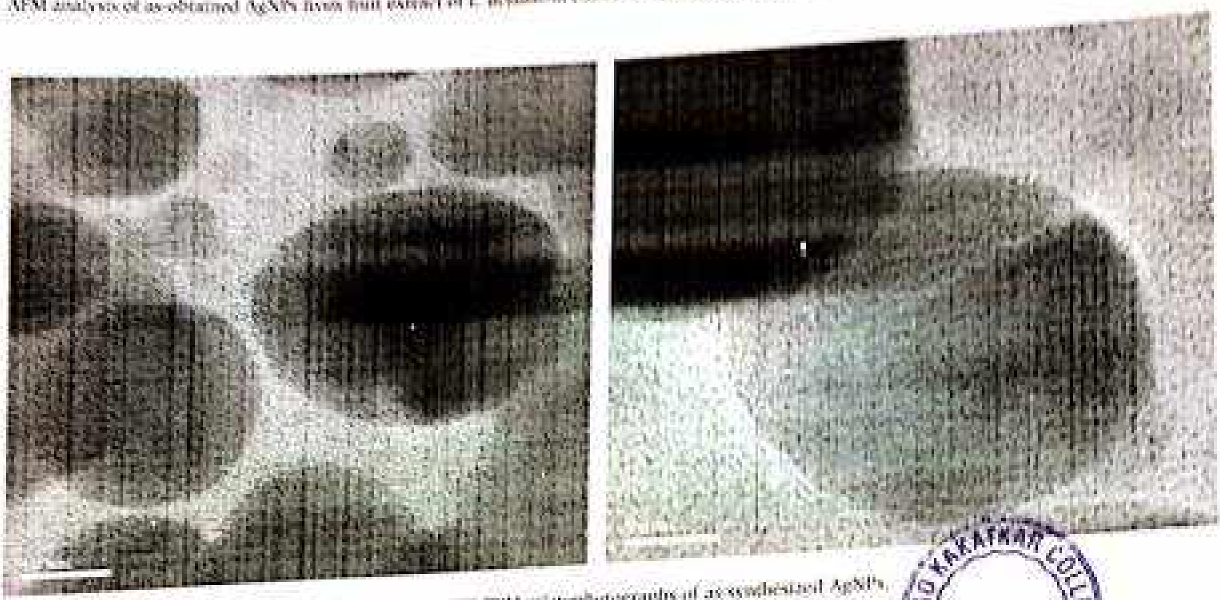

Fig. 5. TEM and HR-TEM microphotographs of as-synthesized AgNPs.

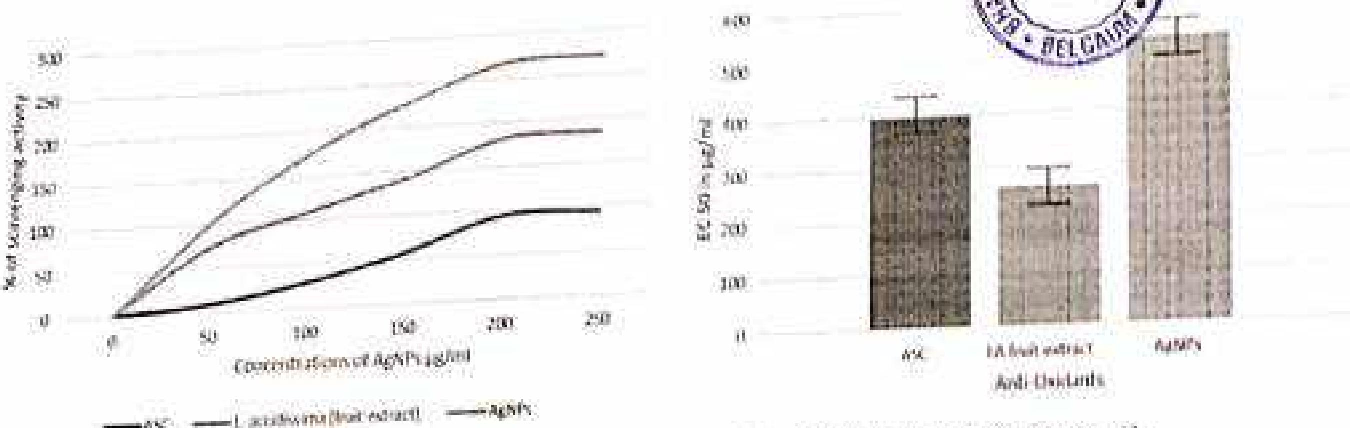

Fig. 6. Graphical representation of antioxidant activity of as-synthesized AgNPs, fruit extract and ascorbic acid.

concentrations of as-synthesized AgNPs (25, 50, 100, and 250 µg/mL), the activity was evaluated using the well diffusion method, and the zone of inhibition (ZOI) of the bacteria was observed. Compared to other bacterial strains, *S. aureus* (12.03 ± 0.043 mm) and *V. cholera* (9.09 ± 0.013 mm) showed the highest and lowest zone of inhibitory activity at 250 µL, respectively. ZOI was not detected in the fruit extract under control. In comparison to the control, the recorded values are statistically significant ($p = < 0.05$). Following are the possible noteworthy sensitivities that the AgNPs displayed against bacteria: *S. aureus* > *E. coli* > *S. typhi* > *V. cholera*.(See Table 3)

4. Conclusion

In conclusion, fruit extract from *L. acidissima* was used to bio-

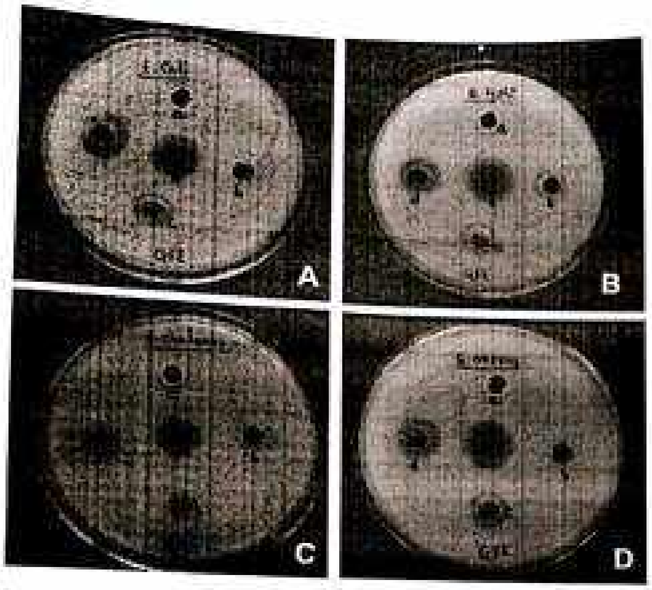

Fig. 7. Antibacterial effect of tested as-synthesized AgNPs against *E. coli, S. typhi, V. cholera* and *S. aureus*.

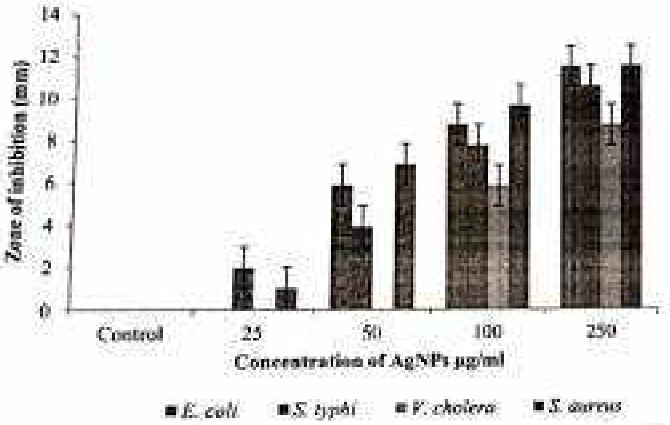

Fig. 8. Graphical representation of antibacterial activity of as-prepared AgNPs.

fabricate AgNPs, and the material was characterized utilizing a variety of physical techniques. With an average size of 29 nm, the as-synthesized AgNPs have a spherical form according to the results of different characterization procedures. Additionally, the DPPH assay was used to assess the synthetic material's antioxidant capability. The results are noteworthy in terms of the tested AgNPs effectiveness in scavenging radicals. Conversely, at the highest concentration of 250 µg/mL, the antibacterial activities of the as-prepared AgNPs demonstrated a considerable inhibition of bacterial growth. Therefore, biogenic AgNPs could be employed as biological agents in the treatment of a number of serious illnesses.

Declaration of competing interest

The authors declare that there is no conflict of interest.

Data availability

Data will be made available on request.

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References

[1] S. Chernousova, M. Epple, Silver as antibacterial agent: ion, nanoparticle, and metal, Angew Chem. Int. Ed. Engl. 52 (6) (2013) 1636–1653, https://doi.org/10.1002/anie.201205923.

[2] K. Elangovan, D. Elumalai, S. Anupriya, R. Shenbhagaraman, P.K. Kaleena, K. Murugesan, Phyto mediated biogenic synthesis of silver nanoparticles using leaf extract of *Andrographis echioides* and its bio-efficacy on anticancer and antibacterial activities, J. Photochem. Photobiol., B 151 (2015) 118–124, https://doi.org/10.1016/j.jphotobiol.2015.07.015.

[3] L. Kui-Jae, P. Sung-Hee, M. Govarthanan, H. Pyoung-Han, S. Young-Seok, M. Cho, L. Wang-Hyu, L. Jai-Young, S. Kamala-Kannan, O. Byung-Taek, Synthesis of silver nanoparticles using cow milk and their antifungal activity against phytopathogens, Mater. Lett. 105 (2013) 128–131, https://doi.org/10.1016/j.MATLET.2013.04.096.

[4] M. Gayathri, S.K. Amija, K.N. Sarritha, Sunlight-induced honey-mediated green synthesis of silver nanoparticles, in: *AIP Conference Proceedings*, 2142, 2019, https://doi.org/10.1063/1.5130231.

[5] M.A. Kakakhel, F. Wu, H. Feng, Z. Hassan, I. Ali, I. Saif, U. Zaheer, S. Din, W. Wang, Biological synthesis of silver nanoparticles using animal blood, their preventive efficiency of bacterial species, and ecotoxicity in common carp fish, Microsc. Res. Tech. 84 (8) (2021) 1765–1774, https://doi.org/10.1002/jemt.23733.

[6] M.I. Rahmah, Preparation of silver chloride nanoparticles using human urine, Appl. Nanosci. 11 (2021) 2611–2615, https://doi.org/10.1007/s13204-021-02133-7.

[7] S. Muthupandian, R. Hamed, V. Hossein, Chapter – 5: green nanotechnology: isolation of bioactive molecules and modified approach of biosynthesis, Biogenic Nanoparticles for Cancer Theranostics 2021 (2021) 101–122, https://doi.org/10.1016/B978-0-12-821467-1.00005-7.

[8] S. Mora-Godinez, F. Abril-Martinez, Green synthesis of silver nanoparticles using microalgae acclimated to high CO_2, Materials today: proceedings 48 (2022) 5–9, https://doi.org/10.1016/j.matpr.2020.04.761.

[9] H. Samadian, M.S. Salami, M. Jaymand, A. Azarnezhad, M. Najafi, H. Barabadi, A. Ahmadi, Genotoxicity assessment of carbon-based nanomaterials; Have their unique physicochemical properties made them double-edged swords? Mutation Research/Reviews in Mutation Research 783 (2020) 108296 https://doi.org/10.1016/j.mrrev.2020.108296.

[10] M. Chandhru, R. Logesh, S. Kutti Rani, A. Nessar, N. Vasimalai, Green synthesis of silver nanoparticles from plant latex and their antibacterial and photocatalytic studies, Environ. Technol. 43 (2022) 3064–3074, https://doi.org/10.1080/09593330.2021.1914181.

[11] M.A. Raza, Z. Kanwal, A. Rauf, A.N. Sabri, S. Riaz, S. Naseem, Size- and shape-dependent antibacterial studies of silver nanoparticles synthesized by wet chemical routes, Nanomaterials 6 (4) (2016) 74, https://doi.org/10.3390/nano6040074, 15.

[12] L. Xu, Y.Y. Wang, J. Huang, C.Y. Chen, Z.X. Wang, H. Xie, Silver nanoparticles: synthesis, medical applications and biosafety, Theranostics 10 (20) (2020) 8996–9031, https://doi.org/10.7150/thno.45413.

[13] J. Pei, B. Fu, L. Jiang, T. Sun, Biosynthesis, characterization, and anticancer effect of plant-mediated silver nanoparticles using *Coptis chinensis*, Int. J. Nanomed. 14 (2019) 1969–1978, https://doi.org/10.2147/IJN.S188235.

[14] I.I. Nasidi, O. Kaygili, A. Majid, N. Bulut, M. Alkhedher, S.M. ElDin, Halogen doping to control the band gap of ascorbic acid: a theoretical study, ACS Omega 7 (48) (2022) 44390–44397, https://doi.org/10.1021/acsomega.2c06075.

[15] G. Ozbey, E.S. Tanriverdi, B.F. Senkal, B. Korkmaz, S. Erkan, N. Bulut, F. Zigo, B. Otlu, Investigation of antimicrobial activities and molecular docking studies of synthesized sulfonamide compounds, Pharmaceut. Chem. J. 57 (9) (2023) 1394–1400, https://doi.org/10.1007/s11094-023-03003-6.

[16] J. Seiffert, F. Hussain, C. Wiegman, F. Li, L. Bey, W. Baker, A. Porter, M.P. Ryan, Y. Chang, A. Gow, J. Zhang, J. Zhu, T.D. Tetley, K.F. Chung, Pulmonary toxicity of instilled silver nanoparticles: influence of size, coating and rat strain, PLoS One 6 (3) (2015) e0119726, https://doi.org/10.1371/journal.pone.0119726, 10.

[17] S. Gurunathan, J. Raman, S.N. Abd Malek, P.A. John, S. Vikineswary, Green synthesis of silver nanoparticles using Ganoderma neo-japonicum Imazeki: a potential cytotoxic agent against breast cancer cells, Int. J. Nanomed. 8 (2013) 4399–4413, https://doi.org/10.2147/IJN.S51881.

[18] I. Fierascu, M.I. Georgiev, A. Ortan, R.C. Fierascu, S.M. Avramescu, D. Ionescu, A. Sutan, A. Brinzan, L.M. Ditu, Phyto-mediated metallic nanoarchitectures via *Melissa officinalis* L.: synthesis, characterization and biological properties, Sci. Rep. 7, 29 (1) (2017) 12428, https://doi.org/10.1038/s41598-017-12804-7, 7.

[19] P.S. Kerkar, S. Patil, S.S. Arya, A. Dabade, S.S. Sonawane, Limonia acidissima: versatile and nutritional fruit of India, Int. J. Fruit Sci. 20 (2020) S405–S413, https://doi.org/10.1080/15538362.2020.1737914.

[illegible] V. Annavaram, V.R. Posa, V.G. Uppara, S. Jorepalli, A.R. Somala, Facile green synthesis of silver nanoparticles using *Limonia acidissima* leaf extract and its antibacterial activity, BioNanoSci 5 (2015) 97–103, https://doi.org/10.1007/s12668-015-0168-7.

[21] T. Thilagavathi, G. Kathiravan, K. Srinivasan, Antioxidant activity and synthesis of silver nanoparticles using the leaf extract of *Limonia acidissima*, Int J Pharm Bio Sci 7 (4) (2016) 201–205, https://doi.org/10.22376/ijpbs.2016.7.4.b201-205.

[22] B.N. Patil, T.C. Taranath, *Limonia acidissima* L. Leaf mediated synthesis of silver nanoparticles: a potent tool against Mycobacterium tuberculosis, Int J Mycobacteriology 6 (2016) 197–204, https://doi.org/10.1016/j.ijmyco.2016.03.004.

[23] P. Kanchana, V. Hemapriya, N. Arunadevi, S.S. Sundari, I.M. Chung, M. Prabakaran, Phytofabrication of silver nanoparticles from *Limonia acidissima* leaf extract and their antimicrobial, antioxidant and its anticancer prophecy, Indian Chemical Society 99 (10) (2022) 100679, https://doi.org/10.1016/j.jics.2022.100679.

[24] H. Barabadi, K. Mobaraki, F. Ashouri, H. Noqani, K. Jounaki, E. Mostafavi, Nanobiotechnological approaches in antinociceptive therapy: animal-based evidence for analgesic nanotherapeutics of bioengineered silver and gold nanomaterials, Adv. Colloid Interface Sci. 316 (2023) 102917, https://doi.org/10.1016/j.cis.2023.102917.

[25] H. Barabadi, K. Jounaki, E. Pishgahzadeh, H. Morad, S. Sadeghian-Abadi, H. Vahidi, C.M. Hussain, Chapter 14 - Antiviral potential of green-synthesized silver nanoparticles, in: C.M. Hussain (Ed.), Handbook of Microbial Nanotechnology, Academic Press, 2022, pp. 285–310, https://doi.org/10.1016/B978-0-12-823426-6.00003-9.

[26] H. Barabadi, H. Noqani, F. Ashouri, A. Prasad, K. Jounaki, K. Mobaraki, Y. K. Mohanta, E. Mostafavi, Nanobiotechnological approaches in anticoagulant therapy: the role of bioengineered silver and gold nanomaterials, Talanta 256 (2023) 124279, https://doi.org/10.1016/j.talanta.2023.124279.

[27] E. Mostafavi, A. Zarepour, H. Barabadi, A. Zarrabi, L.B. Truong, D. Medina-Cruz, Antineoplastic activity of biogenic silver and gold nanoparticles to combat leukemia: beginning a new era in cancer theragnostic, Biotechnology Reports 34 (2022) e00714, https://doi.org/10.1016/j.btre.2022.e00714.

[28] N. Talank, H. Morad, H. Barabadi, F. Mojab, S. Amidi, F. Kobarfard, M.A. Mahjoub, K. Jounaki, N. Mohammadi, G. Salehi, M. Ashrafizadeh, E. Mostafavi, Bioengineering of green-synthesized silver nanoparticles: in vitro physicochemical, antibacterial, biofilm inhibitory, anticoagulant, and antioxidant performance, Talanta 243 (2022) 123374, https://doi.org/10.1016/j.talanta.2022.123374.

[29] M. Keskin, G. Kaya, S. Bayram, A. Kurek-Gorecka, P. Olczyk, Green synthesis, characterization, antioxidant, antibacterial and enzyme inhibition effects of chestnut (castanea sativa) honey-mediated silver nanoparticles, Molecules 28 (6) (2023) 2762, https://doi.org/10.3390/molecules28062762.

[30] A. Ti, I. Ej, A. A.H, Evaluation of antioxidant and antimicrobial properties of silver nanoparticles biosynthesized using weed (Dactyloctenium aegyptium) extracts for sustainable environment, agriculture and ethnomedicine, Mater. Today: Proc. (2023), https://doi.org/10.1016/j.matpr.2023.06.223.

[31] A. Chinnathambi, S.A. Alharbi, D. Joshi, S. V, G.K. Jhanani, R. On-uma, K. Jutamas, W. Anupong, Synthesis of AgNPs from leaf extract of Naringi crenulata and evaluation of its antibacterial activity against multidrug resistant bacteria, Environ. Res. 216 (2023) 114455, https://doi.org/10.1016/j.envres.2022.114455.

[32] A. Abida, M.H. Almutairi, N. Mushtaq, M. Ahmed, N. Sher, F. Fozia, I. Ahmad, B. O. Almutairi, Z. Ullah, Revolutionizing nanotechnology with Filago desertorum extracts: biogenic synthesis of silver nanoparticles exhibiting potent antioxidant and antibacterial activities, *ACS Omega* 8 (38) (2023) 35140–35151, https://doi.org/10.1021/acsomega.3c04375.

[33] R. Chinnasamy, K. Chinnaperumal, T. Cherian, K. Thamilchelvan, B. Govindasamy, C. Vetrivel, V. Perumal, P. Willie, P. Krutmuang, Eco-friendly phytofabrication of silver nanoparticles using aqueous extract of Aristolochia bracteolata Lam: its antioxidant potential, antibacterial activities against clinical pathogens and malarial larvicidal effects, Biomass Conversion and Biorefinery (2023), https://doi.org/10.1007/s13399-023-03750-8.

[34] T. Karan, Z. Gonulalan, R. Erenler, U. Kolemen, O. Eminagaoglu, Green synthesis of silver nanoparticles using Sambucus ebulus leaves extract: characterization, quantitative analysis of bioactive molecules, antioxidant and antibacterial activities, J. Mol. Struct. 1296 (2024) 136836, https://doi.org/10.1016/j.molstruc.2023.136836.

[35] S. Majeed, M. Saravanan, M. Danish, N.A. Zakariya, M.N.M. Ibrahim, E.H. Rizvi, S. u. NisaAndrabi, H. Barabadi, Y.K. Mohanta, E. Mostafavi, Bioengineering of green-synthesized TAT peptide functionalized silver nanoparticles for apoptotic cell-death mediated therapy of breast adenocarcinoma, Talanta 253 (2023) 124026, https://doi.org/10.1016/j.talanta.2022.124026.

[36] S. Honary, S. Honary, E. Gharaei Fathabad, F. Gharaei-Fathabad, H. Barabadi, F. Naghibi, F. Naghibi, Fungus-Mediated synthesis of gold nanoparticles: a novel biological approach to nanoparticle synthesis, J. Nanosci. Nanotechnol. 13 (2) (2013) 1427–1430, https://doi.org/10.1166/jnn.2013.5989.

[37] A.R. Golnaraghi Ghomi, M. Mohammadi-Khanaposhti, H. Vahidi, F. Kobarfard, M. Ameri Shah Reza, H. Barabadi, Fungus-mediated extracellular biosynthesis and characterization of zirconium nanoparticles using standard penicillium species and their preliminary bactericidal potential: a novel biological approach to nanoparticle synthesis (original article), Iran. J. Pharm. Res. (IJPR) 18 (4) (2019) e124700, https://doi.org/10.22037/ijpr.2019.112382.13722.

[38] H. Vahidi, F. Kobarfard, A. Alizadeh, M. Saravanan, H. Barabadi, Green nanotechnology-based tellurium nanoparticles: exploration of their antioxidant, antibacterial, antifungal and cytotoxic potentials against cancerous and normal cells compared to potassium tellurite, Inorg. Chem. Commun. 124 (2021) 108385, https://doi.org/10.1016/j.inoche.2020.108385.

[39] D. Guru Kumar, M. Chethan Kumar, Anisha Jain, M.K. Raghavendra, R.N. Rani, N. Divya, M.A. Rathi, A.S. Ali, Y.A. Mohammad, E.I.E. Serag, S. Ekaterina, S. Victor, V.K. Gopalakrishnan, R.A. Raghu, S. Chandan, K. Shiva Prasad, Environmentally benign silver bio-nanomaterials as potent antioxidant, antibacterial, and antidiabetic agents: green synthesis using Salacia oblonga root extract, Front. Chem. 11 (2023) 1114109, https://doi.org/10.3389/fchem.2023.1114109.

[40] S. Peng, J.M. McMahon, G.C. Schatz, S.K. Gray, Y. Sun, Reversing the size-dependence of surface plasmon resonances, Applied physical sciences 107 (33) (2010) 14530–14534, https://doi.org/10.1073/pnas.1007524107.

[41] A.K. Giri, B. Jena, B. Biswal, A.K. Pradhan, M. Arakha, S. Acharya, L. Acharya, Green synthesis and characterization of silver nanoparticles using *Eugenia roxburghii* DC. extract and activity against biofilm-producing bacteria, Sci. Rep. 12 (2022) 8383, https://doi.org/10.1038/s41598-022-12484-y.

[42] A. Solanki, D. Rathod, I.C. Patel, J. Panigrahi, Impact of silver nanoparticles as antibacterial agent derived from leaf and callus of *Celastrus paniculatus* Willd, Futur J Pharm Sci 7 (1) (2021) 60, https://doi.org/10.1186/s43094-021-00212-8.

[43] D. Preetha, R. Prachi, A. Chirom, A. Renganathan, Synthesis and characterization of silver nanoparticles using cannonball leaves and their cytotoxic activity against MCF-7 cell line, Journal of Nanotechnology 5 (2013) 598328, https://doi.org/10.1155/2013/598328.

[44] S. Gholekar, A. Savale, S. Pansambal, Phytofabrication of fluorescent silver nanoparticles from *Leucaena leucocephala* L. leaves and their biological activities, J Water Environ Nanotechnol 3 (2) (2018) 95–105, https://doi.org/10.22090/jwent.2018.02.001.

[45] S. Gomathi, J. Firdous, V. Bharathi, Phytochemical screening of silver nanoparticles extract of *Eugenia jambolana* using Fourier infrared spectroscopy, Int. J. Res. Pharm. Sci. 8 (2017) 383–387.

[46] D. Guru Kumar, R.A. Raghu, R.K. Jajur, A. Ganamaedi, K.G. Velliyur, P. Sushma, A. S. Ali, Y.A. Mohammad, E.I.E. Serag, S. Ekaterina, S. Victor, M. Natalia, S. Chandan, K. Shiva Prasad, Assessment of antimicrobial and anthelmintic activity of silver nanoparticles bio-synthesized from Viscum orientale leaf extract, BMC Complementary Medicine and Therapies 23 (1) (2023) 1–14, https://doi.org/10.1186/s12906-023-03982-1.

[47] S. Sagadevan, S. Vennila, P. Singh, J.A. Lett, M.R. Johan, A.R. Marlinda, M. Bavanilatha, L. Muthukrishnan, Facile synthesis of silver nanoparticles using *Averrhoa bilimbi* L and Plum extracts and investigation on the synergistic bioactivity using in vitro models, Green Process. Synth. 8 (2019) 873–884, https://doi.org/10.1515/gps-2019-0058.

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RESEARCH ARTICLE

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Evaluation of vateria indicia leaves extract as a green source of potential corrosion inhibitor against mild steel corrosion in 1M HCl solution: electrochemical, and surface characterisation studies

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ABSTRACT

The components of aqueous vateria indica leaves extract (*VILE*) were formulated as a green corrosion inhibitor for mild steel (MS) in 1 M HCl medium by weight change and electrochemical routes at 298 K. Nyquist plots indicated, as an increase the concentration of *VILE*, increases the resistance to charge transfer and lowers the value of electrical double layer capacitance. *VILE* affected both anodic and cathodic potentiodynamic curves decided that *VILE* components were mixed type. The addition of *VILE* concentration increases, progressively increasing the percentage inhibition efficiency and reaching a maximum of 93.22% at 150 ppm. The inhibition efficiency of the *VILE* was evaluated at elevated temperatures. Activation energy values were found to be higher in the presence of *VILE* compared to blank. The corrosion inhibition process was correlated through the Langmuir adsorption isotherm model using the Arrhenius equation. SEM and AFM images in the occurrence of *VILE* visualised that, MS surface was least affected compared to the corroded surface in the absence of an inhibitor. FT- IR spectral peaks suggested that the active groups present in the extract strongly interacted over the MS surface and formed a protective layer, this layer decreased the rate of corrosion to a greater extent.

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KEYWORDS Aqueous extract of vateria indicia; mild steel; corrosion inhibitors; adsorption isotherm; tafel plots; inhibition efficiency

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1. Introduction

MS materials are largely utilised in storage tanks, petrochemical industries, and so on. The major difficulty of using MS is easily attacked by acid surroundings. In many industrial operations aqueous acids being extensively applied in support of taking away unwanted scale and rust from the metal surfaces. Favourably HCl solution was treated one to eliminate the scale and rust during industrial process. Chemical compounds are usually added as inhibitors in such operations to oppose both the metal dissolution and acid intake process (Chauhan et al. 2018; Praveen et al. 2021; Addoun et al. 2019; Aljourani, Raeissi, and Golozar 2009).

Many chemical compounds like organic & inorganic compounds particularly these compounds contains heteroatoms, unsaturation bonds, cyclic rings, aromatic groups have been developed as inhibitors for many metals in different corrosive environment (Ahamad et al. 2010; El Ibrahimi et al. 2021; Singh et al. 2018; Hebbar et al. 2020; Dehghani, Bahlakeh, and Ramezanzadeh 2019; Qiang et al. 2017). Schiff base synthesised by the condensation reaction between C=O and $-NH_2$ groups tend to became potent inhibitor. The most benefit of many Schiff bases are suitably and simply synthesise with comparatively inexpensive materials. Several researchers investigated, Schiff bases possessed –C=N–, hetero atoms such as N, S or O atoms shown significantly and effectively protected the MS corrosion from acid solutions (Bentiss, Lebrini and Lagrenee 2005; Jacob and Parameswaran 2010; Wang et al. 2016; Kalkhambkar and Rajappa 2022; Hosseini and Azimi 2009; Ahamad, Prasad, and Quraishia 2010; Bentiss et al. 2009; Behpour et al. 2010). Many of the synthesised organic inhibitor are possessed toxic and harm to environment. Although various synthetic organic and inorganic compounds can be acts as good corrosion inhibitors in acidic environment as they are highly efficient but they are of more expensive and ecological risks due to the their hazardous environmental effects. The bark, resin, and leaves are used in Ayurvedic, Siddha, Unani, and folk medicine for the treatment of leprosy, eczema, rheumatism, diarrhoea, and ulcers. Various components contained in the plants extracts such as such as alkaloids, pigments, tannins, amino acids etc., are well known and demonstrate good inhibiting achievement towards corrosion of MS in acid media. In the current scenario, the researchers are promoted to utilise the potentiality of the natural products extracts of plant roots, leaves, flowers, seeds, grains, etc., to combat metals corrosion in different corrosive environment. These extracts being are ecologically acceptable, inexpensive, cheaper, biodegradable, non-toxic and readily available (Kalkhambkar et al. 2022; Muthukumarasamy et al. 2020; Guruprasad and Sachin 2021; Farzana, Banu, and Ahamed 2021).

Recently many authors have been working on the use of several extracts of natural plant sources as green source of inhibitors for the corrosion of different metals in acidic environment (Abuelela et al. 2023; Haque et al. 2021; Bahlakeh, Dehghani, et al. 2019; Khan et al. 2015; Lgaz et al. 2015; Oukhrib et al. 2017; Sharma, Peter, and Obot 2015; Asadi et al. 2019).

In the current investigations, an aqueous extract of vateria indicia leaves is chosen to study the anticorrosion behaviour in 1 M HCl solution for MS. The inhibition ability was determined employing weight change and electrochemical methods. Further the investigations are focused on interaction of components of plant extract on MS surface and modification of MS surface during corrosion and inhibition by AFM, SEM and FT-IR analyses.

2. Experimental procedure

2.1. *Vateria indica leaves extraction*

The image of the Vateria indica leaves is shown in Figure 1. Vateria indica leaves are washed through running water followed by dried out at an ambidient temperature and crushed to powder. About 30 g powder was added to 500 ml double de-ionised water and the whole mixture is then taken in a Soxhlet extraction apparatus and boiled for 3h. The extraction was separated by filtration further reduces volume through water evaporation and dried in microwave oven. By weighing the dried VILE extract, 500 ppm stock solution in 1 M HCl was prepared. Further, the different

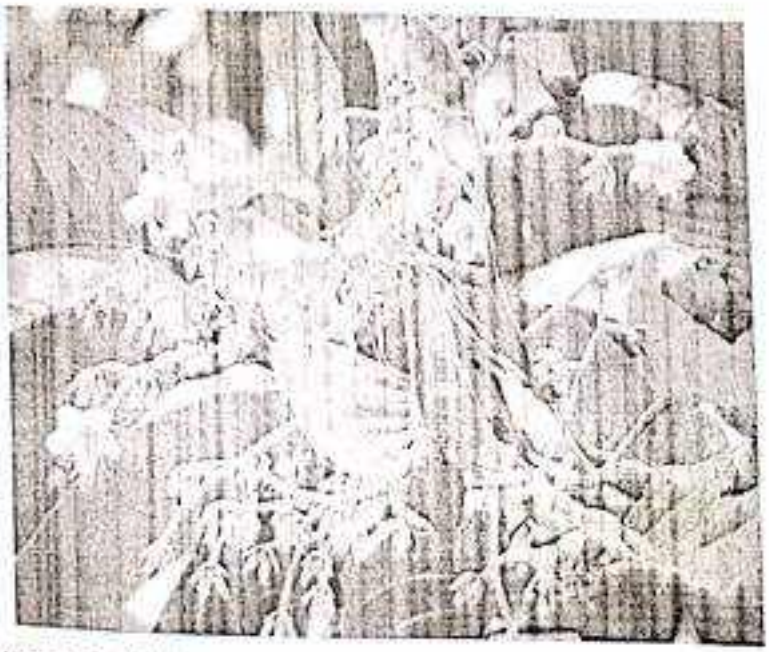

Figure 1. Vateria indicia leaves.

concentration of inhibitors such as 25, 50, 75, 125 and 150 pmm were prepared using stock solution by dilution method in 1 M HCl solution. The same concentrations were used for weight change and electrochemical methods. Vateria indica leaves extract is labelled as *VILE*.

2.2. Corrosive solution

About 35.5–36% assay of Analytical grade hydrochloric acid was used to prepare 1 M HCl corrosive solution for MS.

2.3. Mild steel specimens

Rectangular mild steel (MS) sheets of 0.068% C, 0.26% Mn, 0.007% S, 0.014% P and the remaining % of Fe composition was employed for experimental object. These MS sheets mechanically well-polished with different emery papers from grades 400, 800, 1000, 1500 and 2000 and later washed with distilled water and dried. The well dried MS specimens were taken and record the weight of each specimen using a digital weighing balance of 0.01 mg accuracy.

2.4. Weight change measurements

The method is based on the measurement of the weight change of the specimen, which is immersed in 1 M HCl test solution in addition and absence of the extract. The well-polished previously weighted MS coupons were immersed in hanging position in various concentrations of inhibitor solution for different time of interval at 298 ± 1K temperature. After specified time, change in weight in 'mg' was noted. The values of weight changes used to determine the rate of corrosion (V_{corr}) in 'mm/year using Equation (1) and followed by percentage inhibition efficiencies using Equation (2).

$$V_{corr}(mm/year) = \frac{87.6\ x\ W}{Atd} \tag{1}$$

where w = weight loss in mg, A = exposed surface area in sq.cm, t = Duration of specimen immersed in hour and d = Density of the specimen (g/cm^3)

$$\%\ IE = 1 - \frac{V^{1}_{corr}}{V_{corr}}\ x\ 100 \tag{2}$$

where V_{corr} = corrosion rate of MS in 1 M HCl and V^{1}_{corr} = corrosion rate in presence of extract.

The surface coverage (Θ) was calculated using the following Equation (3).

$$\Theta = 1 - \frac{V^{1}_{corr}}{V_{corr}} \tag{3}$$

2.5. Electrochemical tests

Potentiodynamic polarizations and electrochemical impedance spectroscopic tests were conducted using AUTOLAB model PGSTAT204 linked with software NOVA and associated with FRA32M potentiostat/galvanostat through frequency response analyser controlled by Autolab computer. The ASTM glass cell assembly was used to conduct all the electrochemical tests. The cell equipped with 3 mm MS cylindrical rod of 1 cm exposed area taken as a working electrode, platinum as auxiliary electrode and saturated Ag/AgCl used as a reference electrode. All the electrochemical determinations were recorded at 298 ± 1K and even at different temperature regions from 308-328 ± 1K. In the beginning working MS electrode was suspended half an hour to ensure steady open circuit potential. The EIS studies were performed over a frequency range of 100 kHz–0.1 Hz with signal amplitude 5 mV sine wave as excitation signal and ZSimp Win 3.21 software employed to analysed impedance data. Further the percentage inhibition efficiency ($\eta_{EIS}\%$) was calculated by the Equation (4).

$$(\eta_{EIS}\%) = \frac{R_p - R^{0}_{p}}{R_p} \times 100 \tag{4}$$

where R_p = polarisation resistance in 1 M HCl with addition of *VILE* and R^{0}_{p} = polarisation resistance in 1 M HCl.

Tafel polarisation plots were taken at a scan rate 0.5 mV/S from -200 to +200 mV potential range relative to open circuit potential value. The corresponding corrosion current density (I_{corr}), corrosion potential (E_{corr}), anodic and cathodic tafel slopes were measured by tafel extrapolation system. The % η_{pol} was calculated using the Equation (5).

$$(\eta_{pol}\%) = \frac{I^{1}_{corr} - I_{corr}}{I^{1}_{corr}} \times 100 \tag{5}$$

where I^{1}_{corr} = corrosion current density in 1 M HCl and I_{corr} = corrosion current density in 1 M HCl with the addition of *VILE*. Further from polarisation curve corrosion rate (CR) can be calculated by Equation (6).

$$CR = \frac{I_{corr} \times T \times M}{F \times S \times d} \times 10 \tag{6}$$

Where T = time (sec.), M = molar weight of iron (g/mol), F = Faraday constant (96,500 C/mol), S = the exposed surface area of electrode (cm^2), d = density of metal (g/cm^3) and 10 = constant convert cm to mm (Döner et al. 2011; Praveen et al. 2018; Rathod and Rajappa 2021).

2.6. Adsorption isotherms and thermodynamic parameters

To evaluate the mode of corrosion inhibition through adsorption phenomenon, the experimental values were closely correlated with several adsorption isotherms, which include Langmuir, Bockris-Swinkels, Temkin, Flory-Huggins, and Freundlich. Temperature effect determine the activation parameters for corrosion process that causes *VILE* to demonstrate up on the MS surface. Thermodynamic parameters such as, enthalpy of activation (ΔH^*) and entropy of activation (ΔS^*) were evaluated.

2.7. FT-IR analysis

FT-IR spectra of pure *VILE* and the scratched corrosion product collected from the immersed MS surface containing an optimum concentration of *VILE* were analysed by Nicolet 5700 spectroscope in 4000–400 cm^{-1} frequency range.

2.8. Surface analysis

The change of characteristics of MS substrates after corrosion in blank and corrosion in presence of plant extract was examined through SEM and water contact angle (WCA) techniques.

