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India's Goals in Science, Technology & Innovation – The way forward

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ABSTRACT

India has one of the richest and oldest scientific heritages in the world. From ancient times, India has seen significant developments in various fields such as Ayurvedic medicine, Physics, Mathematics, Farming, Wastewater management systems, Metallurgy, Pottery, and Systematic town planning. The Constitution of India mentions that 'practicing scientific temperament' is a moral duty of every Indian citizen. The leaders envisioned a new India as a homeland to citizens with a growth mindset, capable of eradicating hunger, poverty, and unemployment by creating opportunities and curating innovative solutions. With this vision in mind, the 'Council of Scientific and Industrial Research' (CSIR) was established, which is now one of the largest publicly funded Research and Development organizations in the world.

As we celebrate 75 years of independence, the country boasts 216 institutions actively engaged in scientific research across various domains. In 2020, the Government of India launched the '5th National Science, Technology & Innovation Policy (STIP)' and initiated the 'National Research Foundation' to emphasize involving undergraduate and postgraduate students in scientific research. With more people getting involved and dedicating their time and expertise to drafting the Science, Technology & Innovation (STI) framework, India is preparing to re-establish itself as the 'Vishwa-Guru'. In the last decade, India has significantly improved its global ranking in terms of the innovations and scholarly outputs. It is the rich heritage of India that has led to the current advancements in science and technology. This paper showcases India's goals in science, technology, and innovation, paving the way forward for becoming a superpower in scientific research.

Key Words: Scientific temperament, STIP & STI

INTRODUCTION

India has completed 75 years as an independent democratic nation and is progressing towards re-establishing itself as the *'Vishwaguru'* – the knowledge superpower. With its growing economy and advancements in the Science, Technology and Innovation (STI) sector, India is on the voyage to discover itself as a developed nation. Significant steps have been taken by the governing bodies, communities and private entities to accelerate the country's growth with a special focus on the scientific outcome. In this paper, the authors have tried to capture India's journey on the STI development forefront over the years.

HISTORICAL ASPECTS

Science is an inseparable component of India's rich cultural heritage. The profound connection between science and culture in India dates back thousands of years. Ancient literature, including the four Vedas, Upanishads, and other mythological scriptures written in the first millennium, contains references to complex scientific principles that have influenced various fields. These texts are not merely spiritual or religious documents but are also rich sources of scientific knowledge and exploration. The Rigveda, for instance, discusses the concept of cosmology, while the Yajurveda provides insights into the science of rituals and ceremonies, reflecting a sophisticated understanding of chemistry and physics. It is a widely accepted fact that India has laid the foundations of modern society. The advancements in science, medicine, mathematics, metaphysics, religion, and astronomy all find their origins in

ancient Indian civilization.

The Indus Valley Civilization, one of the oldest and most advanced civilizations in the world, exemplifies India's early achievements in urban planning, architecture, and engineering. The well-planned cities of Mohenjo-Daro and Harappa, with their sophisticated drainage systems, standardized weights and measures, and advanced metallurgical techniques, reflect a high level of scientific and technological development.

When the British Empire arrived in India, they recognized the vast potential of India's heritage and invested in its propagation. The British colonial period saw the establishment of institutions and the documentation of India's ancient knowledge systems. Indian scriptures, such as the Susruta Samhita and Charaka Samhita, serve as ancient treatises on medicine. These texts are considered some of the oldest and most comprehensive works on surgery, anatomy, and medicinal herbs. India's scientific heritage is a testament to the nation's innovative spirit and intellectual achievements. The integration of science and culture in ancient India laid the groundwork for a legacy of inquiry, discovery, and knowledge that continues to inspire and inform modern scientific endeavours.

Institutionalization of Science in India

During the late nineteenth and early twentieth centuries, India underwent a significant intellectual revival, characterized by the convergence of new western ideas and traditional religious and cultural insights (Gosling, D., 2023). This period saw a renewed interest in cultural heritage and an eagerness to blend it with contemporary scientific and technological advancements.

The British government played a crucial role in fostering this intellectual awakening by establishing university campuses in the Madras, Bombay, and Calcutta presidencies. These institutions were pivotal in formally training the Indian population in various disciplines, including the sciences, humanities, and engineering. The establishment of these universities marked the beginning of a structured and institutionalized approach to higher education in India.

Applied sciences began to gain significant traction in the mid-nineteenth century with the establishment of key institutions like the Roorkee Engineering College (now known as IIT Roorkee) and Poona College of Engineering. These colleges were among the first to offer specialized training in engineering and technology, laying the groundwork for India's future advancements in these fields.

Calcutta University took a pioneering step in science education by introducing a Bachelor of Science (BSc) degree in 1902. This initiative was a significant milestone, marking the formal entry of scientific education into the Indian academic curriculum. From this point on, science education gained momentum across the country, with advanced courses and research programs being introduced at multiple institutions. This period saw a rapid expansion of scientific knowledge and the establishment of a robust educational infrastructure.

The Indian Institute of Science (IISc) in Bangalore, established on 27 May 1909, stands as a testament to India's commitment to scientific research and higher education. The creation of IISc was made possible through the visionary efforts of Jamsetji Nusserwanji Tata, a pioneering industrialist who recognized the importance of scientific education for the nation's progress. Tata's dedication and philanthropic spirit were instrumental in founding IISc, which has since become one of India's premier institutions for advanced scientific research and education.

This era of intellectual renaissance not only laid the foundation for modern scientific education in India but also fostered a spirit of inquiry and innovation that continues to drive the country's scientific achievements today. The confluence of traditional knowledge and contemporary scientific thought during this period set the stage for India's emergence as a significant player in the global scientific community.

Inter-woven history of India's freedom struggle and foundations to a robust scientific ecosystem in the country

The role of the scientific community in building a self-reliant new India has not received the limelight it deserves. When India's freedom movement gained momentum, leaders began to formulate policies and reforms for an independent, democratic nation. The scientists of the time made efforts to carve India's identity on the global platform, advocating for the utilization of science to build a progressive nation.

Prof. C.V. Raman, the first Nobel Laureate from Indian soil, sponsored the establishment of the Indian Academy of Sciences and endowed the Raman Institute of Research in Bangalore. He also served as the first Indian Director at IISc, Bangalore, post-independence.

Pt. Jawaharlal Nehru, India's first Prime Minister, strongly supported science. During his speech at the Indian Science Congress on December 26, 1937, he asserted that only science could address issues such as hunger, poverty, poor sanitation, illiteracy, superstition, restrictive traditions, and the inefficient use of resources in a nation rich in potential but plagued by widespread starvation.

Several scientists in the twentieth century dedicated their lives and work to science and its potential to uplift society. Sir Shanti Swaroop Bhatnagar, Acharya Jagadish Chandra Bose, Dr. Homi Jahengir Bhabha, Dr. Vikram Ambalal Sarabhai, and Dr. Mahendralal Sircar were some of the brightest minds of the century who laid the foundations for modern science in India.

CULTIVATION OF SCIENCE IN INDEPENDENT INDIA

The visionaries believed that for a nation to progress, it has to incorporate scientific practices. Article 51A of the Indian constitution acknowledges this, saying that it is every Indian citizen's essential responsibility "to develop the scientific temper, humanism, and the spirit of inquiry and reform." To promote this, several initiatives have been taken by the Government of India.

Governance of S&T ecosystem in India

The Ministry of Science & Technology in India currently oversees the scientific ecosystem. The Department of Science & Technology (DST), the Department of Scientific and Industrial Research (DSIR), and the Department of Biotechnology (DBT) are the three main S&T departments under the ministry's management (Thukral, A., 2022). The Government of India founded the Council of Scientific and Industrial Research (CSIR) in 1942 as an independent organization to advance scientific understanding and foster industrialization and economic expansion.

India's efforts in Science, Technology, and Innovation started in 1958 when the Scientific Policy Resolution, the first significant policy in the series, was formulated. The Technology Policy Statement, which was published in 1983, highlighted the concept of technical self-reliance and emphasized the use of indigenous technology to minimize vulnerabilities in important sectors and make the best use of available local resources, both material and human. The Science and Technology Policy 2003, the third in the series, placed a strong emphasis on sustainable and equitable development. Eventually, the importance of creating a strong national innovation ecosystem was recognized by the Science, Technology, and Innovation Policy 2013 (India Bioscience Blog, 2020).

The Office of the Principal Scientific Advisor was set up in November 1999 by the Atal Bihari Vajpayee government to advise the Prime Minister and the cabinet on matters of Science and Technology. Dr. APJ Abdul Kalam (1999-2001) was appointed as the first Principal Scientific Advisor (PSA), followed by Dr. R. Chidambaram (2001-2018), Prof. K. Vijay Raghavan (2018-2022), and Prof. Ajay Kumar Sood (2022-present).

Scientific Institutions in India

To build and maintain the infrastructure needed to support the nation's Science, Technology, and Innovation (STI)

ecosystem, educational and research institutes have been built. Among the nation's leading scientific institutions are the Indian Institutes of Science Education & Research (IISERs), Indian Institutes of Technology (IITs), and the Indian Institute of Science (IISc, Bangalore). There are 216 educational institutions in India that offer courses in many fields, including biological and medical sciences (63), Agricultural Sciences (66), Materials, Minerals, and Metallurgy (7), Chemical Sciences (9), Physical and Mathematical sciences (31), multidisciplinary and other areas (18).

Initiatives to Promote Science

At several levels, initiatives have been implemented to encourage Indian population to adopt a scientific temperament. The National Council for scientific & Technology Communication (NCSTC) was founded by the Indian government in 1982 with the intention of actively involving Indian citizens in scientific and technology-related activities. The NCSTC seeks to promote science, spread scientific literacy, and foster a scientific mindset.

Table I: Fellowships and Awards to encourage participation in STI ecosystem

For Students
• Kishore Vaigyanik ProtsahanYojana (KVPY)
• National Scholarship Portal
• Innovation in Science Pursuit for Inspired Research (INSPIRE)
• National Science Concours
• SOF Girl Child Scholarship Scheme
• Dr APJ Abdul Kalam IGNITE Awards
• CSIR Innovation Award for School Children
• Science Academies Summer Research Fellowship Programme
For Academicians
• Fulbright-Kalam Climate Fellowship
• Indo-US Fellowship for Women in STEMM
• Sponsored Research (RESPOND)
• Innovative Young Biotechnologist Award (IYBA)
• CSIR Young Scientists Awards
• SERB Overseas Postdoctoral Fellowship
• Early Career Research Award
• National Postdoctoral Fellowship (N-PDF)
• Ramanujan Fellowship
• J C Bose National Fellowship
• Start-UP Research Grant (Young Scientists)
• Empowerment and Equity Opportunities for Excellence in Science
• Scheme for funding High Risk – High Reward Research
• Extra Mural Research Funding (Individual Centric)

Table II: Schemes for a robust Science Research & Innovation Ecosystem

School Level
• International Olympiad Movement
• BLISS-DBT
Higher Education/Industry/Professional
• Atal Innovation Mission

• Incubator Program
• National Science & Technology Entrepreneurship Development Board
• Startup India
• Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI)
• National Research Development Corporation
• Biotechnology Industry Research Assistance Council (BIRAC)
• Technology Development Board
• National Innovation Foundation
• Agrinovate India Ltd

INDIA'S ACHIEVEMENTS IN SCIENCE & TECHNOLOGY

India has been making consistent yet noteworthy advancements in Science, Technology, and Innovation through the combined efforts of scientists, researchers, and governmental agencies. In eight domains—Agricultural Sciences, Biological and Medical Sciences, Chemical Sciences, Physical Sciences and Mathematics, Earth Sciences, Engineering Sciences, Materials, Minerals and Metallurgy, and other multidisciplinary areas—there are currently 216 institutes in the nation conducting high-caliber research.

- India's Global Innovation Index (GII) rating has increased dramatically from 81st in 2014 to 40th in 2022, according to the World Intellectual Property Organization's (WIPO) 2022 report.
- In terms of scientific publications, India ranked third globally in 2020, up from seventh in 2010 (National Science Foundation, 'Science & Engineering Indicators 2022' report).
- India ranked third in terms of the number of PhDs in science and engineering in 2020, with an increase in scholarly production from 60,555 publications in 2010 to 1,49,213 papers (White, K. (n.d.)).
- From 2,511 in 2018–19 to 4,003 in 2019–20 and 5,629 in 2020–21, the number of patents awarded to Indian scientists at the India Patent office has significantly increased (Year-end review 2022: DST).

THINKING AHEAD – STI (SCIENCE TECHNOLOGY & INNOVATION) IN INDIA @ 2047

India is making strides in reclaiming its rightful place as the "Vishwaguru." Academics predict that India would experience a demographic dividend opportunity window from 2005–06 through 2055–2056. The Economic Survey 2018–19 projects that India's demographic dividend would reach its zenith in 2041, when 59% of the country's population is estimated to be of working age (20–59 years old), presenting enormous opportunities for economic expansion. India must develop flexible policies to guarantee that the vast majority of its people have the skills necessary to prosper in the twenty-first century if it is to fully utilize this population's potential.

Crucial steps have been taken in the right direction by the Government of India to ensure this, including the introduction of the New Education Policy (NEP) 2020 by the Ministry of Education and the Science, Technology, and Innovation Policy (STIP) 2020 by the Ministry of Science and Technology. Inspired by the National Science Foundation (NSF) in the US, India has also devised a five-year plan to establish a National Research Foundation (NRF) to facilitate public funding for scientific research in the country (Principal Scientific Adviser, n.d.).

CONCLUSION

The Government of India launched several events to celebrate the achievements of the last 75 years of independence and to initiate conversations on proposed policies to further enhance development. Contributing to this, scientific

bodies (autonomous institutions and government offices) have also shared their vision and goals to achieve by 2047. If executed properly, these interventions can significantly impact and accelerate the rate of development in the country.

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Cultivation of soybean for the preparation of Tofu

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ABSTRACT

The presented research study was aimed to cultivation of seven varieties (MAUS 162, MAUS 612, Pb-1, Hardee, JS 2094, Pk 472 and NRC 127) of soybean for the preparation of tofu to find out the consequence of seed growing area on the quality of experimental samples. The crop seeds were purchased from Indian Council of Agriculture Research (ICAR)-Indian Institute of soybean Research (IISR), Indore, Madhya Pradesh (India) and grown at Shanti Nagar, Khasra 359, Dayalbagh, Agra, Uttar Pradesh (India) near the river bank area of Yamuna. There were several changes occur in the crop during the period of sowing (June) to harvesting (October). It was observed that from 50 g seeds of each variety (MAUS 162, MAUS 612, Pb-1, Hardee, JS 2094, Pk 472 and NRC 127) the number of plant grown were 99-100, 103-105, 83- 85, 75-80, 62-65, 54-66 and 30-40, leaves 7.60±1.34, 5.80±1.22, 7.10±1.66, 9.00±1.41, 8.20±.91, 7.90±1.10 and 5.30±.94 increase to18.20±2.14, 17.90±1.72, 20.80±1.47, 22.20±2.34, 21.20±2.52, 20.00±1.49 and 18.40±.96, branches 2.60±.96, 2.80±.78, 3.20±.91, 5.30±.67, 5.20±.78, 3.30±.67 and 3.30±1.05 increase to 10.80±.91, 13.90±1.85, 14.00±.81, 14.10±.99, 14.30±1.33, 12.40±1.26 and 12.40±1.34 and height 6.39±.33, 8.52±.55, 6.44±.38, 9.13±024, 5.48±.40, 7.43±.42 and 8.37±.34 increase to 21.37±1.34, 19.39±.76, 17.02±.65, 21.09±.67, 20.96±.74, 19.25±.62 and 21.17±.70 as in the month of June or July, increased at the time of harvesting from each variety, respectively. The yield of seeds (390, 356, 84, 65, 142, 110.5 and 195.8 g) were different; only 40 to 50% seeds were grown. It depends on the atmospheric conditions, field preparation and lack of fertilizers of this area. The study suggested the yield of soya seeds which will be responsible for extraction of soymilk for the preparation of tofu. The prepared tofu was observed good organoleptic characteristics.

Keywords: - Cultivation, soybean, varieties, tofu and yield

INTRODUCTION

Soybean [(Glycine max L.) Merrill] is a member of *Fabaceae* family and often called as 'Golden Grain'. The seeds are known for its high grade plant protein to feed human and monogastric creatures (Montoya *et al.*, 2017; Benedetti *et al.*, 2016). Dietary fibre and isoflavones content was found higher compared to some other legumes (Mamta *et al.*, 2015). Soybeans have long been converted into many forms of soy food, staple food are usually consumed as nutritive soymilk, tofu, and fermented bean curd products such as *miso, soy sauce, tempeh,* and *Mao-tofu (*soft variety of tofu) with cheesy body, unique flavor and conventional foods in East Asian nations (James and Yang, 2016). It contained 40% protein (dry weight basis) while 20 % fats and reduced cholesterol in the human body owing to high content of polyunsaturated fatty acid (PUFA) along with dietary fibre (20%), carbohydrates (35%) and ash (5%) (Jooyandeh, 2011). The seeds are good source of bioactive compounds, isoflavones, peptides, protease inhibitors, phytosterols etc. and reported to recover human wellness (Juritsch and Moreau 2018). Consumption of this legume can inhibit many severe diseases in women such as cancer (breast and prostate), menopausal symptoms, cardiovascular disease as well as osteoporosis. As per the statistics of Food and Agriculture Organization (FAOStat, 2021), the production of soy legume was 350 million tons in 2018. The major soy producing countries includes USA, Argentina, Brazil, China and India with approximately 92% of total world soy production (Pagano and Miransari, 2016). The climatic conditions for cultivation in the northern parts of Uttar Pradesh are suitable whereas many negative factors decreased the rate of output like sunlight period, atmospheric temperature and rain, mainly during the growth and flowering span (Mandi´c *et al*., 2017; Gawęda *et al.,* 2020). Hot weather was found suitable for the ripening (Kühling *et al.*,

2018). the protein of soya is chemically similarto animal protein and used for preventing protein deficiency (Ergashovich and Akmalovna, 2022).

MATERIAL AND METHODS

Field trials were carried out at experimental site named as Shanti Nagar, Khasra 359 Agra, U.P and research work was done in the Department during rainy season (June to October) 2021. The crop was cultivated using soybean seeds collected from ICAR- IISR, Indore. Cow dung manure and fertilizers were procured from research field.

Methods

Field preparation

Field preparation of seeds was completed according to methodology recommended by (Thentu *et al.,* 2014) with a few changes. The soil was left open to the summer sun by deep ploughing (20 to 30 cm). It helps in management of weeds, insect's diseases and nutrition in strong sunlight, as well as facilitates accumulation of rain water in the soil. Field was prepared for sowing seeds, the cultivator was run twice in the opposite direction, after that levelled the field with the help of a tractor, to increase yield of seeds. Manure of cooked cow dung was spread at the rate of 5 to 10 ton and levelled by running the reader.

Selection of soybean seeds

The process for selection of soybean seeds was completed according to methodology recommended by Thentu *et al* (2014) with some modifications. Seven varieties of soybean seeds were selected JS 2094, NRC 127, MAUS 162, MAUS 612, PB 1, HARDEE and PK 472 based on their good protein percent, maturity, more yield along with superior quality.

Treatment of soybean seeds

Treatment of soybean seeds was completed according to methodology recommended by (Thentu *et al.,* 2014) with some modifications. Before sowing, soybean seeds were treated by 0.2% thorium and 0.1% carbdaizem for the protection of seeds from various fungal diseases. After drying the seeds treated by these fungicides were kept in shade. Both, Rhizobium and PSB culture (organic fertilizers) were used for sowing immediately using 5% of seeds.

Sowing of seeds

Selected varieties of soybean seeds were used for sowing after germination test and seeds treatment according to the procedure of Aydinsakir (2018). Soybean seeds were sown in last week of June to first week of July in rows, spaced 45 cm having the sowing density of 100–150 possible seeds in a square metre area. The depth of rows was made 3 to 4 cm by forming a bed of 10×10 metre straight line. The distance from plant to plant was kept at 4 to 5 cm. Weed domination by using machine was performed manually with disturbing earlier as well as end of the organic fertilizer was used.

Harvesting of soybean seeds

Selected varieties of soybean seeds were harvested manually according to the procedure of Aydinsakir (2018) in the last quarter of October to initial days of November month to avoid the damage caused before the pods cracked.

Yield attribute of dry seeds and storage

Yield was calculated dry weight basis according to Thentu *et al* (2014). After that grain moisture was determined by sun drying for 2 to 4 days, Grains were filled in polyethylene zipper bags of 1 kg. capacity and maintained at room temperature (25± 2ºC) for subsequent uses.

Weather Conditions

Weather conditions during the experiment are demonstrated in Fig 1. The higher rain was recorded in July (22.32 cm), whereas the lower value was shown in November (0.3 cm). Utmost average monthly heat was noticed in June (35°C), whereas least was recorded in Nov (21°C).

Squeezing of milk from soybean seeds:

Soymilk was produced by the method followed by Shin (2014) with several alterations. 100 g of soybean seeds was rinsed and soaked in 1L of distilled water for at least 16 h at ambient temperature. Soaked seeds ware drained, rinsed and then grind with boiling water in a power operated blending machine for a period of 3 min at full speed of the mixer. Further, the water was incorporated to create a total volume of 1.1 L of seeds slurry besides the proportion of dry seeds to water was reached 1:10 on weight basis. Thus, produced slurry was filtered by way of four-fold muslin cloth and separated 750 to 880 mL milk.

Preparation of plain and probiotic tofu:

Plain tofu was manufactured by extracted soymilk. It was pasteurized for 10 min at 80-85°C whereas, probiotic type tofu was prepared by curdling the milk using a combination of 0.5% shell powder together with calcium sulphate. Further, the obtained curd was mixed and kept undisturbed for almost 10 min to coagulate proteins. Thus, constructed soy milk curd was put into a two-fold cheese cloth followed by pressing in tofu-forming rectangular box. Weight was applied on the top of the box for pressing. Finally prepared probiotic tofu was stored at 4°C in a refrigerator for further study.

Statistical analysis

Research data was analyzed and calculated by means of SPSS software (version 20.0). All results were estimated in the replication of 10 data and expressed as one way ANOVA with standard deviation and error of mean (SEM).

RESULT AND DISCUSSION

Growth of plants

In the present investigation fresh plants of soybean crop were calculated manually. Fifty grams seeds of each variety such as MAUS 162 (V_1) , MAUS 612 (V_2), Pb-1 (V_3), Hardee (V_4), JS 2094 (V_5), Pk 472 (V_6) and NRC 127 (V_7) were sowed in 10×10 meter lines in 9-10 days and found that the soybean seeds were started to grown up as V_1 (99-100), V_2 (103-105), V_3 (83- 85), V_4 (75-80), V_5 (62-65), V_6 (54-66) and V_7 (30-40), separately. In the same way, Thentu, *et al* (2014) indicated that the treatment with 150% RDF recorded maximum and significantly dry substance accumulation of plants. The noted maximum accumulation was due to 40 kg S ha application and was at par with 30 kg S ha and 20 kg S ha. The findings of Malik *et al* (2015) and Habib *et al* (2018), it was obvious that the crucially more grains pod (7.30) were made in test T_9 (RDF + Zn @ 5 kg/ ha+ B @ 2.5 kg/ ha+ Mo @ 1 kg/ ha) which kept on par with trial T_7 (RDF + Zn @ 5 kg/ ha+ Mo @ 1 kg/ ha). Test sample T_1 (control plot) observed lowest number of grains pod (3.75) followed by T_2 (RDF (20:40:20) kg/ ha). The observations were inline to the reports of Monu *et al.* (2015). Highest development of plants (3.17) was produced in treatment T_9 which remained on par with T_7. Treatment T_1 observed the minimum maturation of plant (1.12) followed by T_2. Sharaby, *et al.,* (2019) showed that the results of sowing rate was 600,000 seeds (almost 80 kg) in a hectare area, plant growth and yield were good but did not lead to boost up in yield. On the basis of experimental trials, it was noted that the most preferable sowing

norm for soybeans was 500,000 or 70 kg seeds/ha. In order to set and recommend a clear sowing norm, it is essential to go through the purity of seeds, its fertility, suitability for sowing along with the weight of 1000 seeds. Gupta, *et al* (2022) also found that with the implementation of similar quantity of fertilizer (T_9) displayed notable consequence on yield (13.91 q ha) as well as yield of moong bean than other micro nutrients trials. The highest net return was noted in T_9 followed by T_7, while in it was lowest in T_1. Elevated values of benefit cost fraction (2.35) were found in T_9 and it was identified as more environmentally sustainable to legumes.

Height of plants

Height of the plant was measured manually by selecting 10 fresh plants of soybean seeds randomly and measuring the length. It was noticed that the difference was notable ($p<0.05$) within the columns V_4 (9.13±0.08), V_5 (5.48±0.13) and V_6 (7.43±0.14) but there was negligible ($p>0.05$) variation in V_1 (6.39±0.11), V_2 (8.52±0.18), V_3 (6.44±0.13) and V_7 (8.37±0.11) from the height in the month of July. The significant difference V_5 (8.41±0.1) but there was non-significant difference V_1 (9.61±0.07), V_2 (11.45±0.15), V_3 (9.27±0.09), V_4 (12.14±0.12), V_6 (11.53±0.14) and V_7 (12.48±0.16) in the month of Aug. There was non-significant difference in V_1 (17.08±0.19), V_2 (15.28±0.19), V_3 (14.77±0.28), V_4 (16.63±0.13), V_5 (17.1±0.18), V_6 (13.41±0.25) and V_7 (13.77±0.7) in the month of Sep. The significant difference in V_3 (17.02±0.21) but there was non-significant difference in V_1 (21.37±0.43), V_2 (19.39±0.25), V_4 (21.09±0.22), V_5, (20.96±0.24) V_6 (19.25±0.2) and V_7 (21.17±0.23) in the month of Oct. Start of flowering at the stage of Sep to Oct, fruiting of seeds had commenced in the month of Oct and water turned into furnished to the wetted beds of soybean plot. The height of soybean plant Fig 2. Similar with the research of Thentu, *et al* (2014) who indicated that the three levels of fertilizers as targeted plot, 150% RDF treatment noted highest and positive changeable height of plants. The plant height was not significantly influenced by sulphur application. Similarly, Blanco *et al* (2022) reported that the structural investigation about soybean crop at the first vegetative stages demonstrated notable decrease in the development of plants height.

Leaves count

Leaves were counted manually by selecting 10 fresh plants of soybean seeds casually and leave count monthly. It was observed that the variance was negligible ($p>0.05$) within the columns V_1 (7.6±0.42), V_2 (5.8±0.38), V_3 (7.1±0.53), V_4 (9±0.45), V_5 (8.2±0.30), V_6 (7.9±0.35) and V_7 (5.3±0.3) from the leaves count in the month of July. There was non-significant contrast in V_1 (10.9±0.28), V_2 (9±0.43), V_3 (10.7±0.48), V_4 (13.8±0.76), V_5 (12.7±0.27), V_6 (12.8±0.42) and V_7 (9.1±0.24) the month of Aug. There was nominal difference in V_1 (14.7±0.3), V_2 (14.1±0.61), V_3 (15.7±0.62), V_4 (18.3±0.75), V_5 (17.5±0.27), V_6 (15.9±0.49) and V_7 (13.8±0.33) in the month of Sep. There was inconsiderable dissimilarity in V_1 (18.2±0.68), V_2 (17.9±0.55), V_3 (20.8±0.45), V_4 (22.2±0.75), V_5 (21.2±0.8), V_6 (20±0.48) and V_7 (18.4±0.31) in October. The data of leaves count was showed in Fig 3. The observations were similar to the findings of Sepasthika (2022) revealed that the leaves count in the 2nd week of the early vegetative phase was highest (6.10) in multi-cropping (3:1) system, at the 4th week it was found uppermost (16.66) in mixed cropping (5:1). They also reported that in generative phase, the amount of leaves was notably unusual in each treatment at 6th, 8th, 10th and 12th week while it was noted greatest in 3:1 alley cropping.