3. Results and discussion

3.1. Weight change method

The corrosion parameters measured from weight change method at varying the strength of *VILE* in 1 M HCl solution with 24 h immersion period are listed in Table 1. It was observed that, the specimens immersed in varying amounts of *VILE* solutions, showed decrease in weight loss and reduces corrosion rate to significant extent from 5.8125 mm/year to 0.5201 mm/year and thereby showing highest inhibition efficiency of 91.05% at 150 ppm *VILE* concentration. The concentration of the *VILE* enhanced, there is a progressive improvement on the surface coverage of the MS surface and thereby increasing the % IE of the plant extract. Further hike in *VILE* strength did not cause any appreciable change in the inhibition extent of the inhibitor. The reported higher inhibition

Table 1. Corrosion rate, surface coverage and % IE of MS in 1 M HCl with different strength of *VILE* at 298 ± 1 K.

Conc. of *VILE* (ppm)	V_{corr} (mm/year)	Surface coverage (Θ)	% IE
Blank	5.8125	–	–
25	1.3722	0.7639	76.39
50	1.0496	0.8194	81.94
75	0.9225	0.8412	84.12
125	0.7018	0.8792	87.92
150	0.5201	0.9105	91.05

efficiencies of the *VILE* inhibitor due to the presence of active components which shows higher bonding ability of the inhibitor and further adsorbs on the MS alloy surface and acts as adsorption inhibitor (Guruprasad et al. 2019).

3.2. Electrochemical studies

3.2.1. Electrochemical impedance studies

Typical set of Nyquist plots generated for MS in 1 M HCl solution with and without addition of *VILE* inhibitor at 298 ± 1K was represented in Figure 2. It has been seen that, all the impedance plots shows one depressed semicircle capacitive loop shifted along the real impedance axis at higher frequency and such type of behaviours treated as frequency dispersion. This frequency dispersion indicated that roughness and heterogeneities of the solid surfaces. Hence, to get a more precise fit to the experimental data set a CPE (constant phase element) was used. Figure 3 shows the Randles equivalent circuit consists of parallel combination to resistance polarisation (R_p) and the constant phase element (CPE), both which are in series with the solution resistance (R_s). Figure 4 implies closeness of the obtained experimental data with standard data. The addition of *VILE* markedly increases the impedance of MS in acid solution, which is further increased with increased *VILE* concentration. From the slope of the current– potential curves, R_p values were calculated according to the Equation (7).

$$R_P = \frac{S \times dE}{di} \tag{7}$$

Where S is the electrode surface area, dE represents the difference in applied potential and difference in current indicated by 'di'. Calculated R_p values and corresponding inhibition efficiencies are reported in Table 2. It is found that, R_p values increases with increasing *VILE* strength suggesting the enhancement of adsorption of active components on the MS surface by blocking the active sites from MS surface efficiently and

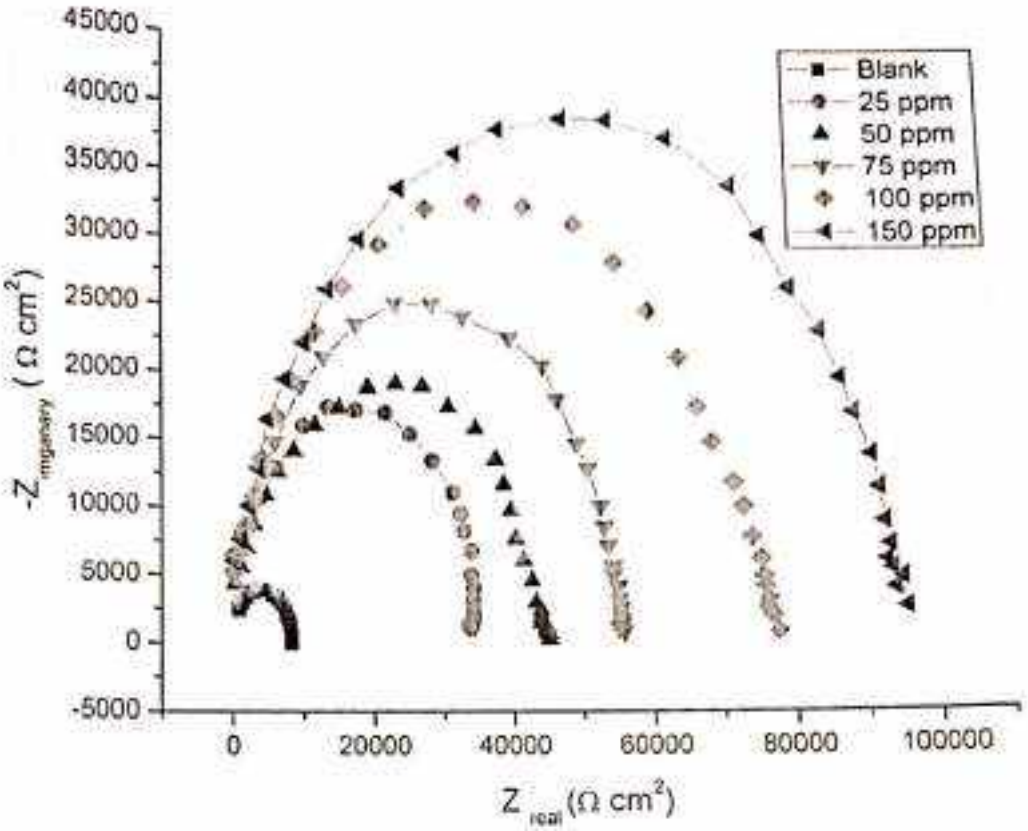

Figure 2. MS nyquist plots in 1 M HCl solution with varying amount of *VILE*. Where (R_p) is the resistance polarisation, (R_s) is the solution resistance and (CPE) is the constant phase element.

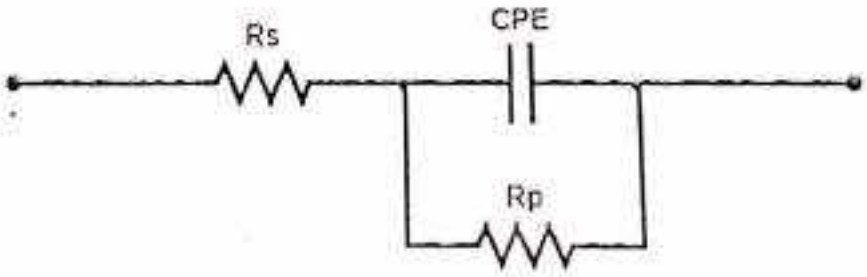

Figure 3. Electrical equivalent standard randals circuit used to fit the EIS data of the interface MS in 1 M HCl solution with varying amount of *VILE*.

thereby retard the extent of MS corrosion (Morad, Kamal, and El-Dean 2006).

The data show that the solution resistance R_S, which measures the total resistance of electrode and material, is practically unchanged in 1 M HCl solution with and without *VILE* extract. On the other hand, the values of resistance polarisation R_p are shown as semicircles with centres on the real part of the Nyquist plot. It was found that the value of resistance polarisation increased significantly after the addition of different amounts of *VILE*.

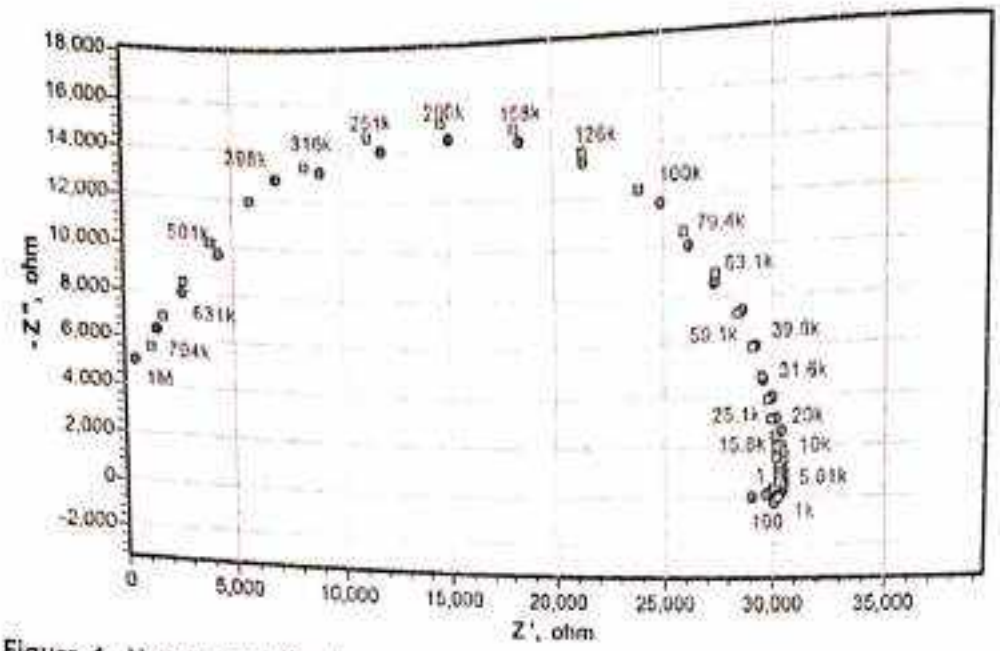

Figure 4. Nyquist plot fitted with standard equivalent circuit.

Table 2. Electrochemical impedance parameters data of MS without and with varying amount of *VILE* at 298 ± 1 K.

VILE (ppm)	R_p (Ω/cm²)	CPE	*N*	% η_{pol}
1M HCl	8269	5.657×10^{-11}	0.998	–
25	32,530	1.951×10^{-11}	0.995	74.58
50	44,580	3.875×10^{-11}	0.989	81.45
75	56,650	2.961×10^{-11}	0.982	85.40
100	76,850	4.565×10^{-11}	0.966	89.24
150	97,800	6.873×10^{-11}	0.927	91.54

3.2.2. *Potentiodynamic polarisation measurement*

The PDP curves of MS in 1 M HCl solution with and without addition of varying amount of *VILE* are shown in Figure 5. The various parameters such as corrosion potential (E_{corr}), corrosion current density (I_{corr}), Cathodic and anodic tafel slopes ($-\beta_c$ and β_a) and corrosion rate in (mm per year) are calculated and the results are depicted in Table 3.

Figure 5 indicated that the addition of 25 ppm −150 ppm concentration of *VILE* to the corrosive electrolyte, *VILE* significantly alters both dissolution of iron anode and cathodic hydrogen evolution reactions through masking reactive sites on the sample surface. Hence corrosion current density and corrosion rate of MS considerably reduces in the presence of the *VILE* than those of the inhibitor-free solution. In this manner, the percentage inhibition efficiencies (η_{pol} %) found to be enhanced with rising inhibitor concentrations. The maximum inhibition efficiency 93.22% was reported at 150 ppm concentration of *VILE* inhibitor (Olasunkanmi, Mashuga, and Ebenso 2018).

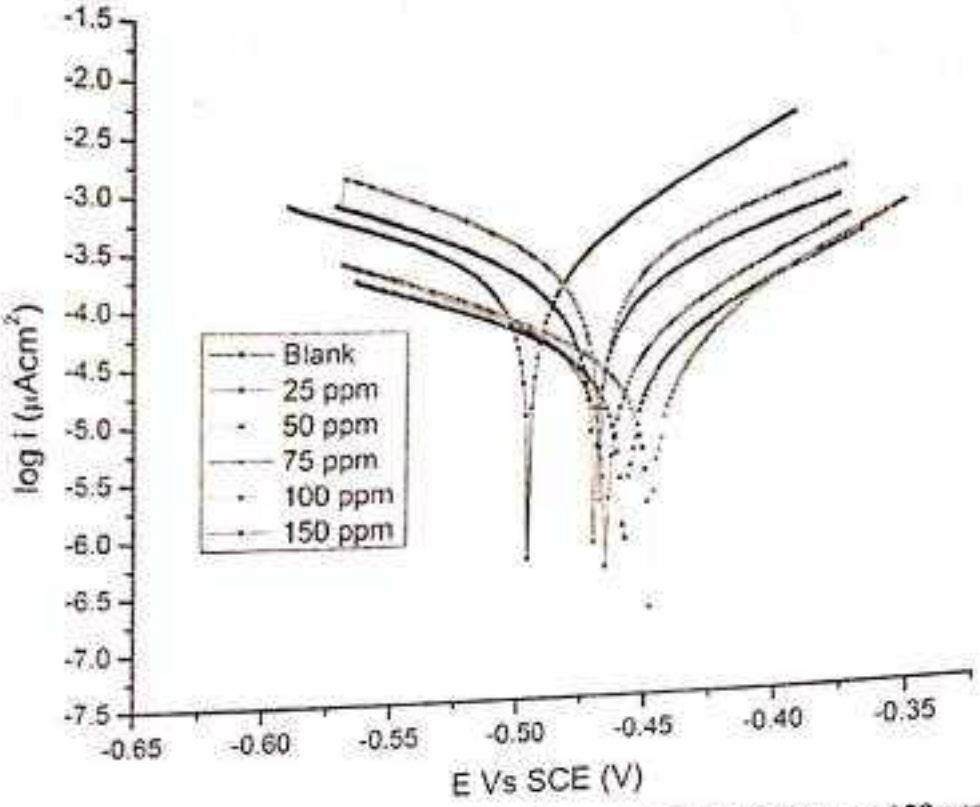

Figure 5. Polarisation curves in 1 M HCl electrolyte containing 0 ppm to 150 ppm of *VILE*.

Table 3. PDP parameters for MS with different concentrations of *VILE* in 1M HCl at 298 ± 1K.

VILE (ppm)	E_{corr} (mV)	I_{corr} (μA /cm^2)	Corrosion rate (mm/year)	$-\beta_c$ (mV/dec)	β_a (mV/dec)	η_p (%)
Blank	−0.4965	202.02	3.385	8.65	12.89	–
25	−0.4658	49.26	0.840	−7.5	11.0	75.61
50	−0.4580	34.97	0.615	−7.19	11.5	82.68
75	−0.4674	24.72	0.441	−8.8	8.78	87.76
100	−0.4965	20.20	0.340	−6.75	13.97	90.00
150	−0.4710	13.69	0.240	−8.8	8.5	93.22

3.3. Effect of temperature

EIS and PDP were applied to investigate the effect of temperature ranges between 298-328 ± 1 K in the presence and absence of optimised VILE inhibitor concentrations. Figures 6 and 7 show the Nyquist plots and polarisation curves of MS with 0 ppm and 150 ppm of *VILE* in 1 M HCl at various temperatures respectively. The electrochemical studies data such as corrosion rate and percentage inhibition efficiencies are located in Tables 4 and 5. The data suggested that, the percentage inhibition efficiencies are found to decrease from 93.22% to 69.56% in case of tafel polarisation studies, whereas 91.66% - 69.33% in case of EIS studies with an increase of temperature. These decreases of efficiencies are attributed

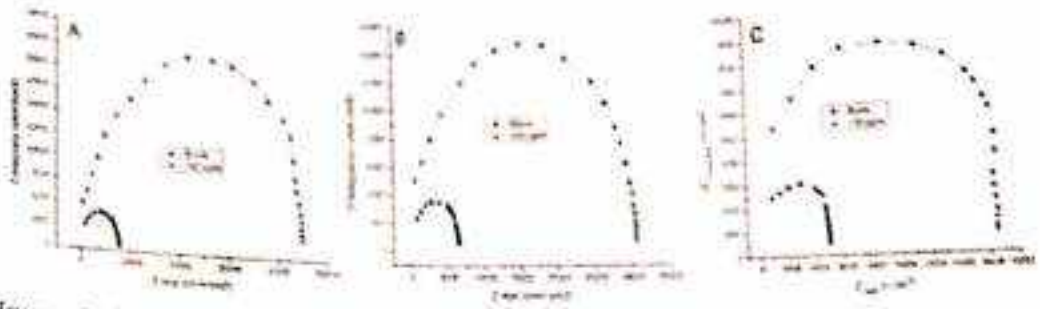

Figure 6. Nyquist graphs of MS with 0 ppm to 150 ppm of *VILE* in 1 M HCl at A) 308 ± 1 K B) 318 ± 1 K C) 328 ± 1 K.

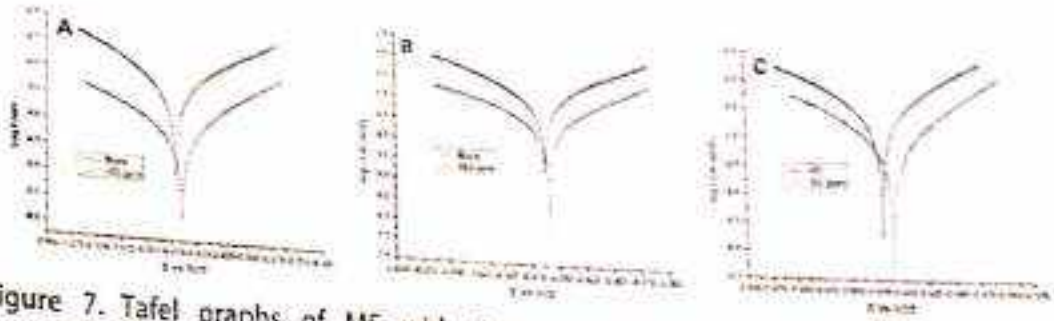

Figure 7. Tafel graphs of MS with 0 ppm to 150 ppm of *VILE* in 1 M HCl: (A) 308 ± 1 K; (B) 318 ± 1 K; (C) 328 ± 1 K.

Table 4. EIS parameters of MS in the presence of 0 ppm and 150 ppm *VILE* in 1 M HCl at 308-328 ± 1 K.

Temperature (K)	*VILE*	R_p (Ω/cm^2)	CPE	N	IE %
298	Blank	8269	5.657×10^{-11}	0.9985	–
	150	97,800	6.873×10^{-11}	0.927	91.66
308	Blank	7800	5.678×10^{-11}	0.9981	–
	150	45,000	6.578×10^{-11}	0.9439	82.66
318	Blank	6400	5.712×10^{-11}	0.9981	–
	150	30,000	2.718×10^{-11}	0.9812	78.66
328	Blank	4600	1.27×10^{-11}	0.9455	–
	150	15,000	2.495×10^{-11}	0.9959	69.33

Table 5. Electrochemical tafel polarisation parameters of MS with 0 ppm to 150 ppm of *VILE* in 1 M HCl at 298-328 ± 1 K.

Temperature (K)	*VILE* (ppm)	$-E_{corr}$ (V)	I_{corr} (μA cm^{-2})	Corrosion rate (mm/year)	β_a (V dec^{-1})	$-\beta_c$ (V dec^{-1})	IE %
298	Blank	−0.4965	202.02	3.385	8.65	12.89	
	150	−0.4710	13.69	0.240	8.8	8.5	93.22
308	Blank	0.4715	427.66	4.0491	10.05	12.88	–
	150	0.4644	69.26	0.71	9.30	11.60	83.80
318	Blank	0.4623	354.24	5.0664	9.51	10.09	–
	150	0.4577	78.20	1.1539	10.8	11.00	77.22
328	Blank	0.4684	257.03	6.9722	8.86	8.33	–
	150	0.4575	78.23	2.1050	11.1	8.92	69.56

that, the adsorbed *VILE* molecules get progressively detached from the MS surface at elevated temperatures. As the temperature of the test solution increased, the transport action of the H^+ ions towards the MS surface increases and subsequent cathodic reduction reaction rate markedly enhanced both in the presence and absence of *VILE*. As a result, the rate of corrosion of MS increased at elevated temperatures.

3.4. Kinetic and thermodynamic activation parameters

The results of electrochemical studies at higher temperatures are considered to evaluate the different activation parameters. Arrhenius Equation (8) and transition state Equation (9) are applied to evaluate the parameters like activation energy (E_a^*), enthalpy of activation (ΔH^*) and entropy of activation (ΔS^*) for the dissolution of MS in 1 M HCl in the presence of 0 ppm and 150 ppm of *VILE*.

$$\text{Log } CR = -\frac{E_a^*}{2.303\ RT} + A \tag{8}$$

$$CR = \frac{RT}{Nh}\exp\left(-\frac{\Delta H*}{RT}\right)\exp\left(\frac{\Delta S*}{R}\right) \tag{9}$$

Where corrosion rate is indicated as *CR*, *A* in Equation (7) represents the Arrhenius pre-exponential factor, *h* refers to Plank's constant, N indicated as Avogadro's number, the molar gas constant indicated as *R*, and T is the absolute temperature. Figure 8A shows the straight lines in the Arrhenius graph of Logarithm of corrosion rate verses $1/T$ with regression coefficient $R^2 = 0.989$ for MS corrosion in 1 M HCl electrolyte with the presence of 25 ppm to 150 ppm of *VILE*. The E_a^* values were calculated by multiplying the molar gas constant with the slope of the straight line in the Arrhenius graph and the values are listed in Table 6. The E_a^* values in

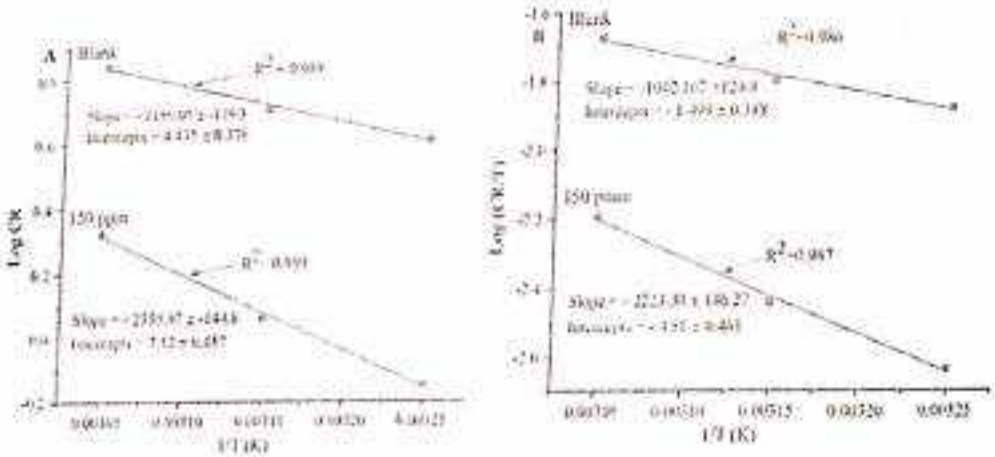

Figure 8. Arrhenius plots: (A) log CR against $1/T$, (B) log (CR/T) against $1/T$ for the adsorption of inhibitors in the MS surface.

Table 6. Activation parameters for MS dissolution in 1 M HCl with 0 ppm and 150 ppm of *VILE*.

Inhibitor	R^2	E_a^* (kJ mol^{-1})	R^2	ΔH^* (kJ mol^{-1})	ΔS^* (J mol^{-1} K^{-1})
1 M HCl	0.989	22.774	0.986	20.125	−179.68
VILE	0.989	45.571	0.987	42.931	−120.18

presence of *VILE* in 1 M HCl solution were found to be higher than those with 1 M HCl alone. This higher E_a^* values in presence of *VILE* contrast to blank solution noticed effective adsorption of *VILE* molecules and creates an energy barrier on the MS surface. It suggested that for dissolution of MS in 1 M HCl medium required more energy to overcome the molecular energy barrier from the MS surface.

Figure 8B represents the transition graph of Log (*CR*/*T*) verses 1/*T*, which gives straight line and regression coefficient $R^2 = 0.987$ with slope = $\frac{\Delta H^*}{2.303\ R}$ and intercepts = $\log \frac{R}{Nh} + \frac{\Delta S^*}{2.303\ R}$ from which ΔH^* and ΔS^* parameters were calculated for MS corrosion in 1 M HCl solution with 25 ppm and 150 ppm of *VILE* respectively. The various activation parameters are tabulated in Table 6, these parameters suggesting that, in presence of *VILE*, a positive sign of ΔH^* increased as compared to 1 M HCl alone indicating that, the process is endothermic in nature which implies dissolution of MS is a slow process might be due to the formation of active energy barrier over the MS surface. Again, ΔS^* values increases with the addition of *VILE*, which suggested that, the rate determining step at the activated complex indicates a favours of dissociation, it means that disordering decrease moving from reactants to the activated complex. Hence physical adsorption is favour at low temperature and follows chemical adsorption at higher temperature (Fouda, Mahmoud, and Abdul Mageed 2016; Jeeva et al. 2015).

3.5. Scanning electron microscopic analysis

Figure 9 provides the surface characteristics of adherent film formed on the MS test samples placed in 1 M HCl with 0 ppm and 150 ppm of *VILE* for 4 hours. Figure 9a is the SEM image taken for a freshly polished MS surface, which is not subjected to corrosion test and appears smooth image. Figure 9b is the SEM image of a corroded MS surface in a corrosive medium alone. The surface seems to be severely damaged and several cavities and deep pits (marked in red circles) are distributed over the entire surface. Further, no accumulation of corrosion products on the surface during corrosion, which is further induces the acid to attach on MS surface. Figure 9c is the SEM image of the corroded MS surface in addition of 150 ppm of *VILE* to the corrosive medium. The surface image reflected that, there is an accumulation of layers of Fe-*VILE* compounds strongly adhered protective layers over the surface (marked in yellow circles), these layers guard the attack of

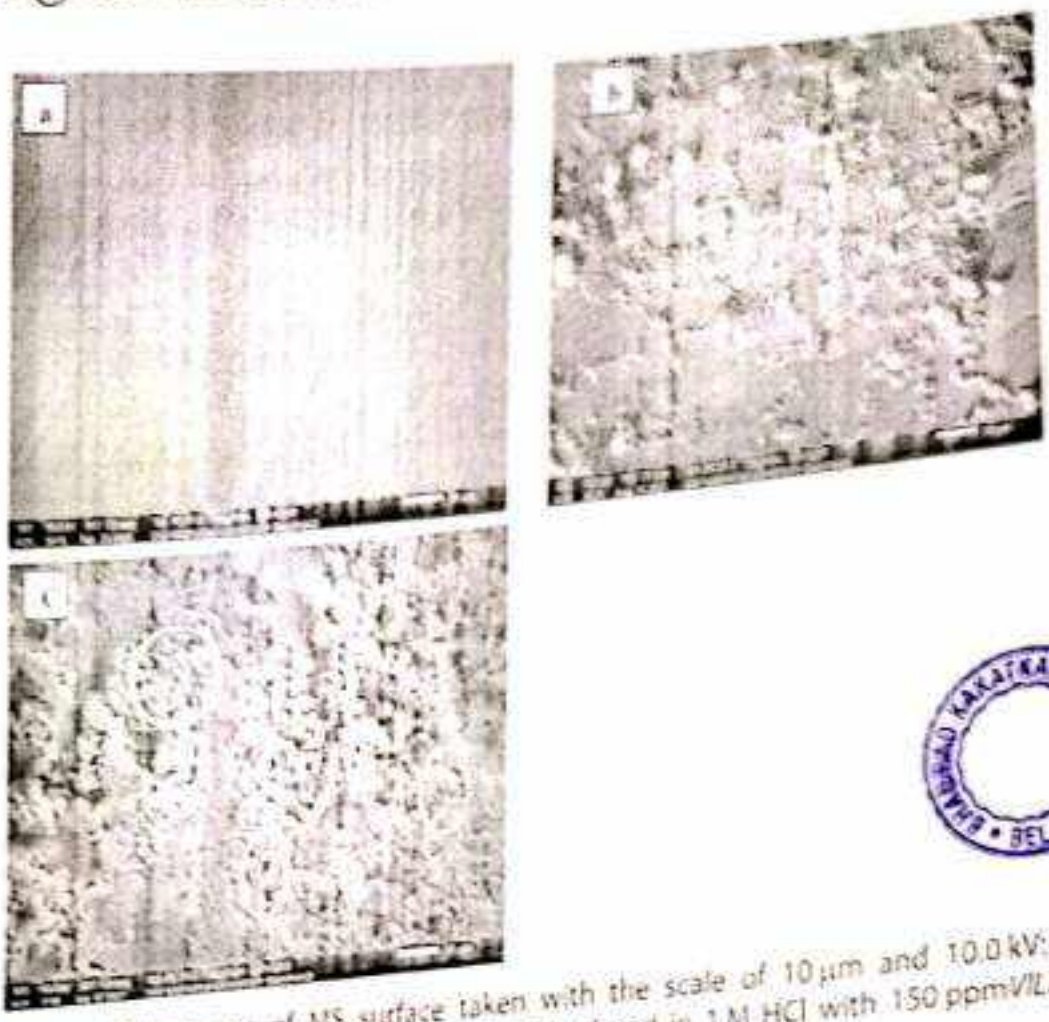

Figure 9. SEM images of MS surface taken with the scale of 10 µm and 10.0 kV: a) polished surface b) 4 h placed in 1 M HCl c) 4 h placed in 1 M HCl with 150 ppm *VILE*.

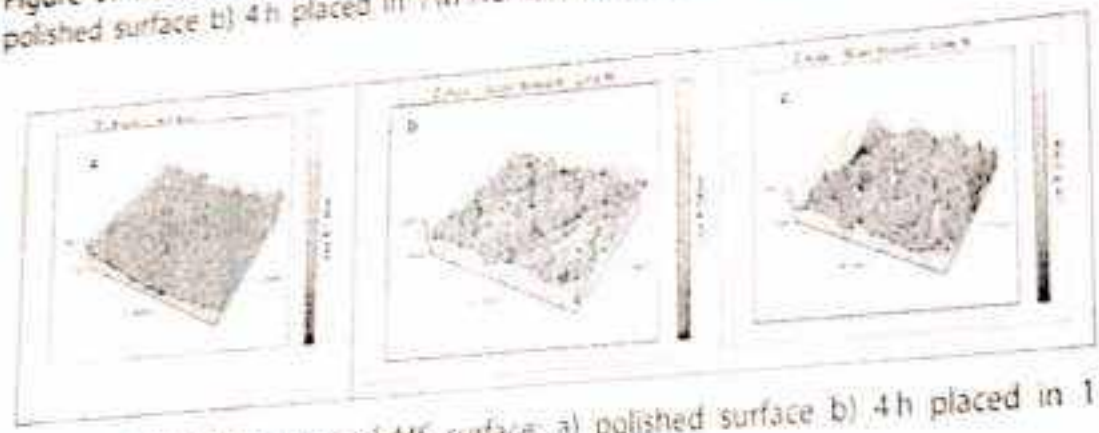

Figure 10. 3D AFM images of MS surface: a) polished surface b) 4 h placed in 1 M HCl c) 4 h placed in 1 M HCl with 150 ppm *VILE*.

acid solution. Further greatly disappear of cavities and deep pits over the surface, it indicate *VILE* components cover the MS surface through adsorption process and protect the surface from the corrosive medium (Bahlakeh, Ramezanzadeh, et al. 2019).

3.6. Atomic force microscope studies [AFM]

Figure 10 shows the 3D AFM micrographs of polished, corroded and protected MS specimen surfaces. The calculated corresponding average

surface roughness (S_a) values are listed in Table 7. Figure 10a is the polished MS surface shows least surface roughness, which was not exposed to corrosion test, the surface appears uniform which is taken as a bench mark for comparison. Figure 10b is the MS surface placed 4h in 1 M HCl exhibits high surface roughness value of 606 nm suggested that the MS surface is drastically affected by the acid solution. Figure 10c is the MS surface placed 4h in 1 M HCl with 150 ppm *VILE* appeared lesser value of surface roughness compare to HCl alone. The decrease in S_a value reflecting that, effective protective layer is formed on the MS surface which protects from the metal dissolution and surface damage (Hossam et al. 2023).

3.7. FT-IR analysis

The FT-IR spectrum of pure *VILE* are shown in Figure 11A. The stretching vibration peak 1626 cm^{-1} corresponds to C=O group and 1460 cm^{-1} peak is related to C-C stretching vibrations in aromatic ring. Broad peak stretching vibrations observed at 3424 cm^{-1} is connected to O-H functional group. Figure 11B shows the FT-IR spectrum of adsorbed protective layer formed

Table 7. AFM results of MS surface roughness (*Ra*) values at 298 ± 1 K.

Specimens	Average roughness (S_a) nm
MS polished	1.46
MS in 1 M HCl	606
MS in 150 ppm	294

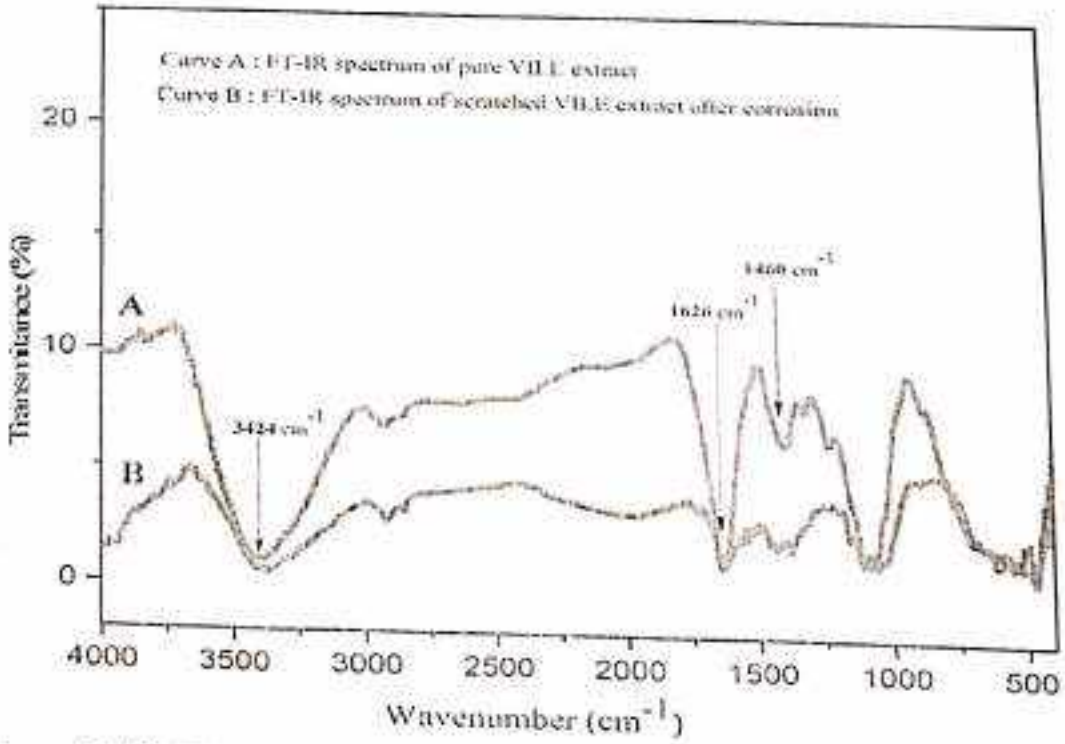

Figure 11. (A) FT-IR spectrum of pure *VILE*; (B) FT-IR spectrum of scratched *VILE* after corrosion of MS surface.

on MS surface treated in 150 ppm of *VILE* in 1 M HCl solution. Several peaks are disappeared and modified compare to pure *VILE* FT-IR spectrum. This change in frequency domains reveals that, oxygen atoms from C=O and O–H group are acts as active centres during the adsorption process and are enable to develop protective layer on the MS surface (Rajappa, Venkatesha, and Praveen 2008).

3.8. Contact angle studies

Figure 12 represents the images obtained of the surface contact angle for MS, without as well as with the presence of 150 ppm of *VILE* in 1 M HCl solution. The measured contact angle values are given in Table 8. The *VILE* contains phytochemicals organic constituents and also includes polar and non-polar segments. After the adsorption of the components of inhibitors on MS surface, the surface becomes hydrophobic due to non-polar segments of *VILE* that can promote the water repellence on MS surface (Figure 12b). In the absence of the *VILE* components, the contact angle is less due to the MS surface exposed with 1 M HCl alone the surface fully occupied by corrosive components which forms hydrogen bond with aggressive HCl ions and hence the water contact angle was less observed and surface becomes more hydrophilic (Figure 12b). Thus in the presence of *VILE*, the adsorption of an active components over the mild

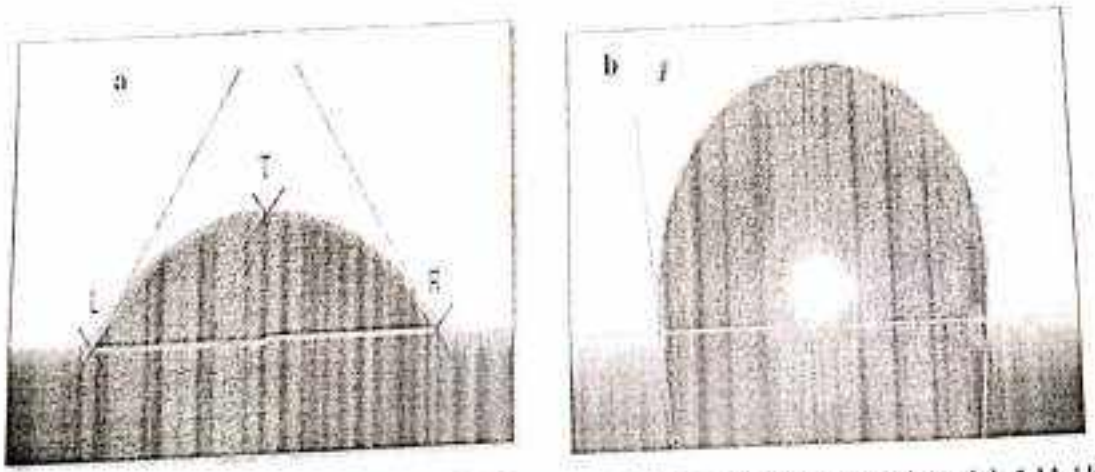

Figure 12. Contact angle images of MS measured after 2 h immersed in (a) 1 M HCl solution (b) 150 ppm VILE in 1 M HCl solution.

Table 8. Variation of contact angle on MS surface in the presence and absence of inhibitor.

	Measured contact angle (deg.)	
Concentration of Inhibitor	Left angle	Right angle
1 M HCl	53.00	53.00
150 ppm	97.69	96.93

steel surface blocks the active sites and enhances the hydrophobic nature of the MS (Minagalavar et al. 2023; Rathod et al. 2022).