Branches count

Branches were counted manually by selecting 10 fresh plants of soybean seeds randomly. It was observed that the change was minimal within the columns V_1 (2.6±0.31), V_2 (2.8±0.25), V_3 (3.2±0.30), V_4 (5.3±0.22), V_5 (5.2±0.25), V_6 (3.3±0.22) and V_7 (3.3±0.34) in the month of July. There was nominal difference V_1 (4.4±0.17), V_2 (6.1±0.41), V_3 (6.8±0.47), V_4 (8±0.26), V_5 (7.8±0.42), V_6 (6.7±0.3) and V_7 (6.9±0.46) in the month of August. There was non-significant difference in the counting of branches such as V_1 (7.9±0.24), V_2 (10.8±0.56), V_3 (10.6±0.4), V_4 (11.2±0.25), V_5 (10.9±0.53), V_6 (9.4±0.34) and V_7 (9.9±0.38) in the month of September. Also there was negligible in V_1 (10.8±0.30), V_2 (13.9±0.59), V_3 (14±0.26), V_4 (14.1±0.32), V_5 (14.3±0.43), V_6 (12.4±0.4) and V_7 (12.4±0.43) in the month of October. Branches count had been shown in Fig 4. Similarly, Thentu, *et al* (2014) indicated that the

treatment 150% RDF recorded maximum and the number of branch counts was not significantly determined by sulphur application.

Yield of seeds

The yield of dry soybean was calculated by weighing of seeds. It was noticed that by cultivating different varieties the weight was not same such as 390, 356, 84, 65, 142, 110.5 and 195.8 g from V_1 to V_7, respectively using 1 kg seeds. Only 40 to 50% seeds were grown, may be owing to the atmospheric conditions of the site so that pods of grain became cracked and damaged. Field preparation method and inclusion of lack of fertilizers in the area may be the reasons for small yield. This type of seeds may be grown correctly after itself for a length of June to October in regions in which it's far cultivated for the primary time shows in Fig 5. Similarly, Karges *et al* (2022) revealed that yield and protein content of soybean harvested in a hectare area were changed mainly by both irrigated and rain fed plots in a year of cultivation and the fundamental interaction issue caused the yield and protein harvested in rain fed plots of the soybean crop. However, the change was negligible in the grain as well as protein yields. Księżak (2022) also reported that the best yield was obtained when the climatic situation is favourable to the crop during the growth phase of soybean sown while there was nominal change on the yield with critical weather conditions at the time the sowing date. It was also noticed that the protein contained of the crop decreased to only 9% protein under limited rainfall conditions compared to those grown under most suitable ecological weathers. The 20 days interrupted growth in sowing date firmly modified the aggregation of protein into seeds. Similarly, Thentu, *et al* (2014) indicated that the treatment of seeds with 150% RDF noted highest and crucially change in grain capsules quantity together with yield of plant seeds. The seed yield was significantly higher owing to 150% RDF than 100% as well as 125% treatment level. These observations were in-line with the results of Pandey (2013), who observed that treatment of crops using micronutrients did not induce any discernible alteration in sample weight. Weight of 1000 grains was noted highest in T_9 (35.25 g) whereas it was noticed lowest in T_1 (31.65 g). Micronutrients are known to boost up the convenience of plant nutrients which results in major nourishment of crops along with the development of large seeds, eventually increasing the seed weight.

Impact of cultivated seeds on organoleptic properties in prepared tofu

The tofu prepared using the different varieties of soy seeds in combination of different treatment obtained good sensory profiles as per the judges and the research work will be continued for standardizing the best quality of soybean with or without the use of probiotic cultures.

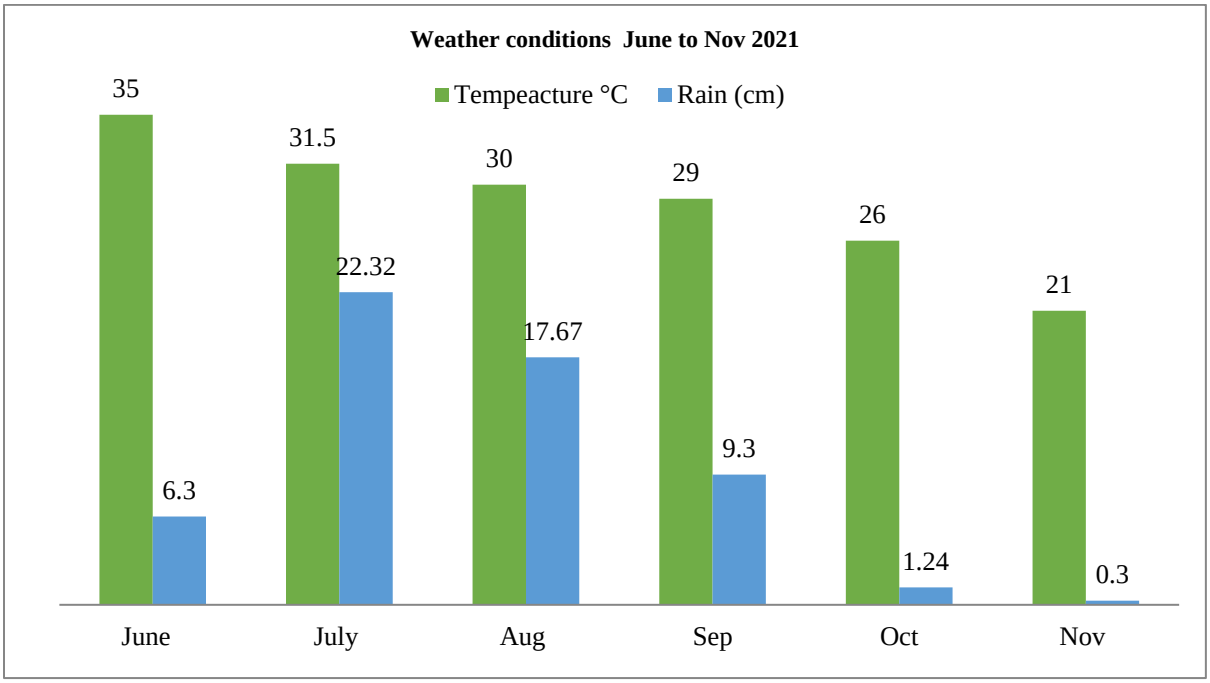

Fig 1. Weather condition

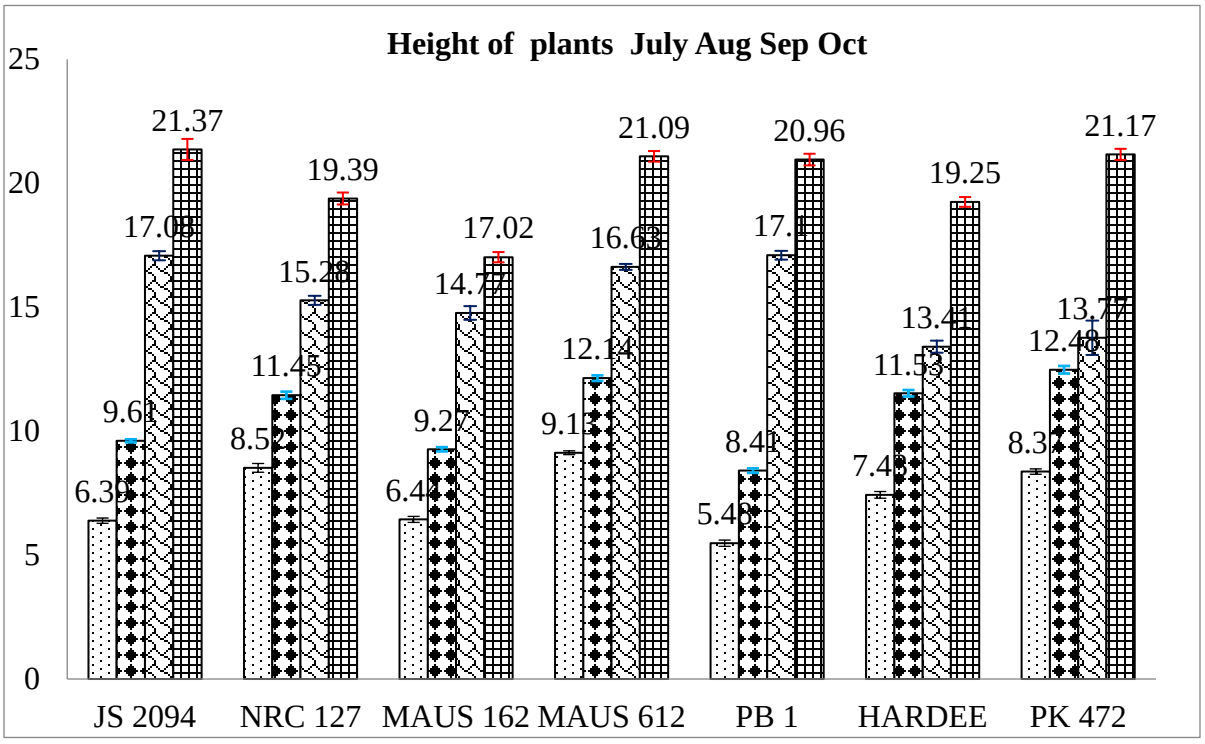

Fig 2. Height of plants (cm)

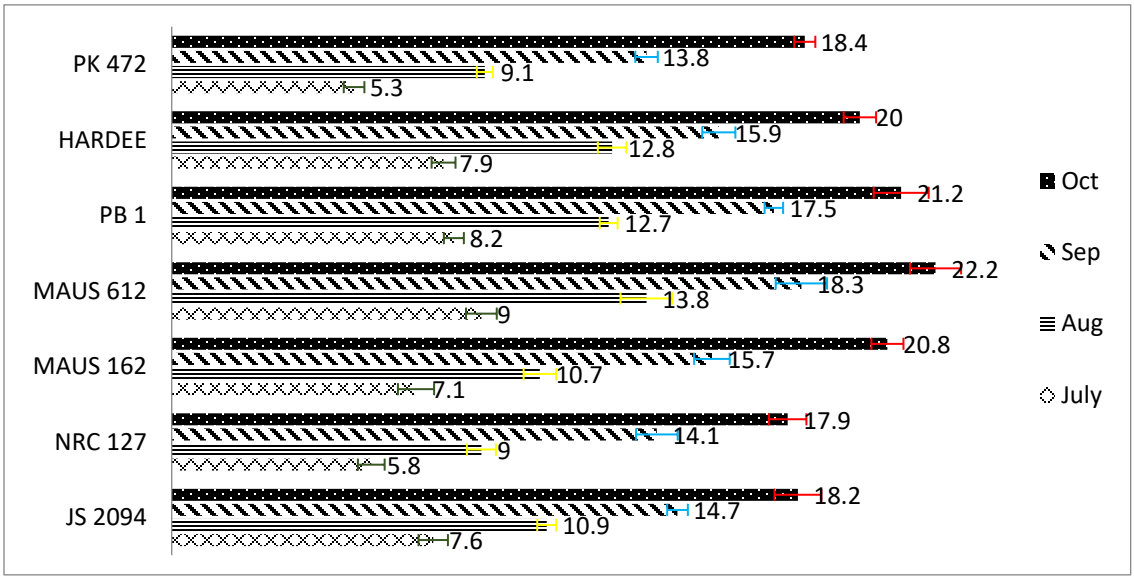

Fig 3. Leave count of plants

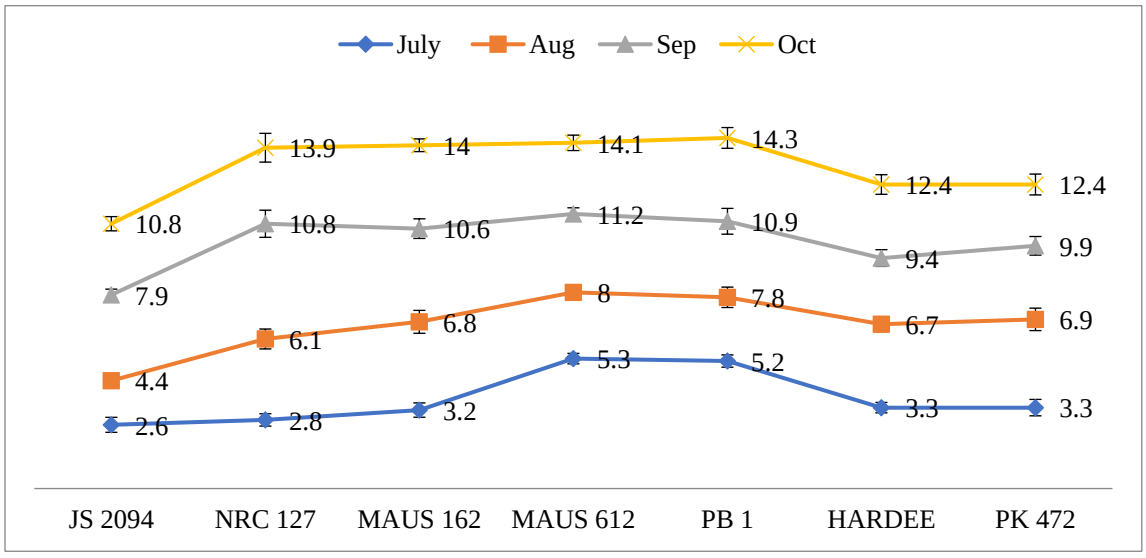

Fig 4. Branches count of plants

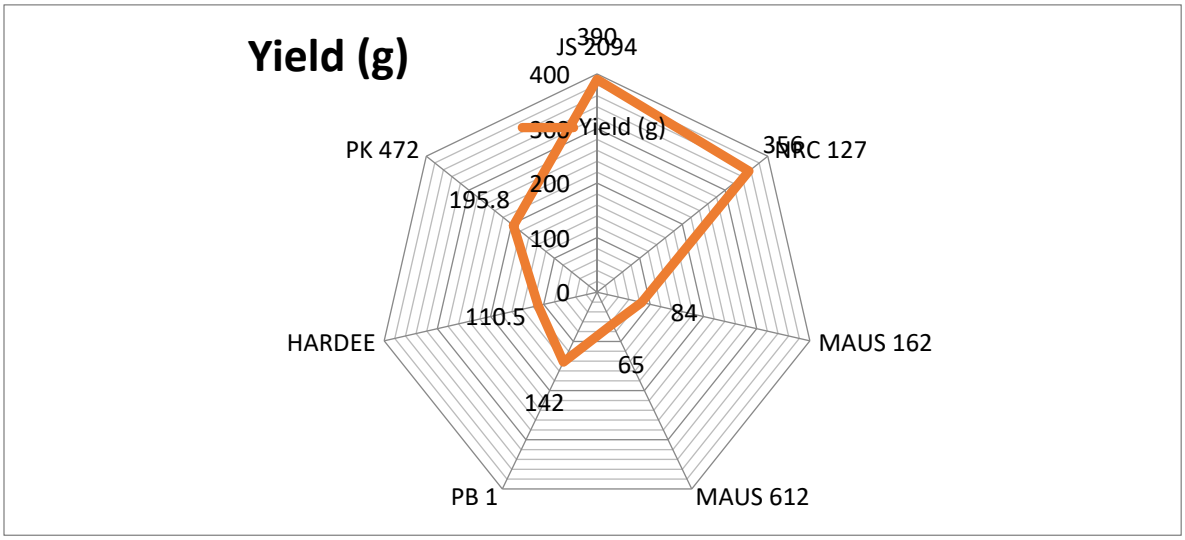

Fig 5. Yield of dry seeds

CONCLUSION

The findings of the research results concluded that among all seven different varieties of soybean seeds sown, MAUS 162 and MAUS 612 were obtained higher yield. Only 40 to 50% seeds were grown, depending upon the weather conditions, field preparation and amount of fertilizers of the particular region. These types of seeds can be grown perfectly during June to October in the suitable climatic regions. The legume can used for extraction of milk for the preparation of unfermented and fermented tofu. This research work will continue for standardizing the quality with different concentration of coagulant.