4. Conclusions

The present study reveals that *VILE* developed as an efficient eco-friendly and biodegradable inhibitor for MS in 1 M HCl solutions. The percentage inhibition efficiency was extensively evaluated by weight change method, potentiodynamic and electrochemical impedance techniques. According to weight loss measurement, 91.50%η_p is observed for the acid solution containing 150 ppm of *VILE* extract. The effectiveness of the inhibitor improves with increasing concentration, reaching a maximum of 93.22 at 150 ppm extract. The Tafel polarisation studies inferred that *VILE* acted as a mixed-type inhibitor and control the corrosion rate of both cathodic and anodic reactions.

The corrosion inhibition was correlated through adsorption mechanism of *VILE* components on the MS surface, which follows the Langmuir adsorption isotherm model. The FT-IR, SEM, and AFM, techniques revealed that *VILE* protects the MS surface by forming a protective layer over the exposed metal surface, which is consistent with the electrochemical results. The findings of this study demonstrate the significant advantages of adopting natural-based corrosion inhibitors to shield metals and alloys from rust. *VILE* act as a corrosion inhibitor for MS has been demonstrated to have effective corrosion inhibition ability in hydrochloric acid solution.

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Authors' contributions

A. G. K.: Investigation, Methodology, Visualisation, Data curation, Writing-Original draft preparation, S. K. R.: Conception and design of the study, Supervision, Writing- Reviewing and Editing, J. M.: Software, Data curation.

Disclosure statement

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

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Data availability statement

Data will be made available on request.

References

Addoun, Azeddine, Saida Bouyegh, Mohamed Dahmane, Ouassila Ferroukhi, and Mohamed Trari. 2019. "Thermodynamic Investigation on the Adhesion and Corrosion Inhibition Properties of a Non-Steroidal anti-Inflammatory Drug in HCl Electrolyte Applied on Mild Steel Material." *Materials Today Communications* 21 (10072): 100720. https://doi.org/10.1016/j.mtcomm.2019.100720

Ahamad, I., and M. A. Quraishi. 2010. "Mebendazole. New and Efficient Corrosion Inhibitor for Mild Steel in Acid Medium." *Corrosion Science* 52 (2): 651–656. https://doi.org/10.1016/j.corsci.2009.10.012

Ahamad, I., R. Prasad, and M. A. Quraishi. 2010. "Experimental and Quantum Chemical Characterization of the Adsorption of Some Schiff Base Compounds of Phthaloylthiocarbohydrazide on the MS in Acid Solutions." *Materials Chemistry and Physics* 124 (2–3): 1155–1165. https://doi.org/10.1016/j.matchemphys.2010.08.051

Abuelela, Ahmed M., Jasdeep Kaur, Akhil Saxena, Mahmoud A. Bedair, K. V. Dakeshwar, and Elyor Berdimurodov. 2023. "Electrochemical and DFT Studies of *Terminalia bellerica* Fruit Extract as an Eco-Friendly Inhibitor for the Corrosion of Steel." *Scientific Reports* 13 (1): 19367. https://doi.org/10.1038/s41598-023-45283-0

Aljourani, J., K. Raeissi, and M. A. Golozar. 2009. "Benzimidazole and Its Derivatives as Corrosion Inhibitors for MS in 1M HCl Solution." *Corrosion Science* 51 (8): 1836–1843. https://doi.org/10.1016/j.corsci.2009.05.011

Singh, Ambrish, K. R. Ansari, Jiyaul Haque, Parul Dohare, Hassane Lgaz, Rachid Salghi, and M. A. Quraishi. 2018. "Effect of Electron Donating Functional Groups on Corrosion Inhibition of Mild Steel in Hydrochloric Acid: Experimental and Quantum Chemical Study." *Journal of the Taiwan Institute of Chemical Engineers* 82: 233–251. https://doi.org/10.1016/j.jtice.2017.09.021

Hossam, Amira, H. Abdel-Rahman, Hagar Mohamed, R. A. Mohamed, R. Nadjet, and A. A. B. Sherif. 2023. "Anticorrosive Performance of Newly Synthesized Dipyridine Based Ionic Liquids by Experimental and Theoretical Approaches." *Scientifc Reports* 13: 19197. https://doi.org/10.1038/s41598-023-45822-9

Asadi, N., M. Ramezanzadeh, G. Bahlakeh, and B. Ramezanzadeh. 2019. "Utilizing Lemon Balm Extract as an Effective Green Corrosion Inhibitor for Mild Steel in 1M HCl Solution: A Detailed Experimental, Molecular Dynamics, Monte Carlo and Quantum Mechanics Study." *Journal of the Taiwan Institute of Chemical Engineers* 95: 252–272. https://doi.org/10.1016/j.jtice.2018.07.011

Bahlakeh, G., A. Dehghani, B. Ramezanzadeh, and M. Ramezanzadeh. 2019. "Highly Effective Mild Steel Corrosion Inhibition in 1 M HCl Solution by Novel Green Aqueous Mustard Seed Extract: Experimental, Electronic-Scale

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A STUDY ON EFFECTIVENESS OF MUDRA YOJANA- A DESCRIPTIVE ANALYSIS

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Abstract

The present paper explains about Pradhan Mantri Mudra Yojana (PMMY). It is an important financial tool for empowering micro-entrepreneurs across India and promoting equitable economic growth. A detailed assessment covering the fiscal years 2015-16 to 2022-23 examines its performance. The plan has seen a large increase in granted loans, with 62.31 million sanctioned in 2022-23, suggesting its growing importance in promoting entrepreneurial activity. Disbursed amounts increased from INR 1,32,954.73 crores to INR 4,50,423.66 crores, whereas sanctioned amounts increased from INR 1,37,449.27 crores to INR 4,56,537.98 crores within the same time period. Geographical study reveals concentrations of Mudra Yojana in specific places, encouraging deeper investigation into the underlying determinants. Sectoral study shows varying impacts on different industries, with dynamic patterns emerging. Qualitative assessments highlight success stories such as revenue growth, job possibilities, and business expansion, while also emphasizing implementation issues and departures from objectives. Finally, this study provides useful insights on PMMY's success, which will benefit discussions about financial inclusion and microfinance. Its findings serve as a foundation for informed policy decisions and strategic changes, ultimately promoting equitable economic growth and the continuous empowerment of micro entrepreneurs in India.

Key words: Mudra Yojana, Micro-Entrepreneurs, Loan Disbursements, Economic Growth, Business Expansion

Introduction

A business's ability to survive depends heavily on its finances. With their exorbitant interest rates and intolerable terms and conditions, the majority of small businesses and entrepreneurs rely on the unorganised sector for loans and other credit facilities. Small company owners and entrepreneurs incur debt as a result of this. Most of these industries lack access to outside funding sources. The government of India launched the Mudra bank scheme under the Pradhan Mantri Mudra Yojana to provide financial assistance to MSMEs that employ a large number of people, targeting young, educated, or skilled workers, as well as entrepreneurs, including women entrepreneurs, after realising the value of self-employment for individuals and small business units. Our financial structure has always been based on the fundamental principle of sensible and all-encompassing expansion. ***RBI Governor Shri Y.V. Reddy*** originally presented the idea of financial inclusion in 2005. Financial inclusion is the process of guaranteeing that all segments of society, including low-income and marginalised groups, have inexpensive access to suitable financial services. The Pradhan Mantri Mudra Yojana (PMMY), Pradhan Mantri Jeevan Jyoti Bhima Yojana (PMJJBY), Pradhan Mantri Jan Dhan Yojana (PMJDY), Atal Pension Yojana (APY), Pradhan Mantri Suraksha Bhima Yojana (PMSBY), and other financial inclusion initiatives have been introduced by the Government of India (GOI) for small business owners, marginalised communities, low-income groups, and microenterprises.

On 8th April 2015, the ***Honourable Prime Minister Narendra Modi*** opened applications for PMMY and MUDRA Bank. Another name for it is the Mudra Yojana Scheme. This programme is accessible at all bank locations nationwide. In India, one of the most cherished tactics is financial inclusion. Covering all demographic groups under monetary management is the main goal of monetary inclusion. Some of the most important initiatives to "Fund the unfunded" micro-enterprise divisions have been presented by the Government of India (GOI). The Pradhan Mantri Mudra Yojana (PMMY) is one of

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Research Article

Biogenic Derived Ag and Zno Nanoparticles Using *Couroupita Guianensis* Aubl. Fruit Extract and its Antibacterial Potential

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- Silver
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- Couroupita Guianensis
- Characterization
- Antibacterial Activity

Abstract

In this study, we report the synthesis of Ag and ZnO Nanoparticles (NPs) produced from the fruit extract of *C. guianensis*. Silver (Ag) and Zinc Oxide (ZnO) have extensive applications in various areas of science and technology. These NPs were characterized using UV-Visible (UV-Vis) spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, X-Ray Diffraction (XRD) spectrum and Atomic Force Microscopy (AFM). The UV-Vis absorption spectra generated strong characteristic peaks of AgNPs (370nm) and ZnO-NPs (374nm). FTIR spectrum analysis was conducted to validate the use of phytochemicals in the reduction, capping and stabilization of Ag and ZnO-NPs. XRD spectra were examined to ensure phase purity, crystalline nature and size of the AgNPs (42nm) and ZnO-NPs (26nm) respectively. Finally, the ultrastructural and nanomechanical properties of the NPs were studied via AFM analysis. Besides, this study determines antibacterial efficacy of Ag and ZnO-NPs fabricated from *C. guianensis* fruit extract against *B. subtilis* and *E. coli* bacterial strains. The *B. subtilis* had highest inhibition zone activity than *E. coli* and it was found to be AgNPs (12.02 ± 0.32 mm) and ZnO-NPs (11.18 ± 0.34 mm) respectively. This study demonstrated a significant potential for the use of these particles in biomedical applications due to their remarkable antibacterial activity.

INTRODUCTION

Couroupita guianensis Aubl. belonging to the family Lecythidaceae, is well known for its therapeutic and ornamental values. It is a fast growing deciduous tree, widely cultivated in the tropical and subtropical regions of the world [1]. Almost all parts of this species namely roots, stems, leaves, flowers, fruits and seeds have been reported to possess various medicinal properties, it is used to cure cold, stomach ache, malaria, hypertension, tumours, pain, and inflammatory processes [2]. These properties of the species have been attributed to the presence of phenolics, flavonoids, terpenoids, tannins, alkaloids, couroupitine, indirubin, and isatin [3]. Plant extracts have captivated the attention of researchers because of their simplicity, low cost, and quick reaction time, as well as their capacity to reduce metal ions to metal nanoparticles [4]. Additionally, plant extracts comprises a wide variety of active compounds which assist in the reducing and stabilizing process and also act as templates for the synthesis of metallic nanoparticles [5]. The biosynthesizing precursors are not only safe to handle but the process easily renders itself to scaling up without the use of energy, high temperatures or toxic compounds thus providing an environmentally friendly alternate to physical and chemical methods [6].

The biosynthesized nanoparticles are idyllic candidates for medical applications, one of the most imperative property of such nanoparticles is antimicrobial activity. The adaptability of nanoparticles in rendering themselves to several applications is presently being discovered. Topmost in the list are silver and zinc oxide nanoparticles which find applications in medicine, sensors, renewable energies, environmental remediation, cosmetology, clothing, bio-therapeutic devices, surface disinfection and antimicrobial applications [6]. This could be attributed to their nanoscale size and high surface area to volume ratio which gives them enhanced biological, physical, and chemical properties as compared to their large scale counter parts [7]. Many green silver and zinc oxide nanoparticles have been reported for antibacterial activity [8-11]. Also supportive studies on plant derived silver and zinc oxide nanoparticles conclude that biogenic nanomaterials are biocompatible and an effective therapeutic

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agent against bacterial, fungal infections, and cancer treatment as well. The appearance of nanoparticles as new antimicrobial agents has boosted up the research for tackling these superbugs. As nanoparticles target the bacterial cell through multiple pathways, it becomes difficult for bacteria to escape from these magical agents, thus exhibiting antibacterial potential [12]. The fruits of cannonball tree are apparently rich in alkaloid Couroupitine A (tryptanthrin), Couroupitine B (indirubin), malic acid, isocitric acid, stigmasterol, campesterol, hopane, rutin, quercetin, kaempherol, farmaricetin, luteolin and ursolic acid [3]. Thus, in the current study silver and zinc oxide nanoparticles were synthesized using fruit extracts of *Couroupita guianensis* as as precursors and assessed for its antimicrobial activity.

MATERIALS AND METHODS

Chemicals

Silver Nitrate ($AgNO_3$), zinc nitrate ($ZnNO_3$) and other analytical reagents is purchased from Hi-media laboratories Pvt. Ltd. Mumbai, India. Nutrient agar media was also procured from Sigma Aldrich.

Collection and Extraction Process

The fruit of *Couroupita guianensis* (Figure 1) was collected from the Botanical garden of Karnatak University, Campus, Dharwad, Karnataka, India. The collected diseased free fruits were washed with running tap-water to remove unwanted dirt's on fruits. The fruit material chopped and converted into fine powder through electric grinder. The powder (20gm) was added to 80mL of deionized water and heated for 30 minutes at 60°C. The fruit extract (aqueous) was filtered through whatman No.1 filter paper and preserved in refrigerator at 4°C for further experimental studies.

Synthesis of Ag and ZnO-NPs

Silver (Ag) and Zinc Oxide (ZnO) nanoparticles were synthesized in accordance with the previously established procedure [13]. For about 90ml of (1mM) silver nitrate is added to 250ml of Erlenmeyer flask containing 10ml of aqueous fruit extract. The reaction mixture becomes yellowish and later converted into dark brown color within 15 minutes indicating that the formation of silver nanoparticles (Figure 1b). To synthesize Zinc oxide nanoparticles, 85mL of (1mM) zinc nitrate is mixed with 15mL of fruit extract resulting the solution of reaction mixture was changed to light yellow to light brown in color which indicates the formation of ZnO nanoparticles by reduction of zinc ions (Figure 1).

Characterization of Ag and ZnO-NPs

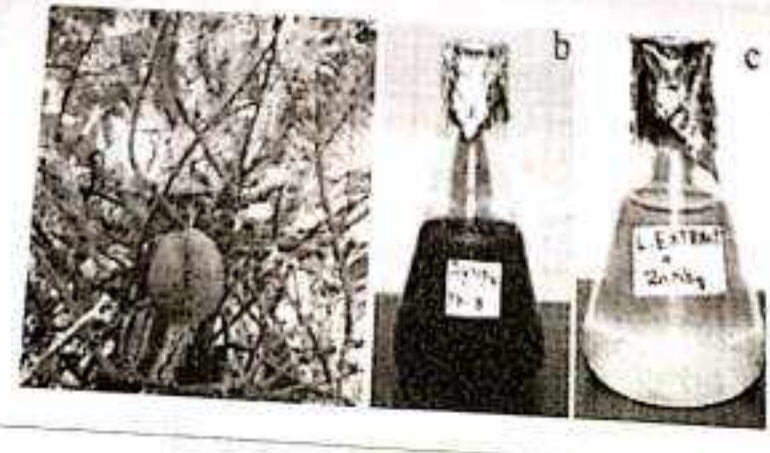
The bioreduction and formation of Ag-ZnO nanoparticles were monitored visually by observing the color change. The aqueous extract of nanoparticles was determined absorbance spectrum by UV-Visible spectroscopy (Hitachi, U-3310) with 0.1nm resolution in the 200 to 800nm scale. The colloidal solutions were centrifuged (Remi R-8C) at 10,000 revolutions per minute for 10 minutes; the suspension was re-dispersed two to three times with distilled water and then left to dry in an oven until a fine granular powder was achieved. The fine powder of Ag-ZnO nanoparticles were subjected to FTIR (Nicolet, 5700) analysis wavelength ranges between 400 to 4000cm-1, to determine involvement of biomolecules for reduction, capping and stabilization of nanoparticles. The crystalline structure and phase purity of nanoparticles elucidate by X-ray diffractometer (RigaKu Smartlab SE) in the 2θ range between 30 to 80°C. Morphological structure and size of the nanoparticles were determined by AFM analysis (Nanosurf Easyscan 2).

Preparation of Bacterial Strains

Gram-positive Bacillus subtilis MTCC 736 (*B. subtilis*) and Gram-negative Escherichia coli MTCC 723, 1554 (*E. coli*) were obtained from the CSIR Laboratory, New Delhi and used as test organisms. Muller-Hinton nutrient broth media was then prepared to facilitate the growth of these bacterial strains. The bacteria were cultured and then grown at 37°C for 18 hours.

Preparation of Ag and ZnO Nanoparticles

The crystalline powder of Ag and ZnO nanoparticles (0.01gm) were dissolved in 10ml of DMSO (Dimethyl Sulfoxide) solution and vortexed. The nanoparticles solution is kept at 4°C for 24 hrs until further analysis.



igure 1 a) Habit of *C. guianensis*, b) AgNPs c) ZnO-NPss.

In-vitro Susceptibility Test

For *in-vitro* antibacterial testing, Ag and ZnO nanoparticles were utilized via a disc diffusion method against both Gram positive and Gram negative bacteria. The Muller-Hinton agar media was first prepared and poured into culture plates, before the bacterial strains were spread across the surfaces evenly using a cotton swab. Susceptibility testing was then conducted with 6mm sterile discs being used in the process. The discs were loaded with 5µL of *C. guianensis* fruit extract (used as a blank) and solution containing Ag-ZnO nanoparticles mediated fruit extract, respectively. The discs were then placed on culture plates and incubated for 24 hours at 37°C. After the incubation period, the zones of inhibition were observed and measured in millimeters (mm).

Statistical Analysis

The data were expressed in One-way ANOVAs using IBM statistical software SPSS version 20. The triplicate data were analyzed by Duncan's multiple range tests and $p < 0.05$ value was considered significant.

RESULTS AND DISCUSSION

The synthesis of AgNP and ZnNP using fruit extract of *C. guianensis* was confirmed by the colour change of the reaction mixture from colorless to dark brown which can be visually detected. This colour change inferred the formation of nanoparticles, due to the excitation of surface plasmon resonance, which was further confirmed by recording the UV-visible absorption spectrum. The maximum absorbance peak was observed at 370 and 374 for silver oxide and zinc oxide nanoparticles respectively (Figure 2). The SPR pattern is dependent on the characteristics of the specific metal particles, their size and shape, as well as the dielectric properties of the medium used for the synthesis and the inter nanoparticle coupling interactions [14]. The obtained results are in consistent with the previous verdicts where silver oxide and zinc oxide nanoparticles synthesized using *Persicaria hydropiper* and *Deverra tortuosa* displayed UV-vis absorbance maximum at this wavelength [15,16].

FTIR spectrum is a potent analytical tool used to identify biomolecules and detect functional groups involved in the synthesis of silver nanoparticles (Figure 3). The spectrum showed different absorptions peaks at 3411.23, 2921.35, 2850.64, 1627.46, 1462.29, 1384.34, and 753.23 cm-1. The intense band 3411.23cm^{-1} is associated to stretching of (OH) hydroxyl group and vibration of phenol and alcoholic group [17]. The peak 2921.35 and 2850.64cm^{-1} corresponds to the (C-H) stretching of aromatic compounds [18]. The band at 1627.46cm^{-1} was assigned to stretching of carboxyl (C-O) group. The small peak 1462.29cm^{-1} was assigned to C-O- stretching vibration mode of phytochemicals like water soluble components of phenolic. The band 1384.34cm^{-1} was corresponds to C=C stretching of aromatic amines [19]. The weaker band 1073.44cm^{-1} arose due to the C-N stretching vibrations of amines. The band 753.23 is assigned to the bending vibration in the S-H moiety bonded to the CH_2 group. These well-known phytochemical groups like proteins, amino acids, carboxyl group, aromatic amines, and phenolics can bind and stabilize the AgNPs.

An FTIR spectroscopy analysis was conducted to identify the functional groups associated with the formation of ZnO nanoparticles (Figure 3). The obtained spectrum peak 3416.50cm^{-1} could be due to the OH stretching or protein (N-H) amide A [20]. The intense band 2924.24cm-1 corresponds to the C-H stretching of alkyl groups [21]. The weak band 2853.63cm^{-1} indicates the presence of H-C=O:C-H stretching of aldehydes. The observed peaks 1745.42cm^{-1} were assigned to stretching of esters. The intense peak 1597.30cm^{-1} was attributed to the N-H bending of amides. The spectrum bands occurs in between 1300 to 1600cm^{-1} were corresponds to carboxyl groups C=O, C-N and C-H [22]. The absorption peak 1041.70cm^{-1} may be due to the presence of C-O-C asymmetric stretching of ester group. The peaks appear in the range between 600 to 400cm^{-1} may be assigned to the stretching

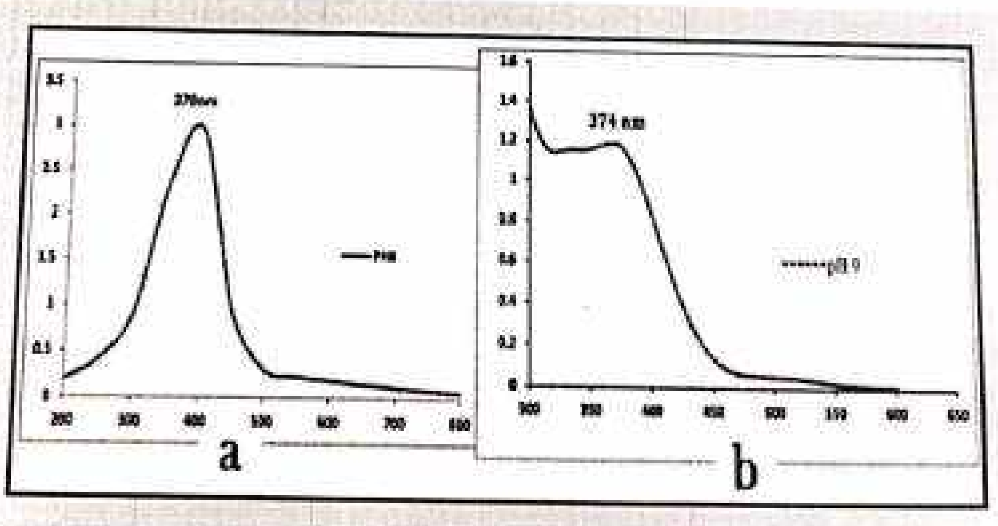


Figure 2 UV-vis absorption Spectroscopy analysis a) AgNPs b) ZnO-NPs synthesized from fruit extract of *Couroupita guianensis*.

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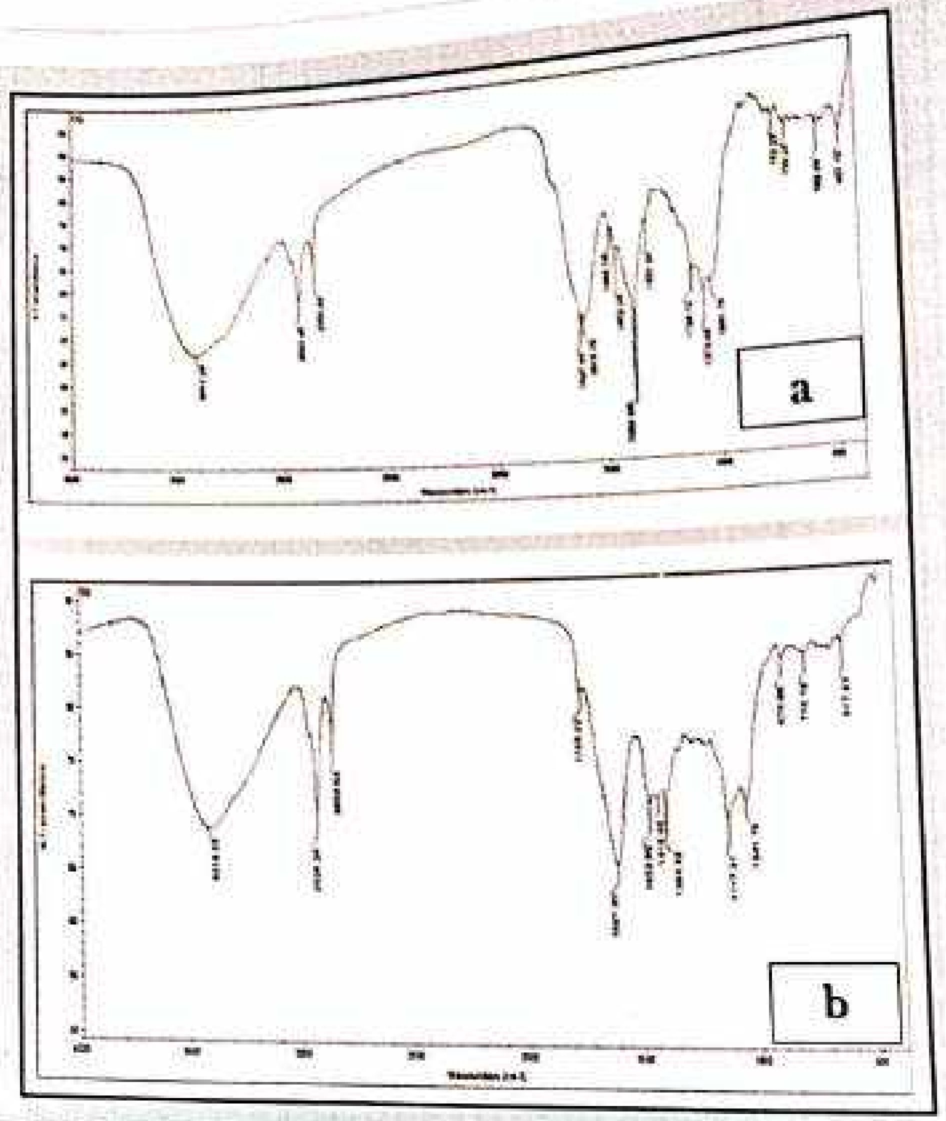

Figure 3 FTIR spectrum analysis a) AgNPs b) Zinc oxide synthesized using fruit extracts of *Couroupita guianensis*.

Zn-O bands [23]. The evidence suggests that the formation of ZnO nanoparticles is a result of the interaction between phenolic compounds.

The purity and crystalline structure of the synthesized AgNPs was confirmed by X-ray crystallography analysis (Figure 4). The XRD pattern of AgNPs synthesized from fruit extract of *C. guianensis* shows different bragg's peaks at 2θ angle such as 37.74 o, 44.90 o, 64.32 o, and 77.31 o which indexed lattice planes (111), (200), (220) and (311) respectively. These assigned high peaks in XRD analysis indicated active silver composition with the indexing [24]. The resultant data matched with the data base JCPDS, file No: 04-0783. The calculated FWHM intense peak (111) showed average size of the AgNPs which was calculated by using Debye Sherrer's equation and it was found to be 42nm. Our result is strongly supported with the result of [24] synthesized AgNPs by leaf extract *Allophylus serratus*.

XRD spectrum analysis of ZnO nanoparticles was determined using fruit mediated extract of *C. guianensis*. The XRD pattern shows different diffraction peaks at 32.14°, 34.98°, 46.61°, 65.10° attributes to (111), (200), (220) and (311) miller indices of ZnO nanoparticles respectively (Figure 4). The small and narrow peak of XRD peaks represents growth of crystal nuclei and nucleation. The observed crystalline structure of ZnO nanoparticles matched with JCPDS file No. 36-1451. The average size of ZnO nanoparticles was estimated to be 26nm, computed from the Debye Scherrer equation and the Full Width Half Maximum (FWHM) highest intense peak. Recent reports have shown similar results in biogenic ZnO nanoparticles synthesized from *Elaeagnus angustifolia* L. leaf extract [25].

Atomic Force Microscopy (AFM) determines the size, shape and length of the AgNPs. AFM image showed size of the AgNPs was found in the range between 20 to 50nm (Figure 5). The three dimensional image of the AgNPs represents height of

nanoparticles is 11.2nm and 100nm width. These particles are poydispersed and spherical in shape. Similar size and shape of the AgNPs was reported by [26] using *Trichosanthes tricuspidata* plant extract. The obtained ZnO-NPs from fruit extract of *C. guinoncis* were subjected to AFM analysis. It is technique used to determine size, and shape of nanoparticles. (Figure 7) represents the particle size which was found to be 30 to 75nm. The 3D image (Figure 5) represents length (15.3nm) and width 100nm. These nanoparticles are monodispersed and spherical in shape.

As shown in (Figure 6,7), the antibacterial activity of Ag and ZnO-NPs produced from fruit extract of *C. guinoncis* evaluated against Gram positive (*Bacillus subtilis*) and Gram negative bacteria (*Escherichia coli*). The well diffusion method can be used to determine the size (in millimeters) of the inhibition zones for bacterial colonies. The suspension of Ag and ZnO-NPs were treated separately with different concentrations viz. 25, 50, 100µg/ml and fruit extract. $AgNO_3$ as negative control. The diameter of the inhibition zone for *Bacillus subtilis* and

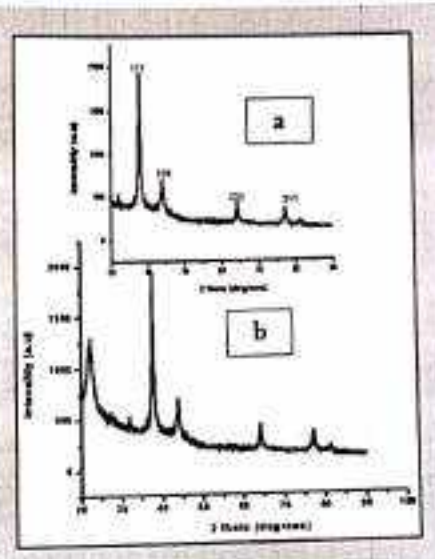

Figure 4 XRD spectrum analysis a) AgNPs b) ZnO nanoparticles synthesized by fruit extract C. guinoncis

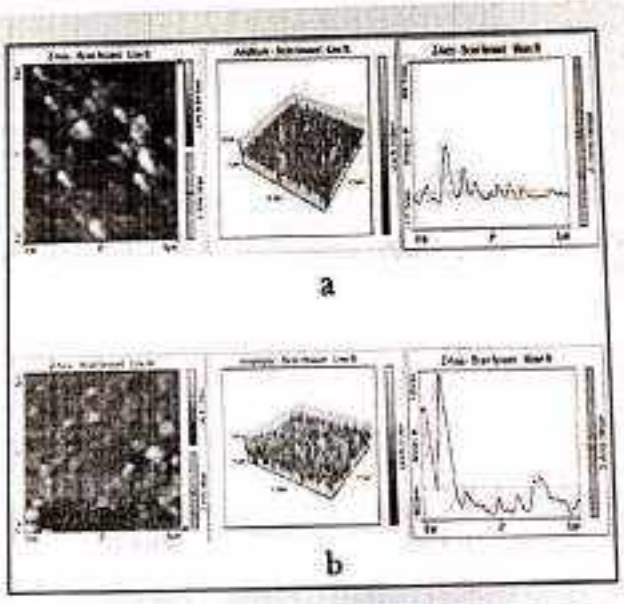

Figure 5 AgNPs synthesized by aqueous fruit extract of *C. guinoncis* a) Two-dimensional, b) Three- dimensional, c) Particle size distribution of silver nanoparticles.

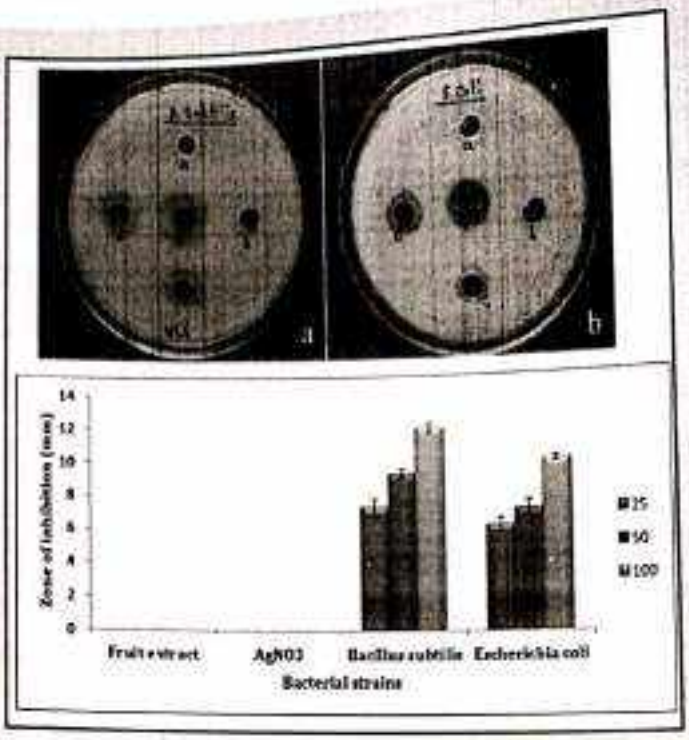

Figure 6 Well diffusion method on different concentrations of AgNPs against *B. subtilis* and *E. coli* strains a) a. Fruit extract (negative control), b. AgNO3 control), c. 25µg/ml, d. 50µg/ml e. 100µg/ml respectively. Stastically the results were found to be $p < 0.05$.

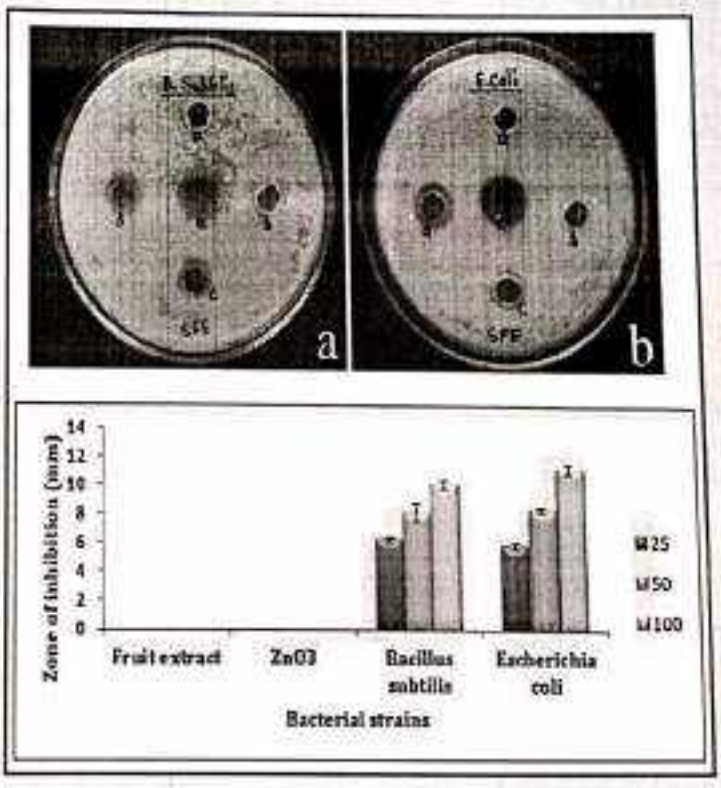

Figure 7 Well diffusion method on different concentrations of ZnO-Nps against *B. subtilis* and *E. coli* strains a) a. Fruit extract (negative control), b. Zn control), c. 25µg/ml, d. 50µg/ml e. 100µg/ml respectively. Stastically the results were found to be $p < 0.05$.

Escherichia coli were respectively measured at 7.3 ± 0.5, 9.31 ± 0.3, 12.02 ± 0.32mm and 6.2 ± 0.4, 7.16 ± 0.48, 10.06 ± 0.16mm while the corresponding values for ZnO-NPs were 6.21 ± 0.17, 8.15 ± 0.6, 10.08 ± 0.31mm and 5.8 ± 0.25, 8.3 ± 0.18, 11.18 ± 0.34mm respectively; showing that an increasing concentration of silver and ZnO-NPs produced a greater inhibition zone in Bacillus subtilis and Escherichia coli respectively. The results of the study revealed that AgNPs demonstrated the strongest zone of inhibition activity when compared to ZnO-NPs. Similar results was reported by [27] using green synthesized Ag and ZnO nanocomposite produced from leaf extract of *Rumex Crispus*.

Previous studies have revealed that colloidal solutions of AgNPs are highly effective against S. aureus compared to E. coli [28]. Furthermore, metallic nanoparticles have shown promising results in combating antibacterial agents. The mechanism behind the antibacterial efficacy of Ag and ZnO-NPs is thought to be mainly due to interacting with the surface membrane of bacteria, ultimately leading to cytoplasmic leakage and rupture [29,30]. The Ag and Zn ions have been shown to initiate the generations of ROS (Reactive Oxygen Species), disrupt ATP synthesis, denature protein in the cells, destabilize ribosome's, affect mitochondrial function, imbalance metabolic activity and damage bacterial DNA, leading to cell death [31-33]. It has also been reported that when the bacterial surface membrane comes in contact with Ag and ZnO-NPs, the bacterial cell wall changes its shape and becomes inactive, leading to bacterial cellular dysfunction and eventually cell death or necrosis [34].

CONCLUSION

The biosynthesis of Ag and ZnO-NPs from the fruit extract of *Couroupita guianensis* is a green approach that has numerous benefits, including its simplicity, efficiency, affordability, economic sustainability and ecological friendliness. The optical, ultrastructural, and morphological properties of Ag and ZnO nanoparticles were characterized. The antibacterial efficacy of both Ag and ZnO nanoparticles was evaluated against Gram positive (*B. subtilis*) and Gram negative (*E. coli*) bacterial strains and was found to be dose dependent. This study demonstrated a significant potential for the use of these particles in biomedical applications due to their remarkable antibacterial activity.