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Biodiversity Conservation– The more variety, the better society

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ABSTRACT

This paper examines the importance of biodiversity and its conservation, biodiversity loss, causes of biodiversity loss, why there is a need for biodiversity conservation and methods for the biodiversity conservation.

INTRODUCTION

Edward Wilson, a sociobiologist, popularised the word "biodiversity" which refer to the integrated diversity present at all tier of biological hierarchy. Biodiversity is basically defined as: " The diversity of life forms across all environments, encompassing sea, land, and various aquatic ecosystems; which additionally encompasses the internal variety/diversity in and among species, along with ecosystems."
Biodiversity is considered at 3 major levels which are –

1. Genetic Diversity- A particular one species can display significant genetic variation across its range. One such example could be - The plant with restorative properties Rauwolfia vomitoria which grows in Himalayan chain shows great genetic concerning the strength and concentration of the active chemical (Reserpine) produced by the plant. India boasts over thousands of varieties of mangoes and several thousand distinct strains of rice.
2. Species Diversity- The level of variety among the species. The diversity of species is used to measure it. For ex- The ghats in west have greater diversity of amphibian species.
3. Ecological Diversity- This pertains to the range of biotic communities, ecological processes, and habitats found throughout the biosphere. For example, at the level of ecosystem, India has a much paleobiodiveristy than a country like Norway.

Importance of biodiversity

Paul Ehrlich's "Rivet Popper Hypothesis" makes it simple to comprehend the value of biodiversity in an ecosystem.

Each component of an aeroplane (ecosystem) is connected by numerous rivets (species). If each individual travelling inside of it begins popping a rivet to bring home (leading to the extinction of a species), the flight safety (the ecosystem's healthy functioning) would not be immediately impacted, though if rivets are removed continuously over time, the plane gradually becomes fatally frail. Moreover, it becomes important which rivet is taken out.

Benefits of biodiversity/why should we conserve biodiversity?

This can be divided into three main categories-

1. Narrowly Utilitarian: It is defined as the direct economic benefits which we derive from the nature like – food, firewood, fibre, materials construction, industrial products, pharmaceutical products etc.

2. Broadly Utilitarian: It is defined as the indirect benefits which we derive form nature like photosynthesis, pollination, etc.
   For example- It is estimated that the Amazon rainforest produce around 20% of the complete quota of O2 on Earth.

3. Ethical: Any living organism that exists on this planet has the right to exist whatever its value for the human species. Therefore, it becomes our moral duty and responsibility to look after the well-being of biodiversity and transmit to the next generation our biological heritage.

4. Aesthetic value: Human beings really enjoy spending time in nature. The government works with many NGO'S and organisations and spends a lot of money to conserve the biodiversity. We enjoy-
   Leisure Time – sitting and listening to the chirping of birds, watching them.
   Hearing, touching, watching wildlife.

Estimated species on earth and in India

The comprehensive figure of animal and plant species that have been described to date is little over 1.5 million, according to IUCN (2004), although Robert May's more conservative and scientifically valid estimate puts the number at nearly 7 million.

Animal species account for more than 70% of all known species, while plants (inclusive of algae, bryophytes, pteridophytes, fungi, angiosperms and gymnosperms) constitute a maximum of 22% in all.

India being in the class of the world's 12 mega diversity countries even though it only makes up 2.4% of the planet's surface area and has a remarkable 8.1% proportion of the world's species diversity.

Biodiversity loss

Biodiversity loss and environmental fluctuations are occurring rapidly than ever before in the history and there is absolutely no sign of a downward trend. A danger is, by definition, any activity or occurrence, whether it be human or naturally induced that may adversely affect the condition or components of biological diversity.

The biodiversity and the natural wealth of our planet has been decreasing rapidly for one obvious reason – human activities.
Example- Human colonization of the tropical islands in the Pacific has resulted in the the disappearance of almost 2,000 native species of birds.
The Red List published by IUCN in the year 2004, records vanishing of approximately 784 species (including invertebrates, vertebrates and plants) over the past years.

Some extinct animals are- Dodo (Mauritius), Steller's Sea Cow (Russia), Quagga (Africa), Thylacine (Australia), and three species of Tiger (Bali, Javan and Caspian).

It can be said that the loss of biodiversity in a particular area leads to various disturbances such as-

1. Plant productivity decreases
2. The resilience power of the environmental to fight against natural calamities like drought, flood also decreases etc.

CAUSES OF BIODIVERISTY LOSS

It is well known that the major cause of biodiversity loss are human activities and urbanization. In the name of development, we are destroying the homes of poor animals that have done us no harm.

Major causes of biodiversity losses are-

1. Habitat loss and Fragmentation-

One of the most foremost and decisive cause for the extinction of animals and plants. We can understand the adverse impacts of fragmentation and habitat loss through a simple example-

Tropical Rain Forest – which used to cover over 14% of the planet's land area, but more recently the situation is that these forests now cover no more than 6 %.
"LUNGS OF THE PLANET"- The Amazon rain forest is being cut down and cleared for growing soya beans and also converted to grasslands for beef cattle.

2. Over- Exploitation-

Since ancient times, humans are dependent on nature for the basic necessities of life like food, shelter, clothing since time immemorial. But everything was working fine till the time the need was satisfied, but overuse of natural resources results when necessity transforms into greed. Many animals got extinct just because they were over exploited by human beings.
For ex- Steller Sea Cow- Passenger pigeon, many species have become extinct due to human overexploitation.
Over exploitation can be done through various means by hunting, food gathering etc. Many species, including animals, plants, and marine fish and invertebrates, are seriously threatened by over-exploitation. Currently many marine organisms around the world have disappeared due to overfishing.

3. Alien Species Invasion-

The concept of alien species can be interpreted as- when an alien species which is not native to that particular place is intentionally introduced, in a particular area, some of them become invasive species and result in the reduction of native species or the extinction of species.
For ex-

- The emergence of Nile perch to East Africa's Lake Victoria ultimately culminated in the annihilation of the lake's unique biological arrangement, that included over 200 species of cichlid fish.
- African catfish- Clarias gariepinus was introduced for aquaculture purpose, and is now posing commination to our native species or the extinction of species.
- Invasive wheat species like carrot grass (Parthenium) posed threat to our native species. It came into India as a contaminant.

4. Co- extinction-

When two species are in an obligate mutualistic relationship with each other, in that case, if any one of the species goes extinct, the other species in relation to it goes extinct with it. For Ex- When two coevolved plant pollinators operate in a mutualistic symbiotic connection, the extinction of one will perpetually cause the extinction of the other.

5. Population-

Given the daily growth in the human population, from 1950 to 2022, with the increase in population from 2.5 billion to 8 billion. As the human population increases, the demand for raw material is also increasing, which ultimately leads to the exploitation of biodiversity. Population as found to have a greater impact on biodiversity than any other factor.

6. Climate Change-

With the increasing carbon dioxide concentration in the world, the extent of global warming is also increasing. Elevated temperatures in some areas brought about by abrupt climatic shifts have already had a major effect on ecosystems and biodiversity. They have an impact on population numbers, species ranges, and the timing of migratory or reproductive events. The average surface temperature will rise by 2 to 6.4 degrees Celsius by 2100 compared to pre-industrial levels, predicts the Intergovernmental Panel on Climate Change (IPCC). Global biodiversity is predicted to suffer as a result of this (Millennium Ecosystem Assessment, 2005).

METHODS AND EFFORTS FOR BIODIVERISTY CONSERVATION

To put it in simple terms, conservation is an approach of preserving Earth's precious resources for future generations as well as the present.
In other words, it's crucial to preserve all kinds of life on Earth as well as the health and functioning of the planet's natural ecosystems. This includes the recovery, upkeep, sustainable usage and the preservation of the biological diversity's constituent parts.

Sustainable development is defined as growth that satisfies present-day demands without compromising the ability of future generations to do the same.

In-situ conservation

It also goes by the name of "on-site conservation.", which means the protection of species (wild-life) in its natural habitat.
A network of protected areas consisting of 448 wildlife sanctuaries, biosphere reserves (18), and 102 national parks have been established. The outcomes of this network have had a substantial impact on the recovery of large mammal populations, including elephants, tigers, lions, rhinoceroses, and crocodiles. Sacred groves also fall under this category.

Ex-situ Conservation
It also goes by the name of offsite conservation. This approach involves removing the endangered or vulnerable animal or plant species from their native environment and relocating them to a suitable setup where they can be given extra protection and care.
Zoological parks, wildlife safaris and botanical gardens serve this purpose.

Today, it has become feasible to store viable and fertile gametes of endangered or vulnerable species for extended periods of time using cryopreservation procedures, fertilize eggs in vitro, and propagate plants utilizing tissue culture techniques.

Community Participation in Biodiversity Conservation

Sometimes conservation policies are created, but they are not enforced well. Therefore, it has been recognized that without local communities' involvement in the development, administration, and oversight of conservation programs, no legislative requirements will be productive.
Governments and NGOs have taken several initiatives to achieve this. For example, the concept of forest co-management emphasizes the local communities' participation
in the regeneration and protection of degraded forest lands near villages.

Efforts at International level for biodiversity conservation

Recognizing that safeguarding biodiversity is a global concern, therefore, each and every country needs to take steps for the same. Various treaties at international level and several agreements have done at international level for its conservation.
Some of them are: -

- The 1992 United Nations Conference - Environment and Development (UNCED)/Earth Summit, held in Rio de Janeiro, called on all countries to take right actions to conserve biodiversity and use its benefits in a sustainable manner.
- Ramsar Convention on Wetlands of International importance.
- IUCN

India's efforts to conserve biodiversity

India is doing its best for the protect and preserve biodiversity.

We can easily see the sacred grooves which are speeded all over India.

- *The Indian Forest Act and the Forest (Conservation) Act of 1980*.
- *Wildlife (Protection) Act* concerns the safeguarding birds and wild animals, and flora, the main purpose of which is to protect wild animals or their environment through national parks, reserves etc. In addition, the Act contains the provisions prohibiting picking and uprooting of specified plants.
- *The Biological Diversity Act, 2002*, was approved and announced in India. The rapid drop in the number of Gyps vultures across the Indian Subcontinent has been attributed to the use of the drug diclofenac in veterinary medicine, which has been restricted in India. To ensure the future of these vulture species, the Bombay Natural History Society has set up conservation breeding exercises at Pinjore, Haryana; Buxa, West Bengal; and Rani, Guwahati, Assam.
- Various Central and state government schemes have been initiated by the government for the integrated development of wildlife and its protection.
- The Wild Life (Protection) Act of 1972
- Patrolling has been increased in and around the protected areas.

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Research Based Pedagogy for Effective Learning of Physics at Undergraduate Level: A seamless transition towards NEP

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ABSTRACT

Physics, which is an important constituent of science stream at undergraduate level, is gradually losing its learning appetite amongst the students for various reasons. The popular perception is that the subject needs a focused approach to understand its principles and applications. Mechanics, a branch of physics, has been found to be unpopular amongst students as it involves tedious mathematical calculations, formulae and conceptual understanding. It is evident from the fact that day to day applications of different science subjects like geology, human physiology, atmospheric science are all interlinked with the core principles of mechanics. In this paper we have suggested a tool named research-based pedagogy to invoke student's interest in the subject and make it more understandable and conceptually clear. This method is not about doing research but it is a scientific technique to make teaching-learning a student centric approach which transforms students as active learners and researchers. This technique of teaching learning fulfils almost all the objectives of higher education as drafted in the National Education Policy of Government of India. Research based pedagogy consists of five R's: Relevance/context, Resource, Refine, Report and Reward. The vital part of this pedagogy is the framing of problems by the instructors in such a way that it can be related to some observation, news or a story. The context must be open ended in such a way that it must provide a platform for students to think analytically. Mentors are also persuaded to guide the students to think rationally within the ambient of the problem. In this paper two problems of mechanics were chosen to illustrate the application of this pedagogy in teaching mechanics at undergraduate level.

Key words: Physics, mechanics, research, pedagogy, teachers, students, problem, resources

INTRODUCTION

Physics is considered as a hard subject and hence this subject is less popular amongst students. Most of the undergraduate students do not opt for physics as their major subject (P. Sneddon · 2022). The study of mechanics, which is an important branch of physics, requires rigorous mathematical calculations and proper understanding of the concepts and applications of formulae. The principles of mechanics explain almost all phenomena studied in various branches of science like atmospheric science (Emeis, S. 2010), geology, cosmology, astrophysics and human physiology etc. A tool named research-based pedagogy (RBPT) (Kashmiri 2020) is used to invoke interest of students in this subject. According to the National Education Policy the higher educational institutes will focus on research and innovation (National Education Policy, 2020). The application of this tool for teaching will orient the students towards research which helps in achieving the goal of NEP for higher education. The policy says that the Choice Based Credit System (CBCS) will be revised for instilling innovation and flexibility in higher education.

This paper illustrates the methodology of implementation of this method to two important topics of mechanics, viz, theory of special relativity and forced oscillations. This tool used for the two topics has been proved to be very effective for the teaching learning process (Allen et al, 1996). This method of teaching and learning is derived from problem-based learning founded in the medical sciences and first introduced in 1976 (Sorlie & Jones,1976) is becoming increasingly popular in other academic disciplines such as education, psychology and business (Coombs and Elden, 2004), and also popularizing in science for doing chemistry experiments (Belt et al, 2002).

RESEARCH METHODOLOGY

Mechanics is an important paper which is studied by all students pursuing graduation in physics and other allied courses including engineering and technology. Mechanics explains everyday phenomena like the occurrence of day and night due to motion of planets, motion of vehicles, rockets and satellites etc. The research-based pedagogy tool (RBPT) comes into picture to disseminate the teaching of physics to the comfort level of the students. Pedagogy is a science and art of education and learning. The word 'Pedagogy' is derived from the word '*paidagogos'* formed by the combination of two words paida+gogos, meaning child+lead (https://www.newworldencyclopedia.org/entry/Pedagogy). RBPT uses research as a pedagogical tool to create an environment for the students where they think beyond textbooks and classrooms to understand the problem in a more receptive way, and use the acquired knowledge for multitasking creativity (Bracewell, D. et al., 2017). The method is so chosen that it absorbs, processes and retains knowledge during learning. Pedagogy is a science involving methods to simplify the teaching learning interface and make it more interactive for progressive outcomes (Pollock et al, 2011).

NEP emphasizes promoting creativity by granting institutions and faculty the autonomy to innovate in curriculum, pedagogy and assessment within a broad higher education framework. It also states that motivated faculty and institutions will design curricula and pedagogies to provide all students with a stimulating and engaging learning experience. Continuous formative assessment will be utilized to further the goals of each program. To achieve the above-mentioned targets of NEP, it was planned to introduce research based pedagogical tools (RBPT) for effective learning.

The aim of the research-based pedagogy is to see the students as active learners and researchers who may become potential contributors to the scientific community. It is a famous saying by Confucius that *"I hear and I forget. I see and I remember I do and I understand." (*Confucius Quotes, May 2023). Thus, it is important for lifelong learning that all senses must be engaged for which the students should solve the problems by hands -on -approach and learn through trial and error (Qu, G. et al, 2021). According to the learning cone, two weeks after learning, we tend to remember only 10% of what we read, 20% of what we hear, 30% of what we see, 50% of what we see and hear, 70% of what we say, and 90% of what we say and do (Dale, E et al.,1969). This cone of learning clearly indicates that more the number of senses involved in learning, more is the retention of our learning. This is also used in puzzles for small children. The parts of an animal body are remembered for a longer duration if all the jumbled pieces of an animal figure are re-arranged by the child himself as compared to just showing the figure of an animal. In the traditional way of teaching mechanics, students study the teacher-structured content. Each topic is explained to them and the mathematical derivations are carried out by the teachers and students are expected to exactly follow them. Usually, very little is left for the students' own thought or ingenuity. This type of teaching is just giving the content to students and they are following the instructions like passive learners. The experimental problem-based learning has been evaluated and found to be very effective for the learning of physics, mathematics and computer science (Polanco, R, 2004) hence it was decided to implement RBPT in the teaching of mechanics, a foundational branch of physics.

Designing a RBPT Problem

A RBPT problem is quite different from a problem for an assignment. The content of the problem should be from the syllabus so that the desired learning objectives are achieved. The problem must be challenging to develop higher-order thinking skills as per *Bloom's cognitive taxonomy* (Adams, NE., 2015)

The characteristics of a good RBPT problem are as follows:

Engaging: An effective problem must be intriguing for a deep level of thinking and understanding. For this the problem may contain a *hook, trigger* and *scenario*. The *hook* is the first thing the student will hear or read, which is designed to engage the interest of students. The *scenario* defines the point of view adopted by the students to achieve the learning objectives. All problems should have a *real-world* setting.

Multi-Stage: The problem can be divided into many stages. The students should use scientific reasoning to justify their conclusions.

Complex: The problem is required to be complex, but in physics focus is on building simple problems which illustrate the basic principles in a lucid manner. The problem must be related with the real world and it should be simplified by a fragmented approach (Stange KC, 2009).
Open Ended: The problem should be open-ended in order to invite multiple logical reasonings to arrive at a certain conclusion and each methodical approach should be given due weightage in evaluation.

In this paper two important topics of Mechanics subject have been illustrated by using the tool of research-based pedagogy. RBPT helps to achieve the learning outcomes prescribed by Bloom's cognitive taxonomy (Adams NE, 2015) for an effective learning of the topics chosen in Mechanics. Research based pedagogy consists of five R's- Relevance/Context, Resource, Refine, Report and Reward.

In this approach the students are given a relevance/ context of the problem which is the first R of the RBPT pedagogy. The context may be a happening of real life or any news clipping which invokes the interests of the students. Second R is a resource which may include print media, websites, books or any relevant authentic source. The third R stands for refinement which is the heart of RBPT and it may involve pre-class seminars, questionnaires, small activities designed by the teacher to involve maximum number of senses so that the students are deeply engrossed to tackle the problem. The students are divided into groups and each group tackles the problem multidimensionally to obtain their independent inferences and results (Exley, 2004). The role of mentor is very crucial as the students should be properly guided to propel in an appropriate direction to achieve the desired learning. Report is the fourth R, which involves oral/poster presentation or demonstration by the students to their peer groups and mentor. Reward, the fifth R is to evaluate the students on the basis of their approach to the problem.

IMPLEMENTATION OF RBPT

Problem 1: Robotic Surgery at Planet Mars

1. Relevance/ Context: Problem Description

A surgery is to be performed in a hospital located on planet Mars by a robot which is controlled by a surgeon on planet earth. The electromagnetic waves that transmit information take a certain amount of time to travel from one place to another. What kind of problems can arise while performing robotic surgery from a distance and why?

2. Refine

A pre-class seminar /workshop can be arranged involving questionnaires and small experimental /simulation activities to explain the concept of event, frame of reference, etc. Some conditions are also discussed in which Newtonian mechanics fails and the properties of electromagnetic waves are also discussed. The students are made to work on these activities in groups (Wilkerson, L. 1996).

(a) Questionnaire

The students will be asked the following carefully chosen questions to inculcate critical thinking in the students (Bahar, 2003). Following questions can be discussed in context with this problem.

1. Will there be any time lag between the instructions given by the surgeon on the earth and the instructions followed by the robot on Mars?
2. Is it possible to transmit information faster than the speed of light? Does it have any connection to the special theory of relativity?
3. Is it possible that the duration of any event occurring in space is different for two observers?
4. Does increasing the force applied to a body always result in greater acceleration?

5. Is the speed of light emitted from an LED torch in a high-speed vehicle faster than the speed of light emitted by a similar torch outside the vehicle at rest?
6. Is the speed of light the same both inside and outside a fast-moving vehicle?

(b) Activities: Before getting into problem solving, small activities must be arranged by teachers.

1) Video Presentation: Watch the Michelson Morley experiment on youtube and try to correlate the findings with the questions in the above questionnaire.

2) Problem based learning: If you command a Robot at (a) Jupiter (b) Venus from earth. How much time will the electromagnetic wave take to transport information from earth to Jupiter and Venus respectively? Students can take the data from any authentic website.

3) Data interpretation using graph: Half -life time for elementary particles (Muons) is two microseconds. Suppose the initial number of elementary particles is 1000 at time t. After two microseconds, the number of particles becomes 500. After four microseconds the number becomes 250 and so on. Draw the graph between the number of elementary particles and time elapsed. Can you interpret from the curve that after 0.8 seconds, the number of elementary particles is around 800? If on the cliff of the mountain which is 2000 metre high, the number of elementary particles is around 500 then how much time will they require to reach to the base of the mountain? Speed of the elementary particles is around 0.8c. where c is the velocity of light. Using the above curve, find out the number of elementary particles which will reach the base of the mountain. Experimentally this number was 500. Can you explain this discrepancy?

3. Resource

They will explore the problem from different perspectives and find an explanation based on established scientific facts or data from authentic sites, books etc. which are the resources for the students. Time constraint is a crucial factor as ample time must be given to students to work on the concepts, discussion, write down the scientific reasonings and present their work in their class to get the feedback.

4. Report

Each group should work independently on these activities and report their findings in the form of posters. These posters should be open to all the groups for their comments and feedback (Wimpfheimer, T. (2004)).

5. Reward

After rectifying their posters by incorporating the changes suggested by peer groups, a proper understanding of the problem is achieved. The mentors will evaluate the students on the basis of a diverse range of parameters and skills employed during the problem-solving tasks.

6.Outcome of the Problem 1

After solving the questionnaire and performing the above activities students would easily understand that information transmitted to the planet Mars will not be affected by the movement of Mars with respect to the Earth. The velocity of light is constant in any direction in space. Learning this through video lectures and peer discussions will advance their knowledge further and they can easily understand the fact that increasing force does not always increase the speed. These simple activities will guide them to differentiate between Newtonian mechanics and relativistic mechanics. The elementary particle experiment will make them understand that when any light particle moves then time is dilated or lengthened so that the number of elementary particles reaching the earth surface is much larger than expected from their half life time.

After attaining this knowledge, they can easily understand that the movement of robotic arms would be delayed as electromagnetic waves take time to reach such a large distance. This could be catastrophic for the patient as any complexity in the surgery cannot be tackled instantaneously as there will be a time lag between the instructions imparted by the surgeon on Earth and the action taken by the robot on Mars. Thus, the concept of special theory of relativity will be retained in the minds of students for their lifetime through this problem using research-based pedagogy.

Problem 2: Forced Oscillations

1. Relevance/ Context: Problem description

The Millennium Bridge in London was closed for two years immediately after it was thrown open to the public on 10th June 2000. Why? (Bernard J. Feldman. 2010). Watch this link for an excellent video (http://www.youtube.com/watch?v=eAXVa__XWZ8)

2. Refine

(a) Questionnaire:

1. Why is it necessary to apply an external force to keep the swing moving?
2. What is the difference between the motion of a ball thrown from a height and a ball being constantly pushed towards the ground at regular intervals?
3. Will the motion of a simple pendulum in the atmosphere be the same as in vacuum?
4. How do the strings of guitar or sitar produce melodious sound?
5. Why does a glass break when a singer sings with a loud note at exactly the right pitch?
6. Why are soldiers ordered to “route step” (walk out of step) across a bridge?

Students will grasp the concepts of periodic and simple harmonic motion, as well as free, forced, and damped oscillations, and resonance. The students must be involved with the following activities to realize the problem with the real world.

(b) Activities

1. Live/ Video Demonstration: The teacher can play guitar or a video clip of a musician playing it can be shown to familiarize the students with the mechanism of production of sound by striking the strings.

2. Problem based Learning:

(i) A simple thread is tied to a bob on one side and a peg or a hand and the bob is allowed to oscillate for different intervals of time and force applied (figure 1). The length of the thread can be varied in different sets of observation and its effect on time period can be plotted graphically.

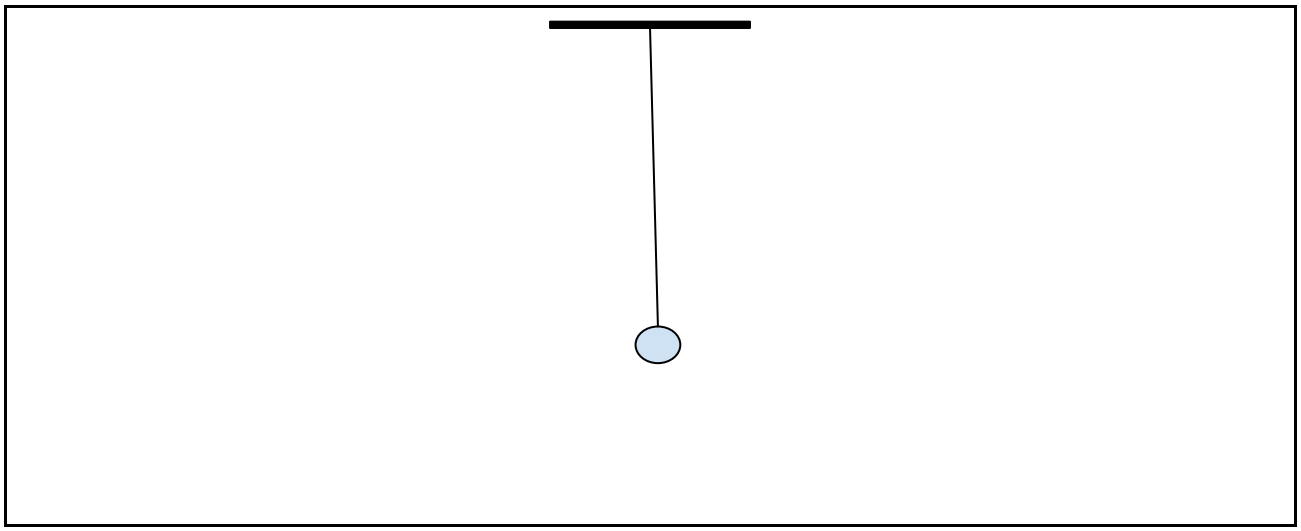

Fig 1. Oscillation of a pendulum

(ii) A tuning fork is struck against a rubber pad or a hammer is struck on one of the legs of the tuning fork. The tuning fork vibrates, if the tuning fork is placed on a wooden table, a large sound is produced. In the second part of this experiment two tuning forks of the same natural frequencies are placed, one each on two hollow wooden or thick cardboard boxes a little distance apart (Figure 2). One of the tuning forks is vibrated with a hammer, after a few seconds the other tuning fork also vibrates.