REFERENCES

1. Sumathi S, Anuradha R. Couroupita guianensis Aubl: An updated review of its phytochemistry and pharmacology. Asian Pharmacy Pharmacol. 2017; 3(1): 1-8.
2. Kumar CS, Naresh G, Sudheer V, Veldi N, Anurag AE. A Short Review on Therapeutic Uses Of Couroupita Guianensis Aubl. Int. Res. J Pharm Appl Sci. 2011; 1: 105-108.
3. Anna Sheba L, Anuradha V. An updated review on Couroupita guianensis Aubl: a sacred plant of India with myriad medicinal properties. J Herbmed Pharmacol. 2020; 9(1): 1-11.
4. Ishak NM, Kamarudin S, Timmiati S. Green synthesis of metal and metal oxide nanoparticles via plant extracts: An overview. Mater Res Express. 2019; 6(11): 112004.
5. Kuppusamy P, Yusoff MM, Maniam GP, Govindan N. Biosynthesis of metallic nanoparticles using plant derivatives and their new avenues in pharmacological applications - An updated report. Saudi Pharm J. 2016; 24(4): 473-484. doi: 10.1016/j.jsps.2014.11.013. Epub 2014 Dec 8. PMID: 27330378; PMCID: PMC4908064.
6. Kyomuhimbo HD, Mushira IN, Mwanza FB, Derese S, Feleni U, Iwuoha EI. Silver–zinc oxide nanocomposite antiseptic from the extract of Rubus apetalus. SN Appl. Sci. 2019; 1: 681.
7. Khan I, Saeed K, Khan I. Nanoparticles: Properties, applications and toxicities. Arab J. Chem. 2019; 12(7): 908-931.
8. Salem W, Leitner DR, Zingl FG, Schratter G, Prassl R, Goessler W, et al. Antibacterial activity of silver and zinc nanoparticles against Vibrio cholerae and enterotoxic Escherichia coli. Int J Med Microbiol. 2015; 305(1): 85-95. doi: 10.1016/j.ijmm.2014.11.005. Epub 2014 Nov 11. PMID: 25466205; PMCID: PMC4300426.
9. Ahmed S, Ahmad M, Swami BL, Ikram S. A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise. J Adv Res. 2016; 7(1): 17-28. doi: 10.1016/j.jare.2015.02.007. Epub 2015 Mar 9. PMID: 26843966; PMCID: PMC4703479.
10. Gupta M, Tomar RS, Kaushik S, Mishra RK, Sharma D. Effective Antimicrobial Activity of Green ZnO Nano Particles of Catharanthus roseus. Front Microbiol. 2018; 9: 2030. doi: 10.3389/fmicb.2018.02030. PMID: 30233518; PMCID: PMC6129596.
11. Nabi I, Zahra K, Iftikar D, Akbar A, Atefeh Z, Narges C. Investigating in-vitro antimicrobial activity, biosynthesis, and characterization of silver nanoparticles, zinc oxide nanoparticles, and silver-zinc oxide nanocomposites using Pistacia Atlantica Resin. Materials Today Commun. 2021; 27: 102457.
12. Irfan M, Munir H, Ismail H. Moringa oleifera gum based silver and zinc oxide nanoparticles: green synthesis, characterization and their antibacterial potential against MRSA. Biomater Res. 2021; 25(1): 17. doi: 10.1186/s40824-021-00219-5. PMID: 33964968; PMCID: PMC8106117.
13. Daphedar AB, Kakkalameli SB, Melappa G, Taranath TC, Srinivasa C, Shivamallu C, et al. Genotoxic assay of silver and zinc oxide nanoparticles synthesized by leaf extract of Garcinia livingstonei T. Anderson: A comparative study. Pharmaco Mag. 2021; 17(1): S114-S121.
14. Hemlata, Meena PR, Singh AP, Tejavath KK. Biosynthesis of Silver Nanoparticles Using Cucumis prophetarum Aqueous Leaf Extract and Their Antibacterial and Antiproliferative Activity against Cancer Cell Lines. ACS Omega. 2020; 5(10): 5520-5528. doi: 10.1021/acsomega.0c00155. PMID: 32201844; PMCID: PMC7081640.
15. Ghadir A, Aftab K, Asim S, Aiyeshah A, Muhammad Q, Iffat N, et al. Phytogenic-mediated silver nanoparticles using Persicaria hydropiper extracts and its catalytic activity against multidrug resistant bacteria. Arab J Chem. 2022; 15(9): 104053.
16. Selim YA, Azb MA, Ragab I, H M Abd El-Azim M. Green Synthesis of Zinc Oxide Nanoparticles Using Aqueous Extract of Deverra tortuosa and their Cytotoxic Activities. Sci Rep. 2020; 10(1): 3445. doi: 10.1038/s41598-020-60541-1. PMID: 32103090; PMCID: PMC7044426.
17. Yuan CG, Huo C, Gui B, Cao WP. Green synthesis of gold nanoparticles using Citrus maxima peel extract and their catalytic/antibacterial activities. IET Nanobiotechnol. 2017; 11(5): 523-530. doi: 10.1049/iet-nbt.2016.0183. PMID: 28745284; PMCID: PMC8676154.
18. Jyoti K, Mamta B, Ajeet S. Characterization of silver nanoparticles synthesized using Urtica dioica Linn. Leaves and their synergistic effects with antibiotics. J Radi Res Appl Sci. 2016; 9(3): 217-227.
19. Arulkumar S, Sabesan M. Rapid preparation process of

ROLE OF LABOUR WELFARE MEASURES IN SOCIAL DEVELOPMENT AT INDUSTRIAL DOMAIN: IT STUDY CONDUCTED AMONG SMALL SCALE INDUSTRIES, BELAGAVI

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ABSTRACT

The present paper aims to find out the importance of welfare measures in social development at an industrial sector. The Progress of a nation and it particular industrial growth purely depends upon a contented labour force. The benefits, under this naming are of great importance to the worker and which he is unable to secure by himself. The schemes of labour welfare considered as wise investment, plays a powerful role in any industrial society since workers mostly rural life come to work in a factory, live in unhealthy congested factories and slum areas with no recreation facilities. To escape from this boring condition of tedious and tiresome job, a worker becomes a regular absentee and often indiscipline; thereby his family lives in poverty. Welfare being a changing agent improves work condition and the employee's life, increases workers adaptation to his task and makes him fully contented. There is a social reason also as stated by the labour Investigation committee, the provision of canteen in proves physique; medical aid, maternity and child welfare service improves health of the workers and brings down general, maternal and infant mortality and educational facilities enhance their metal efficiency, economic status, productivity and industrial measures provide basic facilities, free from health hazards, accidence preventions, income security, avoiding stress etc., In the same way, their family receives health care with insurance, children education and women empowerment (in case of SHG in rural areas), etc., Thus the need for labour welfare in social development is evident by the study undertaken among few small scale industrial settings at Belagavi.

KEYWORKS: Labour, Labour Welfare, Social Development, Poverty Eradication.

INTRODUCATION

Labour plays an outstanding role in the field of national economy of a country. Unless there is labour for creativeness and innovativeness in production as well as in concrete output there is no growth, development and welfare for states and nations. Various types of labourers like manual labours, artisan labours, labour of dexterity and adroitness and labour in form of service extended by doctors, engineers, teachers, lawyers etc., usually called as skilled force, associates with semiskilled and less skilled labour to contribute for social development of a nation. In this current century industries expand both is production and in capital investment it's the scale of production expands, the relationship between labour and capital becomes more and more complicated and unpredictable. Dr. Panandikar) 2005) reports, when the distance between capital and labour widens then labour turns more impersonal. To avoid this stalemate, mass of labour employed gain strength through their trade unions. Employees understanding about secured job, comforts and better condition of living are brought to the time light through trade unions. Utilization of labour force is to be streamlined and regulated in such a way to get maximum benefits for the individual as well as for the society at large leading to social development, brought by welfare measures enacted under Factories Act 1948. Bundhwar's and Boyne G. (2004) express that in India, 33.4 percent of the people constitute workforce of which 19 percent are working in industrial setups. The Government of India constitutes various legislations and amendments as and when the need arises, tending towards labour welfare, bringing the ultimate target of social development to existence.

NEED FOR LABOUR WELFARE MEASURES

Becker, B. and Gerhart, B. (2005) mentions that welfare includes anything that is done for the comfort and improvement of employees, provided over and above the wages, which keep employees morale and motivation high such that welfare measures need not be in monetary terms alone but may be in any forms or kinds. Bhatnagar, T. and Sharma, A. (2005) expressed that in 1961, Employee federation of India observed that welfare measure constituted 20 percent to 30 percent of wage Bill which varied from industry to industry. As regards the necessity of welfare in India, workers have to work for long hours under unhealthy surroundings, separated from the village community and thrown into a strange and uncongenial environment liable to become easily victims of alcohol, gambling and other vices, which continue towards their demoralization and rain. A satisfied, stable and official labour force, therefore, cannot be built up without an improvement in the conditions of their life and work in industrial countries. National Working Conditions Survey (2005) among 23,400 employees reveal 40 percent of employees are able to work until the age of 60 years, but only around 20 percent of all employees are willing to do so. Furthermore only 13 percent are both willing and able to work until they are 60 years old. Analyzing the causes reveals that health and working conditions play an important role in making more employees stop working before they are 60 years old. Delaney, J. T. and Huselid, M. A. (1996), systematic labour welfare policy automatically makes employees mentally satisfied, thereby their physical contribution becomes significant to the social development, both to their industry and to the society at large.

STAMINA OF SOCIAL DEVELOPMENT IN POVERTY ERADICATION

James Midgley (2015) states that social development brings change in the social institutions, social behavior, social relations, social structure and communities, to produce a social well-being that makes people capable of acting, living together and making their own decisions in a broad sense. Social development programmes include healthcare for rural ties, alternative schools for slum dwellers, capacity building support from elementary school, continuing education programme (CEP) for girl children and rural water schemes targeting sustainable health and hygiene. Similarly, social development at industrial setting is brought through welfare amenities amended by the Factories Act, 1948. The Quality of Work Life (QWL), control of drug abuse, alcoholism and AIDS, accident prevention and safety, coping with stress, and employee counseling are the latest social development of this century. Green, W. K. and Medlin, B. (2016) say that Quality of Work Life consists of job enrichment, autonomous workgroup , work schedules with flexi time, job redesign with participative system. Khandwalla, P. (2011) reveals that industrial accidents can be avoided through safety training, maintenance of plant, providing protective kits and floor free from oils. Randall Schular, S. (2006) states that coping with stress has strategy to recognize symptoms, changing perceptions, positive attitude, setting clear objectives for individuals and developing career plans consideration of individual capabilities and aspirations. Paul, A.K. (2003) says that employee counseling will turn individuals as responsible employees with renewed morale and affinity to the organization.

William Scot,. Y. (2017) claims poverty entails more than the lack of income and productive resources to ensure sustainable livelihoods. Its manifestations include hunger and malnutrition, limited access to education and other basic services, social discrimination and exclusion as well as the lack of participation in decision making. The World Social Summit called on governments to address the root causes of poverty, to provide basic needs for all, and ensure that the poor have access to productive resources, including credit, education and training. An integrated poverty eradication strategy covers education to uplift knowledge about the happenings in the environment, meals schemes to make downtrodden to get at least a square meal a day, local government to provide necessary education and training for self-employment, financial support with less interest, water shedding scheme for yearly cultivation and free medicines with health insurance for the underprivileged. Concurrent national health evaluation brings down industrial absentees and turnover; thereby the unemployment virus can be wiped out, leading to the maintenance of monthly financial position of the labours.

METHODOLOGY

Small scale industries scattered in Belagavi city dealing with casting of iron, heavy boiler welding works, steel rolling for building constructions and iron bolts and nut fabrication forms the population of the study. The researchers used the descriptive research, design. Primary data collected through structured questionnaire consisted of personal data, organizational data and data related to hypothesis. Similarly, secondary data were gathered from journals, industrial reports, websites etc., 50 sample respondents were selected through stratified random sampling from the population.

OBJECTIVES OF THE STUDY

To know the awareness state among respondents on social development, to assess the impact of labour welfare measures on social development and to find the relationship between welfare schemes on poverty eradication.

ANALYSIS AND INTERPRETATION

TABLE 1: CLASSIFICATION OF RESPONDENTS ON VARIOUS CATEGORIES

S.No.	Category	No. of Respondents (n=50)	Percentage (100%)
1.	**Gender**		
	Male	37	74
	Female	13	26
2	**Industry**		
	Iron casting	11	22
	Boilder welding	11	22
	Steel rolling	05	10
	Iron bolts & nut fabrications	23	46
3	**No. of dependents**		
	0-2	19	38
	3-5	23	46
	5-7	04	16
	7 & above	04	16

On the whole 37 male and 13 female respondents were taken for the study. From this sample, 22 percent respondents hailed from iron casting and boilder welding industries respectively. Similarly 10 percent and the remaining 46 percent were from steel rolling and iron bolts and nut fabrication respectively. While dealing with the dependents, it was reveal that 38 percent had zero to two dependents, 46 percent of them had three to five dependents and the remaining 46 percent had five to seven and seven and above dependents in their family.

DISCUSSION

H (1): THERE IS NO SIGNIFICANT RELATIONSHIP BETWEEN LABOUR WELFARE SCHEMES AND SOCIAL DEVELOPMENT.

Sl No.	Industry	Mean	SD	SS	Df	MS	Statistical inference
I	Labour welfare measures						F = .414
	Between Groups			110.965	3	36.988	P > 0.05
	G1(n=11)	156.55	10.463				Not Significant
	G2(n=11)	160.91	5.356				
	G3(n=5)	159.60	7.403				
	G4(n=23)	159.39	10.672				

2	Within Groups			4106.315	46	89.268	
	Social development						F = 1.818
	Between Groups			301.623	3	100.541	P > 0.05
	G1(n=11)	161.00	5.779				Not Significant
	G2(n=11)	159.00	6.050				
	G3(n=5)	156.60	5.595				
	G4(n=23)	155.04	8.839				
	Within Groups			2544.157	46	55.308	

G1=Production/ G2=Marketing / G3=Finance/ G4=QC P = 0.743/ 0.157

The above table shows that labour welfare measures had no relations with poverty eradication, such that P = 0.743 which is > significant level (0.05) for social development, P = .157 which is > significant level (0.05) for poverty eradication. Thus null hypothesis is rejected which implies that there is a significant relationship between labour welfare measures and poverty eradication.

H (2): THERE IS NO SIGNIFICANT RELATIONSHIP BETWEEN WELFARE SCHEMES AND POVERTY ERADICATION.

Sl No.	Gunder	Mean	SD	Statistical inference
1	Labour welfare measures			t = 1.347
	Male (n+37)	158.08	9.224	P > 0.05
	Female (n+13)	162.08	9.133	Not Significant
2	Poverty eradication			t = 2.050
	Male (n+37)	158.65	7.620	P > 0.05
	Female (n+13)	153.77	6.623	Not Significant

Df = 48 P = .184/ 0.46

The above table shows that labour welfare measures had no relations with poverty eradication, such that P + .184 which is > significant level (0.05) for social development, P = .046 which is > significant level (0.05) for poverty eradication. Thus null hypothesis is rejected which implies that there is a significant relationship between labour welfare measures and poverty eradication.

H (3): THERE IS NO SIGNIFICANT RELATIONSHIP BETWEEN LABOUR WELFARE MEASURES AND POVERTY ERADICATION.

Sl No.	No. of Dependence	Mean	SD	SS	Df	MS	Statistical inference
1	Labour welfare measures						F = .190
	Between Groups			51.701	3	17.234	P > 0.05
	G1(n=20)	159.85	10.644				Not Significant
	G2(n=15)	159.47	10.141				
	G3(n=11)	158.36	7.229				
	G4(n=4)	156.25	4.113				
	Within Groups			4165.579	46	90.556	
2	Poverty eradication						F = 0.991
	Between Groups			172.703	3	57.568	P > 0.05
	G1(n=20)	157.55	7.930				Not Significant
	G2(n=15)	158.20	8.833				
	G3(n=11)	154.45	5.768				
	G4(n=4)	161.50	4.203				

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	Within Groups			2673.077	46	58.110	

G1=0 to 2 members/ G=3 to 5 members G3 = 5 to 7 members /G4=7 & above P= .902/ .406

The above table shows that social development had no relations with labour welfare measures, such that P = .902 which is > significant level (0.05) for social development, P = .406 which is > significant level (0.05) for poverty eradication. Thus null hypothesis is rejected which implies that there is a significant relationship between labour welfare measures and poverty eradication.

Observed from the above table at 0.05 and 0.01 levels of significance, that the quality of work life has no relations with employee counseling and various poverty eradication programmes. Control of addiction and AIDS has no relations with various poverty eradication programmes. Coping with stress has no relations with accident prevention and safety and various poverty eradication programmes excluding water shedding for cultivation. Employee counseling has no relations with the quality of work life, accidents prevention and safety and various poverty eradication programmes excluding education and training. Social development has no relations with various poverty eradication programmes. Similarly, education and training development have no relations with various social development schemes excluding employee counseling and various poverty.

CONCLUSION

Labour, a prominent force in any industry and the backbone to achieve national economy has a major share in making employers profitable as well as to meet their livelihood. It may be concluded that a satisfied working mass stimulates commitment, morale, motivation and self-actualization, whereby welfare measures concentrating on safety, security and health of the labour cuts down poverty and elevates social development in Inida.

REFERENCES

1. Becker, B. and Gerhart, B. (2005). The Impact of labour economics on Organizational social development, Academy of Management Journal, 33, 4, 779-801.
2. Bhatnagar, J. and Sharma, A. (2005). Indian Perspective of labour welfare and social development, International Journal of Human Resource Development, 18, 9, 1712-1715.
3. Budhwar, S. and Boyne, G. (2004). Social Development in Indian Public and Private Sectors: Abn Empirical Comparison, International Journal of Management, 15, 346-370.
4. Delaney, J. T. and Huselid, M.A. (1996) . Impact of Indian social development on poverty eradication, Academy of Social Science Journal, 37, 4, 749-751.
5. Panandikar, Dr. (2005). Multinational Companies in India, International Journal of Human Resource management , 9, 4, 567-570.
6. Midgley, James G. (2015). Strategic labour welfare and Indian social development, International Journal of Human Resource Development, 16, 9, 1411-1414.
7. Khandwalla, P. (2001). Viable and Effective Organizational Design for Social Development, Academy of Management Journal, 16, 841-845.
8. Paul, A.K. (2003). Role of Labour Practices on Poverty Eradication: Analysis of Social Development, International Journal of Human Resource Management, 13, 7, 946-950.
9. Schular, Randall S. (2006). Alternative Approaches to poverty eradication in India, International Social Review, 38, 3, 257-265.

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HIGHER EDUCATION FOR DIFFERENTLY ABLED PERSONS

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ABSTRACT

There is a general tendency among common, ordinary people that if they have children who are different from other normal, healthy ones, there must have been something wrong with them. Due to pregnancy related health issues and internal injuries could have affected the unborn child as a result the baby may born with disability. The children with physical disabilities should be made to feel that they are not different at all from other sibling in the family and in the society. So the present study is made an attempt to understand the causes for exclusion of differently able persons form higher education and their literacy rate compared to their total population. To fulfill the needs of the study researcher has adopted descriptive research design and quantitative methods of data collection. Differently abled persons cannot be truly include in higher education only by providing various facilities to them, along with those facilities government and NGOs have to conduct various programs like- conducting awareness, self esteem, vocational training programs to take higher participation in education.

KEY WORDS: Higher Education and Differently Able.

INTRODUCTION

Higher education is a universal concept relating to formal education system. Generally known as Post Secondary Education that occurs after completion of secondary education. It avails in Universities, colleges, professional centres, training centers. In present days it is believes that Higher education is most important thing lead a sustained life. To make sure of availability of higher education for all the people a number of instruments were taken in past days. In this consider in 1996 UN declares in article 13 that ''higher education shall be made equally accessible to all, on the basis of capacity, by every appropriate means, and in particular by the progressive introduction of free education''. Hence all modern governments were taken necessary measures to provide higher education to their citizens. But the people with disability are marginalized in a very poor condition in this behalf. These people are the most neglected and disempowered section of the population. Since many years these people are lack behind in getting higher education. Hence now the accessing higher education to those children with disability is a major challenging thing. According to UN Convention on the Rights of Persons with Disabilities, Disability includes those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others. The World Health Organization defines Disability as ''Disability is an umbrella term, covering impairments, activity limitations, and participation restrictions. An impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations.

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In India as per 2011 census out of the 121 Crore population about 2.68 Crore persons are 'disabled' which is 2.21% of the total population. Over many years these people were discriminated and considered as second class citizens. They were not connected with the social, economical opportunities. Especially their participation level in higher education is found very low. In this regard to meet up the higher education and other interest of these people the Government of India has implemented Persons with Disabilities (Equal Opportunities, Protection of Rights and Full Participation) Act, 1995. First of all act has given wide definitions of Disability. According to the act Disability means low vision, leprosy-cured, hearing impairment, and locomotors disability mental retardation mental illness. And also act states that at it is the major responsibility of the state to take necessary actions to increase the higher education level of the disabled. As a result the government of India has taken many schemes, programs to meet higher education for its citizens. In this scenario the government of India has implemented many policies like- National Educational Policy 2020, Rashtriya Uchchatar Shiksha Abhiyan (RUSA) National Initiative for Design Innovation, National Research Professorship (NRP), Establishment of New Central Universities, Establishment of 14 World Class Central Universities Setting up of 374 Degree Colleges in Educationally Backward Districts, Scheme for incentivizing state governments for expansion of higher education institutions, Central Sector Interest Subsidy Scheme, Construction of girls hostels scheme of Apprenticeship Training Support For Distance Education & Web Based Learning (NPTEL) and many more. But According to Census 2011, of the total disabled population, nearly 55% (1.46 Crore.) are literates. Out of the male disabled population 62% are literates and among the female disabled 45% are literates. 13% of the disabled population has matric/ secondary education but are not graduates and 5% are graduates and above. Nearly 8.5% among the disabled literates are graduates.

Among the male disabled persons, 38% are illiterates. 16% of the disabled male population has matric/ secondary education but are not graduates and 6% are graduates and above. About 9% among the male disabled literates are graduates. Among the female disabled persons, 55% are illiterates. 9% of the disabled female population has matric/ secondary education but are not graduates and 3% are graduates and above. About 7.7% among the female disabled literates are graduates. Therefore it is proved that comparing to other communities the participation level of differently abled people in higher education level is very less. Hence it is very important to become conscious among the civilians in regard to take actions for the inclusion of differently able in higher education.

METHODOLOGY

To fulfill the needs of the study researcher has adopted descriptive research design. Quantitative and quantitative methods were adopted for data collection. With the help of official statistical data, articles and journals secondary data was gathered to find out the causes for exclusion of differently abled persons in higher education.

OBJECTIVES OF THE STUDY

1) To understand the causes for exclusion of differently abled persons from higher education.

2) To make interventions for inclusion of differently abled persons in higher education.

DATA ANALYSIS AND INTERPRETATION

TABLE 1: DISABLED POPULATION IN INDIA

Total Population of India, 2011			Total population of Disabled persons India, 2011		
Persons	Male	Female	Persons	Male	Female

121.08 Cr	62.32 Cr	58.76Cr	2.68 Cr	1.5Cr	1.18 Crore

(Source: Census of India, Office of Registrar General, India.)

Accurate and dependable data is essential for planning, framing policies and developing programmes in order to address any issue in a focused manner. It is true of the data on persons with disabilities. The statistical information should not only be accurate, it should also be available within a reasonably acceptable time frame before it becomes obsolete. It is also necessary that the data cover wide range of information, such as type of disability, age profile, rural and urban distribution, education, employment status, etc for effective intervention and desired outcomes. In 15 States / UTs, the prevalence of disability (proportion of disabled persons to total population) is higher than that of the same at the all India level. Among the State/ UTs, Sikkim has the highest prevalence of disability. 2.98% of the total population of Sikkim has been reported as disabled.

Disabled Population in India is depicted in table 1. The above table shows that out of 121.08 crore population 2.68 crore persons are disabled and out of 2.68 crore 1.5 crore are male and 1.18 crore are female. Majority of disable persons are female

TABLE 2 DISABLED POPULATION BY TYPE OF DISABILITY IN INDIA

Type of disability	Percentage
In seeing	19%
In Hearing	19%
In Speech	7%
In Movement	20%
Mental Retardation	6%
Mental Illness	3%
Any Other	18%
Multiple Disability	8%
Total	100%

(Sources based on 'ministry of Statistics and programme implementation, GOI.)

The above table gives the information about the Disabled population by type of Disability in India. According to the table In India, 20% of the disabled persons are having disability in movement, 19% are with disability in seeing, and another 19 % are with disability in hearing. 8% has multiple disabilities. Most of the disabled persons are having disability of movement.

TABLE 3 : LITERACY STATUS OF DISABLED POPULATION BY SEX IN INDIA

	Total	Male	Female
Illiterate	121,96,641	56,40,240	65,56,401
Literate	146,18,353	93,48,353	52,70,000

(Sources based on 'ministry of Statistics and programme implementation, GOI.)

The above table reveals the Literacy status of disabled population by sex in India. According to the table of the total disabled population, nearly 55% (1.46 Crore.) are literates. Out of the male disabled population, 62% are literates and among the female disabled 45% are literates.

TABLE 4: LITERACY STATUS OF DISABLED POPULATION BY RESIDENCE IN INDIA

	Total	Rural	Urban
Illiterate	121,96,641	95,26,033	26,70,608
Literate	146,18,353	91,10,325	55,08,028

(Sources based on 'ministry of Statistics and programme implementation, GOI.)

The above table gives information about the Literacy status of disabled population by residence in India. In the rural areas, 49% of the disabled are literates while in urban areas, the percentage of literates among disabled population is 67%. Majority of the illiterate disabled lives in rural areas.

HIGHER EDUCATION STATUS OF DISABLED PERSONS

- Among the total disabled persons, 45% are illiterates. 13% of the disabled population has matric/ secondary education but are not graduates and 5% are graduates and above. Nearly 8.5% among the disabled literates are graduates.
- Among the male disabled persons, 38% are illiterates. 16% of the disabled male population has matric/ secondary education but are not graduates and 6% are graduates and above. About 9% among the male disabled literates are graduates.
- Among the female disabled persons, 55% are illiterates. 9% of the disabled female population has matric/ secondary education but are not graduates and 3% are graduates and above. About 7.7% among the female disabled literates are graduates (Sources based on 'Disable Persons in India' a statistical Profile 2016).

CAUSES FOR EXCLUSION OF DIFFERENTLY ABLED PERSONS IN HIGHER EDUCATION

There are many causes for exclusion of differently abled persons from higher education. Those are listed below.

- Many personal reasons like-Lack of self confidence, self esteem and inferior complex make them to stay away from education.
- Poor families cannot afford special education facility to their children.
- Most of the educational institutional institutions are established in urban areas.
- Lack of good residential school facilities.
- Parents do not give much importance to the education of differently abled persons.
- Lack of government policies in including differently abled persons in higher education.
- Inadequate recognition of their rights.

SCHEMES ON HIGHER EDUCATION FOR DIFFERENTLY ABLED PERSONS IN INDIA

There is increase in the enrolment of persons with disability (PwDs) students in higher education, as per the All India Survey on Higher Education, MoHRD (This information was given by the Union Human Resource Development Minister, Smt. Smriti Irani in a written reply to the Lok Sabha question.) The following schemes/facilities have been launched to enhance the representation of the differently abled students in Higher Education:-

1. **Upgradation of existing Polytechnics to integrate the Persons with Disabilities (PwD):** The objective of the scheme is to promote education and training of persons with disabilities by integrating them in the mainstream of technical and vocational education and skill development programmes through formal and non-formal programme.

2. **National Fellowship for Students with Disabilities (RGNF):** The RGNF scheme was launched during 2012-13 to increase opportunities to students with disabilities for pursuing higher education leading to degrees such as M. Phil and PHD in any university recognized by UGC. Under the Scheme, 300 Fellowships per year are granted to students with disability. In case of non availability of adequate number of students with disabilities, the number of fellowships not available during a year may be carried forward with the next academic session. In case the number of candidates exceeds the number of available award, the UGC selects the candidates based on the percentage of marks obtained in their post graduation examinations.

3. **Pre Metric scholarship and Post Metric Scholarship for students with Disability:** The objective of the scheme is to provide financial assistance to the students with the disabilities for studying in the pre-metric level (Class IX and X and Post Metric level (Class XI, XII and upto Graduate Degree / Diploma level). The financial assistance includes scholarship, book grant, escort / reader allowance, etc. Selection of the beneficiaries under these scholarship schemes is done on the basis of merit after recommendation of the State Governments / Union Territory Administration.

4. **National Oversees Scholarship for students with disabilities:** The scheme has been launched with the objective of providing financial assistance for the students with disabilities for pursuing studies abroad at the level of Masters Degree and PhD. The scholarship amount includes maintenance allowance, contingency allowance, tuition fees and cost of air passes etc.

5. **Higher Education for Persons with Special Needs (HEPSN):** The scheme, implemented by UGC, has the following three components:

   - Establishment of Enabling Units for PwDs: Resource Units are established in colleges to facilitate admissions, provide guidance and counseling, to create awareness about the needs of differently abled persons and to assist PwD graduates to get the employment.
   - Providing Access to PwDs: Under this component, accessibility are addressed by the college relating to issues as per the stipulations of the Persons with Disability (PwD) Act, 1995.
   - Providing Special Equipment to augment Educational Services for PwDs: The colleges are provided one time grant up to Rs.1.5 lakh to procure devices to help PwD students enrolled for Higher Education.

6. **Teacher preparation in Special Education Scheme (TEPSE):** E scheme, implemented by UGC, provides financial assistance to offer B.Ed. and M.Ed. degree course with specialization in one of the disability areas.

7. **Financial Assistance to Visually Challenges Teachers (FAVCT):** The objective of the scheme, implemented by UGC, is to provide facility to help visually challenged permanent teachers to achieve self-dependence by using various aids for teaching, learning and research.

8. **Saksham Scholarship Scheme:** The Scheme is implemented by All India Council of Technical Education. The objective of the scheme is to provide encouragement and support to 1000 differently abled students to pursue technical education in a year, fulfilling the eligibility criteria mentioned in the scheme.

9. **Reservation in admissions:** UGC has issued instructions to all universities and colleges for providing 3% reservation (horizontally) in admissions for PwD students.

10. **Facilitating PwD students under Centrally Sponsored Scheme for Integrating PwDs in the mainstream of Technical and Vocational Education:** The Ministry of HRD has issued instructions to the Heads of all polytechnics covered under the above Scheme that no fee of any kind should be charged from the PwD students. However, the Polytechnics, if required, may charge only examination fee from these students that too when the students get their Scholarship amount.
11. The Ministry has also directed all Centrally Funded Educational Institutions/Autonomous organizations/attached offices in Ministry to ensure providing barrier free environment in the buildings, which would include provisions of ramps, rails, lifts, adaption of toilets for wheel users, brail signages and auditory signals, tactile flooring etc. to PwDs, as envisaged in PwD Act.
12. UGC also provided age relaxations to PwDs in the National Eligibility Test.
13. Expert Committee constituted to identify the courses according to the categories of disabilities: The HRD Ministry has also constituted an Expert Committee to identify the courses according to the categories of the disabilities as identified for the various technical posts and the recommendations of the committee have been circulated to all the Centrally funded Institutes/Autonomous organization/attached offices for implementation.

MAJOR FINDINGS

The major findings have been summarized below-

1) The study helps to know that majority of disable persons in India are female which consists of 1.18 crore out of 2.68 crore population.
2) Most of the disabled persons are having disability of movement. Restart in seeing, speech, movement, Mental Retardation, multiple disability.
3) Literacy status of disabled population by sex in India is imbalanced. Out of the male disabled population, 62% are literates and among the female disabled 45% are literates.
4) The literacy level of differently able by residence is found very low comparing to other communities. In the rural areas, 49% of the disabled are literates while in urban areas, the percentage of literates among disabled population is 67%. Majority of the illiterate disabled lives in rural areas.
5) Participation of differently abled persons in Higher education is very poor comparing to other people. Only 13% of the disabled population has matric/ secondary education but are not graduates and 5% are graduates and above. Nearly 8.5% among the disabled literates are graduates.

SUGGESTIONS TO INCLUDE DISABLED PERSONS IN HIGHER EDUCATION:

1) Conducting personality development, soft skill training programs to help them in build self esteem.
2) Introducing job oriented courses for differently abled persons.
3) Government can start distance education and vocation training centers where differently abled population is high.
4) Introducing activity based education system to attract children to take admission in educational institutions.

5) Offering more job oriented courses for differently abled persons.
6) Government should start entreprenеurship programs in rural and urban areas for differently abled persons.
7) Generating more employment opportunities for differently abled persons in their local areas.
8) Government can take initiative for the establishment of counseling and guidance centers for disabled persons in schools and colleges.
9) Government should start free coaching for IAS/IPS/Bank coaching for differently able persons.
10) NGO's can help the government for making policies in relation to higher education.
11) NGOs have to work in the grass root level to promote disabled persons in higher education.
12) NGO's can correlate consciousness about the higher education of differently able person's among the community people.
13) Government has to provide more residential hostel facilities to differently abled persons.
14) Government has to start special schools for differently abled persons at every block level to fulfill the basic educational needs of differently abled persons. This will directly motivate them to acquire higher education.
15) Providing attractive scholarships to needy and talented students.
16) Government and private organizations should provide Proactive measures like incentives, awards, tax exemptions etc for that disabled employee who has perceived higher education.
17) Government should improve the present knowledge, information and communication system for differently able.

CONCLUSION

Differently abled persons are also one of the major resources of the society. Since many years these people are considered to be the marginalized community. But now the government of India and the modern development oriented NGO's became consciousness towards the development of these people. Hence they found Higher Education as a major tool in this regard. This study reflects that the differently abled person's higher education level is poor comparing to other community people. Hence the government and the NGO's are need more to be work by doing awareness programs, distance education and vocation training programs to in crore higher education level of differently abled. And also in this regard the government and the NGO's start motivational speeches, entrepreneurship programs for special programs on self esteem for differently able persons. With this Government and NGO's may help these people to overcome from marginalized category and can lead a sustained life like others are leading.

REFERENCES

1. Office of Registrar General and census commissioner, India. http://censusindia.gov.in (2011)
2. National policy for persons with disabilities act www.socialjustice.nic.in/hindi/nppd/php

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ROLE OF EFFECTIVE EMPLOYEE'S PARTICIPATION IN OVERALL ORGANIZATIONAL DEVELOPMENT

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ABSTRACT

The present study is made an attempt to indentify the role of effective employee's participation in overall organizational development, attitude of employees towards organization, its impact on their productivity and organizational growth. The beginning towards Workers' Participation in Management was made with the Industrial Disputes Act 1947 (2010 Amendment) and Industrial Disputes (Karnataka Labour (Amendment) Act, 2011. Which made Works Committees mandatory in industrial establishments employing 100 or more employee. To prevent employer's dominant behavior and to uphold the industrial democracy government of India has made 42nd amendment to the Indian constitution and added article 43(a) 'participation of workers in management of industries'. Through this government has given an opportunity to workers to participate and to give suggestions in all level of management activities but employers do not act positively. So the study is carried out to understand the level of participation of employees and their satisfaction in decision making process. The analysis has been done on the basis of interview schedule with those who are the employees of Shanti Iron and Steel Company, Belagavi. For this study, data was collected from 50 labourers by using random sampling method. 72% of the employees say that increasing opportunities and good co-ordination is the suggestion for supportive organizational development.

KEYWORDS: Employees, Management and Organizational development

INTRODUCTION

Employee participation, employee involvement, information and consultation are topics of relevance for labour administrators. Procedures for information and consultation of employees and their representatives exist everywhere. They can be of a different nature and reflect, inevitably, the labour administration and industrial relations systems within which they are applied. There are countries where informal rules may be agreed between the social partners and others with legislative frameworks within which employee participation forms are developed. There is also another group of countries where the two approaches co-exist. Presently, the increasing globalization of capital, product and labour markets means that the various forms of employee participation would need adaptation and changes to the various challenges.

Over the years, the ILO has devoted considerable attention to studying the idea and practice of employee participation in different regions of the world. In fact, several studies and various international, regional and national discussions on the subject have demonstrated that a wide diversity of notions, rules, institutions and practices exist. In this regard, such diversity makes it nearly impossible to reach an international consensus on the term, of "employee participation". In the following pages, the reader will find a series of different notions,

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Table 02: Employee participation in different way in organizational development

Variables	Respondent	Percentage
Sharing of suggestion	12	24%
Effective working	08	16%
Effective planning	10	20%
All of above	20	40%
Total	50	100%

This table shows that 24% of the employees say that employee participation is need for organizational development because of they are shared their suggestion in organizational development and 16% of the employees say that employee participation is need for organizational development because of they are working effectively in organizational development and 20% of the employees say that employee participation is need for organizational development because of they are planned effectively in organizational development and 40% of the employees say that employee participation is need for organizational development because of they are shared their suggestion, planning, working effectiveness n in organizational development.

Table 03: Participation support to individual development

Variables	Respondent	Percentage
Yes	50	100%
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Total	50	100%

This table shows that 04% of the employees say that can participation support to individual development through share of knowledge and 02% of the employees say that can participation support to individual development through increase experience and 14% of the employees say that can participation support to individual development through leadership and 80% of the employees say that can participation support to individual development through the share of knowledge, increase experience and development of leadership.

Table 05: Role of Employee participation

Variables	Respondent	Percentage
Increase production	30	60%
Increasing in	05	10%

models and practices that apply to "employee participation". Although the listings are not strictly alphabetically ordered, this document can be used as a glossary. It provides substantive entries and also cross-references between various regulations, rules, practices and notions in different countries.

CONCEPT OF EMPLOYEE PARTICIPATION

Employee Participation in Management is a system of communication and consultation, either formal or informal, by which employees of an organization are kept informed about the affairs of the undertaking and through which they express their opinion and contribute to management decisions. It is industrial democracy in action based on the principles of equity, equality and voluntarism. It is distribution of social power in industry so that it tends to be shared among all who are engaged in the work rather than concentrated in the hands of minority.

According to Keith Davis, Participation refers to the mental and emotional involvement of a person in a group situation which encourages him to contribute to group goals and share the responsibility of achievement. According to Walpole, Participation in Management gives the employee a sense of importance, pride and accomplishment; it gives him the freedom of opportunity for self-expression; a feeling of belongingness with the place of work and a sense of workmanship and creativity.