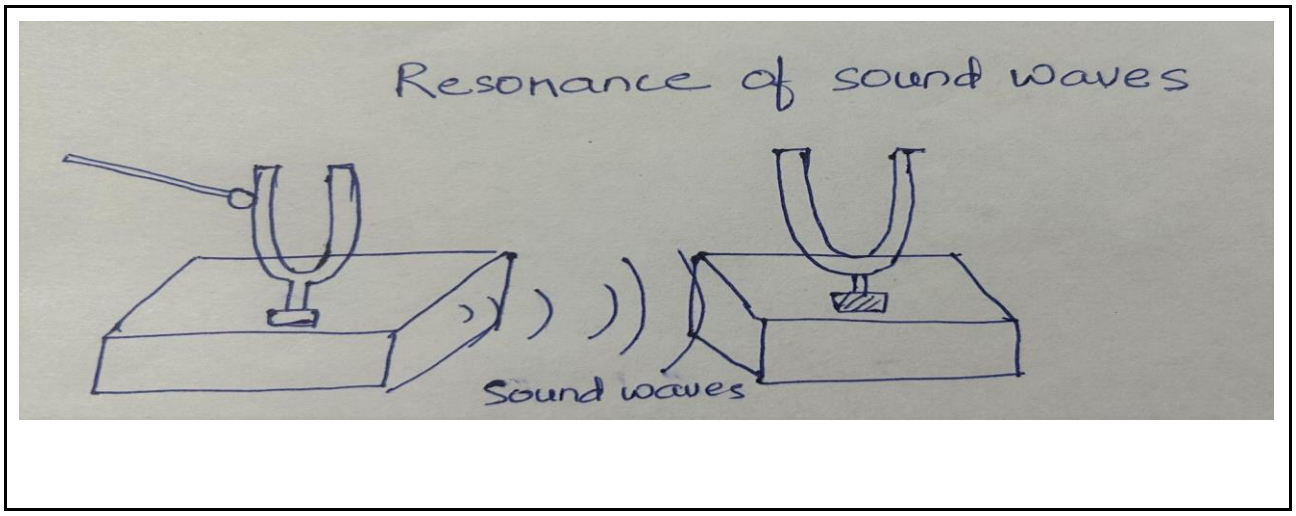

Fig 2. Resonance of sound waves in tuning forks

(iii) Take four simple pendulums made with bobs of equal sizes and threads of two different lengths are tied to a rod fixed at two ends (Figure 3). If one of the pendulums with longer thread is oscillated with a hand then the other bobs also start oscillating. The students will observe the frequency of vibration of all the four pendulums.

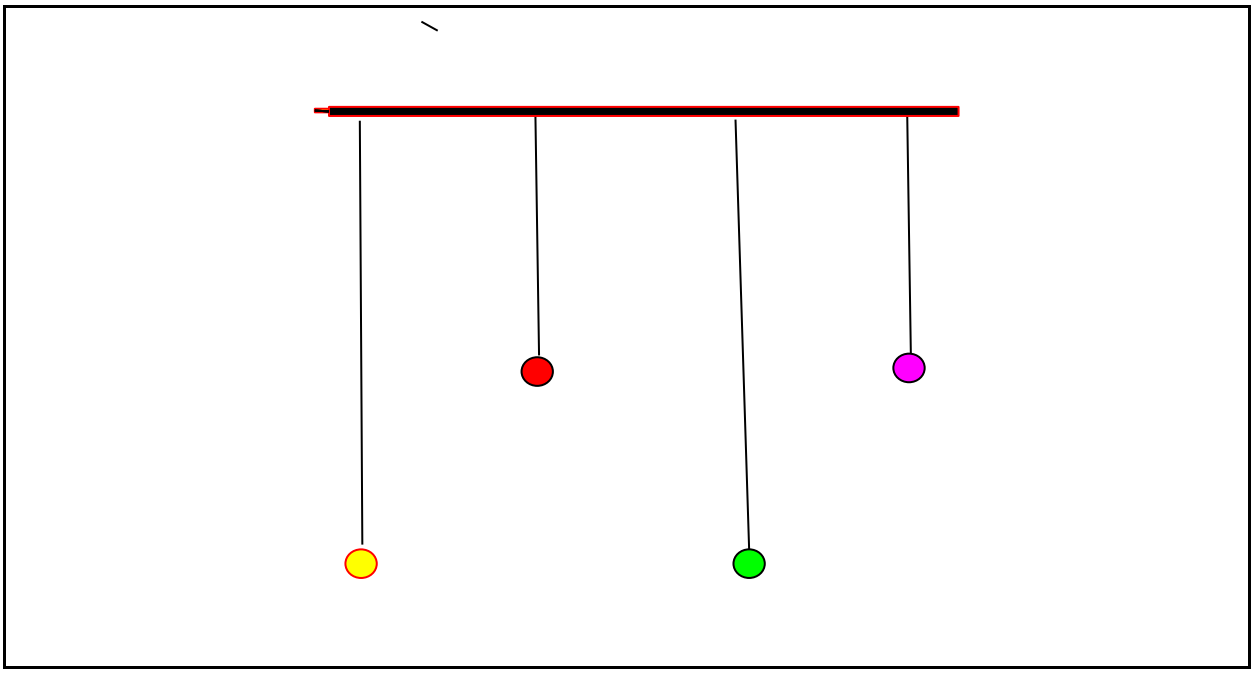

Fig 3. Concept of forced oscillations

3. Resource: The students can investigate the problem from various perspectives by referring to the library resources, credible websites to find a satisfactory answer to their queries.

4. Report: The students will perform these activities groupwise and report their observations and their interpretations in the form of posters.

5. Reward: This learning gateway will evaluate students for their comprehensive assessment of proficiency across various parameters and will provide an opportunity to showcase the applications of their relevant skills and if required they can also reskill themselves in tackling and solving problems.

6. Outcome of the Problem 2

The students will be able to understand the periodic motion, oscillations and vibrations. By seeing the musicians play the stringed instruments the vibrations of a string through an applied force can be understood. The difference between free and forced oscillations can be visualized. They can easily interpret that the sound is produced by striking the strings, causing them to vibrate. The energy from these vibrating strings is transferred to the soundboard through the bridge. The hollow body of the guitar amplifies the sound of the vibrating strings. The pitch of the vibrating strings and hence the sound varies with factors like mass, tension and length of the strings. The experiment performed with a simple pendulum (made by a bob and a thread) by the students explains the terms like amplitude, time period and frequency. The graph shows the variation of time period with the length of the pendulum. Thus, they can understand how different notes are produced by striking chords of different thickness and length in a guitar. The concepts of natural frequency and resonance are learnt experientially with tuning fork. The amplification of the sound when the tuning fork is touched with the table is an example of forced oscillations. This activity with two tuning forks placed on hollow boxes also depicts forced oscillations. The students can easily understand why the soldiers are asked to miss a step while marching on a bridge. The students are able to understand the concepts of the forced oscillations by activity-based learning, which will be retained forever in their life.

CONCLUSION

Research based pedagogical tools (RBPT) can be used to teach many complex topics in physics at undergraduate level. RPBT is used to develop the content knowledge and understanding of physics in a better way which is missing in the traditional classroom teaching of physics at undergraduate level. This tool instils a research approach amongst students without actually doing research. Through this technique of learning, students will be active learners. They will try to explore any complicated problem in a structured way with rational thinking. They will learn to work in groups where mutual discussions should be done to include everyone's points of view (Susan M, et al 1996). Through group discussions, participants exchange ideas, explain and elaborate on their viewpoints and engage in questioning and responding to one another, leading to the derivation of better solutions [Boyle and Nicol, 2003].

[Pollock et al, 2011]. The students are thus thrown into the web of learning and give way to more polished results. In this technique of learning students are encouraged to ask questions which makes them inquisitive and engaged in the topic. They actually take the data, analyze it and do the calculations, plot the graphs and interpret the results. The traditional method of rote learning takes a back seat and instead students find this method more effective and the art of retaining knowledge makes them lifelong learners with the RBPT method. Reporting of data in the form of a presentation or poster/article enhances their skills of communication and presentation. The method of continuous assessment used in RBPT approach is in accordance with the aim of the NEP to have a "criterion-based grading system which assesses student achievement based on the learning goals for each program, making the system fairer and outcomes more comparable" (NEP 2020). Higher education institutions are encouraged to shift from high-stakes examinations to a more continuous and comprehensive evaluation approach. RBPT transforms students to be active and lifelong learners who learn to solve any problem by working in groups, discussions, and hands-on activities. The role of teachers is transformed to mentors who will steer the minds of the students and help them achieve their learning outcomes and evaluate them by continuous assessment involving their problem-solving approach, techniques and presentation skills.

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Intelligent system for face mask detection and alert

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ABSTRACT

After the global COVID-19 pandemic broke out, a severe need for protection mechanisms to curb the spread was felt. The face masks came to the fore in this situation. However, people's reluctant, careless, and carefree attitudes posed threats to others. Thus, the need arose to develop an intelligent system that could detect whether a person is wearing a mask and generate an alert accordingly. The proposed approach in this paper detects the real-time presence of a face mask on the human face using two different Machine Learning Models. The first model uses a pre-trained model (VGG16) as a feature extractor and a trained new classifier on top of it. This technique is known as transfer learning, where the pre-trained model is fine-tuned for a new task.

In contrast, using the training dataset provided, the second model trains a convolutional neural network (CNN) from scratch. An alert through Arduino Uno using LED is integrated using pyFirmata. It is an interface that allows serial communication linking a Python script and the Arduino. Both systems have been tested and provided an accuracy of more than 95%. Both models are trained by intermixing two different datasets. The CNN model is tested using our own created dataset. The model can also detect multiple faces in a single frame, viz. Everyone wearing a mask/ no one wearing a mask/ only a few wearing a mask. These three conditions are accordingly represented by the glowing green/red/toggling LEDs. Distance optimization has also been implemented to find the most suitable spacing for mask detection between the camera and the person.

Keywords: Face mask detection, Transfer learning, OpenCV, CNN, Arduino, pyFirmata.

INTRODUCTION

In 2019, the COVID-19 pandemic began and quickly spread worldwide. The World Health Organization recognized the outbreak, leading to global travel restrictions and lockdowns. A highly contagious disease is primarily transmitted via respiratory droplets from an infected person. Face masks are the most commonly used method of preventing virus spread. Using a face mask that covers both the nose and mouth can aid in halting the transmission of COVID-19 by intercepting respiratory droplets. These droplets can carry viruses into the air when an infected person talks, sneezes, or coughs. It is important to note that face masks alone are not enough to protect against the spread of diseases and must be used in conjunction with other measures, such as regular hand washing, physical distancing, and vaccination.

Machine learning has been comprehensively used for face detection and related algorithms. Early simple algorithms used edge detection and color histograms to detect faces. However, those methods were often limited by the available computational power and the complexity of the algorithms. With advanced machine algorithms such as convolutional neural networks (CNNs) and deep learning, face mask detection has become much more reliable. These algorithms can learn from large datasets of images and accurately distinguish between the mask and without mask face with real-time data through image processing. The process of machine learning applied for face recognition is widely used in the process of matching faces to individuals. This has been used in a variety of applications, including security systems, social media, and biometrics.

With the help of a face mask detector, authorities can monitor and enforce the compliance of the masses with these regulations. Face masks are an essential tool in reducing the spread of COVID-19, especially in public transport as well as public places. With an automated face mask detector, these places can monitor and strictly enforce the

wearing of masks and thus reducing the risk of exposure to the virus. Screening for face masks at entrances can be slow and stressful, particularly with large crowds. Face mask detectors can automate this process, making it faster and more efficient. Buzzer or LED can be used as the alarm system in case anyone without a masked face is detection.

LIBRARIES AND HARDWARE

There are a variety of libraries used in the program. These libraries are essential for visualization, image processing, and data manipulation. Similarly, for hardware implementation, a microcontroller-based board, Arduino, has been used.

(i) **TensorFlow:** computations to facilitate machine learning. Multidimensional arrays are also called tensors. To run operations on the dataset, TensorFlow constructs a computational graph similar to a flowchart, determining the data flow from one operation to the next. That is why it is called TensorFlow (it defines how data or tensors will flow through the system).

(ii) **OpenCV:** Open-Source Computer Vision Library is a free software library dedicated to machine learning and computer vision. It was created to standardize computer vision tasks and make machine perception more common. OpenCV includes over 2500 algorithms that developers can use for different computer vision and machine learning tasks. These activities include identifying and recognizing faces, detecting objects, categorizing human actions in videos, monitoring movements of cameras and moving objects, constructing 3D models of objects, producing 3D point clouds from stereo cameras, creating high-resolution collages from various images, searching for similar images in a database, eliminating red-eye in photos, following eye movements, identifying scenes, and placing markers for augmented reality applications.

(iii) **Matplotlib:** Matplotlib is a Python library that makes simple and complex visual effects achievable. Matplotlib is a great tool for making 2D plots of arrays in Python and is very powerful for data visualization across multiple platforms. It works well with NumPy arrays and the SciPy ecosystem. With Matplotlib, you can create various data visualizations like bar charts, scatter plots, histograms, line charts, and more, making it easier to analyze large amounts of data.

(iv) **NumPy:** NumPy is one of the most widely used and powerful Python libraries for performing a variety of mathematical operations, including algebra, statistics, FFTs, logic, and random simulations. It provides comprehensive support for object-oriented programming.

(v) **pyFirmata:** pyFirmata is a Python library that controls Arduino boards using the Firmata protocol. It allows users to directly manipulate Arduino inputs and outputs from Python scripts, facilitating hardware integration in projects.

(vi) **Arduino:** Arduino is an open-source platform that simplifies the creation of interactive electronic devices for novices and professionals. It utilizes straightforward microcontroller boards and a user-friendly Integrated Development Environment (IDE), enabling users to easily build projects that interact with their surroundings through sensors and actuators. Based on Atmel's AVR and ARM microcontroller architectures, these boards support programming in C and C++. They can be enhanced with various Arduino shields for internet connectivity, broadening their application across numerous fields.

MODELS DESCRIPTION

(i) Model 1 utilizes the transfer learning method, starting with a pre-trained model as its foundation for a new task. This pre-trained model has previously mastered recognizing diverse features from extensive datasets. The concept of transfer learning involves using this existing knowledge to enhance performance on a new, similar task. During this process, the pre-trained model is fine-tuned for the new task by modifying the weights in certain layers to accommodate the new data better.

(ii) Model 2 is based on a Convolutional Neural Network (CNN), which is a type of deep neural network often used for classifying images. CNNs have layers that can learn features from images (convolutional layers) and layers that make predictions based on those features (fully connected layers)

METHODOLOGY

The designed system aims to develop two different real-time models that detect if an individual is wearing a mask person is wearing a mask. These models are suitable for deployment in pandemic hotspots like hospitals, metro stations, airports, adverse polluting work conditions, construction sites, etc. [1]

Model Requirements

Libraries used:

(i) pyFirmata 1.1.0

(ii) OpenCV 4.5.3

(iii) TensorFlow 2.6.0

(iv) Keras 2.6.0

(v) Matplotlib 3.3.4

(vi) NumPy 1.19.5

Hardware requirements:

(i) Arduino Uno

(ii) LED /Buzzer

(iii) Laptop

(iv) Connecting jumper wires

(v) Breadboard

Dataset Description

There are two different datasets used in the model. For training purposes, we have merged two different datasets. MaskedFace-Net [2]; is a database of images where persons are wearing the face mask in a correct or incorrect manner in relation to COVID-19. The dataset is provided into three sections, namely, the dataset where one is wearing the face mask in a correct manner (CMFD), the incorrect manner (IMFD), and the third is the combination of the two (MaskedFace-Net). For this work, we used the Correctly Masked Face Dataset (CMFD) and the Incorrectly Masked Face Dataset (IMFD). Additionally, we included another dataset sourced from the 'prajnasb' GitHub repository. [3]

For 'Model 2', we have created our testing dataset that features college students, family members, and others.