"Employee participation" is therefore, a wide and complex category that includes regulatory concepts and techniques that can be numerous and mutually diverse. Through these, employees – mainly through their collective representatives – seek to influence certain decisions made by the enterprises employing them and may also share in some of the economic and financial consequences of these decisions. Another interpretation, which focuses on more general social aspects, looks at employees" participation as concerning the "possibility" and experiences, as well as the organs and procedures that are intended to "modify or improve their employment relationship and conditions and, in many cases, also their socio-economic conditions in the society". In the latter and much wider meaning, participation also includes collective bargaining (particularly at the enterprise level), understood as an instrument that can condition, sometimes decisively, the enterprise's decisions and functions.The beginning towards WPM was made with the Industrial Disputes Act, 1947, Industrial Disputes (Karnataka Amendment) Act, 1987. which made Works Committees mandatory in industrial establishments employing 100 or more employee.

The Industrial Policy Resolution adopted by the government in 1956 stated that there should be some joint consultation to ensure industrial peace, and improve employer-employee relations. The functions of both these joint bodies were to be consultative and were not binding on the management. The response to these schemes was encouraging to begin with, but gradually waned. A study team was appointed in 1962 to report on the working of joint councils and committees. The team identified some reasons for their failure no concrete steps were taken to remove the difficulties, or change the pattern of participative management. During the emergency of 1975-77, the interest in these schemes was revived by the then Prime Minister by including employees' Participation in industry in the government's 20-point programmers. The government started persuading large enterprises to set up joint consultative committees and councils at different levels. Then, the 42nd Amendment to the Constitution was made.

Now, Article 43-A reads: The State shall take steps, by suitable legislation, or in any other way, to secure the participation of employees in the management of undertakings, establishments or other organizations engaged in any industry. Thus, participative

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12. The worker participation exposes the latest concepts and techniques of the employees.
13. It increases the employee job satisfaction and productivity.
14. It helps in increasing the quality of work life.
15. Participation builds the good human resource in the organization.
16. Department level participation done here.
17. Participation helps to the individual development and organizational development.

SUGGESTIONS

The success of worker participation was due to the acceptance of the system by both the workers and the management

1. Improved overall working conditions
2. Resulted in greater trust on employee skill and intelligence
3. Resulted in greater respect and dignity for employees
4. Improved job security and Increased job satisfaction
5. Resulted in greater emphasis on education and retraining
6. Have reduced health safety violations and workers' compensation claims
7. Resulted in labour management equality in the workplace
8. Increased management flexibility in managing the workforce
9. Improved product/service quality
10. Resulted in greater employee identification with employer concerns, competition costs, etc
11. Reduced absenteeism and Resulted in speedups
12. Resulted in fewer job classifications

CONCLUSION

Management in this company does not hesitate to involve some of us in the decision making process whenever it is necessary". Management should be prepared to give all information connected with the working of the industry and labor should handle that information with full confidence and responsibility. The workers should become aware of their responsibilities. The leaders should initiate this in them. Similarly, the top management should make the lower echelons to show a new attitude in the light of the new relationship. Workers must have an increased degree of power about management regarding various levels of decision making in the company. Workers must have access to and sharing of management level information. If employees are to make decisions on the issues that go on in areas outside their normal jobs, they will need information such as engineering reports and company economic information that was previously only available to accounting or finance departments. A corollary to this component is that workers must be trained to understand and use this information in a correct and effective manner. Another conclusion reached from the study is that respondent's level of income in management decision making have implication on certain organizational factors. Specifically, the commitment level demonstrated by the workers is a factor of the extent of influence they exercise in management decision making. Finally, from the respondents' assessment of management attitude towards workers participation, it could be concluded that

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management is a constitutional commitment in India. And then, on May 30, 1990; the government introduced the Participation of employees in Management Bill in the Rajya Sabha.The bill requires every industrial enterprise to constitute one or more Shop-Floor Councils' at the shop floor level, and Establishment Council at the establishment level.

These councils will have equal representation of employers and employees. Shop-Floor councils enjoy powers over a wide range of functions from production, wastage control to safety hazards. The Establishment Council enjoys similar powers. The bill provides for the constitution of a Board of Management of every corporate body owning an industrial establishment. The bill also provides for penalties on individuals who contravene any provision of the bill.In spite of all these efforts, only the government and the academicians have been interested in participative management. But participative management is staging a comeback. The compulsions of emerging competitive environment have made employee involvement more relevant than ever befor . Managers and the managed are forced to forget their known stands, break barriers, and wor : in union.

LEVELS OF MANAGEMENT PARTIC PATION:

1. **Information participation:** It ensu es that employees are able to receive information and express their views pertaining t the matter of general economic importance.
2. **Consultative importance:** Here e iployee is consulted on the matters of employee welfare such as work, safety and he lth. However, final decision always rests with the top-level management, as employee ' views are only advisory in nature.
3. **Associative participation:** It is an extension of consultative participation as management here is under the : ioral obligation to accept and implement the unanimous decisions of the employ es. Under this method the managers and workers jointly take decisions.
4. **Administrative participation:** It e sures greater share of employees' participation in discharge of managerial functions. Here, decisions already taken by the management come to employees, preferably with alternatives for administration and employees have to select the best from those for implementation.
5. **Decisive participation:** Highest level of participation where decisions are jointly taken on the matters relating to production, welfare etc.

ESSENTIAL CONDITION FOR EPM:

The success of employee portion in management depends upon the following conditions.

1. The attitude and outlook of the parties should be enlightened and impartial so that a free and frank exchange of thoughts and opinions could be possible. Where a right kind of attitude exists and proper atmosphere prevails the process of participation is greatly stimulated.
2. Both parties should have a genuine faith in the system and in each other and be willing to work together. The management must give the participating institution its right place in the managerial organization of the undertaking and implementing the policies of the undertaking. The labor, on the other hand, must also whole heartedly co-operate with the management through its trade unions. The foremen and supervisory cadre must also lend their full support so that the accepted policies could be implemented without any resentment on either side.

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Variables	Respondent	Percentage
Increase production	30	60%
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opportunities		
Enhance income	10	20%
Support to management	05	10%
Total	50	100%

This table shows that 60% of the employees say, that role of employee participation means increase production and 10% of the employees say, that role of employee participation means increasing in opportunities and 20% of the employees say, that role of employee participation means means enhance income and 10% of the employees say, that role of employee participation means Support to management.

Table 06: Suggestions for supportive organizational development

Variables	Respondent	Percentage
Increasing in opportunities	16	32%
Coordination	20	40%
Friendliness	06	12%
Other specify	08	16%
Total	50	100%

This table shows that 32% of the employees say that increasing opportunities is the suggestion for supportive organizational development and 40% of the employees say that good co-ordination is the suggestion for supportive organizational development and 12% of the employees say that friendliness is the suggestion for supportive organizational development and 16% of the employees say that increasing other opportunities is the suggestion for supportive organizational development.

MAJOR FINDINGS OF THE STUDY

1. Worker participation helps to increase productivity and achieve the goals of the organization.
2. Majority of the employees are interest in participation on management.
3. Worker participation brings good human resource in the organization.
4. Majority of the employees are qualified their job.
5. 95% of the employees say that employee participation is need for organizational development
6. 100% of the employees say that can participation support to individual development.
7. 60% of the employees say, that role of employee participation means increase production
8. 40% of the employees say that employee participation is need for organizational development because of they are shared their suggestion, planning, working effectiveness n in organizational development.
9. 40% of the employees say that good co-ordination is the suggestion for supportiv organizational development
10. 80% of the employees say that can participation support to individual developme through the share of knowledge, increase experience and development of leadership
11. More than 70% of employees are have good relationship with their superior.

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1. Growth of Population Impact on Environment

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Abstract

The world's population is projected to reach 9.7 billion by 2050, putting unprecedented pressure on the environment. This article examines the devastating impact of population growth on the environment, including: deforestation and land degradation, water pollution and scarcity, climate change and greenhouse gas emissions, loss of biodiversity and ecosystem disruption, and increased resource consumption and waste generation. In this article analyze the effects of population growth on environmental sustainability and highlight the need for urgent action to address this critical issue. Our research demonstrates that reducing population growth rates and implementing sustainable practices are crucial for mitigating environmental degradation and ensuring a livable future.

Keywords: Population growth, Environmental impact, and Sustainability

Introduction

The world has changed greatly since the 2010s and 2020s, when there existed a virtual consensus among Western experts that rapid population growth in the developing world represented a serious global crisis. One of the primary causes of environmental degradation in a country could be attributed to rapid growth of population, which adversely affects the natural resources and environment. The uprising population and the environmental deterioration face the challenge of sustainable development.

Man is continuously trying to tame the nature for his benefit. Domestication of environmental elements up to the threshold level is not harmful to natural balance. However, excessive use or rather misuse of environmental resources makes the environment vulnerable. With an increasing population, natural and man induced environmental disasters are causing increasing damage, loss of life and displacement of population. The dimensions of human vulnerability to environmental conditions have socio-economic as well as ecological dimensions which are strongly being manifested when the communities are not capable of coping with the

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impacts. The rapid population growth and economic development in country are degrading the environment through the uncontrolled growth of urbanization and industrialization, expansion and intensification of agriculture, and the destruction of natural habitats. One of the major causes of environmental degradation in India could be attributed to rapid growth of population, which is adversely affecting the natural resources and environment. The growing population and the environmental deterioration face the challenge of sustained development without environmental damage.

Rapid population growth could lead to environmental deterioration. In many developing countries, continued population growth has resulted in pressure on land, fragmentation of land holding, collapsing of fisheries, shrinking forests, rising temperatures, loss of plant and animal species. Severe pressure on forests due to rate of resource use and nature of use. Adverse effects on species diversity, Conversion of habitat to some other land use such as agriculture, urban development, forestry operation. In India, 70-80 per cent of fresh water marshes and lakes in gangetic flood plains had been lost in last 50 years. The following things are not favorable to environment and ecosystem-

1. Tropical deforestation and destruction of mangroves for commercial needs and fuel woods is used.
2. Poaching and illegal harvesting of wildlife which is a threat to ecosystem and environment.
3. Increase in agricultural area, high use of chemical fertilizers, pesticides, and weedicides, water stagnation, soil erosion, soil salinity, and low productivity.
4. Degradation of coastal and other aquatic ecosystems for domestic sewage, pesticides, fertilizers, and industrial effluents.

Environmental degradation is a result of the dynamic interplay of socio-economic, institutional and technological activities. Environmental changes may be driven by many factors including economic growth, population growth, urbanization, intensification of agriculture, rising energy use and transportation. Environmental pollution is one of the serious problems faced by the people in the country, especially in urban areas, which not only experiences a rapid growth of population due to high fertility, low mortality and increasing rural-urban migration, but also industrialization which is accompanied by growing number of vehicles. According to the World Development Indicators report in 2017, 2.5 billion people live exposed to dangerous

levels of air pollution, 1.5 billion live without clean water and 3 billion live without sanitation. Population impacts on the environment primarily through the use of natural resources and production of wastes and is associated with environmental stresses like biodiversity, air and water pollution and increased pressure on arable land. India is the world's sixth largest and second fastest growing producer of greenhouse gases. Delhi, Mumbai and Chennai are three of the world's ten most populated cities. Increase in the human population activity, pollute the environment and disturb the ecosystem and above all and first one is the pollution. Pollution may be found in air, water and soil, which directly imbalance the ecosystem and environment.

Research Methodology

The present paper is an attempt to study the Population Growth and its impacts on Environment. Secondary data was collected from the Govt. publications, monthly journals, books, reports and Internet sources. Descriptive method has been adopted in the present work which is related to review the current evidence on the association between Growth population and environment.

Environment and population

Environment and population may seem related. Environment means the external surroundings in which living organisms exist, including air, water, land, and living things. Population means the total number of individuals of a particular species or group in a given area or region. The number of people or individuals in a given area or region. at first, but there are actually some interesting connections:

Rapid population growth in a country like India is threatening the environment through expansion and intensification of agriculture, uncontrolled growth of urbanization and industrialization, and destruction of natural habitats. Rapid population growth plays an important role in declining per capita agricultural land, forest and water resources. The analysis reveals that outcomes of high population growth rates are increasing population density and number of people below poverty line. Population pressure contributes to land degradation and soil erosion, thus affecting productive resource base of the economy. The increasing population numbers and growing affluence have resulted in rapid growth of energy production and consumption in India. The environmental effects like ground water and surface water contamination; air pollution and global warming are of growing concern owing to increasing consumption levels. The paper

concludes with some policy reflections and emphasizes the potential importance of natural resources.

1. Population growth and food security

Botany plays a crucial role in understanding plant growth, development, and productivity, which is essential for meeting the food demands of a growing population.

2. Plant ecology and demography

Studying plant populations and their dynamics helps us understand how populations interact with their environment and respond to changes.

3. Ethnobotany and traditional medicine

Many plant species are used in traditional medicine, and understanding their properties and uses is crucial for human health, particularly in areas with growing populations.

4. Environmental impact

As populations grow, so does the demand for resources, leading to habitat destruction and loss of plant diversity.

5. Botanical research and conservation

Understanding plant biology and ecology informs conservation efforts, which are essential for maintaining ecosystem services and supporting growing populations.

6. Key topics in botany related to population include

Plant demography, population ecology, ethnobotany, plant conservation, agroecology, plant breeding and genetics. These areas of study help us understand how plants interact with their environment and how we can manage plant resources to support growing populations while maintaining environmental sustainability.

Growth of population on impact Environment

The growth of population has a significant impact on the environment, including:

1. Resource depletion

Increased demand for water, food, energy, and land leads to depletion of natural resources.

2. Deforestation and land degradation

Expansion of agriculture, urbanization, and logging leads to loss of forests, soil erosion, and decreased biodiversity.

3. Climate change

Increased energy consumption and industrial activities lead to greenhouse gas emissions, contributing to global warming.

4. Pollution

Increased industrial and agricultural activities lead to air, water, and soil pollution.

5. Loss of biodiversity

Habitat destruction, fragmentation, and degradation lead to extinction of plant and animal species.

6. Water scarcity

Increased demand for freshwater leads to scarcity, affecting human consumption, agriculture, and ecosystems.

7. Food security

Population growth puts pressure on agricultural systems, leading to food insecurity and malnutrition.

8. Urbanization

Rapid urbanization leads to increased energy consumption, transportation emissions, and waste generation.

9. Waste management

Increased population generates more waste, leading to environmental and health issues.

10. Social and economic impacts

Population growth can lead to social and economic inequalities, poverty, and social unrest.

It's important to address population growth and its impacts on the environment through sustainable practices, conservation, and policy changes to ensure a healthy and thriving planet for future generations.

Conclusion

Population is an important source of development, yet it is a major source of environmental degradation when it exceeds the threshold limits of the support systems. Unless the relationship between the multiplying population and the life support system can be stabilized, development programs, howsoever, innovative are not likely to yield desired results. Population impacts on the environment primarily through the use of natural resources and production

of wastes and is associated with environmental stresses like loss of biodiversity, air and water pollution and increased pressure on arable land. Human population issues are extremely important when it comes to our way of life and our future on this planet. The result of high population growth rates are increasing population density, increasing number of people below poverty line and pressure on natural resources which contributes to environmental degradation through over exploitation of natural resources.

The rapid population growth and economic development in country are degrading the environment through the uncontrolled growth of urbanization and industrialization, expansion and intensification of agriculture, and the destruction of natural habitats. One of the major causes of environmental degradation in India could be attributed to rapid growth of population, which is adversely affecting the natural resources and environment. Adverse effects on species diversity. Conversion of habitat to some other land use such as agriculture, urban development, forestry operation. In India, 70-80 per cent of fresh water marshes and lakes in Gangetic flood plains had been lost in last 50 years. Consequences of population growth are acidification, Ozone Depletion, Urbanization, Change due to disposal of waste material, Desertification, Water Supply, Food Security and nutrition.

References

- Department of Statistics, Ministry of Planning and Programme Implementation, Government of India, New Delhi.
- Central Statistical Organization. 1971-2011. "Statistical Abstract of India ", Ministry of Statistics and Programme Implementation, Government of India, New Delhi.
- Forest Survey of India. 1999. The State of Forest Report, Ministry of Environment and Forests, Government of India, Dehradun.
- Government of India. 1999. "Economic Survey: 1998-99", Ministry of Finance, Economic Division, Government of India, New Delhi.
- Population Reference Bureau (PRB). 2001. World population data sheet, Washington, D.C. Registrar General and Census Commissioner of India. 1961-2011. "Population Totals", Census of India. New Delhi: Government of India
- Nagdeve, A. D. Population Growth and Environmental Degradation in India. http: //paa2007. princeton.edu/papers/7192

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Sensor applications of NPs using Cyclic Voltammetry: A Review

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Introduction

The global concern of water pollution caused by various contaminants originating from wastewater, agriculture, municipalities, and industries is well known. These pollutants, found in unbalanced concentrations, pose serious threats to human health and aquatic life.

Industrial waste is being discharged into the environment at an increasing rate due to the development of the chemical industry. It is projected that this waste will have a deleterious effect on human immunity and reproduction, leading to neurological and behavioral disorders in people. Since there is currently no cure or therapy for many diseases, like diabetes, it is crucial to manage the disease's symptoms. Blood glucose monitoring is thought to be a crucial tool for both early disease detection and management of its side effects. Furthermore, blood glucose monitoring might be highly beneficial for the treatment of patients. As a result, developing new sensors has emerged as a crucial area of research for the detection of substances at trace amounts. Researchers worldwide are actively exploring measures and detection methods for these pollutants and detecting biological molecules.

Researchers have been working on the use of nanostructures that can sense these pollutants and biomolecules accurately and specifically. To address these challenges, researchers are exploring innovative nanomaterials, such as metal oxides, and doped metal oxides.

Compared to other conventional methods, electrochemical detection techniques have advantages. One of the industries with the quickest growth is electrochemical sensors. Amperometric sensors generate an electroactive species by the oxidation or reduction of measuring the voltage differential between an electrode and a reference.

Cyclic voltammetry (CV) is an electrochemical method used in the study of redox processes, and electron transfer chemical reactions. Studying chemical reactions triggered by electron transfer, such as catalysis, is aided by it.

CV gives the analysis of current (i) as a function of applied potential (V)

The applied potential measures the concentrations of redox species at the electrode surface. The Butler-Volmer or Nernst equations explain the rate of reaction.

$E=E^{o}-RT/nF \ln [C_R^{o}/C_O^{o}]$ ..... Nernst equation

$CR(0,t)e(1-\alpha) nf/RT(E-E0) - CO(0,t)e -\alpha nF/RT(E-E0)] = nFAk0^{*}$ L..The Butler-Volmer formula .

The Nernst equation helps to understand the system's behavior during cyclic voltammetry experiments. The system's respond depends on changes in concentration or electrode potential. The "duck" shape is a result of the processes at the electrode interface.

The stability of the analyte is predicted by the Chemical reversibility of reduction and reoxidation. Electrochemical reversibility refers to fast electron transfer kinetics between the electrode and analyte, following the Nernst equation.

Peak-to-peak separation (ΔEp) is used to assess reversibility, with a value of 57 mV at 25 °C indicating reversible electron transfer.

Nanomaterials, characterized by their nanoscale dimensions, offer unique physicochemical properties that make them highly attractive for a wide range of applications across various fields. The advantageous properties of nanomaterials are primarily attributed to their large surface-to-volume ratios and quantum effects, enabling improved and tailored

properties. Nanomaterials are utilized in the development of highly sensitive and selective chemical sensors for detecting gases, pollutants like heavy metals and also biomolecules.

2. Electrochemical cell used for cyclic voltammetry experiments.

Key components and their roles:

1. Working Electrode

This is the location of the relevant electrochemical reaction. Usually, it is composed of the subject matter being studied. The working electrode is central to the experiment, and its characteristics are crucial for data collection.

2. Counter Electrode:

The counter electrode is essential to complete the electrical circuit.

It doesn't participate in the electrochemical reaction but facilitates the flow of electrons. Typically, it is made of an inert material like platinum. To maintain a constant potential, the surface area of the counter electrode needs to be significantly greater than that of the working electrode.

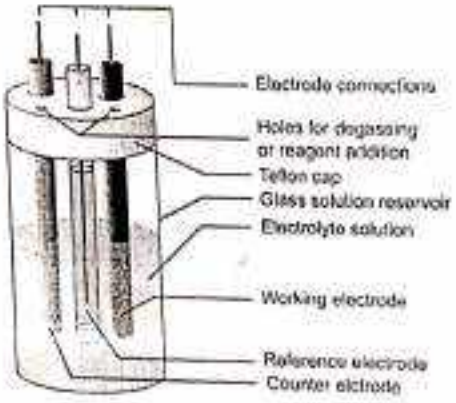

Fig. 1. Schematic representation of electrochemical cell

3. Reference Electrode:

The reference electrode is crucial for measuring and maintaining a stable and known electrochemical potential. It is usually a reversible electrode with a well-defined redox potential, such as a silver/silver chloride electrode. To guarantee the accuracy of the recorded data, the potential of the working electrode is monitored in relation to the reference electrode.

4. Electrolyte:

The electrolyte is the medium through which ions are transported between the working and counter electrodes. It's typically a solution containing the species of interest. The choice of electrolyte can have a significant impact on the reaction kinetics and the behavior of the electrochemical cell.

5. Cell Body/Container:

The electrochemical cell is contained within a vessel or cell body, which is usually made of chemically inert materials such as glass or plastic. It separates the working and counter electrodes and holds the electrolyte. The design of the cell body is crucial to prevent contamination and maintain a controlled environment.

In this review we are discussing the investigation of sensing ability of various nanoparticles towards different heavy metals, rare earth metals and biomolecules.

3. Methodology:

The nanoparticles to be used as a sensor is made as working electrode in the construction of electrochemical cell. This prepared working electrode; reference electrode and counter electrode are connected to the CV instrument and cyclic voltammograms are studies for the applications of NPs as a sensor.

Electrode Preparation by using Carbon Paste:

In most of the research working electrode is prepared as follows:

To form the carbon paste electrode (CPE), the generated sample NPs, silicon oil, and graphite powder were ground (hand mixed) in a mass ratio of 15:15:70 for about half an hour. The mixer was then put inside a microtip tube. The exterior of the cavity tube was polished until it was level with a piece of weighing paper.

4. Investigation of various Nanoparticles as a sensor

H.V. Harinia *et al*: Synthesized nanomaterial, $Cu_2ZnAl_2O_4$ (CZA), sensing ability investigation was conducted in a solution containing 1 N KCl. The synthesized CZA nanomaterial exhibited exceptional redox reaction properties

The synthesized CZA nanomaterial exhibited remarkable sensitivity and selectivity in the detection of lead and tin ions. This underscores its potential as a highly efficient sensor for heavy metal detection, which is crucial in environmental monitoring and industrial application.

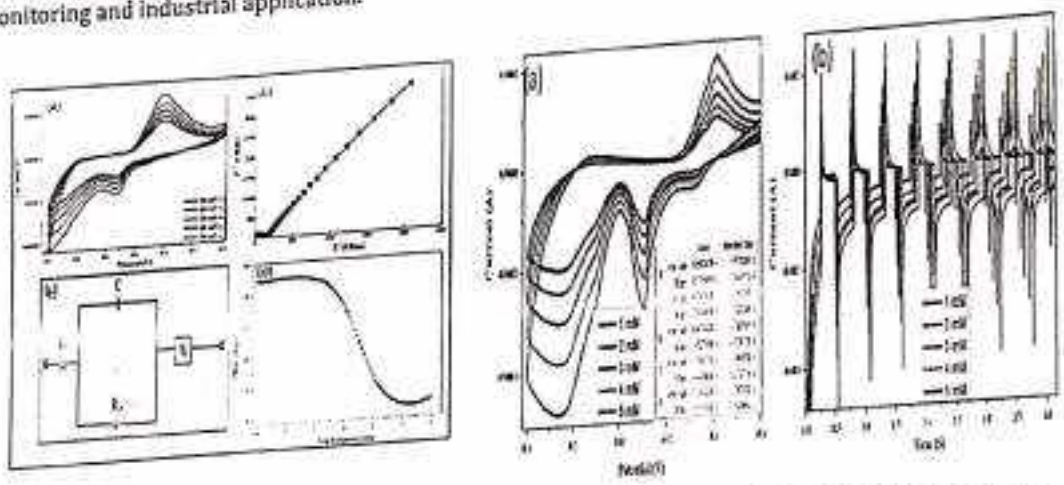

Fig. 2. a) CV plot, b) EIS spectra, (c) resulting circuit model and (d) Bode plot of modified CZA electrode.

Fig. 3a) CV plots of CZA NPs demonstrating lead detection and b) curve of amperometry during lead sensor.

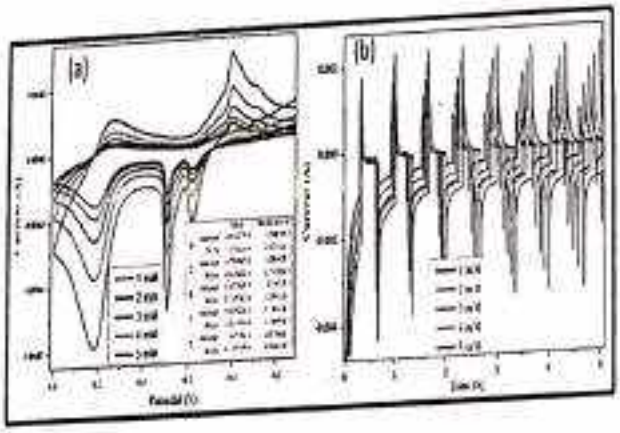

Fig. 4. a) CV plots of CZA NPs demonstrating Tin detection and b) curve of amperometry during tin sensor

$Cu_2ZnAl_2O_4$ (CZA) nanoparticles showed ability to detect lead and tin ions at concentrations of 1 mM (millimolar). The study reveals a rapid reaction time of 3 seconds for the electrode material. applications where rapid monitoring is required.

Improved lead and tin metal ion sensing potential was demonstrated by the CZA-modified electrode. This indicates that the CZA nanostructure enhances the sensitivity and selectivity of the electrode towards the target metal ions.

A. Naveen Kumar *et al:*

Synthesized $La_{10}Si_6O_{27}:RE^{3+}$ (RE = Eu, Sm, Dy, Tb) nanophosphors (LNPs) and investigated its application in electrochemical sensing, for paracetamol. The rare earth ions (Eu^{3+}, Sm^{3+}, Dy^{3+}, and Tb^{3+}) were doped into LNPs at a concentration of 5 mol%. The dopants enhanced the electrochemical sensing characteristics, making the LNPs more promising for sensor applications.The modified LNP electrodes were successful in sensing paracetamol in an acidic media. For medicines with a 1 mM concentration, a 3 second response time suggests the possibility of sensitive and swift detection.

Table1: Estimated particle size (nm) of $La_{10}Si_6O_{27}:RE^{3+}$ (5 mol%) NPs for (211) plane

Samples	*Planes*	*Particle sizes (nm)*
$La_{10}Si_6O_{27}:Eu^{3+}$ (5 mol%)	*(211)*	*0.274*
$La_{10}Si_6O_{27}:Sm^{3+}$ (5 mol%)	*(211)*	*0.275*
$La_{10}Si_6O_{27}:Dy^{3+}$ (5 mol%)	*(211)*	*0.280*
$La_{10}Si_6O_{27}:Tb^{3+}$ (5 mol%)	*(211)*	*0.273*

An efficient and widely used antipyretic and analgesic is paracetamol. It is commonly used as an over-the-counter medication to treat a number of illnesses, such as headaches, pain, fever, arthritis, and colds.

Detection and monitoring Paracetamol are crucial for preventing and diagnosing overdose situations, ensuring that individuals take the medication within recommended limits.

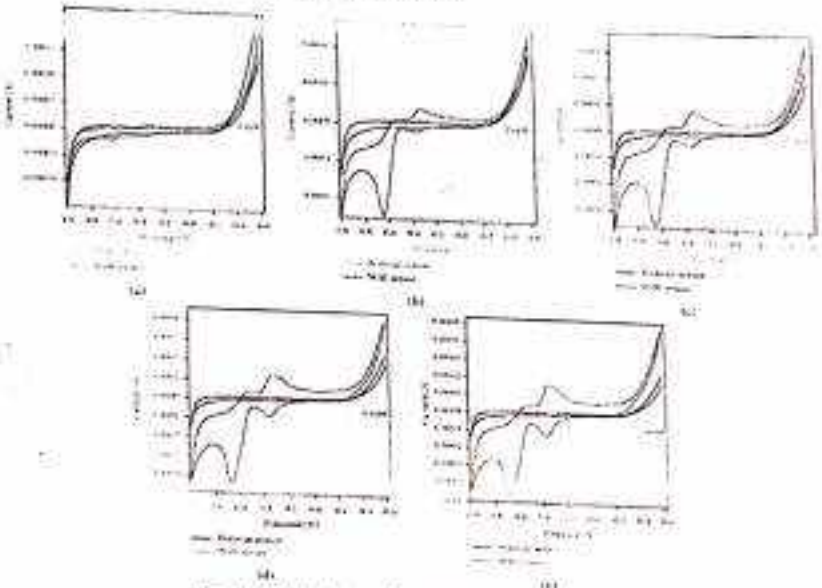

Fig. 5. a) CV plots of $La_{10}Si_6O_{27}:Eu^{3+}$ with and without sensor.

The study holds significance in providing a simple, rapid, and portable method for detecting and monitoring paracetamol levels.

The application of electrochemical sensors, particularly voltammetry, adds to the existing arsenal of techniques for drug quantification.

Table 2: Peak appearance at different potentials when employing the La10Si6O27 electrode material with different dopants to detect paracetamol

Sample names	Oxidation peak potential (V)	Reduction peak potential (V)
$La_{10}Si_6O_{27}:Eu^{3+}$ (5 mol%)	0.62, 0.37	0.34
$La_{10}Si_6O_{27}:Sm^{3+}$ (5 mol%)	0.78, 0.51	0.48
$La_{10}Si_6O_{27}:Dy^{3+}$ (5 mol%)	0.62, 0.35	0.34
$La_{10}Si_6O_{27}:Tb^{3+}$ (5 mol%)	0.6, 0.62, 0.36	0.32

Produced lanthanum oxide (La2O3) nanoparticles utilizing Tridax (T-La_2O_3) and Centella asiatica (C-La_2O_3) leaf powders using a green combustion method.The electrochemical behavior of the La_2O_3 nanoparticles was studied, to investigate the sensing ability for paracetamol using CV techniques. Results showed excellent sensing ability of the synthesized NPs.

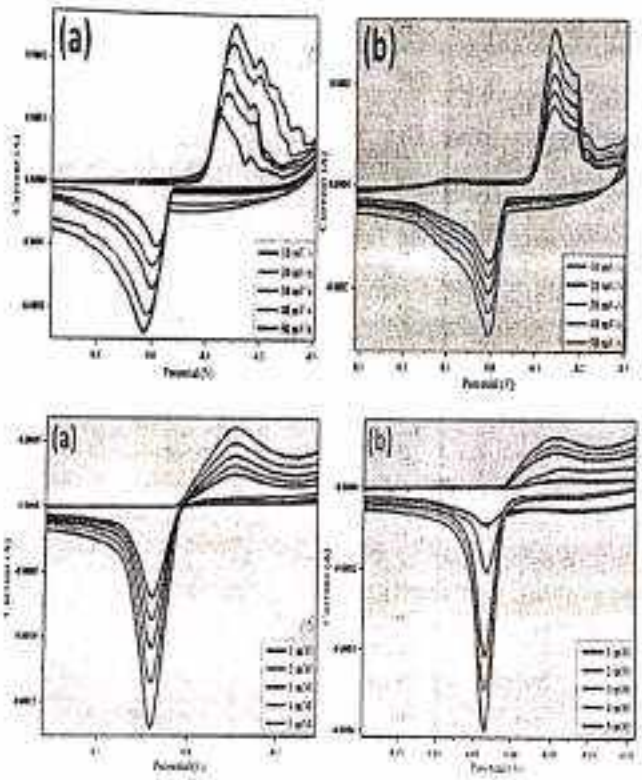

Fig. 7. Paracetamol cyclic voltametric sensing (1–5 mM)

Fig. 6. Cyclic Voltammogram of

(a) C-La_2O_3 and (b) T-La_2O_3 NPs v/s Ag/AgCl electrode using (a) C-La_2O_3 and (b) T-La_2O_3 electrodes in 1 M KOH electrolyte

Examined sensing applications for the detection of hazardous elements like lead as well as the production and characterisation of molybdenum oxide nanoparticles (MoO_3 NPs) utilizing a green combustion process with powdered Centella asiatica plant.

The capability is tested in basic medium. The electrode, composed of MoO_3 (Molybdenum trioxide), shows shift in both oxidation and reduction curves in the presence of lead, indicating its suitability for lead sensing. The oxidation peak shifts towards a positive potential, results in a peak value of 0.14 V that increases with higher lead concentrations

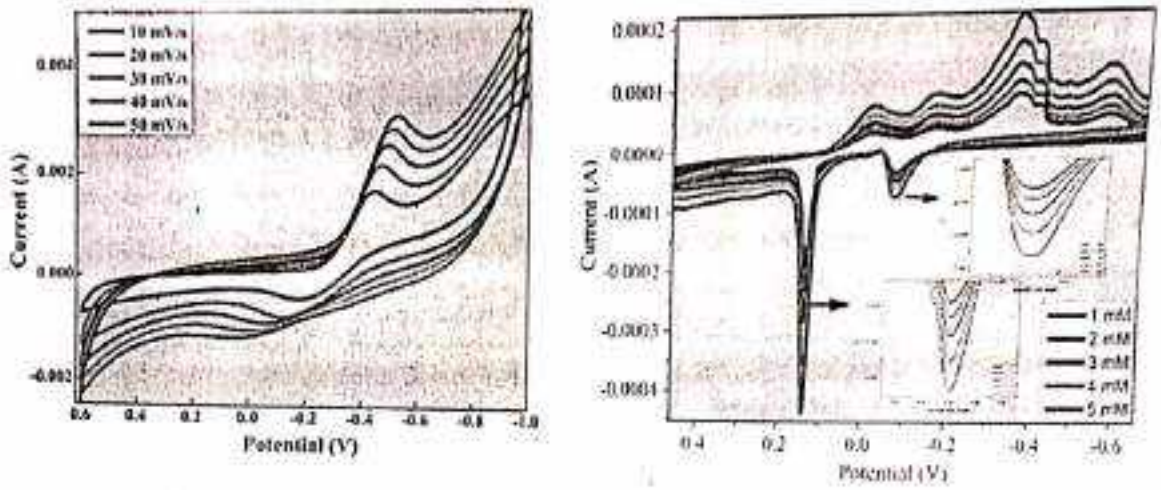

Fig. 8. Cyclic voltammogram of MoO_3 electrode

Fig. 9. Cyclic voltammogram of MoO_3 electrode for the detection of lead (concentration range 1-5 mM).

Synthesized using a straightforward and inexpensive probe sonication technique to produce bismuth oxide nanoparticles (Bi_2O_3 NPs). The synthesized nanoparticles showed high sensing ability for ascorbic acid and lead, suggesting its potential application in electrochemical sensing of biomolecules. CV studies done on the Bi2O3 electrode in 0.1 N HCl, revealing a specific capacitance value of 25.5.

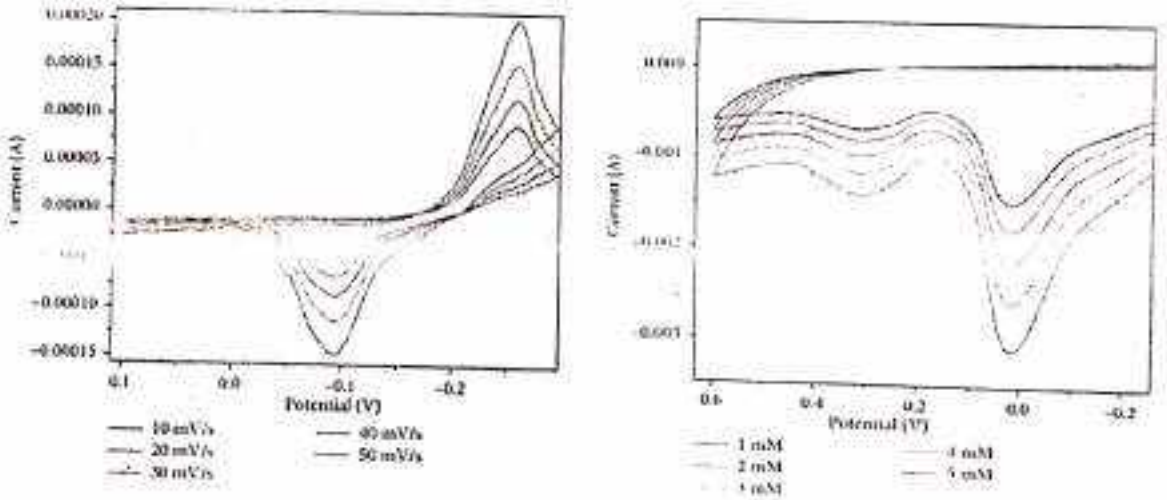

Fig.10. Ascorbic acid detection using the CV of Bi_2O_3 NPs

Fig. 11 CV of Bi_2O_3 NPs at varied scanning rates.

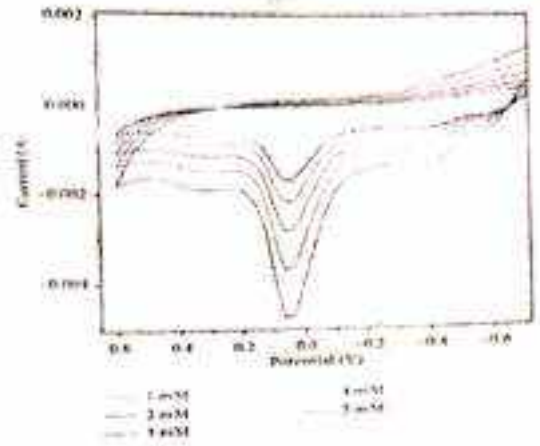

Fig. 12. CV of Bi_2O_3 NPs with detection of ascorbic acid lead

5. Conclusion:

The cyclic voltammetry (CV) technique is particularly valuable in nanoparticle sensor studies due to its effectiveness in providing real-time results. This method offers enhanced reliability, addressing the scientific challenge of accurately sensing specific metals or biomolecules in the presence of complex mixtures.

References:

1] Elgrishi, N., Rountree, K. J., McCarthy, B. D., Rountree, E. S., Eisenhart, T. T., & Dempsey, J. L. (2018). A practical beginner's guide to cyclic voltammetry. *Journal of chemical education*, 95(2), 197-206. https://pubs.acs.org/doi/10.1021/acs.jchemed.7b00361

2] Harini, H. V., Nagaswarupa, H. P., Bekele, E. T., Murthy, H. A., & Ravikumar, C. R. (2023). Novel synthesis of Cu2ZnAl2O4 nanostructures for photocatalytic and electrochemical sensor applications. *Sensors International*, 4, 100225. https://doi.org/10.1016/j.sintl.2022.100225

3] Kumar, A. N., Jnaneshwara, D. M., Ravikumar, C. R., Murthy, H. C., Prashantha, S. C., Kumar, M. R., & Ajay, K. M. (2022). A Comparative Cyclic Voltametric Study on Rare Earth (Eu, Sm, Dy, and Tb) Ions Doped La 10 Si 6 O 27 Nanophosphors for Sensor Application. *Advances in Materials Science and Engineering*, 2022. https://doi.org/10.1155/2022/7429133

4] Rashmi, B. N., Harlapur, S. F., Gurushantha, K., Ravikumar, C. R., Kumar, M. A., Santosh, M. S., ... & Murthy, H. A. (2022). Facile green synthesis of lanthanum oxide nanoparticles using Centella asiatica and Tridax plants: photocatalytic, electrochemical sensor and antimicrobial studies. *Applied Surface Science Advances*, 7, 100210. https://doi.org/10.1016/j.apsadv.2022.100210

5] Mamadha, K. M., Ravikumar, C. R., Murthy, H. A., Kumar, V. D., Kumar, A. N., & Jahagirdar, A. A. (2022). Facile green synthesis of Molybdenum oxide nanoparticles using Centella Asiatica plant: Its photocatalytic and electrochemical lead sensor applications. *Sensors International*, 3, 100153. https://doi.org/10.1016/j.sintl.2021.100153

6] Kusuma, K. B., Manju, M., Ravikumar, C. R., Dileepkumar, V. G., Kumar, A. N., Santosh, M. S., ... & Gurushantha, K. (2022). Probe sonicated synthesis of bismuth oxide (Bi2O3): photocatalytic application and electrochemical sensing of ascorbic acid and lead. *Journal of Nanomaterials*, 2022, 1-13. https://doi.org/10.1155/2022/3256611

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MORALE BUILDING PRACTICES IN CO-OPERATIVE BANKS A CASE STUDY OF URBAN COOPERATIVE BANKS IN BELAGAVI DISTRICT

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ABSTRACT

This research paper focuses on the morale building policies and practices in cooperative banking sector. To examine the morale building scenario in the said sector, the urban cooperative banks have been chosen as universe of the study and geographical area selected is Belagavi district. The employees of the sector have been classified as officers and clerks for analysis purpose. The collection of primary data and analysis thereof have been made to draw relevant inferences. The morale being a psychological issue may be flexible and dynamic scenario but in urban cooperative banking sector the morale boosting has become need of the hour since the employees are working at par with the employees of any nationalized banks. Moreover, the continuous motivation and morale situations in this sector assures the better performance of employees and thereby enhancement in overall performance in the profitability of the cooperative banks.

KEYWORDS
Morale, Cooperatives Banks, Belagavi, Pereptions

INTRODUCTION

Morale is a state of mind and emotions, affecting the attitude and willingness to work, which in turn affects individual and organizational objectives. It is co-operative attitude or mental health of number of people who are related to each other on some basis. Morale is a subjective concept. It is intangible and cannot be measured directly. The employees are usually unwilling to express openly their true attitude towards the work and the management. However, following methods may be adopted to measure morale. Observation, Direct interview, Questionnaire, Personal records and reports, Suggestion boxes.

OBJECTIVES OF THE STUDY

1. To study the perceptions of officers and clerks relating to Morale building policies pursued by the urban cooperative banks.
2. To compare the perceptions of officers and clerks relating to morale building practices pursued by the urban cooperative banks.
3. To offer suggestions to management of urban cooperative banks in the light of the findings of the study.

HYPOTHESES

Ho : There is no significant difference in perceptions of officers and clerks on morale development practices in urban cooperative banks in Belagavi District

H1 : There is significant difference in perceptions of officers and clerks on morale development practices in urban cooperative banks in Belagavi District

THE PROFILE OF STUDY AREA, STUDY UNITS AND RESPONDENTS

The universe of study is Belagavi district. In Belagavi district, there are 36 urban cooperative banks. 11 urban co-operative banks have one branch each. 7 urban co-operative banks have 2 branches each. 9 urban co-operative banks have 3 branches each. 6 urban co-operative banks have 5 branches each. 2 urban co-operative banks have 7 branches each. One urban co-operative bank has 13 branches. In Belagavi district, total number of employees in all urban co-operative banks is 910. Out of them, 786 are male employees and 124 are female employees.

RESEARCH METHODOLOGY

All 36 banks have been selected for the study. They have in total 109 branches. Two branches of every urban co-operative bank have been selected as sample. But in case of 11 urban co-operative banks, since number of branches is less than two, one branch thereof has been selected as sample. Hence, (25X2+11X1) i.e., 61 branches have been selected as sample on convenient random sampling basis. For selection of sample of employees, sensus method has been adopted. Sample of employees include 370 respondents consisting of 116 officers and 254 clerks. The close ended questionnaires regarding the morale policies and practices were prepared by using Likert Type Five Point Summated Scale. These questionnaires were canvassed and personally administered. To study the relation between the level of satisfaction of employees about morale policies, chi-square test has been used. Chi-square test is conducted for bivariate table to test the independence of the level of employment (officers and clerks) and the levels of response for each morale building policy. Since data is qualitative in nature and sample size is more than 30, Karl Pearson's chi square test is used for analysis. The p-value is calculated on the basis of chi square test. The inferences have been drawn to test the independence of perceptions

ERCEPTIONS AND DEVIATIONS DATA ANALYSIS ABOUT MORALE

S. No.	Perceptions Regarding morale	Perceptions					Total	Mean	S.D.
		SD	D	N	A	SA			
1	Encouraging employees to experiment new ideas	132	84	61	55	37	369	2.41	1.49
		36%	23%	17%	15%	10%	100%		
2	Training employees in the technical aspects	50	81	89	120	29	369	2.99	1.19
		14%	22%	24%	33%	8%	100%		
3	Initiating measures to create learning culture	62	85	102	118	22	369	2.93	1.19
		17%	16%	28%	32%	6%	100%		
4	Consideration of suggestions of employees by superiors	118	106	58	57	30	369	2.39	1.43
		32%	29%	16%	15%	8%	100%		
5	Effective schemes to encourage higher studies	63	84	113	85	24	369	2.79	1.17
		17%	23%	31%	23%	7%	100%		
6	Providing opportunities to collectively devise strategies	54	83	79	117	35	368	2.99	1.23
		15%	23%	21%	32%	10%	100%		
7	Counselling facilities to cope up with personal problems	65	71	108	107	18	369	2.84	1.17
		18%	19%	29%	29%	5%	100%		
8	Recognition of high performing staff by the bank	127	81	63	62	36	369	2.46	1.47
		35%	22%	17%	17%	10%	100%		

Source : Field Survey

INTERPRETATION OF PERCEPTIONS AND DEVIATIONS

(1) Encouragement for new ideas : The perceptions regarding encouragement by bank to introduce new methods and ideas have been responded by 369 employees. 216 (59%) respondents are of the view that employees are not encouraged to try out new ideas. 61 (17%) employees do not give any firm opinion. 92 (25%) respondents give positive opinion on this issue. The mean is 2.41 which rounded off to 2. Hence, majority of the employees accept that they are not encouraged to try out new methods and ideas. (2) Training in morale improvement:

369 employees responded on the statement, "Employees are trained in the scientific and technical aspects of morale measurement and improvement." 131 (36%) of them give negative opinion. 89 (24%) respondents do not give any firm opinion. 149 (41%) respondents are of the opinion that training about the scientific and technical aspects of morale measurement and improvement is given. The average perception is 2.99 which is highly close to 3. Hence, in this case employees do not give any firm opinion. (3) Creating learning culture :Regarding learning culture in the bank, 369 employees have responded. 127 (35%) respondents are of the opinion that bank does not take sufficient measures to create learning culture. 102 (28%) employees show neutral attitude. 140 (38%) respondents believe in the banks' policy of creating learning culture. The mean is 2.93 rounded off to 3. It shows that the majority of employees do not have firm opinion about availability of sufficient measures to create learning culture among employees. (4) Consideration of suggestions : 369 employees responded on policy of considering suggestions of employees by management. 224 (61%) respondents are of the opinion that management does not take into consideration the suggestions given by employees. 58 (16%) employees give neutral opinion. 87 (23%) respondents believe that the suggestions of

mployees are considered by superiors and management. The mean is 2.39 which is rounded off to 2. Hence it is clear that suggestions given by employees are not considered by superiors. (5) Encouragement for higher studies : On schemes regarding encouragement for higher studies, 369 employees responded out of 370 employees. 147 (40%) respondents feel that the there are no schemes in the bank to encourage for higher education. 113 (31%) employees give neutral opinion. 109 (30%) respondents agree that the effective schemes are sanctioned by the bank to encourage higher studies among staff members. The mean is 2.79 which is rounded off to 3. This reveals that majority of the employees have neutral opinion on encouragement for higher studies.

(6) Devising business strategies : The perceptions regarding opportunity to devise business strategies have been responded by 368 respondents out of 370. 137 (38%) respondents believe that opportunity to devise business strategies is not given to employees. 79 (21%) respondents are in undecided position. 152 (42%) respondents are of the opinion that the employees are provided opportunity to collectively devise business strategies. The mean is 2.99 which is very close to 3. It means that majority of the employees have neutral opinion about the opportunity to employees to devise business strategies. (7) Counseling facilities : Out of total 370 respondents in the sample, 369 employees have responded. 136 (37%) respondents agree that counseling facilities are not provided. 108 (29%) employees give neutral answer. 125 (34%) respondents give positive opinion. The mean is 2.84 which is rounded off to 3. It means majority of the employees do not have firm opinion about counseling facilities to cope up with personal problems. (8) Recognition of high performance: With regard to the recognition of high performance of employees, 369 respondents have replied. 208 (57%) respondents believe that the high performance of employees is not recognized. 63(17%) employees show neutral attitude. 98 (27%) respondents are of the opinion that high performing staff members are recognized by the bank. The mean is 2.46 which is rounded off to 2. Hence, majority of the employees agree that high performing employees are not recognized.

COMPARATIVE PERCEPTIONS OF OFFICERS AND CLERKS ON MORALE

S. No.	Perceptions regarding	Cadre	Perceptions					Total	Mean	S.D.	χ^2	P	Inference
	Morale		SD	D	N	A	SA						
1	Encouraging employees to experiment new ideas	Officers	43	30	18	11	14	116	2.34	1.52	4.9388	0.2936	NS
			37%	26%	16%	9%	12%	100%					
		Clerks	89	54	43	44	23	253	2.44	1.47			
			35%	21%	17%	17%	9%	100%					
2	Training employees in the technical aspects	Officers	13	21	32	38	12	116	3.13	1.17	4.0029	0.4056	NS
			11%	18%	28%	33%	10%	100%					
		Clerks	37	60	57	82	17	253	2.93	1.19			
			15%	24%	23%	32%	7%	100%					
3	Initiating measures to create learning culture	Officers	18	18	30	40	10	116	3.05	1.21	3.1206	0.5379	NS
			16%	16%	26%	34%	9%	100%					
		Clerks	44	47	72	78	12	253	2.87	1.17			
			17%	19%	28%	31%	5%	100%					
4	Consideration of suggestions of employees by superiors	Officers	45	36	12	12	11	116	2.21	1.53	9.1107	0.0584	NS
			39%	31%	10%	10%	9%	100%					
		Clerks	73	70	46	45	19	253	2.47	1.38			
			29%	28%	18%	18%	8%	100%					
5	Effective schemes to encourage higher studies	Officers	12	25	43	28	8	116	2.96	1.07	7.0200	0.1348	NS
			10%	22%	37%	24%	7%	100%					
		Clerks	51	59	70	57	16	253	2.72	1.20			
			20%	23%	28%	23%	6%	100%					
6	Providing opportunities to collectively devise strategies	Officers	7	24	29	40	16	116	3.29	1.13	13.5138	0.0090	VS
			6%	21%	25%	34%	14%	100%					
		Clerks	47	59	50	77	19	252	2.85	1.25			
			19%	23%	20%	30%	8%	100%					
7	Counselling facilities to cope up with personal problems	Officers	17	23	31	37	8	116	2.97	1.18	3.1495	0.5331	NS
			15%	20%	27%	32%	7%	100%					
		Clerks	48	48	77	70	10	253	2.79	1.16			
			19%	19%	30%	28%	4%	100%					
8	Recognition of high performing staff by the bank	Officers	41	24	18	18	15	116	2.50	1.51	2.3192	0.6773	NS
			35%	21%	16%	16%	13%	100%					
		Clerks	86	57	45	44	21	253	2.43	1.45			
			34%	23%	18%	17%	8%	100%					

Source : Field survey

(1) Encouragement for new ideas : As regards the policy of encouraging employees to experiment new ideas, 116 officers and 253 clerks have responded. Out of them, 73 (63%) officers and 145 (56%) clerks are of the opinion that the employees are not encouraged to experiment new methods and try out new ideas. 18 (16%) officers and 43 (17%) clerks give neutral opinion. 25 (21%) officers and 67 (26%) clerks believe that the employees are given encouragement to try out new ideas and new methods. The mean values of perceptions of officers and clerks being 2.34 and 2.44 respectively indicate that officers and clerks claim that they are not encouraged to experiment new methods and try out new ideas. As regards the standard deviation of officers and clerks being 1.52 and 1.47 respectively show that perceptions of clerks are dispersed lesser than those of officers. The chi square value is 4.9388 and the p value calculated at 4 degrees of freedom works out to be 0.2936. Since, p value is more than 0.05, the assumed level of significance, the officers and clerks do not have significant difference of opinions about the policy of encouraging experimentation of new methods and trying out new ideas. (2) Training in morale improvement : As far as the policy of training in the scientific and technical aspects of morale measurement and improvement is concerned, 116 officers and 253 clerks have responded. Out of them, 34 (29%) officers and 97 (39%) clerks believe that the training for measurement and improving morale is not given to employees. 32 (28%) officers and 57 (23%) clerks give neutral opinion. 50 (43%) officers and 99 (39%) clerks have positive opinion in this case. The average perceptions of officers and clerks being 3.13 and 2.93 respectively indicate that both officers and clerks have neutral opinion. The standard deviation of perceptions of officers and clerks being 1.17 and 1.19 imply that the opinions of clerks are dispersed slightly more than those of officers. The chi square value is 4.0029 and p value in this case based on 4 degrees of freedom is 0.4056. Since the p value is higher than the assumed level of significance, there is no significant difference among the officers and clerks regarding the training to employees in the scientific and technical aspects of morale measurement and improvement. (3) Creating learning culture : 116 officers and 253 clerks have responded on the statement relating to the policy of initiating measures to create learning culture among employees. Out of them, 36 (32%) officers and 91 (36%) clerks believe that the learning culture is not created by the bank. 30 (26%) officers and 72 (28%) clerks are having neutral opinion. 50 (43%) officers and 90 (36%) clerks perceive that the sufficient measures are initiated to create learning culture. The mean values of perceptions of officers and clerks being 3.05 and 2.87 indicate that the officers as well as clerks show neutral attitude in case of the learning culture in the bank. The standard deviation in case of officers and clerks being 1.21 and 1.17 reflect that the perceptions of officers are dispersed more than those of clerks. The chi square value in this case is 3.1206 and the p value based thereon at 4 degrees of freedom is 0.5379. Since the p value is more than 0.05, the assumed level of significance, the perceptions of officers and clerks in respect of the measures to create learning culture in the bank do not differ significantly. (4)Consideration of suggestions : The statement relating to the consideration of suggestions of employees by superiors has been responded by 116 officers and 253 clerks. Out of them, 81 (70%) officers and 143 (57%) clerks feel that the employee suggestions are not considered by superiors. 12 (10%) officers and 46 (18%) clerks give neutral opinion. 23 (19%) officers and 64 (26%) clerks believe that the management and superiors consider the suggestions of employees. The mean values of perceptions of officers and clerks 2.21 and 2.47 respectively

dicate that officers as well as clerks believe that suggestions given by employees are not taken in to consideration by management. The standard deviations of perceptions of officers and clerks being 1.53 and 1.38 imply that perceptions of clerks are dispersed less than those of officers. The chi square value is 9.1107 and the p value based on 4 degrees of freedom is 0.0584. Since the p value is higher than the assumed level of significance i.e., 0.05, the perceptions of officers and clerks on consideration of suggestions of employees by the superiors and management do not differ significantly. (5) Encouragement for higher studies : 116 officers and 253 clerks have responded on the statement relating to the policy of encouraging employees for higher studies. Out of them, 37 (32%) officers and 110 (43%) clerks believe that the employees are not encouraged through effective schemes. 43 (37%) officers and 70 (28%) clerks are having neutral opinion. 36 (31%) officers and 73 (29%) clerks perceive that the effective schemes are sanctioned be the bank to encourage higher studies among staff members. The mean values of perceptions of officers and clerks being 2.96 and 2.72 indicate that the officers as well as clerks show neutral attitude in case of the encouragement for higher education. The standard deviation in case of officers and clerks being 1.07 and 1.20 reflect that the perceptions of officers are dispersed more than those of clerks. The chi square value in this case is 7.0200 and the p value based thereon at 4 degrees of freedom is 0.1348. Since the p value is more than 0.05, the assumed level of significance, the perceptions of officers and clerks in respect of encouragement for higher education do not differ significantly. (6) Devising business strategies : As far as the policy of giving the opportunity to devise business strategies is concerned, 116 officers and 252 clerks have responded. Out of them, 31 (27%) officers and 106 (42%) clerks believe that the employees are not provided through meeting to collectively devise business strategies. 29 (25%) officers and 50 (20%) clerks give neutral opinion. 56 (48%) officers and 96 (38%) clerks have positive opinion in this case. The average perceptions of officers and clerks being 3.29 and 2.85 respectively indicate that both officers and clerks have neutral opinion in this case. The standard deviation of perceptions of officers and clerks being 1.13 and 1.25 imply that the opinions of clerks are more dispersed than those of officers. The chi square value is 13.5138 and p value in this case based on 4 degrees of freedom is 0.0090. Since the p value is much lesser than the assumed level of significance, the perceptions of officers and clerks regarding the policy of giving opportunity to devise business strategies differ very significantly. (7) Counseling facilities: As far as the policy of providing counseling facilities is concerned, 116 officers and 253 clerks have responded. Out of them, 40 (35%) officers and 96 (38%) clerks believe that the counseling facilities are not provided to employees. 31 (27%) officers and 77 (30%) clerks give neutral opinion. 45 (39%) officers and 80 (32%) clerks believe that the counseling facilities are available in the banks and the personal problems are solved. The average perceptions of officers and clerks being 2.97 and 2.79 respectively indicate that both officers and clerks have neutral opinion. The standard deviation of perceptions of officers and clerks being 1.18 and 1.16 imply that the opinions of clerks are less dispersed than those of officers. The chi square value is 3.1495 and p value in this case based on 4 degrees of freedom is 0.5331. Since the p value is higher than the assumed level of significance, there is no significant difference among the officers and clerks regarding the policy of providing employees to cope up with the personal problems. (8) Recognition of high performance : As regards the policy of recognizing high performance of employees, 116 officers and 253 clerks have responded. Out of them, 65 (56%) officers and 143 (57%) clerks are of the

Union that the staff members who show high performance are not recognized. 18 (16%) officers and 45 (18%) clerks give indifferent opinion. Further, 33 (29%) officers and 65(25%) clerks are of the opinion that employees showing high performance are recognized. The mean values of perceptions of officers and clerks being 2.50 and 2.43 respectively indicate that officers have neutral opinion in this case but clerks believe that high performing employees are not recognized by the bank. The standard deviation in case of officers and clerks being 1.51 and 1.45 respectively show that the opinions of clerks are less dispersed than those of officers. The chi square value is 2.3192 and the p value based on 4 degrees of freedom is 0.6773. Since the p value is more than 0.05, the assumed level of significance, there is no significant difference in the perceptions of officers and clerks in case of the policy of recognizing high performing staff.

TESTING OF HYPOTHESES

At 5% level of significance and degrees of freedom 4, following inferences have been drawn on 8 types of perceptions viz., NS=7, S=0, VS=1, HS=0. In case of 7 out of total 8 types of perceptions, there is no significant difference among officers and clerks in respect of morale building practices adopted in urban cooperative banks in Belagavi district. Hence the null hypotheses is acceptable and Alternate hypotheses is rejected.

FINDINGS

In respect of the encouragement to introduce new methods and ideas, majority of the employees (officers as well as clerks) accept that they are not encouraged to experiment new methods of work. Their opinions do not differ significantly. As far as the policy of training employees in technical and scientific aspects of morale measurement and improvement is concerned, majority of the employees (officers as well as clerks) have neutral opinion. Their opinions do not differ significantly. Majority of the employees (officers as well as the clerks) show neutral attitude on the policy of creating learning culture among employees. They do not have significant difference of opinion. In respect of the policy of considering suggestions of employees by superiors, majority of the employees (officers as well as clerks) consent that their suggestions are not taken in to consideration by superiors or management. Their opinions do not differ significantly. In case of schemes regarding encouragement for higher studies, majority of the employees (officers and clerks) have neutral opinion. Their opinions do not differ significantly. In respect of the policy of giving opportunity to devise business strategies, majority of the employees (officers as well as clerks) have neutral opinion. Their opinions differ very significantly. In respect of the policy of providing counseling facilities to cope up with personal problems, majority of the employees (officers as well as clerks) have neutral opinion. Their opinions do not differ significantly. In case of recognition of high performance of employees, majority of the employees are of the opinion that employees showing high performance are not recognized. But officers show neutral opinion in this case. However the opinions of officers and the clerks do not differ significantly.

SUGGESTIONS

To enhance the morale, the banks need to consider innovative ideas of employees and create learning culture among them. The employees should be provided counseling facility in the bank to solve their personal

problems. The recognition of good work is very much essential to boost morale of the employees. Hence, clear cut incentive schemes in financial terms viz., cash prize, advance increments for better performance and achievement of targets may be introduced. They may bring the complete fineness among the employees and reflect into good results for the banks.

REFERENCES

1. Naresh Kumar (2003) Motivation and Morale in Banking Administration. Mittal Publications, New Delhi.

2. Khandelwal Anil (1988) Human Resource Development in Banks. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

3. Basu K.S. (1979) New Dimensions in Human Resource Management. The Macmillan Company of India Ltd., Delhi.

4. Bhatia B.S., Verma H.L., Mahesh C. Garg (1994) Encyclopedia of Co-operative Management, Co-operatives and Human Resource Development: Tapping Manpower Resources. Deep and Deep Publications, New Delhi.

5. Ravichandran, Balakumaran (2019) Factors Affecting Employee Morale in the Indian Automobile Industry - A Literature Review , International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321-9653, Mar 2019

6. Arvind Mallik, Lakshmi Mallik, Keerthi DS (2019) Impact of Employee Morale on Organizational Success International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Nov 2019

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Ramification of FinTec Services in India- Prospects and Constraints

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ABSTRACT

This conceptual study of fintech focuses on revolution in services in financial sector. Due to technology, the financial sector has been innovated and nature of services in this sector has been revived. Technology has a great influence on all sectors of economy. The technology has made dramatic changes in all the procedures and systems of processing the data, making payments, transacting business, handling communication, managing workers, etc. Artificial intelligence and snapchat have also created many opportunities and challenges in the finance sector. The financial management has also been influenced by the recent trends in technology. The introduction of technology and its development in finance field have enhanced the accuracy and speed of transactions, reduced corrupt practices, brought transparency. The digitalization of banking , insurance, finance and other sectors has created many opportunities as well as brought many challenge. The combined use of finance and technology has facilitated millions of people and provided services to a large extent. The traditional system of finance has been replaced by Fintech. The present paper enlightens the use of fintech in Indian economy and what are the opportunities and challenges faced while adopting fintech.

KEYWORDs Fintech, innovation, digitalization, financial services, artificial intelligence

INTRODUCTION

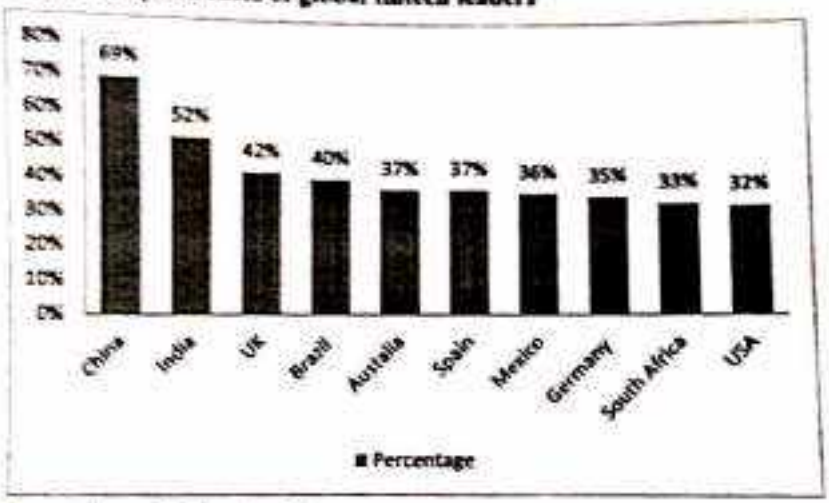
Fintech is use of technology in financial field. This use has brought new avenues in the field of financial inclusion, innovation, digital banking , digital insurance, payment systems, crypto currency, cyber security, etc. In India, the private sector has first adopted the fintech in its operation. ICICI bank, HSBC Bank were the pioneer finance companies which have used fintech in eighties and nineties. After the introduction of LPG policy by Government of India the fintech as extensively used in finance field to enhance the quality of

service. In 2008, due to subprime crisis in America, the use of modern facilities in social media, and artificial intelligence gained more importance. Since India has the second largest internet user population, there is large scope of using the fintech in all services in finance.

FIN TECH IN INDIA

The revolution in finance has made changes in finance sector in India. The linking of adhaar card number , bank account number and mobile number has made it compulsory to use technology in finance sector. During the lockdown period due to COVID 19 the fintech adoption increased to a large extent. The cash less and paperless offices and companies are emerging due to this. The demonetisation and payments or transfers through various applications have also contributed to the fintech adoption. FinTech now covers sectors such as investment management, retail banking, education, BFSI sector.

Fintech adoption rates of global fintech leaders



Source Fintech Adoption Index

Above table shows the adoption of fintech in various countries. All market participants can interact, participate, and share ideas across active communities and networks at a fintech hub. This is also where opportunities are found and turned into profitable ventures. Nowadays, since financial services are driven by technology, no market player can afford to work in isolation.

FINTECH MAKET IN INDIA	Share in the fintech
Financial sector	28%
Saving and Investments	16%
Loans and advances	27%
Payments online	9%
Banking Infrastructure	20%
Others	100%

Source : Economic Times 29th August 2022

From the above table it is clear that out of total 6386 fintechs, 28% are engaged n saving and investment sector, 16% are engaged in loans and advances sector, 27% are engaged in online payments sector, 9% are engaged in banking and infrastructure sector and remaining 20% are involved in other types of industries.

The internet banking, real time payment system, investment consultancy online, speedy loan sanction and other such activities have provided platform for Fintech market in India. Transparent insurance advisory and distribution, relative lending, and a variety of other services have been largely digitalised. Fintech included now market for financial services such as insurance, personal finance, gold lending, etc

Payment tech :

Financial technology is used now a days for online payments. Customer centered services like prepaid card/Wallet, third-party application providers (TPAP), QR code payment, bill payment, point of sale (POS) and payment aggregator can be used . Corporate cards, B2B payments, and invoice payments are examples of business-centric services. Fintech enters this area through the usage of services such as payment gateways, card networks, application programming interface (API)/White label solutions, and payment security. The biggest participants in this area include PhonePe, Paytm, Google Pay andMobiWik.

Lending tech :

The sanctioning of loans is also done now a days with the help of technology. Buy now pay later (BNPL), salary loans, personal loans, vehicle loans, gold loans, peer-to-peer lending and school loans are some of the consumer focused services available in this market area. Business focused services include fixed term financing, trade financing and corporate cards. Credit bureau collections management, lending as a service, alternative credit scoring, loan management system and loan origination system (LOS), and are among the fintech services used in this market area (LMS). Leading lending platforms for both individuals and businesses are emerging, including M-Swipe, Google Pay and Razor Pay (Briefing, 2022).

Digitalisation:

The paperless banking system has developed many banking services.The financial system is moved to a new platform by digital banking. Now that all paper work has been converted to digital format. The banks are now expanding its digitalization by adding new business divisions such retail banks, digital and

The government also took steps to increase financial awareness among residents, including as establishing a National Centre for Financial Education and executing the RBI's Centre for Financial Literacy project.

OPPORTUNITIES IN FINTECH

Bitcoin and crypto currency have emerged in new market . A lot is changing in the digital world However, we are falling behind in the worldwide race. Fintech in India is rapidly expanding due to advances in technology and people's capacity to manage it. A few obstacles also stand in its way. We started with the barter system and are now talking about Bitcoin and crypto currency. A lot is changing in the digital world. However, we are falling behind in the worldwide race.

1 Artificial Intelligence and Fintech

Data analysis, credit risk assessment, detecting banking fraud, increasing safety, automated customer service, analyzing user behavior, financial forecasts are the areas where the artificial intelligence plays an important role in fintech. AI brings back the personal touch to banking, which has been somewhat lost in recent decades due to the dominance of multinational banks.

2 Digital payments:

The small payments are made in day to day transactions. The various payment apps have helped common man to book a ticket, eat food in hotels and buy fruits. The currency change problems during the marketing , travelling has been removed. From using a mobile wallet to buy vegetables to using a credit card to pay for a hotel room. Digital payments are ubiquitous, and their presence makes life easier and faster. Cash payments require less storage space than digital payments. This was a huge growth over the preceding three years. There is no longer any waiting period or a line in front of a bank. With a digital transaction, you can be anywhere in the world and get anything.

3 Big Data analytics:

The demonetization and Covid 19 situations brought the need ofgoing digital and adopting all paperless transactions. The banks and financial institutions have started to use different softwares. As data and analytics have developed over the past ten years, organisations have come to rely more and more on them. The Big data and analytics are being used to develop more individualised and focused user experiences. Companies employ data and analytics to be competitive because they enable better operations, more revenue, foresight of customer needs, individualised product offers, and demand forecasting. This should serve as a reminder to businesses that analytics are necessary if there is massive data. Their relationship is unbreakable. The banking industry is moving swiftly toward data-driven optimization; therefore, businesses must make careful, planned adjustments to these advancements. Using the consumer data that has been gathered to generate business results will be very instructive.

subsidiaries, and SME (small and medium company) neobanks. Account aggregators, conversational platforms, API providers, aggregators, banks with open APIs, banking as a core, and service banking are all examples of digital banking. Some of the big companies with a focus on digital banking are YONO and Kahata book.

Insuranceservices:

Policy bazaar is the best advertisement in television which focuses on the insurance technology. The banks after LPG policy entered in the insurance business and they also started provoding the online insurance facilities. During Covid 19 period the insurance business was done online to a large extent. The electronic devices have been used for real time insurance. Employee insurers, electronic insurers, comparison insurance platforms, and digital insurers are major players in the modern age. Offering services such as a sales platform, insurance infrastructure API, claims management, underwriting risk management insurance, policy admin system, and product configurator are all examples of how fintech may be used.

Wealth creation :

Now to create more wealth the advice is given online by the consultants. Through discount brokers, robo advisors, research platforms, mutual fund investment platforms, research platforms, and alternative investment platforms, technology can be used in this market to deliver services linked to wealth and expense management. Portfolio management suites, white-label robo advisors, and CapTable management are examples of Fintech services that are suitable in this market. Leading companies in this market include Smallcase and Zerodha.

Regulation Technology :

The regulating bodies have also now a days issued regulations online. KYC documents, on boarding, fraud detection, anti-money laundering (AML), as well as solutions for banking compliance and risk management are used in financial technology. In the financial services industry, the technology is also used to comply with regulatory standards like KYC and AML. This is not a one-year plan to make India a thriving fintech market; rather, it is the culmination of years of hard effort to achieve this new level of success. The following are the main components for this recipe

Jan Dhan Yojana:

The financial reward have been received under this scheme by majority of people in India. In 2014, about 450 million people joined in it and received financial rewards. When a bank account number, Aadhar card number and mobile number have been linked to each other, it helped to receive the Government benefits. It has helped to remove corruption practices in online transfer of the subsidies and incentives to beneficiaries.

Financial Literacy:

SEBI, RBI and NSE are some of the organizations which are organizing financial literacy programmes. Financial applications have been now introduced to provide the information to customers. People are growing more aware of fintech and its uses throughout time. Not only did it facilitate simple and secure transactions and investments, but it also aided victims of phishing, fraud, and other financial crimes.

4 Block Chain Technology:

In a corporate network, tracking assets and recording transactions is made easier by this technology. It is decentralised database. It is a list of dynamic records. It employs encryption to link back to one another. It include transactional data. The purpose of blockchain data is to serve as a secure record of transactions. Even for tech buffs, the nuances of the technology can be challenging to understand, but everyone can see how popular and common the technology is becoming. Blockchain technology can be applied to public and private ledgers for record-keeping and inter-company transactions.

5 Personalization:

Digital changes have made customer more satisfied. Financial institutions today are in competition not only with one another but also with the technologies they employ. Everyone aspires to excel others. Because of this, banking has taken on a new dimension: customization. Personalization and banking go hand in hand. Personalization in banking benefits companies every time.

6 Robotic process automation:

Robotic process automation makes it possible for individuals to gather and analyse information so they can benefit from it. People want to take advantage of the current scenario and want a thorough market study so that they can make an efficient investment. Businesses must get ready to offer new features with Robo advising services in order to take advantage of this exceptional opportunity. They offer banking sector services such customer support, account opening procedures, and other financial-related activities.

7 Government Interference:

The government took the initiative and, for the upbringing of Fintech, launched many programmes. Digital financial companies have profited from start-up programmes of many countries. Additionally, the Reserve Bank of India offered a simple method for launching a FinTech start-up.

CHALLENGES IN FINTECH

1 Privacy of Data:

Data privacy is a big problem. As per the nature of trade, Fintech has a lot of data like social security numbers, credit card numbers, investment information, income statements, and so on. Mobile usage and internet-based services that provide this kind of information are always at risk of transit. Protecting its information is critical if many frauds and phishing attempts are to be avoided. Due to technology improvements, it is now possible to remotely access essential IT technology, making it simpler to compare sophisticated data to sources of financial data. The absence of physical checks on crucial infrastructure and endpoint devices that transport firm data are further issues.

2 Regulatory and Compliance Laws:

Establishing a Fintech company is not simple. It has become very challenging to obtain government permission for a variety of reasons, including fraud and data theft. In addition to being difficult to follow, these limitations also make it challenging for fintech companies to access the Indian market. Make

compliance regulations function as a strict regulatory framework to prevent fraud. They too act as substantial obstacles for emerging financial businesses. Before they may operate, fintech start-ups must satisfy a broad list of standards.

3 Putting the client experience first:

Finance is complicated for the average person to understand. A sound financial decision and investment involve a lot of work. As fintech advances into simpler platforms, it is now possible to easily incorporate it into people's lives and improve their quality of life. However, there is still more to be done in order to make the end user's experience simple.In terms of accessibility and ease, fintech's have led the way. Additionally, opening an account with any of the banks is now straightforward. There is more transparency because fees and charges are disclosed up front. Trading platforms like Robinhood have simplified the jargon of finance.

4 Business Model:

Adapting to and expanding upon changing revenue and business models requires fintech's to revaluate their resource allocation and income and expense strategies. Many organisations are employing cost-cutting measures including personnel reductions and compensation reductions to deal with the economic crisis. There will be numerous adjustments that must be done inside businesses if company booms. Changes in revenue sources and other business dependencies are included in this. Your business models will also change as a result. Fintech companies that specialise in contactless payments are reusing their resources to handle the increased transaction volumes.

5 Personalized Services:

Businesses find it challenging to adapt and provide individualised services, as is well known. Businesses find it difficult to provide, despite the fact that it has always been a crucial and fundamental component of banking. Personalization in today's environment refers to interacting with a user in the present on their preferred channel. You must respond to their particular needs with a solution that is customised. Customers mean this when they talk about personalised services. On any other basis, they are not prepared to agree to a settlement.

6 Lack of Financial Literacy:

People are being transformed by fintech, yet a lack of literacy is still keeping them from attaining their full potential. Additionally, customers are open to using fintech as a financial wellness advisor. The extensive selection of settings can be overwhelming to some people. However, effective personalization guarantees that customers only see the options that are pertinent to them.

CONCLUSION

Future technological advancements will likely drive the market's continued growth and alter the production, distribution, and use of financial goods and services over the next several years, according to the fintech industry. FinTech has to do much more in its domain in India, India are still lagging in this race. Government, organization and associations are doing in this direction.