Fig.1. Dataset with Mask

Fig.1.1. Dataset without Mask

Fig.1.2. Own curated dataset

Implementation

This system employs a combination of hardware and software for face detection and mask identification. The training and testing processes are carried out on a Dell Inspiron 14 5420 Intel(R) i5-1235U laptop using Jupyter Notebook for coding. The hardware components consist of an Arduino UNO and LEDs. We used the HAAR cascade frontal face classifier from OpenCV as our face detection algorithm. For Model 1, the dataset is split into training and testing sets, while for Model 2, separate training and testing datasets are provided. The testing dataset is collected on our

own. The pyfirmata library is used to embed the hardware components in the program. The software component is responsible for identifying masks and detecting 'No face' conditions, while the hardware acts as an alarming system. If 'no mask' is detected, a red LED will glow, whereas a green LED will glow if a mask is detected.
The program can also detect incorrect mask-wearing and multiple faces at a time.

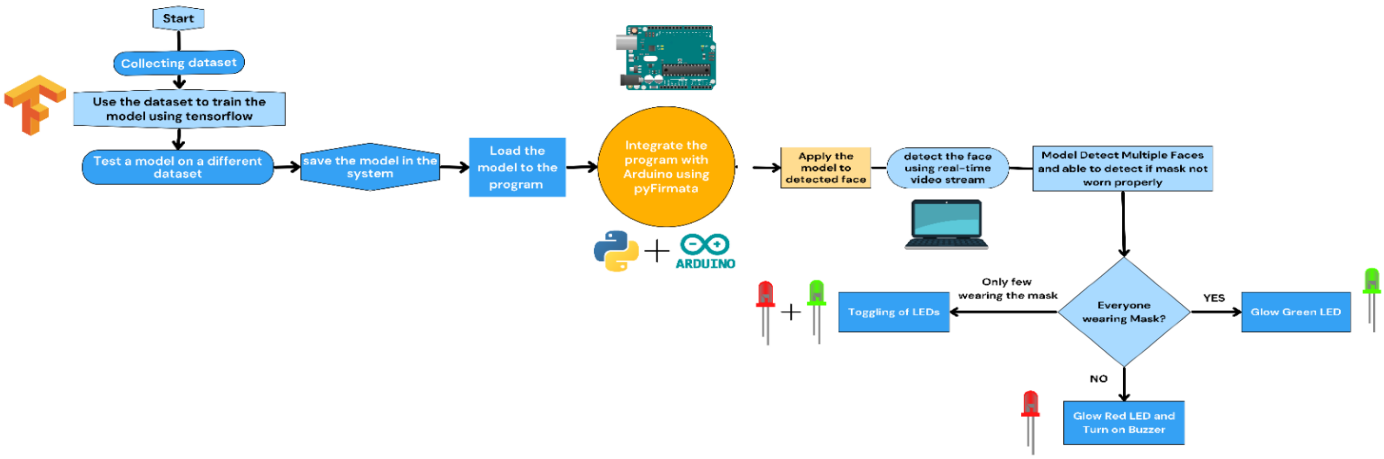

Fig.2. Flowchart representing the methodology

RESULT

As seen in Fig.3.1, Red LED glows when the person is not wearing a mask whereas the Green LED glows when the person is wearing it.

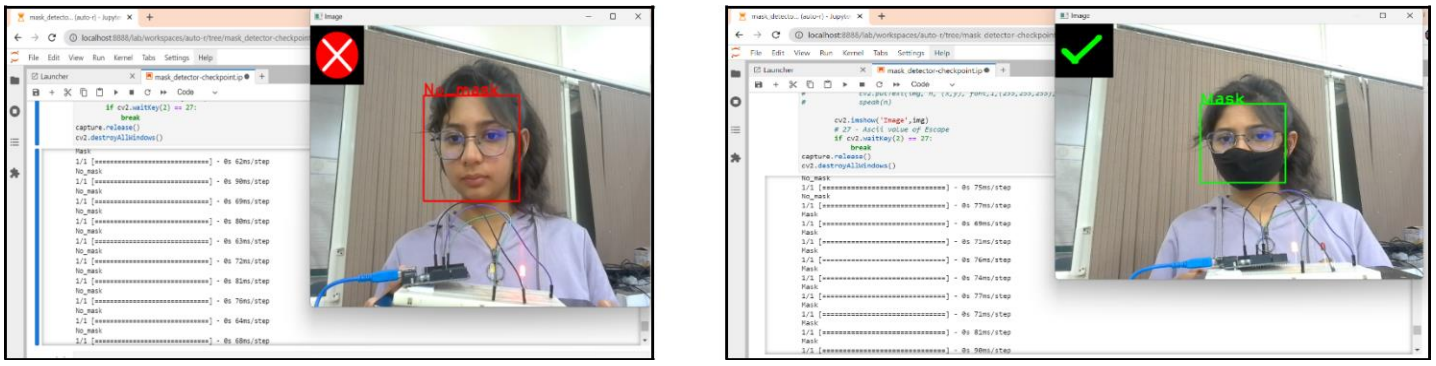

Fig.3.1 No Mask and Mask Detection -Model 1

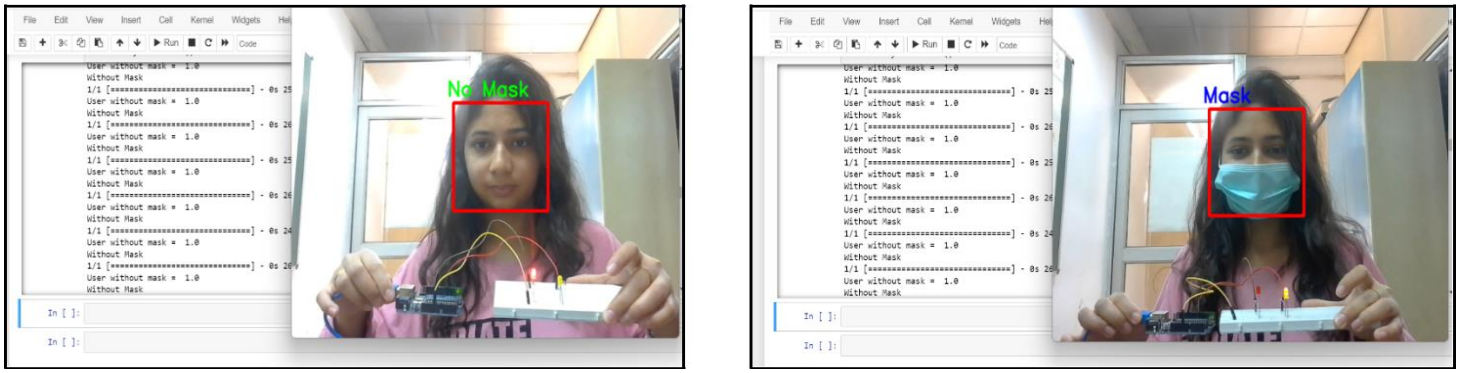

Fig.3.2 No Mask and Mask Detection -Model

Fig 3.3 and Fig 3.4 represents the accuracy of Model 1 and Model 2 with Epoch=3 and Epoch =12 respectively. The accuracy of model 1 is 99% whereas that of model 2 is 96%.

```
Epoch 3/3
73/73 - 266s - loss: 0.0047 - accuracy: 0.9991 - val_loss: 0.0060 - val_accuracy: 0.9990 - 266s/epoch - 4s/step
```

Fig.3.3 Accuracy-Model 1

```
Epoch 12/12
WARNING:tensorflow:Can save best model only with val_accuracy available, skipping.
26/26 - 193s - loss: 0.1091 - accuracy: 0.9603 - 193s/epoch - 7s/step
```

Fig 3.4 Accuracy-Model 2

Fig 3.5 represents that model 1 does not detect the face if the eyes and some portion of the face are covered
.

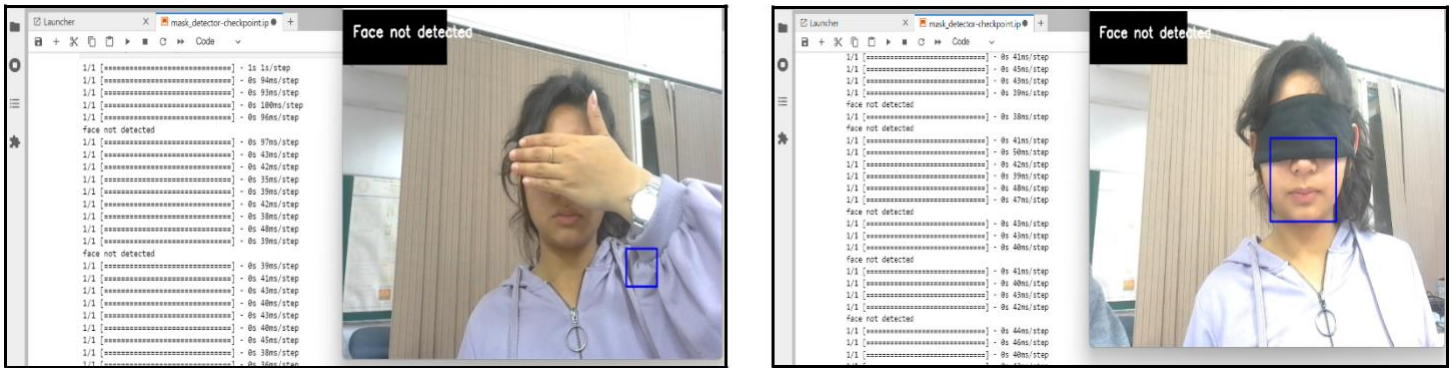

Fig.3.5. No Face Detection

Fig 3.6 shows that model 1 is unable to detect the mask if not worn properly. A similar trend is shown in Model 2. However, Fig 3.7 shows that it is capable of detecting multiple faces at a time. However, the flickering of LEDs is also observed as one object is wearing the mask whereas the other is not. Additionally, the most accurate detection distance for Model 2 is manually measured to be 96cm.

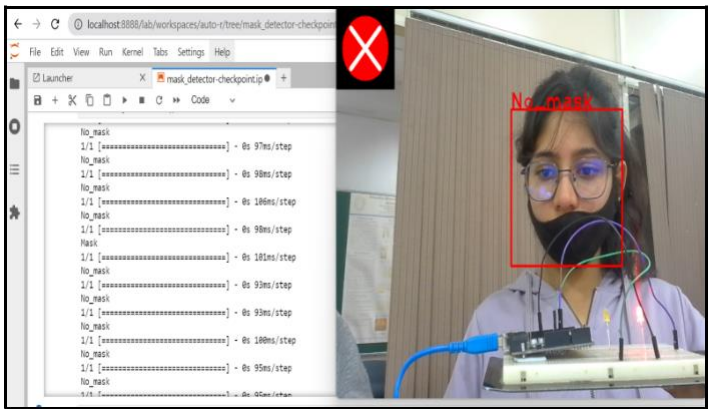

Fig.3.6 Mask not worn properly

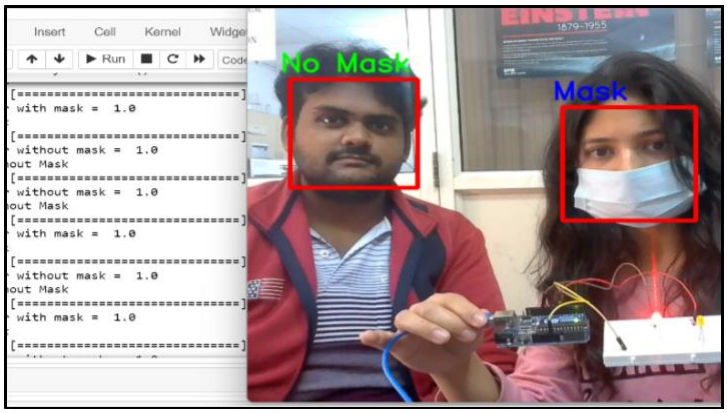

Fig.3.7 Mask recognition for multiple faces

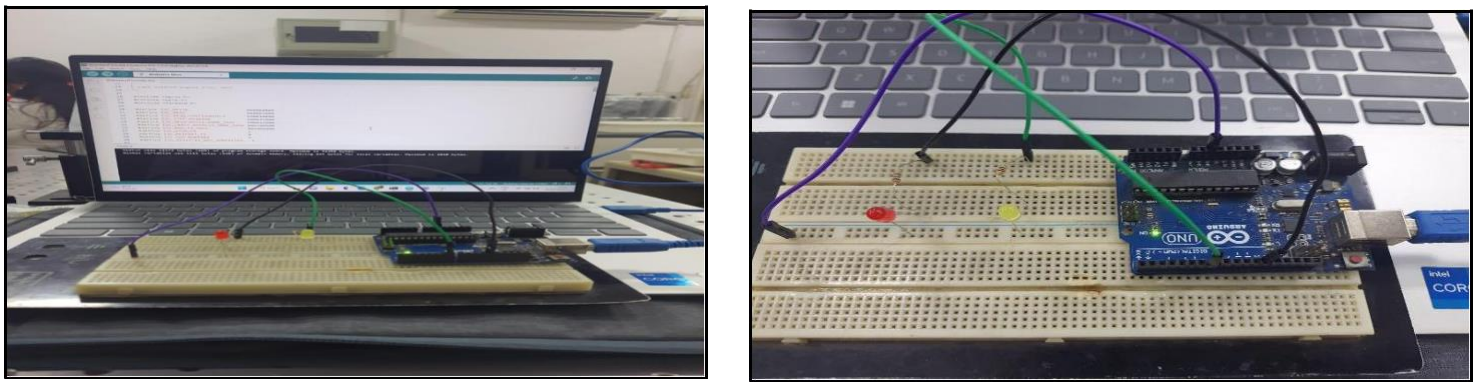

Fig.3.8 Arduino Setup

CONCLUSION

Nowadays, the world is shifting towards IoT, Machine Learning, and AI. Many problems can be deciphered easily by using uncomplicated devices and programming knowledge. This paper presents two face mask detection systems using Transfer learning and CNN respectively with OpenCV, TensorFlow, and Arduino. The system successfully detects the real-time presence of face masks on human faces with an accuracy of 99% for model 1 and 96% for model 2 respectively. The system uses pyFirmata to allow a Python script on a computer to communicate with an Arduino. The Arduino then uses an LED to create the right output signal. The system is intended to enforce mask-wearing in crowded public places, automating the screening process and reducing the risk of exposure to COVID-19. This approach can also be utilized to develop many other serviceable systems.