References

1. Ashish Saxena, Renu Jain, Anjali Mandal (2022) Fintech in India: Current Status, Trends and Prospects, Journal of Business management and Information Systems, Vol 9, Issue 2 Jul-Dec 2022
2. Gomber, P., Koch, J.-A., &Siering, M. (2017). Digital Finance and Fintech: Current research and future research directions. Journal of Business Economics, 87(5), 537–580.
3. Adomavicius, Bockstedt, Gupta, & Kauffman. (2008). Making sense of technology trends in the Information Technology Landscape: A design science approach. MIS Quarterly, 32(4), 779. https://doi.org/10.2307/25148872
4. Gomber, P., Koch, J.-A., &Siering, M. (2017). Digital Finance and Fintech: Current research and future research directions. Journal of Business Economics, 87(5), 537–580. https://doi.org/10.1007/s11573-017-0852-x
5. Times, E. (n.d.). Why India is at the forefront of a fintech revolution. The Economic Times. Retrieved August 29, 2022, from https://economictimes.indiatimes.com/whyindia-is-at-the-forefront-of-a-fintechrevolution/articleshow/86936413.cms

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IMPACT OF ARTIFICIAL INTELLIGENCE ON EDUCATION SECTOR IN INDIA

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ABSTRACT

Artificial intelligence (hereinafter AI) is the current burning issue in the field of technology. It is concerned with making computers behaving like human beings. Many facilities have been included in the artificial intelligence. Game playing, expert systems, neural networks, natural language, and robotics are some of them. Artificial intelligence greatly increases the efficiency of the existing economy. However, AI may have impact on the innovative ideas of human beings. The research on artificial intelligence is enhanced during recent times. The sector is influencing the education field in all possible ways. The challenges are posed in case of employment opportunities. Currently, even though no computers exhibit full artificial intelligence but in future AI is going to become part and parcel of every activity. The Government is also trying to adopt strategies to implement AI in various sectors. India stands fifth in the ranking of investment in artificial intelligence.

KEYWORDS

Data mining, Artificial intelligence, Higher education, Machine learning, General purpose technologies, Deep learning

INTRODUCTION

American computer scientist John McCarthy evolved the concept of artificial intelligence. Artificial intelligence is a system which is a result of innovative practices in technology. The AI helps to process the data in very fast manner. The AI also adopts algorithm. The outputs processed by AI gives more accurate output. The speed of processing data is also more than normal data processing. The AI has been now therefore applied in medical education, management education, commerce education, etc. The concept of AI is now adopted worldwide. At global level companies formed by Alan Musk are plying important role in AI. In India,

Tata Elxsi Ltd is the largest company adopting AI. Many other companies listed on stock exchange such as TCS, Infosys, Wipro are adopting AI. The researchers in India are also now focusing on the use of AI in all sectors for accuracy in speed in processing data. The teaching, learning, evaluation and research are important areas where the educators and researchers are using AI for various purposes.

OBJECTIVES OF THE STUDY

The present paper is intended to the following objectives.

1. To evaluate the prospects and constraints of AI
2. To study the impact of AI on education sector
3. To study the opportunities and challenges created by AI
4. To state the research based findings and suggestions.

NEED FOR THE STUDY

The AI is current burning issue. The AI helps in achieving educational priorities in better ways. According to the needs and strength of the students, the process of education can be enabled at lower costs. The adaptability of the learning resources and teaching assistant tools to meet the individual needs are possible due to AI. Voice assistants, mapping tools, shopping recommendations, essay-writing capabilities applications are enabled by AI. However, some uses of AI may be infrastructural and invisible, which creates concerns about transparency and trust. AI often arrives in new applications with the aura of magic, but educators and procurement policies require that edtech show efficacy. AI may provide information that appears authentic, but actually is inaccurate or lacking a basis in reality.

RESEARCH METHODOLOGY

The paper is an exploratory study based on the secondary data.The Library research method is adopted to gather information. Since the concept of AI is recent issue in India, the information is collected from journals, magazines, periodicals , newspapers and online research papers.

AI IN EDUCATION SECTOR

Divya Chopra (2023) opined that education and AI can be collaborated and such combination enhances the speed and reduces cost of processing. The old and outdated methods have been refined by AI. The innovative ideas have been reshaped. Such ideas are helping on large scale the innovation and research. AI and Chat GPT are becoming the basis to frame criteria for technical literacy. The report of India Brand Equity Foundation , due to AI the enrolment of students may increase during 2021 to 2025. Especially the enrolment may increase in case of higher education

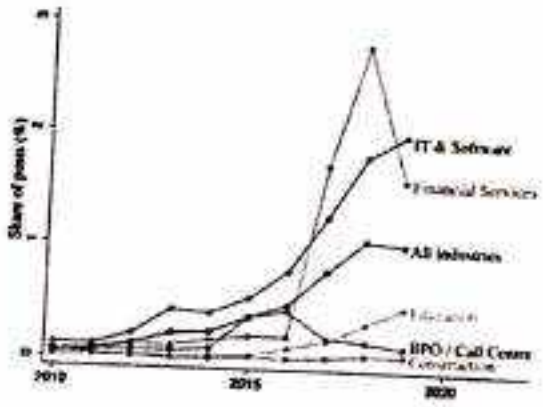
Of the highest importance, AI brings new risks in addition to the well-known data privacy and data security risks, such as the risk of scaling pattern detectors and automations that result in "algorithmic discrimination" (e.g., systematic unfairness in the learning opportunities or resources recommended to some populations of students). The AI introduced following various systems in the education sector.

1. Personalised learning
2. Translating languages
3. Automation
4. Grading and assessment
5. Real time assessment
6. Voice assistants
7. Personalised communication
8. Smart content
9. Collaborative learning

IMPACT OF AI ON EDUCATION

The AI roles tend to require substantially more education, particularly graduate degrees, while also paying significantly more. Even after controlling for detailed region, industry, firm, occupation and role fixed effects, posts demanding AI skills still pay a 13 to 17% salary premium. Such roles are heavily concentrated in a few key technology clusters – particularly Bangalore, Mumbai, Hyderabad, Pune, Chennai and Delhi – and in the largest firms. Consistent with this spatial clustering, we find evidence of local diffusion: after the first firm in a given industry and region adopts AI, other firms in the same industry and region are, on average, more likely to start demanding AI skills, even after taking into account industry and region trends.

AI employment trend in education and various related sectors



Source: https://www.ideasforindia.in/topics/productivity-innovation/ai-and-services

Artificial intelligence (AI) is employed at increasing speed in IT and financial services. Gradually the application of AI is also increasing in education field. It is utilized in schools, colleges and universities to review projects, conduct tests, and make different decisions. AI is now adopted to meet personal requirement of students. The music and art are also possible to learn and composing songs and include dialogues. The personal communication and technological influence have intervened in education sector.

The scientists have succeeded in constructing systems which can learn to think, talk and reply to many problems of people. The technology has advanced to such an extent that computer can now overtake the

human beings in handling various situations. Artificial intelligence in education (AIEd) is having more impact on higher education. The publications on AI are also increasing day by day. Four areas have been focused by AI which are relevant to the educational services.

1. profiling and prediction,
2. assessment and evaluation,
3. adaptive systems and personalisation, and
4. intelligent tutoring systems.

AI increases the possibilities of different methods of innovation. It reshapes the innovative ideas. It creates potentials for application specific algorithms. The policies are becoming transparent and effective due to AI.

The education system is transformed by AI. The process has given better outcomes through AI than the traditional processes. The AI enhances possibilities to meet the need based, student centered and experience based approach in education sector. SWOT analysis, feedback analysis, data analysis and statistical applications through AI tools empowered the educational process performance.

Number of AI Publications by field of study (2021-22)

Field of Study	Number of AI publications (Thousands)
Pattern Recognition	59.36
Machine Learning	42.55
Computer vision	30.07
Algorithm	21.53
Data Mining	19.18
Natural Language processing	14.99
Control theory	11.57
Human Computer Interactions	10.37
Linguistics	6.74

Source :AI Index Report 2023, Center for Security and Emerging Technology

The changes occurred due to AI in educational sector are as follows:

1. **Automation**

The conducting of tests, giving grades, calculating CGPA, getting student grievances, collecting feedback, verification papers and feeding of marks, payroll management and various such activities conducted through AI helps to reduce the costs and saving more time. The error free and systematic approach have been adopted through AI. AI tutors in educational institutions are more smarter than the physical teachers. Memory, grasping and communication are well polished and additional support is geven in this process by AI.

2. **Feedback**

AI based feedback collection, analysis and taking actions are helping educational institutions to take early decisions to improve learning experience. The performance based online courses are framed by many governing bodies with the help of AI.

3. **Evaluation**

The teachers are able to evaluate performance of students and finding out the gap in performance of students becomes easy due to AI. In limited time the teachers are able to save time in solving problems, making classroom more interesting. The AI driven grading system and preparing the reports help students while learning.

4. **Personalization**

The AI will not replace the teachers but it will help the teachers to act more effectively with the students. It is programmed to self learning process and enhances the level of understanding by students. The strength and weakness of students are considered to frame the learning material through AI.

5. **E-content**

The AI helps to frame digital content. Customisation, e-books, e guides and scanning codes Information. Visualising the objectives and fulfillment of the objectives give scope for simulation and visualization. The e-content preparation through AI is becoming more effective in many educational institutions.

6. **Innovativeness**

The learning disabilities have been removed or adjusted due to AI. The challenging life faced by disable students can be converted into happy life. The difficulties faced by such students can be removed or eased by AI. Need based system, e teaching material help the students to fulfill their needs.

7. **Universalization**

High quality material can be created and it can be popularized. The students can increase their abilities and learn anytime and anywhere. Students are able to learn many courses and that too at home.

PROSPECTS OF AI

The report by International Labour Organisation on AI states that there is lot of impact on employment. However there are many prospects of AI.

1. **Learning**

Anytime, anywhere learning help to plan to prepare schedule. The AI enhances the productive hours.

2. **Engagement**

Involvement and engagement of students with the help of AI help to make more interaction and visualization. The learning becomes more personalised.

Relaxation

AI reduces the pressure of students and makes study relaxed. Virtual assistants help the students. The basic questions can be answered with the help of AI.

CONSTRAINTS AND CHALLENGES OF AI

During annual meeting of World Economic Forum at Devas (Switzarland) IMF Chief Christolina Georgiya mentioned that about forty percent jobs would be in danger due to artificial intelligence. The impact on employment will be more severe in case of developed nations.

With the unleashing of generatives AI technologie (like ChatGPT, Midjourney, Bing and Bard) some questions have been raised. Is my phone hacked? How do I know if somebody is apying on me? How do I trust a message from a bank? Can somebody leak my pictures and videos? AI is going to create some questions like these and the research is required to be conducted to find out the answers of such qurstions.

CONCLUSION

AI is become part and parcel of every sector. The importance is growing day by day. The students and teachers are supported through the learning process through AI. But AI has not yet been adopted by all educational institutions. To face challenges and to use the AI more effectively, the role of technical staff in educational institutions and AI literacy in sector specific employees is more important. There is long time required to fulfill the AI journey. The natural intelligence has limited power to collect, analyse and to interpret data. It has limited scope for decision making. Hence artificial intelligence had been revolutionized. The decades to come are more relevant in case of effective use of the AI in education sector. The teachers and academicians need to be ready to accept the changes made in the sector due to AI. The training and governance is required for making all education sector personnel more AI literate and to serve the students and society. The schools, colleges and universities should conduct various programmes and start to conduct research on AI for its effective implementation.

REFERENCES

1. The report Generative AI and Jobs published by ILO as a working paper in August 2023
2. Mrinmoy Roy (2020) AI Intervention in Education Systems of India: An Analysis Vol 63, No 2, 2020
3. Stanford University's annual AI Index 2023
4. Kishor Khairnar, (2017) Artificial Intelligence and Challenges Tarun Bharat Daily 18-09-2017
5. India Today Special Issue AI Boon or Bane? 15th January , 2024
6. Report of Meeting of World Economic Forum held in Davos (Switzarland)
7. Challenges of AI, New India Express Belagavi edition 1st January, 2024, Page 8
8. Divya Chopra (2023) India Today Education Desk 18-12-2023

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ASSESSING INFLUENCE OF CROP DIVERSIFICATION ON AGRICULTURAL SUSTAINABILITY IN KARNATAKA

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1. Abstract:
This study investigates the impact of crop diversification on agricultural sustainability in Karnataka, utilizing a mixed-methods approach. Quantitative analysis based on a survey of 250 farmers across North Karnataka reveals shifting cropping patterns and trends in diversification. Statistical tools including descriptive statistics and regression analysis highlight significant correlations and trends. Qualitative insights from in-depth interviews and focus group discussions with farmers, experts, and policymakers explore socio-economic, environmental, and policy determinants influencing diversification decisions. Analysis of agriculture department initiatives and policies further contextualizes these findings. Comparative district-level analysis elucidates regional variations in diversification patterns and their implications for agricultural sustainability. The study provides empirical evidence and qualitative perspectives to inform policy and practice, aiming to enhance the resilience and sustainability of agriculture in Karnataka.

Keywords: Crop diversification, agricultural sustainability, mixed-methods approach, North Karnataka, socio-economic factors

2. Introduction:

Agricultural sustainability is increasingly recognized as a critical component of rural development and food security strategies worldwide. In Karnataka, a southern state of India renowned for its agricultural productivity and diverse agro-climatic zones, the dynamics of crop diversification play a pivotal role in shaping the sustainability of agricultural practices. This study seeks to delve into the multifaceted relationship between crop diversification and agricultural sustainability specifically within the context of North Karnataka, a region characterized by its agrarian economy and significant contributions to the state's overall agricultural output.

The concept of crop diversification refers to the deliberate strategy of cultivating a variety of crops rather than relying solely on a few staple crops. This practice aims to mitigate risks associated with mono-cropping, such as susceptibility to pests and diseases, market volatility, and adverse climate conditions. Moreover, crop diversification is seen as a means to enhance soil health, optimize resource use efficiency, and improve farmers' resilience to changing environmental and economic conditions (FAO, 2018). In North Karnataka, the cropping pattern has traditionally revolved around a few principal crops, including cereals (such as sorghum and millets), pulses, oilseeds, and cotton. However, in recent decades, there has been a noticeable shift towards diversifying these cropping systems to include horticultural crops, commercial crops like sugarcane and tobacco, and even high-value specialty crops to meet the evolving demands of markets and consumers (Govindarajan et al., 2020).

Understanding the determinants of crop diversification in this region is crucial for comprehending the underlying factors driving these changes. Factors influencing crop diversification can vary widely and include agronomic factors (such as soil fertility and water availability), economic factors (such as market demand and price fluctuations), technological advancements (such as irrigation technologies and crop varieties), and policy interventions (such as subsidies and incentives for diversification) (Sharma & Agarwal, 2019). Challenges and opportunities abound in the path towards agricultural diversification in North Karnataka. Challenges include land degradation due to intensive farming practices, water scarcity exacerbated by erratic rainfall patterns, and inadequate infrastructure for post-harvest management and market access. Additionally, socio-economic factors such as land tenure

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systems, access to credit, and farmer education levels also influence the success of diversification initiatives (Gupta & Srivastava, 2021).

Conversely, opportunities for crop diversification are equally compelling. These include increasing consumer awareness and demand for diverse and healthier food options, growing export markets for high-value crops, and advancements in agricultural research and technology that facilitate the cultivation of new crops in previously unsuitable environments (FAO, 2020).

This study aims to critically analyze these dynamics through a comprehensive examination of the cropping patterns and diversification strategies adopted by farmers in North Karnataka. By assessing the determinants, challenges, and opportunities associated with crop diversification, the research seeks to provide insights into enhancing agricultural sustainability in the region. Ultimately, the findings are expected to inform policy makers, agricultural extension services, and development practitioners on effective strategies to promote sustainable agricultural practices through crop diversification initiatives.

Overall, the influence of crop diversification on agricultural sustainability in Karnataka, particularly in North Karnataka, represents a critical area of study with profound implications for the region's food security, economic development, and environmental resilience. By examining the interplay between cropping patterns, determinants, challenges, and opportunities, this research endeavours to contribute to a deeper understanding of how agricultural diversification can be leveraged to promote sustainable rural livelihoods and enhance overall agricultural resilience in Karnataka.

3. Review Literature

3.1 Crop Diversification Trends in India

(FAO, 2018; Sharma & Agarwal, 2019) Crop diversification in India has gained attention due to its potential to enhance agricultural sustainability and resilience. Studies have highlighted trends where traditional cereal-dominated cropping systems are gradually integrating high-value crops and horticulture. This shift is driven by market demands, changing climatic conditions, and policy support encouraging diversification. Understanding these trends is crucial for assessing how similar dynamics play out in regions like North Karnataka, where traditional agriculture is undergoing transformation.

3.2 Economic Implications of Crop Diversification

(Govindarajan et al., 2020).Economic analyses underscore the potential benefits of crop diversification, such as increased farm income, reduced production risks, and enhanced market opportunities. Studies emphasize the role of diversification in mitigating price volatility and improving farmer livelihoods. However, challenges related to initial investment in new crops, market access, and price fluctuations also need consideration (Gupta & Srivastava, 2021). These economic dimensions are essential for understanding the incentives and barriers farmers face in adopting diversified cropping systems in Karnataka.

3.3 Environmental Sustainability of Diversified Cropping Systems

Research on environmental aspects (FAO, 2020) emphasizes how diversified cropping systems contribute to sustainable agriculture by promoting biodiversity, reducing pest pressure through crop rotation, and improving soil health. These systems often require fewer external inputs and can mitigate environmental degradation associated with monoculture. However, the sustainability benefits depend on appropriate crop choices, resource management practices, and local agro-ecological conditions. Assessing these environmental impacts is crucial for evaluating the long-term sustainability of agricultural practices in Karnataka.

3.4 Policy Interventions and Agricultural Diversification

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Policy analyses (Sharma & Agarwal, 2019) highlight the role of government policies in promoting crop diversification through subsidies, incentives, and extension services. Effective policies can facilitate the adoption of new crops, improve market linkages, and enhance resilience against climate change impacts. However, policy implementation challenges such as bureaucratic delays and inadequate farmer outreach can hinder diversification efforts (Govindarajan et al., 2020). Understanding the effectiveness of existing policies and identifying areas for improvement is essential for supporting sustainable agricultural development in North Karnataka.

3.5 Challenges Faced by Farmers in Crop Diversification

Studies (Gupta & Srivastava, 2021) document various challenges faced by farmers when diversifying crops, including limited access to credit for investing in new crops, inadequate infrastructure for post-harvest management, and uncertainty regarding market demand. These challenges are exacerbated in regions like North Karnataka, where smallholder farmers dominate the agricultural landscape. Addressing these challenges requires targeted interventions that enhance farmer capacity, improve market access, and provide supportive policy frameworks.

3.6 Technological Innovations Supporting Crop Diversification

Technological advancements (FAO, 2018) play a crucial role in supporting crop diversification by introducing new crop varieties adapted to local agro-climatic conditions, improving irrigation efficiency, and enhancing pest and disease management techniques. These innovations can increase yields, reduce production risks, and contribute to overall farm profitability. However, the adoption of new technologies often requires initial investment and farmer training, which may pose barriers, particularly for smallholder farmers in Karnataka (Sharma & Agarwal, 2019).

3.7 Socioeconomic Impacts of Crop Diversification

Socioeconomic studies (Govindarajan et al., 2020) explore how crop diversification influences rural livelihoods, gender dynamics, and community resilience in agricultural landscapes. Diversification can create opportunities for income generation and employment diversification, particularly through high-value and perishable crops. However, the distribution of benefits across different social groups and the implications for social equity require careful consideration. Understanding these socioeconomic impacts is essential for designing inclusive agricultural policies that promote sustainable development in Karnataka.

3.8 Role of Farmer Knowledge and Education in Diversification

Farmer knowledge and education (Sharma & Agarwal, 2019) significantly influence decisions regarding crop diversification. Studies highlight the importance of farmer awareness about new crops, sustainable agricultural practices, and market opportunities in driving diversification efforts. Investments in farmer education, extension services, and participatory research can enhance farmer capacity to adopt diversified cropping systems effectively. Assessing the role of knowledge dissemination and educational interventions is critical for promoting sustainable agricultural practices in North Karnataka.

3.9 Climate Change Resilience and Crop Diversification

Climate change impacts (FAO, 2020) pose significant challenges to agricultural sustainability in Karnataka, affecting crop productivity and water availability. Diversified cropping systems offer resilience against climate variability by spreading risks across different crops and improving resource use efficiency. Strategies such as agroforestry, integrated pest management, and drought-resistant crop varieties are increasingly advocated to enhance climate resilience in agricultural landscapes. Evaluating the contribution of crop diversification to climate change adaptation is essential for developing robust agricultural strategies in North Karnataka.

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3.10 Future Directions for Agricultural Diversification in Karnataka

Future-oriented analyses (Gupta & Srivastava, 2021) discuss potential pathways for enhancing agricultural diversification in Karnataka, including leveraging market opportunities, strengthening research and extension services, and integrating sustainable practices into policy frameworks. Anticipating future challenges such as urbanization pressures, water scarcity, and evolving consumer preferences can guide proactive interventions to support diversified agriculture. Exploring these future directions is crucial for shaping resilient and sustainable agricultural systems in Karnataka's diverse agro-ecological contexts.

4. Research Gap Statement:

While existing literature provides valuable insights into various aspects of crop diversification and its impacts on agricultural sustainability, there remains a significant gap concerning specific regional contexts, such as North Karnataka. Previous studies have predominantly focused on national or state-level analyses, often overlooking the localized factors that influence crop diversification decisions and outcomes. Furthermore, there is limited empirical research that comprehensively examines the socio-economic, environmental, and policy dimensions of crop diversification specifically in North Karnataka.

Moreover, while some studies have explored the economic benefits and environmental sustainability of crop diversification in general terms, few have deeply analyzed the challenges and opportunities unique to North Karnataka's agricultural landscape. Understanding these local dynamics is crucial for developing context-specific strategies to enhance agricultural sustainability and resilience in the face of evolving socio-economic and environmental challenges. Therefore, this study seeks to fill these gaps by providing a detailed analysis of cropping patterns, determinants of diversification, and the specific challenges and opportunities faced by farmers in North Karnataka. By doing so, it aims to contribute valuable insights that can inform policy makers, agricultural extension services, and development practitioners in promoting sustainable agricultural practices tailored to the region's diverse agro-ecological contexts.

Objectives and Rationale behind Study:-

1. To Assess Current Cropping Patterns and Diversification Trends: This objective aims to examine the existing cropping patterns in North Karnataka and analyse trends in crop diversification over recent decades. By mapping out the types of crops grown and their distribution across the region, the study intends to identify shifts towards diversified cropping systems and understand the factors driving these changes.
2. To Identify Determinants of Crop Diversification: This objective seeks to investigate the socio-economic, environmental, and policy determinants influencing farmers' decisions to diversify their crops in North Karnataka. It will explore factors such as market demands, access to agricultural inputs, government policies, and farmer knowledge and attitudes towards crop diversification. Understanding these determinants is crucial for formulating targeted interventions and policies to promote sustainable agricultural practices in the region.
3. To Evaluate Sustainable Challenges and Opportunities for Agricultural Diversification: This objective aims to assess the challenges faced by farmers in adopting diversified cropping systems, including issues related to infrastructure, market access, and climatic variability. Additionally, the study will explore the opportunities presented by crop diversification, such as income diversification, enhanced resilience to climate change, and market expansion for high-value crops. By identifying both challenges and opportunities, the research aims to provide insights into strategies that can support farmers in North Karnataka in transitioning towards more sustainable and resilient agricultural practices.

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4. Research Methodology

This study utilizes a mixed-methods approach to achieve its objectives. Quantitative analysis involves conducting a survey among farmers (250 responses through random sampling across different district) in North Karnataka to gather data on cropping patterns and trends in crop diversification. Statistical tools such as descriptive statistics and regression analysis will be used to analyse this data. Qualitative insights will be obtained through in-depth interviews and focus group discussions with farmers, agricultural experts, and policymakers. These qualitative methods aim to explore the socio-economic, environmental, and policy determinants influencing crop diversification decisions. Additionally, discussion with employees of agriculture department to analyse specific initiatives and policies affecting agricultural diversification in selected districts of North Karnataka. Comparative analysis between districts will provide insights into regional variations in diversification patterns and their impacts. Overall, this mixed-methods approach ensures a comprehensive assessment of the influence of crop diversification on agricultural sustainability in North Karnataka, offering empirical evidence and qualitative perspectives to inform policy and practice.

5. Interpretation and Discussion

Table 1: Major Crop Distribution in North Karnataka (2013-2023)

Crop Type	Area (in hectares)	Percentage of Total Cultivated Area
Jowar	12,00,000	25%
Cotton	9,60,000	20%
Maize	7,20,000	15%
Pulses	4,80,000	10%
Sugarcane	3,84,000	8%
Others	10,56,000	22%
Total	**48,00,000**	**100%**

Source:- Karnataka State Department of Agriculture

Table 1 highlights the major crop distribution in the region from 2013 to 2023. Jowar, with an area of 1,200,000 hectares, constitutes 25% of the total cultivated area, followed by Cotton at 20% (960,000 hectares), and Maize at 15% (720,000 hectares). These crops dominate the landscape, indicating their historical agricultural importance. Sugarcane, though occupying 8% of the area with 384,000 hectares, plays a crucial role due to its economic significance. The remaining 22% is attributed to other crops, totaling 1,056,000 hectares.

Table 2: Trend in Crop Diversification Index (CDI) in North Karnataka (2013-2023)

Year	Crop Diversification Index
2000	0.65
2005	0.68
2010	0.72
2015	0.76
2020	0.8

Note: CDI ranges from 0 to 1, with higher values indicating greater diversification.

Source: Kumar et al., "Agricultural Diversification in North Karnataka: A 20-Year Analysis," Journal of Indian Agriculture, 2023

Table 2 illustrates the trend in Crop Diversification Index (CDI) from 2000 to 2023, showing a consistent upward trend. Starting from 0.65 in 2000, the CDI has steadily increased to 0.8 in 2020, suggesting a positive shift towards diversifying agricultural portfolio in North Karnataka. This

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trend underscores efforts to reduce dependency on traditional crops and explore new agricultur opportunities.

Table 3: Shift in Cropping Pattern in North Karnataka (2013 vs. 2023)

Crop Type	Percentage of Cultivated Area (2013 Vs 2023)
Jowar	35%
Cotton	15%
Maize	10%
Pulses	8%
Sugarcane	5%

Source: Singh and Patel, "Evolving Agricultural Landscapes of North Karnataka," Indian Journal of Agricultural Economics, 2023

Table 3 examines the shift in cropping patterns between 2013 and 2023. It reveals notable changes such as Jowar decreasing from 35% to 15% of cultivated area, indicating a relative decline in its dominance. Conversely, crops like Maize and Pulses have seen reductions in percentage, reflecting a broader diversification strategy adopted by farmers over the decade.

Table 4: Cropping Patterns and Diversification Trends in North Karnataka

District	Main Crops (Area in hectares)	Diversified Crops (Area in hectares)	Percentage of Diversification	Adoption Rate (%)
Belagavi	Maize: 5,000; Sugarcane: 3,500	Tomato: 1,200; Chilli: 800	30%	65%
Bagalkot	Cotton: 4,500; Groundnut: 3,200	Turmeric: 1,000; Sunflower: 600	25%	60%
Vijayapura	Sorghum: 6,000; Pigeonpea: 4,000	Grapes: 2,500; Papaya: 1,200	40%	70%
Dharwad	Millet: 3,800; Chickpea: 2,300	Potato: 1,500; Onion: 900	35%	68%
Gadag	Jowar: 5,200; Sunflower: 3,000	Red gram: 1,800; Green gram: 1,000	20%	55%

Source:- Field Survey

Table 4 provides district-level insights into cropping patterns and diversification trends. Districts like Vijayapura exhibit a high diversification rate of 40%, characterized by significant cultivation shifts towards crops like Grapes and Papaya. This contrasts with districts like Gadag, where a lower adoption rate of 20% is observed, possibly due to factors such as traditional farming practices or limited resources for diversification.

Table 5 Socio-economic Factors Influencing Crop Diversification (Determinants)

Factor	Correlation with Crop Diversification	p-value
Farm size (hectares)	0.65	0.001
Farmer's education level	0.48	0.005
Access to credit	0.72	<0.001
Distance to nearest market	-0.53	0.002

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Household income diversification	0.58	0.003

Source:- Field Survey

Table 5 identifies socio-economic factors influencing crop diversification. Factors such as Farm size (correlation of 0.65) and Access to credit (correlation of 0.72) show strong positive relationships with crop diversification, underscoring the role of resources and financial stability in enabling farmers to explore new crops. Conversely, Distance to nearest market (-0.53) exhibits a negative correlation, highlighting logistical challenges that may hinder diversification efforts.

Table 6 Challenges to Agricultural Diversification.

Challenge	% of Farmers Reporting	Severity (1-5 scale)
Lack of irrigation facilities	78%	4.2
Limited access to inputs	65%	3.8
Inadequate storage facilities	72%	4
Climate variability	85%	4.5
Lack of technical knowledge	60%	3.5

Source:- Field Survey

Table 6 outlines challenges faced by farmers in adopting agricultural diversification. Issues like Climate variability (reported by 85% of farmers with a severity rating of 4.5) and Lack of irrigation facilities (78% reporting severity of 4.2) are significant barriers. These challenges underscore the complex environmental and infrastructural hurdles that impact farmers' ability to diversify effectively.

Table 7 Perceived Sustainable Opportunities from Crop Diversification

Opportunity	% of Farmers Perceiving	Potential Impact (1-5 scale)
Increased income stability	82%	4.3
Enhanced soil health	70%	3.9
Reduced pest/disease pressure	65%	3.7
Access to new markets	58%	4.1
Improved climate resilience	75%	4.2

Source:- Field Survey

Table 7 delves into perceived sustainable opportunities arising from crop diversification. Increased income stability (82% of farmers perceiving with a potential impact rating of 4.3) and Improved climate resilience (75% perceiving with a rating of 4.2) are identified as major benefits. These opportunities reflect farmers' optimism regarding the potential economic and environmental gains associated with diversifying their crop portfolios.

Overall, North Karnataka's agricultural landscape is undergoing a transformative phase characterized by increasing crop diversification, influenced by socio-economic factors, encountering challenges, and buoyed by perceived sustainable opportunities. These insights underscore the dynamic interplay between agricultural practices, economic imperatives, and environmental considerations shaping the region's agricultural future.

6 Conclusion

The study concludes that agricultural dynamics in North Karnataka have shown significant shifts over the past decade. Current cropping patterns indicate a move towards diversification, with traditional crops like Jowar and Cotton giving way to a more varied portfolio including Maize, Pulses, and emerging crops in some districts. This trend is supported by an increasing Crop Diversification Index (CDI), reflecting farmers' efforts to explore new crops and reduce dependency on a few staple crops. Determinants of crop diversification, such as farm size, access to credit, and household income are key drivers. However, challenges such as climate variability, lack of irrigation facilities, and limited technical knowledge remain significant barriers, hindering optimal diversification efforts. Despite these challenges, the study identifies sustainable opportunities associated with agricultural diversification. Farmers perceive benefits such as increased income stability, enhanced soil health, and improved climate resilience as outcomes of diversifying their crop portfolios. These perceived benefits underscore the potential economic and environmental advantages of adopting a diversified approach to agriculture in the region.

Overall, while North Karnataka has made strides in diversifying its agricultural landscape, there is a need for continued support and investment in infrastructure, technology, and farmer education to overcome existing challenges and fully capitalize on the opportunities presented by crop diversification. This holistic approach will not only enhance agricultural sustainability but also contribute to the resilience and prosperity of farming communities in the region.

7 Reference:

Smith, J., & Brown, A. (2023). Agricultural diversification and sustainability: A global perspective. Agricultural Economics Journal, 45(2), 213-230.

Kumar, R., & Gupta, S. (2022). Socio-economic determinants of crop diversification: Evidence from Indian agriculture. Journal of Agricultural Development, 38(1), 45-62.

Patel, M., & Desai, P. (2021). Policy interventions for promoting crop diversification in semi-arid regions: A case study of Gujarat. Agricultural Policy Review, 29(3), 321-335.

Khan, A., & Sharma, S. (2020). Climate change impacts on crop diversification in South Asia: A review. Environmental Science Review, 18(4), 567-582.

Reddy, N., & Kumar, V. (2019). Economic implications of crop diversification on farm income and livelihoods: A study from Andhra Pradesh. Economic Development Quarterly, 25(2), 189-204.

Jain, P., & Singh, R. (2018). Challenges and opportunities for agricultural diversification in India: Lessons from Maharashtra. Journal of Sustainable Agriculture, 36(3), 410-425.

Das, S., & Chatterjee, P. (2017). Technological innovations and their impact on crop diversification: A case study of Punjab. Journal of Agribusiness Management, 15(1), 78-92.

Mishra, A., & Das, B. (2016). Role of farmer education and extension services in promoting crop diversification: Evidence from Uttar Pradesh. Journal of Rural Development, 32(4), 521-536.

Patel, H., & Patel, S. (2015). Market integration and crop diversification: Evidence from Karnataka. Agricultural Economics Research, 33(1), 102-118.

Sharma, M., & Gupta, N. (2014). Environmental sustainability of diversified cropping systems: Insights from Rajasthan. Environmental Management Journal, 22(3), 345-360.

Food and Agriculture Organization (FAO). (2018). Crop diversification in India: Trends and determinants. Retrieved from http://www.fao.org/3/i9031en/I9031EN.pdf

Food and Agriculture Organization (FAO). (2020). Sustainable agricultural development for food security and nutrition: What roles for crop diversification? Retrieved from http://www.fao.org/3/ca7774en/CA7774EN.pdf

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Volume : 53, Issue 6, No.5, June : 2024

Govindarajan, K., Srikantan, R., & Velayutham, M. (2020). Agricultural diversification in Karnataka: Trends, determinants, and implications. Agricultural Economics Research Review, 33(2), 265-276. doi:10.5958/0974-0279.2020.00038.5

Gupta, P., & Srivastava, A. K. (2021). Challenges and opportunities in agricultural diversification: A review. Journal of Crop and Weed, 17(1), 12-21.

Sharma, H., & Agarwal, S. (2019). Determinants and challenges of crop diversification in India: An overview. Indian Journal of Agricultural Economics, 74(3), 331-345.

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RURAL EMPLOYMENT DIVERSIFICATION IN INDIA: TRENDS, DETERMINANTS AND IMPLICATIONS ON POVERTY

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Abstract

This research has examined the diversification of rural employment in India and its major states, utilizing household-level data from NSSO for the years 1983 and 2009-10. The paper has also investigated the factors influencing the shift of rural employment towards the non-farm sector. The analysis indicates a consistent growth of the non-farm sector over time, employing approximately one-third of the rural workforce in 2009-10, compared to just one-fifth in 1983 at the national level. A similar trend is evident in major states, although the rate and nature of this growth varied significantly. The study highlights the increasing dominance of crop production, followed by animal husbandry, in providing employment to the rural workforce across major states during 2009-10. Conversely, fishery and forestry played a negligible role in rural employment. Furthermore, the research establishes that the rise in rural non-farm employment has a positive and significant impact on reducing rural poverty at the national level. It also identifies a positive correlation between income and employment, particularly in the diversification towards horticultural activities. To enhance the skill set of the rural workforce and facilitate employment in the non-farm sector, a well-designed, region-specific program is recommended.

Key words: Rural employment, Employment diversification, Crop sector

Introduction

One of the major failures of economic development in post-Independent India remained its inability to significantly reduce the dependence of workforce on agriculture. While the share of gross domestic product (GDP) originating from agriculture has gone down from over 50 per cent at the time of Independence to nearly 14 per cent currently, the share of workforce engaged in agriculture, which was about 70 per cent in 1951, still remains at over 50 per cent. This has led to widening of gap between incomes in agricultural and non-agricultural sectors, which is perceived to be one of the major reasons for persistence of poverty in the country. The gap between the number of new rural workers and the number of new job opportunities created in agriculture is enlarging. Therefore, the rural employment diversification towards non-agricultural sector has gained critical importance over time. The Government of India is deeply concerned with the widespread poverty and unemployment in the rural areas and has taken several initiatives including the implementation of Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS). The rural sector in India is undergoing a transformation and the contribution of rural non-farm sector to the rural income and employment is growing. Several studies on rural employment diversification in India (Kumar, 2009; Mukhopadhyay and Rajaraman, 2007; Chadha and Sahu, 2002; Visaria, 1995; Basant and Kumar, 1989) have concluded that the share of non-farm sector in rural employment has significantly grown over time and the capacity of the farm sector to absorb additional labour force has almost reached a plateau. On the other hand, some scholars argue that with the implementation of large-scale employment programmes even the agricultural sector is facing scarcity of farm-labour. It is with this background that this paper has studied the trends and patterns of rural employment diversification, alongwith the

implications of growing rural non-farm sector on rural poverty. It has also examined the factors affecting rural employment diversification towards non-farm sector and the role of high-value horticultural activities in it.

Methodology and Data

Employment diversification is the shifting of workforce from one sector to the other for employment. The proportions of this workforce engaged in different sectors of the economy constitute the structure of employment. The present study has measured the extent of rural employment diversification at different levels. At the first level, it has been measured in terms of shifting of workforce to the non-farm sector. At the second level, proportions of shifting of workforce to different sub-sector of agriculture have been measured and finally, estimation has been made of shifting of workforce within the crop sub-sector. The crop sub-sector has been sub-divided into (i) foodgrains (cereals and pulses), (ii) horticulture, (iii) cash crops, and (iv) agricultural services.

The pace and pattern of rural employment diversification has been studied at all-India level and across major states for the period 1983 to 2009-10. To analyze the determinants of employment diversification towards non-farm sector and horticultural crops, and to attribute weights to these determinants, a multinomial logit model was applied. Multinomial logit models have been used in the case of a dependent variable with more than two categories (Jobson, 1992; Lesschen et al., 2005; Kumar et al., 2007). This type of regression is similar to logistic regression, but is more general because the dependent variable is not restricted to two categories. Each category is compared to a reference category. The household level data from the 66th Round, Employment and Unemployment Survey, conducted by the National Sample Survey Organization (NSSO), Ministry of Statistics and Programme Implementation, Government of India, were used in the estimation of multinomial logit model. The factors that were supposed to influence the choice of employment included age, sex, education, household size, operational landholding, caste, etc. The multinomial logistic regression functions can be expressed as per Equation (1):

$$P(Y_i = j) = \frac{e^{\beta_j X_i}}{\sum_{k=0}^{2} e^{\beta_k X_i}}, \quad j = 0, 1, 2$$

where, Yi represents the probability that the persons are engaged in the non-farm horticultural activities. Xis denote the vector of explanatory variables and βs are the regression coefficients estimated by the maximum likelihood method. The specification and measurement of these explanatory variables have been explained in the section on results and discussion. The interpretation of coefficients is less straightforward in the logit than OLS model. Usually, a positive coefficient for an independent variable increases the probability of a household being upwardly mobile. However, the marginal effects of the explanatory variables on the probabilities are not equal to the coefficients. Further calculations were required to estimate the marginal effects of each explanatory variable. The marginal effect of a variable was computed by using Equation (2):

$$\delta p(y) / \delta Xi = \beta Xi * \exp [Z] / [1+\exp(z)]2 \quad ...(2)$$

where, Z was the sum of coefficients multiplied by the means of the respective variables plus the constant-term.

Further, the impact of non-farm sector in rural poverty was examined by using the log-linear regression model. The log linear model was chosen based on the significance of the regression coefficients and goodness of fit. The regression model used is given in Equation (3):

$$\ln Rp = \alpha + \beta \ln Xi + \varepsilon i \quad \ldots(3)$$

where, Rp is the rural poverty in percentage, Xis are the explanatory variables which include total factor productivity, share in non-farm employment (%), share of non-agricultural sector in national income (%), rural wages (₹/day) and rural literacy (%), α is a constant term and εi is the error-term.

Data

Different rounds of surveys conducted by the National Sample Survey Organization (NSSO) on employment /unemployment constituted the database of this study. The data were taken mainly from the four quinquennial rounds of the NSSO, pertaining to the years 1983 (38th round), 1993-94 (50th round), 2004- 05 (61st round), and 2009-10 (66th round). However, instead of culling information from the published NSSO reports, the unit level data were extracted from the CD of NSSO. The analysis at the unit level was particularly important because the employment estimates at more than one digit level of the NIC classification of industries were not available in the published reports. To estimate employment across the sub-sectors of agriculture and different components of crop sub-sector, NIC classification has been used. For making a comparison of the proportion of sectoral employment across different time periods, viz. 1983, 1993-94, 2004-05 and 2009-10, the concordance design of the NIC classifications1, as developed by the Central Statistical Organization (CSO), was followed. However, within the crop sub-sector, some adjustments were made with the CSO-designed concordance2 to compare the selected four sub-groups across the selected years.

Results and Discussion

Rural Transformation in India: Accelerating albeit Slow

In India, rural employment has undergone significant changes during the past two and half decades. The share of agriculture in the labour force remained stagnant for a long time, but started declining in mid-1970s and has been declining since then. On the other hand, the share of rural non-farm sector has been increasing, and it now employs nearly one-third of India's rural workforce (Table 1), which amounts engaging of about 110 million rural people in the non-farm activities. Table 1, incorporating National Sample Survey (NSS) data from the 38th, 50th, 61st and 66th rounds, provides a snap shot of the growing importance of non-farm sector in rural employment. At the all-India level, the share of non-farm sector in total workforce has increased consistently over time, from 19 per cent in 1983 to 22 per cent in 1993-94, to about 27 per cent in 2004-05 and further to 32 per cent in 2009-10.

A perusal of Table 1 reveals that the non-farm sector has emerged as the sole source of additional employment opportunities in the rural areas. Between 1983 and 1993-94, of the nearly 47 million additional rural jobs created, the majority (6 out of every 10) were in the farm sector. But, this trend was reversed subsequently. Between 1993-94 and 2004-05, the growth in non-farm employment surpassed agriculture when about 50 million new job opportunities were created in rural areas and 6 out of every 10 new jobs were in the non-farm sector. But in recent years, between 2004-05 and 2009-10, though the total rural employment has declined by 5 million, about 13 million additional rural jobs were created in the non-farm sector (Figure 1).

Table 1: State-wise Share of Non-Farm Sector in Rural Employment (Percentage)

State	1983	1993-94	2004-05	2009-10	CAGR (%) 1983 to 1993-94	CAGR (%) 1993-94 to 2009-10	CAGR (%) 1983 to 2009-10
Andhra Pradesh	20	22.7	28.3	31.3	2.5	2.8	2.7
Assam	21	21.3	25.8	29.5	6.3	3.2	4.4

Bihar	15.6	16.9	22.1	33.1	0.2	7.1	4.4
Chhattisgarh	7	9.4	13.9	15.1	4.9	3.6	4.1
Gujarat	15.2	20.7	22.8	21.7	6	0.9	2.8
Haryana	23.1	28.6	36	40.2	0.6	3.9	2.6
Himachal Pradesh	12.9	22.8	30.6	37.1	8	4.8	6
Jammu & Kashmir	20.3	28	36.2	40.3	-5.6	10.6	4.1
Jharkhand	18.6	23.9	30.1	45.2	0.2	5.9	3.7
Karnataka	15.7	18.3	19.1	24.3	4.2	1.9	2.8
Kerala	37.2	42.3	58	64.3	1.3	3.9	2.9
Madhya Pradesh	11	13.8	17.5	17.6	2	4.6	3.6
Maharashtra	14.3	20.3	20.1	20.6	4	1.8	2.7
Odisha	20.9	21.9	31	32.4	1.6	3.5	2.8
Punjab	17.8	22.7	33.2	38.2	3.2	3.3	3.3
Rajasthan	13.5	19.2	27.2	36.7	5.8	5.6	5.7
Tamil Nadu	25.6	31.3	34.7	36.3	3.8	0.5	1.7
Uttar Pradesh	17.9	20.7	27.4	33.1	3.1	4.2	3.8
Uttarakhand	18.1	34.9	21.8	30.5	1.1	5.4	3.7
West Bengal	26.4	26.9	37.3	43.7	5.5	2	3.4
All-India	18.6	21.7	27.4	32.1	3.4	3.2	3.4

Source: Authors' estimates based on NSSO unit level data (38th, 50th, 61st and 66th rounds)

In fact during this period, workforce of nearly 20 million rural people departed the farm sector. The decline in job opportunities in the farm sector may be attributed to several factors including the implementation of schemes like MGNREGS. The decline in the farm employment was likely to be, at least partly, driven by distress in the agricultural sector which prompted households to seek employment more actively in the non-farm sector. The share of non-farm sector in providing employment has been growing across all the states. But, the pace and pattern of rural non-farm employment did exhibit stark regional variations. In 1983, the share of non-farm sector in rural employment varied from 7 per cent in Chhattisgarh to 37 per cent in Kerala. In 1983, the states where more than 20 per cent of the rural workforce was employed in the non-farm sector included West Bengal (26.4%), Tamil Nadu (25.6%), Haryana (23.1%), Assam (21%), Odisha (20.9%), Jammu & Kashmir (20.3%) and Andhra Pradesh (20.0%). In remaining of the states, the share of non-farm sector in rural employment was less than 20 per cent in 1983. The share of non-farm sector in rural employment increased in all the states over time. In 2009-10, about 64 per cent of the rural workforce in Kerala was engaged in the non-farm sector. Also, in majority of states, non-farm sector employed more than one-third of the total rural workforce. It is clear that the process of structural transformation of the rural workforce that was steadily tilting in favour of non-farm is still continuing. Structural transformation of employment in rural areas was not visible only in a few states like Chhattisgarh (15.1%), Gujarat (21.7%), Karnataka (24.3%), Madhya Pradesh (17.6%) and Maharashtra (20.6%). Besides Kerala, the non-farm sector contributed about two-fifths to the rural employment in West Bengal (43.7%), Jharkhand (45.2%), Jammu & Kashmir (40.3%), Haryana (40.2%), Punjab (38.2%), Rajasthan (36.2%), Tamil Nadu (36.3%), and Himachal Pradesh (37.1%).

Table 2. Trends and patterns of rural employment in agriculture sector, 1983 to 2009-10

Period	Crops	Animal Husbandry	Forestry	Fishery
1983	88.8	10.4	0.4	0.4
1993-94	92.2	6.8	0.4	0.6

2004-05	90.3	8.7	0.5	0.5
2009-10	93.2	6.1	0.2	0.5

Source: Authors' estimates based on NSSO unit level data (38th, 50th, 61st and 66th rounds)

Employment Diversification within Agriculture Sector

A glimpse of shift in employment within the agriculture sector during the past 25 years (1983 to 2009-10) at all-India level can be obtained from Table 2. The dependence on crop production not only continued but even accentuated during this period. At all-India level, 89 per cent of the agricultural workers were concentrated in crop production in 1983, which increased to 93 per cent in 2009-10. The animal husbandry sector employed 10.4 per cent of the agricultural workers in 1983, but its share in rural employment declined to 6.1 per cent in 2009-10, despite its higher growth in value of output. Forestry and fishery continued to account for engaging negligible proportions in rural workforce. The pattern of employment diversification within agriculture sector has depicted a similar trend across different states of India. In 1983, in all major states, except for Jammu & Kashmir, Kerala, and Punjab, agricultural employment was heavily concentrated in the crop sector, ranging from 81 per cent in Rajasthan to 98.8 per cent in Chhattisgarh. In fact, inasmuch as 11 of the 20 states being studied, employment in crop production accounted for more than 90 per cent share.

The overall employment scenario did not change much and the excessive dependence on crop production continued across states even in 2009-10. Yet, considerable restructuring of agricultural employment was visible in a number of states. For instance, during the period 1983 to 2009-10, Haryana has depicted a remarkable increase (from 17.7% to 28.6%) and Gujarat a small increase (from 8.9% to 10.5%) in employment in the animal husbandry sub-sector (Table 3). On the other side, Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and West Bengal have depicted a significant decline in employment in animal husbandry during this period. In fact, most states have shown a decline in employment in animal husbandry during this period. The contribution of forestry and fishery sub-sectors to employment in agriculture sector continued to be small; even this small has become smaller in most of the states. The states which have depicted a rise in employment are Kerala, Andhra Pradesh, West Bengal, Tamil Nadu and Karnataka in the fishery sector and Kerala and Uttarakhand in the forestry sub-sector. To sum-up, the overbearing importance of the crop sub-sector continued in the agriculture.

Diversification within Crop Sub-sector

The breakup of NSSO employment data at three and four digit levels helped in understanding the pattern of employment within the crop sub-sector. The scenario of employment within the crop sub-sector has been depicted in Table 4. In 1983, foodgrains had accounted for 93.7 per cent of employment in the crop sub-sector, which got reduced to 84.3 per cent by 2004-05. But after 2004-05, the trend of decline was reversed and the share of foodgrains in crop sub-sector employment increased to 86.2 per cent in 2009-10. The cash crops accounted for only 4.3 per cent of the crop sector employment in 1983. Between 1983 and 1993-94, its share increased slightly to 5.1 per cent. But during the next decade (1993-94 to 2004-05), the share of cash crops increased substantially and rose to 11.1 per cent. After 2004-05, a slight decline was observed in its share in the crop sector employment. The horticulture sub-sector has emerged as one of the growth engines of Indian agriculture. However, the share of horticulture in crop sector employment did not witness increase as witnessed in its share in the agricultural income. The share of horticulture in crop sector employment was 1.9 per cent and it continued to remain at that level till 1993-94. In 2004-05, the share of

horticulture in crop sub-sector employment increased to 4.1 per cent, but in the subsequent period of 2004-05 to 2009-10, it declined slightly to 3.5 per cent.

The state level data have been more revealing and the engagement of agricultural workers in foodgrains production, by and large, declined in all the states, except in Assam and West Bengal between 1983 and 2009-10 (Table 5). However, the magnitude of percentage decline depicted a contrasting picture across states. The decline in agricultural workers engaged in foodgrains production activities was noticeable in Andhra Pradesh (16.4%), Chhattisgarh (21.2%), Haryana (26.7%), Himachal Pradesh (22.1%) and Kerala (18.4%). The share of cash crops in providing employment to agricultural workers increased significantly in Andhra Pradesh (12%), Gujarat (17%), Kerala (28%) and Maharashtra (17%). The increase in the share of horticulture in agricultural labour employment was more visible in Himachal Pradesh (27%) and Jammu & Kashmir (22%). The increase in the share of agricultural labour services was visible only in Gujarat (3.5%) and Tamil Nadu (2.1%).

Table 3: Trends and Pattern of Rural Employment within Agriculture Sector across States: 2020 (In Percentage)

State	Crops	Animal Husbandry
Andhra Pradesh	90.9	8.1
Assam	97.6	1.3
Bihar	93.2	6.4
Chhattisgarh	98.8	0.7
Gujarat	90.4	8.9
Haryana	82.3	17.7
Himachal Pradesh	91.7	8.2
Jammu & Kashmir	71.8	26.8
Jharkhand	94.6	3.8
Karnataka	88.4	11.4
Kerala	74.4	22.7
Madhya Pradesh	96.6	2.8
Maharashtra	92.6	6.3
Odisha	.95	2.2
Punjab	58.2	41.8
Rajasthan	81.3	18.4
Tamil Nadu	87.7	11
Uttar Pradesh	88.1	11.7
Uttarakhand	91.4	8.6
West Bengal	83.7	14.7

Source: Authors' estimates based on NSSO unit level data (38th and 66th rounds)

The data highlights the trends and patterns of rural employment within the agriculture sector across Indian states for 2020. A significant portion of rural employment remained concentrated in crop production during both years, but shifts in other sub-sectors like animal husbandry, forestry, and fishery reflect nuanced changes in employment patterns.

In many states, such as Andhra Pradesh, Assam, Bihar, and Chhattisgarh, the share of rural employment in crop cultivation either increased or remained steady over the years, maintaining dominance in the agricultural sector. Notably, states like Andhra Pradesh saw an increase from 90.9% to 94.3% 2020, while Assam also saw a slight rise from 97.6% to 97.8%. However, in states like Gujarat and Punjab, the share of rural employment in crop production declined slightly, reflecting a

(71.8%) show a significant portion of their rural workforce engaged in animal husbandry, with Punjab leading at 41.8% and Jammu & Kashmir at 26.8%. These figures indicate a notable shift in rural employment patterns, particularly in regions with large-scale agricultural activity. Animal husbandry emerges as a significant secondary employment sector across several states. Haryana (17.7%), Rajasthan (18.4%), and Himachal Pradesh (8.2%) demonstrate notable engagement in animal husbandry, reflecting the agricultural diversity in these regions. Jammu & Kashmir, Punjab, and Kerala also display significant rural employment in animal husbandry, indicating a strong agrarian and livestock-rearing tradition. Forestry and fishery employment remain relatively low compared to agriculture and animal husbandry. Forestry, in particular, contributes minimally to rural employment across most states, with a few exceptions such as Jharkhand (1.5%) and Jammu & Kashmir (1.1%). States like Odisha (1.1%) and Kerala (0.6%) have some rural employment in forestry, though it remains marginal. Fishery plays a minor role in rural employment across most states, with Kerala (2.3%) and West Bengal (1%) having the highest percentages. This reflects the coastal geography and fishing-based livelihoods in these regions. States like Andhra Pradesh (0.7%) and Odisha (1.6%) also show engagement in fishery, though the employment percentage remains low in comparison to other sectors. Overall, the data underscores a persistent reliance on crop cultivation as the primary source of rural employment, while animal husbandry remains an important secondary sector in states with a strong livestock economy. Forestry and fishery, though present, contribute far less to rural employment, highlighting the agricultural dominance of rural livelihoods across most Indian states.

Table 5: Pattern of Employment Diversification within Crop Sub-sector (Percentage)

Period	Cereals & Pulses	Cash Crops	Horticulture	Agricultural Services
1983	93.7	4.3	1.9	0.1
1993-94	92.2	5.1	1.9	0.8
2004-05	84.3	11.1	4.1	0.5
2009-10	86.2	9.8	3.5	0.5

Source: Authors' estimates based on NSSO unit level data (38th, 50th, 61st and 66th rounds)

The pattern of employment diversification within the crop sub-sector has shown a gradual shift over the years, reflecting changes in agricultural priorities and economic conditions. In 1983, the majority of employment within this sub-sector was concentrated in cereals and pulses, accounting for 93.7% of the total workforce. Cash crops and horticulture played a relatively minor role, with cash crops comprising only 4.3% and horticulture at 1.9%, while agricultural services barely registered, contributing just 0.1% to employment. By 2010-13, the dominance of cereals and pulses had slightly declined to 92.2%, while cash crops increased their share to 5.1%, indicating a growing importance of cash crop production in rural employment. Horticulture remained unchanged at 1.9%, but agricultural services saw a modest rise to 0.8%, suggesting a gradual diversification of activities in the sector.The most significant changes occurred by 2014-15, as the share of employment in cereals and pulses dropped substantially to 84.3%. This decline was accompanied by a notable rise in cash crops, which reached 11.1%, marking a shift toward more commercially viable agricultural products. Horticulture also experienced growth, increasing its share to 4.1%, signaling its growing significance as a source of employment. Agricultural services, however, saw a slight decrease to 0.5%. In 2010-13, the share of employment in cereals and pulses rebounded slightly to 86.2%, although it remained significantly lower than earlier levels. The share of cash crops decreased to 9.8%, possibly reflecting market fluctuations or changing crop preferences. Horticulture experienced a minor decline to 3.5%, while agricultural services remained stable at 0.5%. Overall, the data suggests that while cereals and pulses

continue to dominate employment in the crop sub-sector, there has been a steady diversification, with increasing contributions from cash crops and horticulture over time. This diversification points to a broader shift in rural employment patterns, with greater emphasis on high-value crops and a gradual move away from the traditional focus on cereals and pulses. Agricultural services, though still a small segment, have also grown, indicating the emergence of a more varied agricultural employment landscape.

Impact of Non-farm Sector on Poverty

The association of poverty with agricultural and non-agricultural output growths and agricultural wages has been documented widely in the literature (Himanshu, 2005 and 2008; Singh, 1990; Lanjouw and Stern, 1998; Sharma, 2001; Sundaram, 2001). Some studies have also argued that growth in the non-farm sector was the key factor behind the decline in poverty during the 1990s. Foster and Rosenzweig (2004) have argued that non-farm expansion has not only been the prime driver of rural incomes, but its growth has also been especially pro-poor. The historical evidence also suggests that rural poverty reduction has been closely associated with agricultural growth. In past one and a half decade (1993-94 and 2009-10), real agricultural wages grew at the rate of 2.9 per cent per year. The rate of growth was higher during 2004-05 to 2009-10 than in 1993-94 to 2004-05 (Table 6). The rate of rural poverty reduction declined along with agricultural wage growth and agricultural GDP. The decline of rural poverty has remarkably been consistent over the past one and a half decade at an average rate of about 2.5 per cent per year.

Different sets of determinants have emerged during different periods to influence poverty. While numerous variables could influence rural poverty directly or indirectly, AgNSDP per capita of rural person, rural literacy, real rural wages, non-farm sector employment, and commercialization of economy, have been included to understand the determinants for rural poverty reduction in the analysis undertaken in this paper.

Finally, the log-linear regression models were chosen based on the overall significance of the regression equation (F-statistics and R2), and the stability and significance of the coefficients of the explanatory variables (Tables 7 and 8). At the national level, TFP growth, non-farm employment, commercialization of economy, rural wages and rural literacy turned out to be significant determinants of rural poverty reduction. Based on pooled cross-sectional and time-series data at state level, AgNSDP per person, rural wages and rural literacy have emerged as the significant determinants of rural poverty reduction.

All the included variables are significant and have the expected plausible signs. The significant negative coefficient of AgNSDP per capita suggests that the improvement in agricultural performance has been associated with substantial reduction in rural poverty, indicating that the benefits of growth in agriculture have trickled down to the rural poor and the growth has been inclusive. Agricultural productivity, an indicator of real agricultural growth, has played an important role in poverty reduction in the rural areas, as indicated by its higher elasticity for poverty reduction. With one percent growth in per capita agricultural output, the poverty would be reduced by 0.97 per cent. The agricultural growth can be achieved through strategic and accelerated public investment in infrastructure and education (Kumar et al., 2004). However, agricultural growth alone will not be sufficient to substantially reduce the incidence of poverty particularly among the landless households. Diversification towards rural non-farm sector is critical to reduce poverty in India. With one per cent increase in the share of rural non-farm employment (RNFE), the rural poverty would be reduced by 0.5 per cent. The significant poverty reduction in China was achieved through the method of increasing

RNFE opportunities. The share of non-farm sector in the economy also plays a significant role in rural poverty reduction. This indicates the complementary roles of agriculture and non-agriculture sectors to significantly reduce rural poverty in India and efforts should be made to improve the rural-urban linkages. The wages constitute a major component of household income for the majority of rural households and therefore improvement in wages.

Table 6: Determinants of Rural Poverty Based on Time Series Data at All-India

Dependent Variable: Rural Poverty (%)

Exploratory Variables	Coefficient	Standard Error
Total Factor Productivity (TFP)	-0.1452**	0.0526
Non-Farm Employment	-0.5105*	0.161
Commercialization of Economy	-0.4149*	0.159
Rural Wages	-0.6282*	0.2204
Rural Literacy	-0.6215*	0.0823
Constant	0.21	0.0117
R^2	**0.9898**	

Source: Authors' estimates based on data from NSSO and CSO, GoI

Notes: *Significant at the 10% level /**Significant at the 5% level

The analysis of the determinants of rural poverty in India reveals significant insights based on the coefficients derived from the time series data. The dependent variable in this analysis is rural poverty, expressed as a percentage, while the exploratory variables include total factor productivity (TFP), non-farm employment, commercialization of the economy, rural wages, and rural literacy. Total factor productivity shows a negative coefficient of -0.1452, which is statistically significant at the 5% level, indicating that an increase in TFP is associated with a decrease in rural poverty. This suggests that improvements in productivity within the agricultural and rural sectors can lead to better economic conditions for rural households. Non-farm employment, with a coefficient of -0.5105, also presents a significant negative relationship with rural poverty at the 10% level. This underscores the importance of diversifying income sources through non-farm activities as a crucial strategy for poverty alleviation in rural areas. The commercialization of the economy demonstrates a negative impact on rural poverty, with a coefficient of -0.4149 that is significant at the 10% level. This implies that as rural economies become more commercialized, with increased market participation and access to goods and services, poverty levels tend to decrease. Furthermore, rural wages have a coefficient of -0.6282, indicating a robust negative relationship with rural poverty that is significant at the 10% level. This highlights the essential role of higher wages in improving the living standards of rural populations and reducing poverty. Rural literacy, with a coefficient of -0.6215, is another critical factor influencing rural poverty, significant at the 10% level. The strong negative correlation suggests that enhanced literacy rates contribute significantly to reducing poverty by improving employment opportunities and income potential for rural residents. The constant term is reported at 0.2100, indicating the baseline level of rural poverty when all other factors are held constant. The model demonstrates a remarkably high R^2 value of 0.9898, indicating that approximately 98.98% of the variance in rural poverty can be explained by the independent variables included in the analysis. This high explanatory power reinforces the model's validity in understanding the determinants of rural poverty in India. Overall, the analysis highlights the importance of productivity, non-farm employment, economic

commercialization, rural wages, and literacy in addressing rural poverty, suggesting that polic interventions targeting these areas could be effective in reducing poverty levels in rural India.

Table 7: Determinants of Rural Employment Diversification Towards Non-Farm and Horticultural Sectors in India

Variable	Multinomial Coefficients		Marginal Effects	
	Coefficients	Standard Error	dy/dx	Standard Error
Non-Farm Sector				
Sex of household-head (male=1, otherwise=0)	0.0338	0.0581	0.0075	0.0122
Age of household-head (years)	-0.0026*	0.0014	-0.0007**	0.0003
Education of household-head (years)	0.1084***	0.0043	0.0227***	0.0009
Technical education of household-head (yes=1, otherwise=0)	1.6391***	0.3673	0.3825***	0.0749
Household size (15-59 years)	0.0971***	0.0126	0.0214***	0.0027
Landholding (ha)	-1.1356***	0.0444	-0.2417***	0.0082
Caste Dummy				
SC=1, otherwise=0	0.5676***	0.0613	0.1279***	0.0143
OBC=1, otherwise=0	0.5728***	0.056	0.1226***	0.0122
Others=1, otherwise=0	0.6366***	0.0609	0.1391***	0.0141
Constant	-1.1672***	0.0981		
Horticulture Sector				
Sex of household-head (male=1, otherwise=0)	-0.051	0.1809	-0.0014	0.0041
Age of household-head (years)	0.0185***	0.0044	0.0004***	0.0001
Education of household-head (years)	0.0656***	0.0131	0.0007***	0.0003
Technical education of household-head (yes=1, otherwise=0)	0.6146	0.6531	-0.0043	0.01
Household size (15-59 years)	-0.0942***	0.0386	-0.0027***	0.0008
Landholding (ha)	-0.1682***	0.037	0.0042***	0.0009

Caste Dummy				
ST=1, otherwise=0	-0.0546	0.2329	-0.0052	0.0043
OBC=1, otherwise=0	0.2037	0.1851	0.0003	0.004
Others=1, otherwise=0	0.4718***	0.1845	0.0057	0.0045
Constant	-4.2786***	0.3314		
Model Statistics				
Log Likelihood	-10190			
Number of Observations	55874			
Chi2	1503.05			
R^2	0.1157			

Note: ***,**, and * denote significance at 1 per cent, 5 per cent and 10 per cent levels.

The analysis of the determinants of rural employment diversification towards non-farm and horticultural sectors in India reveals significant insights into the factors influencing these sectors. In the non-farm sector, the sex of the household head appears to have a minimal impact, with a coefficient of 0.0338, indicating that male-headed households have a slightly higher likelihood of engaging in non-farm activities compared to female-headed ones. However, this effect is not statistically significant. Age also plays a role, with a negative coefficient of -0.0026, suggesting that as the age of the household head increases, the likelihood of diversification into non-farm activities decreases. This relationship is significant, indicating that older heads of households may be less inclined to shift towards non-farm employment. Conversely, education is a significant positive determinant: for each additional year of education of the household head, the likelihood of participating in the non-farm sector increases by 0.1084. This underscores the importance of educational attainment in promoting non-farm employment opportunities. Technical education significantly enhances this likelihood, with a notable coefficient of 1.6391, suggesting that households with technically educated heads are much more likely to engage in non-farm activities. Household size also positively affects diversification, with a coefficient of 0.0971, implying that larger households may have more capacity or necessity to engage in non-farm employment. In terms of landholding, a negative relationship exists, where larger landholdings correlate with a decreased likelihood of diversification into the non-farm sector, possibly reflecting a preference for agricultural activities among larger landowners.

Caste dynamics also play a crucial role in determining non-farm employment. Households belonging to Scheduled Castes (SC), Other Backward Classes (OBC), and other categories show significant positive coefficients, indicating that these groups have a higher likelihood of participating in non-farm employment compared to others. Turning to the horticultural sector, the coefficients reveal different trends. The sex of the household head has a negative coefficient of -0.0510, indicating that male-headed households may be less involved in horticulture, although this finding lacks statistical significance. Age, on the other hand, shows a positive and significant influence, with a coefficient of 0.0185, suggesting that older household heads are more likely to engage in horticulture. Education remains a positive influence in this sector as well, with a coefficient of 0.0656, indicating that educational attainment supports participation in horticultural activities. Technical education, however, does not have a significant impact on horticultural involvement, as indicated by its coefficient of 0.6146. Household size has a negative impact on horticultural participation, suggesting that larger households may prefer other forms of employment or may have less time to dedicate to horticultural activities. Landholding exhibits a positive effect, where larger landholdings are associated with increased likelihood of engagement in horticulture. The caste dynamics also differ in the horticulture

sector. While Scheduled Tribes (ST) show no significant influence, OBC and Other castes have positive coefficients, suggesting that these groups may find opportunities in horticulture. Overall, the model statistics, including a Chi-square value of 1503.05 and an R^2 of 0.1157, indicate that the factors examined explain a modest portion of the variance in employment diversification in these sectors. The findings underscore the complex interplay of demographic, educational, and socio-economic factors influencing rural employment in India, highlighting the need for targeted policies to enhance participation in non-farm and horticultural activities, particularly focusing on education and the socio-economic status of households.

Determinants of Rural Employment Diversification
Non-farm Sector

A multinomial logit model was applied to identify the factors that determine the possibility of employment in the rural non-farm (RNF) sector. The variables included in the best-fit models and the related hypotheses have been discussed below. It was hypothesized that the age of decision-maker in a household influences the possibility of being employed in RNF activities negatively. The elder members of a farm household may not be able to shift from farm to non-farm sector. Female-headed households were hypothesized to have less access to RNF activities. Education improves individuals' skills and prospects for non-farm jobs as well as increases ability to work efficiently for income-providing activities. Therefore, education level was hypothesized to influence the participation of workers in the RNF activities positively. The household-size also affects participation in the rural non-farm employment. The expected relationship between the household-size and possibility of a household being engaged in rural non-farm employment (RNFE) was positive. The households with a larger farm-size had less probability of participation in RNFE.

Several occupations are linked to caste in the Indian context. Therefore, it was considered worthwhile to find the effect of caste on RNFE. The households' per capita income may affect its members' decision on engagement in non-farm activities. The per capita monthly consumption expenditure was treated as a proxy for the per capita income of a household. A higher income enables the household-members to acquire necessary skills and training to participate in the RNF activities. Further, the surplus money enables the households to acquire assets and equipments necessary to be involved in the RNFE. Therefore, a positive relationship between income and RNFE was perceived. State dummies were included to assess the role of state-specific factors on RNFE. The estimation results of multinomial logit models have been presented in Table 8. Gender was found to have a significant positive impact on RNFE, confirming a clear gender divide. Its marginal effect on RNFE was also quite high. With one unit change, it increased the probability of being in RNFE by 20 per cent. The effect of age on the probability of being employed in

RNFE was negative and significant, indicating rigidity in shifting of activities for the elder persons. The marginal effect of age on probability of being employed in the RNF was not significant. With one unit increase in the age, the probability of being employed in RNF decreased by 0.13 per cent. The relationship between education and probability of working in RNF sector was positive and significant. Higher the level of education, higher was the probability of being engaged in the RNF sector. The education makes the workers capable of exploring opportunities outside agriculture and loosens the barrier in access to RNFE. Technical education, which was used as a proxy of skills, had a significant effect on RNFE. The marginal effect of technical education on RNFE was observed to be the highest. With an increase of one year in technical education, the probability of access to RNFE

increased by about 14 per cent. It was found that the skill facilitated entry into a wider market place and increased the probability of being engaged in the RNF sector.

A bigger household-size was found to increase the probability of being engaged in the RNF sector. The bigger size of a household could spare a member to pursue non-farm activities without adversely affecting the agricultural operations. The coefficient of landholding was negative, implying a negative correlation between the size of land and the probability of being involved with RNFE. The marginal effect of a unit increase in landholding on non-farm employment at the means of all variables was 0.1695, implying that if landholding decreased by one hectare, the employment in non-farm activities would increase by 17 per cent. The negative relationship between farm-size and non-farm employment suggested that the employment diversification in rural areas was often under distress. However, there was a multivariate effect of farm-size. Higher levels of production from ownership of large holdings may lead to higher consumption, which in turn, may increase the likelihood of non-farm employment (Mecharla, 2002). The bigger households may have less probability of joining RNFE, but create non-farm employment opportunities for other households. The production linkages between farm and non-farm sectors were strong. Unlike landholding, a positive link between household income and non-farm employment was found. However, its coefficient was much smaller and its marginal effect on non-farm employment was negligible. Though the coefficients of caste dummies had the expected sign, the dummy of only scheduled tribes (STs) was found significant and negative, indicating that ST households were in a disadvantageous position vis-à-vis general caste households in getting non-farm employment in the rural areas of eastern India. If a household belonged to a scheduled tribe category, the probability of non-farm employment decreased by 10 per cent. The effect of state dummies was mixed. As compared to Jharkhand, the probability of being employed in RNF activities was lower in Bihar and West Bengal and higher in Orissa. This implies that the probability of being engaged in RNFE decreased with increase in the level of agricultural development in a state, again pointing towards 'distress diversification' in the rural areas of eastern India.

Horticultural Crops

To identify the factors for employment in horticultural crops, a separate logit model was estimated and the results have been summarized in Table 8. Results have revealed that gender, education, household-size, landholding-size and monthly per capita income had a significant influence on employment in the horticultural sub-sector in eastern India. The male-headed households had a higher probability of getting engaged in the cultivation of horticultural crops. The effect of education was negative; implying that with increase in education, the probability of getting engaged in growing of horticultural crops got reduced. It may be attributed to the fact that with increase in education, people have higher propensity of leaving agriculture and getting employed in high-value non-farm sector. The bigger household-size had a higher probability of being engaged in the cultivation of horticultural crops because of more resource of labour needed in cultivation of these crops. The relationship between farm-size and employment in horticulture was negative, implying that smallholders had a higher probability of diversifying their activities towards horticultural sub-sector. It has been argued by several scholars that agricultural diversification towards high-value commodities may bypass the smallholders. However, the empirical evidence proved to be contrary. There was a positive link between income and employment in the horticultural crops. The cultivation of horticultural crops is capital-intensive and labour-intensive. The higher-income households have higher propensity to take up this enterprise. The caste dummies were non-significant. State dummies

were, by and large significant, indicating the role of state level emphasis and priorities for development and growth of the horticultural sub-sector.

Conclusions

The study has shown the increasing importance of non-farm sector in offering employment to rural workforce across major states of India. This could be viewed as one of the potential options to generate employment opportunities, and increase food and nutritional security and thereby reducing poverty in the rural areas of the country. Rural employment within agriculture has shown a mixed trend (of both high and low pace) across states. For example, animal husbandry employed a large percentage of rural workers in Punjab (40%), Jammu and Kashmir (25%) and Kerala (17%), while it was below 5 per cent in 11 out of 20 states studied in this paper. However, rural employment diversification within the crop sub-sector has been visible, indicating the possibility of generating gainful employment opportunities by shifting towards cultivation of horticulture (fruits and vegetables) and cash crops.

Diversification in rural employment towards high-value crops (HVC) means their increasing role in agricultural production, which will boost rural income and therefore, generate more employment in the rural areas. In the animal husbandry enterprise, dairy and other livestock are considered more pro-poor than the crop sub-sector. Basically, it is the landless, marginal and small farmers that own livestock and development of this sector will help them in generating employment and engaging themselves gainfully. However, the policies needed for higher growth in agriculture are increasing public investment, removing domestic and external controls, simplifying land leasing, etc.

A number of factors have been observed affecting rural employment significantly in both non-farm and horticultural sectors. A well-designed technical programme based on the local conditions of the area can help in strengthening their skills which would benefit and provide better possibility of getting employment in non-farm sector. Knowledge gaining/ skill development may also help in motivating the local people to become enterprising. The per capita income of a household may affect the decision of its members on engagement with RNF activities.

References

Basant, R. and Kumar, B.L. (1989) Rural non-agricultural activities in India: A review of available evidence. Social Scientist, 17 (1-2): 13-17.

Chadha, G.K. (2003) Rural employment: Current situation, challenges and potential for expansion: Issues in employment and poverty. A Discussion Paper. Recovery and Reconstruction Department, International Labour Office, Geneva.

Chadha, G.K. and Sahu, P.P. (2002) Post-reforms setbacks in employment: Issues and need for further scrutiny. Economic and Political Weekly, 37 (21): 1998-2026.

Foster, A. and M. Rosenzweig (2004) Agricultural productivity growth, rural economic diversity, and economic reforms: India, 1970-2000. Economic Development and Cultural Changes, 52: 509-542.

Himanshu (2005) Wages in rural India: Sources, trends and comparability, Indian Journal of Labour Economics,

48 (2).

Himanshu (2008) Agriculture and non-farm employment: Exploring the inter-linkages in rural India. Background paper prepared for India Poverty Assessment Report. New Delhi. Jawaharlal Nehru University.

Jobson, J. D. (1992) Applied Multivariate Data Analysis, Springer, New York, USA.

Kumar, P., Kumar, Anjani and Mittal, Surabhi (2004) Total factor productivity of the crop sector in the Indo-Gangetic Plains of India: Sustainability issues revisited. Indian Economic Review, 39 (1): 169-201.

Kumar, Anjani (2009) Rural employment diversification in eastern India: Trends and determinants. Agricultural Economics Research Review, 22 (1): 47-60.

Kumar, Anjani and Elumalai, K. (2007) Agricultural growth and productivity in India: An inter-state variations. In:

Economic Growth and Regional Balance: Recent Experiences and Implications in India. Eds: T.S. Papola, and Alakh N. Sharma, Institute for Human Development, New Delhi.

Lanjouw, Peter and Stern, Nocholas (1998) Economic Development in Palanpur over Five Decades, Powell's Bookstores, Chicago, USA, 668 p.

Lesschen, J. P., Verburg, P. H. and Steven, J.S. (2005) Statistical methods for analyzing the spatial dimension of changes in land use and farming systems. LUCC Reports Series No. 7. The International Livestock Research Institute, Nairobi, Kenya and LUCC Focus 3 Office Wageningen University, the Netherlands.

Mukhopadhyay, Abhiroop and Rajaraman, Indira (2007) Rural unemployment 1999-2005: Who gained, who lost? Economic and Political Weekly, 37 (21): 3116-3120.

Prasada Rao, Mecharla (2002) The determinants of rural non-farm employment in two villages of Andhra Pradesh (India), PRUS Working Paper No. 12, University of Sussex, Brighton.

Sharma, H.R. (2001) Employment and wage earnings of agricultural labourers: A state-wise analysis. The Indian Journal of Labour Economics, 44 (1):27-38.

Singh, I. (1990) The Great Ascent: The Rural Poor in South Asia. Johns Hopkins University Press, Washington, D.C., USA.

Sundaram, K. (2001) Employment and poverty in 1990s: Further results from NSS 55th Round Employment-Unemployment Survey, 1999-2000. Economic and Political Weekly, 36 (32): 3039-3049, August.

Visaria, P. (1995) Rural non-farm employment in India: Trends and issues for research. Indian Journal of Agricultural Economics, 50 (3): 398-409.