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Evaluation of Microbial and Physico-chemical analysis from Dairy waste Effluent

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ABSTRACT

This investigation focuses on physicochemical evaluation of dairy waste effluents, which was conducted at Botany Department, Dayal Bagh Educational Institute. Goal was to modify the quality of wastewater discharged from the dairy plant by comparing its value with WHO's standard water quality values. Samples were collected in the mid of rainy season from the outlet placed in the production unit of Parag dairy, before its mixing into the municipal Collecting System. Identification of microbes from dairy waste effluents through their colony characters, biochemical tests (Nitrate and Starch), morphological characteristics and gram staining was conducted. The bacterial isolates with circular shape of colony, white in appearance with entire margins and flat elevations and gram positive in nature may belong to the *Corynebacterium sps.* or may belong to *Bacillus Sps*. Apart from this, wastewater was analyzed based on physicochemical factors such as Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), alkalinity, acidity, calcium, hardness, magnesium, chlorides, etc. The results from biochemical tests indicate that the bacterial isolates from the dairy industry have the ability to utilize the components like nitrate, starch gelatine and sugar. So, these microbes could be proficiently used for the biological remediation of dairy effluent.

Keywords: Dairy waste, BOD, COD, DO, TSS and TDS

INTRODUCTION

As the quote “water is the driving force of all nature” suggests that it is the most important compound and a basic unit of our lives. That's why it is utmost important to protect it from waste and recognize its quality and search for an alternate approach for its cleaning. Nowadays water pollution has emerged out as one of the consequential problems globally, especially affecting the developing countries. Major cause of the pollution is rapid industrialization and is suffocating the earth’s natural resources with the common problems of pollution. Numerous

reports claiming the discharge of unprocessed sewage is solely prominent issue for surface and ground water pollution in India. A senate committee in U.S. observed that the second prominent source of pollution in streams was due to dairy industries (Worners et al., 1976). According to Forsberg 1998, waste water discharged from dairy are basically organic as well as slightly alkaline, before being discharged into streams prior to treatment, resulting in drastic decline of DO and promoting microbial growth leading to eutrophication. They are among the primary producers of waste effluents with high COD and high odour production. In most of the dairy plants, the quantity, chemical and physical characteristics of effluents depend upon the variety of production, milk products and pasteurizing activities. Dairy industries are considered "wet industries" as they utilize a large amount of water for different purposes resulting in discharge of high volumes of wastewater. Like other agro-industries, dairy industries also generate a huge amount of waste water with high organic content resulting in increased chemical oxygen demand (COD) and simultaneously increased amount of biological oxygen demand (BOD). This discharge of wastewater contributes most significantly to environmental pollution in terms of quantity and quality. In milk processing plants, the major generation of wastewater accounts to cleaning and washing operations. Wastewater effluents vary in terms of quality and quantity as it primarily depends upon production characteristics of dairy industries. Basically, the dairy industry incorporates several processes, to name a few, homogenization, chilling and pasteurization. It involves the processing of unprocessed milk into numerous items for instance milk, butter, cheese, yogurt and byproducts which includes whey, buttermilk and their derivatives. They are the main source of fats, proteins, dissolved sugars and residues of additives in wastewater. These effluents comprise of many characteristics like TSS, TDS, BOD, COD, total solids, pH, colour, temperature etc. which affects the aquatic life and environmental health.

India lacks sufficient facilities to treat this waste effluent using sewage treatment plants. They do not have proper maintenance and do not operate property by governing bodies. This is the biggest issue of our country to get rid of this major environmental problem. On an average these plants produced 6-10 litres of sewerage effluents in producing 1 L of processed milk. It was also reported that on an average approximately 2% from the total produced milk is discarded. Due to this wastage of milk, dairy plants carry a heavy load of pollutants in their drains and discharge barely treated/ untreated wastes into various water reservoirs. It imposes serious health threats and environmental problems to mankind. Many environmentalists are

seeking an alternate, cheap, long-lasting and efficient solution for treating and recycling this wastewater. The importance of biological treatment is the most attractive and attentive topic to look out for in this current problem. This will eventually help in finding an efficient alternative and long-lasting solution to treat this wastewater treatment system. Biological treatment is a well-known technique to remove nitrogen and organic matter from wastewater. This process is useful as it treats wastewater biologically and cost effectively. Current scientists are continuously working to evolve this process with lower cost and greater efficacy. To reduce COD, BOD and remove odour from wastewater effluent, scientists had adopted aerobic treatment. In this process, wastewater or liquid wastes generated from various industries including; dairy, food and animal industry are pretreated with various microbes aerobically. Microorganisms which are used to remove contaminants from water, majorly depend on the water's origin. Commonly it includes a huge amount of heterotrophic microbial species such as *Bacillus subtilis, Enterobacter, Pseudomonas fluorescens, Pseudomonas aeruginosa, Streptococcus faecalis* and *Escherichia coli.* Apart from these, it also includes yeasts from the genus *Saccharomyces, Cryptococcus, Candida* which are recurrently observed in wastewater (H. Porwal et al., 2015).

The importance of wastewater produced from food industries can be understood by the tremendous number of organic compounds present in it. This fact can be corresponded with a large quantity of microbial flora that has been adapted for the process of biodegradation of all those substances present in that environment. For a biological wastewater treatment, it’s a must to understand and have proper knowledge and information about the wastewater that is needed to be treated. the most basic knowledge of the wastewater includes particulars about the biochemical properties and the origin from where pollutants have originated. The industries have now expanded and milk has gained its importance by establishing itself in the list of one of the major commodities. It is a necessary part of one’s life. There are numerous dairies which have opted only for pasteurization and packaging of pasteurized milk. Although there are numerous products that could be produced from milk, these places have limited themselves to production and sales of ghee from milk. The manufacturing of numerous dairy products like cream, ice-cream, paneer, shri khand, milk powder, yoghurt, butter, cheese etc. depends on the availability and quantity of milk being supplied to dairy plants. Thus, the amount of effluent generated simultaneously is based upon the amount of milk being processed. it could range from 1 liter-10 Liters controlled by the product being made. Similarly, the discharge amount

could reach up to a maximum of 5 times the average being produced daily. The dairy waste can easily be identified as it has slightly white colour in appearance and basic in pH but they can readily turn acidic because of the process of fermentation that has the ability to convert milk sugar to lactic acid. The dairy waste imposes pollution to natural sources as it requires prompt and increased oxygen so as to degrade. When casein is decomposed, it leads to the appearance of black and heavy sludges. The characteristic odour of butyric acid makes it obvious that the pollution has the majority of milk waste. The effluents released from dairy industries have the tendency to decompose easily and it also causes depletion in the oxygen level present in the streams where it is released. This eventually leads to anaerobic conditions and bad odours. This wastewater serves as a breeding place for various insects including flies, mosquitoes which causes many harmful ailments like chikungunya, hay fever, dengue, malaria etc. The literature review provided significant evidence that the higher concentration of dairy effluent toxic in nature which harmed fauna and flora. Additionally, this leads to a foul smell, several environmental problems and various diseases to mankind.

METHODS AND METHODOLOGY

Collection of samples: Wastewater sample was collected from the outlet of Parag dairy, before it got mixed in the municipal collecting system. The samples were collected at the mid of august and were kept at 4° C during the course of analysis and observation. Collection of water samples was done with the help of sterilized glass bottles. The sample was tightly covered and taken to the laboratory for process and analysis. Sufficient volume of sample was collected. Water may undergo modifications when it is introduced to a new environment, so it is checked from time to time and tries to ensure that there are no significant changes till analysis.

Analysis of water through various physicochemical characters: Water is an inseparable part of life. Fields like agriculture, domestic, drinking and industrial purposes water is essential and must be tested via various physicochemical parameters, before use. Water consists of various contaminants such as floating, suspended, dissolved, bacteriological and microbiological. To test the physical appearance of water, some physical tests and chemical tests were performed such as pH, TDS, colour, odour, temperature, BOD, COD, dissolved oxygen, hardness and alkalinity.

Colour: Visual Comparison: Equal amount of wastewater sample and distilled water (50 ml) was taken in two separate bottles. Visual comparison of the colour (as clear, milky, greyish,

brownish, blackish etc.) of the sample with distilled water was made.

Temperature: Temperature was measured at the site of sample collection. Took a 500 ml sample, kept the thermometer in it for some time and the reading was noted (expressed as °C).

pH: pH was measured by using pH strips and universal indicators. For this, a sample was taken in the beaker and pH strips were immersed in it. It was kept for some time at room temperature and was air dried and then colour was developed. It was compared with a standard chart and the pH was noted. For testing via universal indicator, few drops were mixed with 10 ml of selected portion and shaked gently. Developed colour was compared with a chart and pH was recorded.

Odour: Estimation of the odour of the sample was done through physiological sense and categorise it into several degrees (such as odourless, acceptable, unpleasant, bad etc).

Dissolved oxygen (DO): Winkler's method was utilized to test dissolved oxygen of the water sample. For this, BOD bottles filled with samples were utilized and 2 ml of $MnSO_4$ was added to the simple just below the surface. After some time 2 ml of an alkali iodide azide solution was also added to the sample. This was kept for precipitation at normal temperature. Then 2 ml of sulfuric acid was appended to the selected portion and shaken carefully. It was stored for eight hours and kept in a cool place. Afterwards, the sample was titrated against the sodium thiosulphate. Following formula was used to calculated DO:

$$DO = \frac{(1000 \times N) \times v}{V}$$

Where,

V = cubic measure of selected portion,

v = cubic measure of the titrant

N = Normality

BOD: To measure BOD of the sample the dilutions were made using various chemicals including phosphate buffer and solution of $CaCl_2$, $MgSO_4$, $FeCl_3$. The whole process was completed in five days. For this process four BOD bottles were taken. Two BOD bottles were

filled with 10 ml of sample while the remaining two bottles were filled with dilutions. Two bottles were analysed immediately and the remaining two were analysed after 5 days. All the observations were noted down at the same temperature (20°C). By putting all the values in the given following formula DO was calculated.

$$\mathbf{BOD = D - D_2}$$

here, D = pretreated DO of the selected portion,

D_2 = DO after incubation (120 hrs)

Chemical oxygen demand (COD): 2 flasks were taken; one was filled with a 20 ml water sample while the other one was considered blank. Each flask was added with 2 ml of potassium dichromate. They were then kept in a water bath for an hour. It was then allowed to cool down for 10 minutes. KI and H_2SO, was added in the ratio of 1:2 (2 ml and 4 ml). They were then titrated against sodium thiosulphate after which colour developed. Afterwards, 0.4 ml of starch was appended to the flask. Blue hue appeared and was titrated till the colour disappeared which marked its end point. The following formula was used to calculate COD:

$$\text{Chemical oxygen demand} = \frac{8 \times C \times 1000 \times (B\text{-}A)}{S}$$

here, C stands for titrant concentration,

A stands for quantity of titrant treated as control,

B stands for quantity of titrant in selected portion,

S stands for cubic measure of selected portion

TSS: To calculate TSS of samples. Firstly, dried samples were weighed and by using clean filter paper 20 ml was filtered. Readings were recorded after drying filter paper at 100 °C. Then take the weight of dried filter medium and readings were recorded.

TSS (mg/l) = final wt. of filter medium – initial wt. of filter medium

TDS: 100 ml of selected portion was filtered through filter paper. Weight of an empty porcelain dish was noted. Sample was poured in the porcelain dish and retained in an oven till all the water had dried. Weight of the dried dish was taken and put in the following formula.

$$\text{TDS (mg/l)} = \frac{W_2\text{-}W, \times 1000}{V}$$

Here, W_1 = wt. of empty porcelain dish,

W_2= wt. of oven dried porcelain dish,

V= cubic measure of the selected portion

TS: TSS and TDS were calculated and both parameters were added.

$$\text{TS (mg/l)} = \text{TSS+TDS}$$

Free carbon-di-oxide: To calculate the free carbon dioxide phenolphthalein solution was used and volumetrically analysed with 0.22 N sodium hydroxide.

$$\text{Free } CO_2 = \frac{(V_t) \times (1000)}{V_s}$$

Here, V_t stands for cubic measure of the titrant

V_s stands for cubic measure of the sample

Alkalinity: 2 drops of phenolphthalein solution were mixed to selected portion. The change in appearance were noted down. Sample was titrated against dilute HCl. Note the reading, where colour disappears. It was again titrated by methyl orange**.** Reappearance of any shade indicated the end point.

$$\text{Alkalinity (mg/1)} = \frac{\text{Volume of HCl used} \times N \times 1000 \times 50}{\text{Volume of sample (ml)}}$$

Here, N=Normality of HCI

Acidity: Concentrated mineral acids, pale acids such as carbonic acid, acetic acid found in various water samples provide acidity to the water. Methyl orange was added to the selected portion. Sample was titrated against sodium hydroxide. Note the appearance of colour. 2 drops of phenolphthalein were added. Sample was again titrated till the colour changes. Acidity was

calculated.

$$\text{Acidity (mg/ l)} = \frac{\text{Volume of NaOH used x N x 1000 x 50}}{\text{Volume of sample (ml)}}$$

Here, N=Normality of NaOH

Hardness: For calculating hardness, the EBT solution was used and was volumetrically analysed against the ethylenediaminetetraacetic acid solution.

$$\text{Hardness (mg/1)} = \frac{\text{Volume of EDTA used x N x 1000 x 50}}{\text{Cubic measure of selected portion}}$$

where,

N is Normality of EDTA

Calcium (Ca): 1 ml of Iso-propyl and 1000 µl of NaOH was mixed in the 50000 µl of selected portion. For measuring calcium content, the murexide indicator was used. After the addition of a murexide indicator a pink colour was produced. Afterwards, the sample titrated with EDTA. The pink colour changes into purple colour indicating the end point.

$$\text{Ca} = \frac{\text{T x 400.5 x 1.05}}{\text{Selected}}$$

$$\text{CaCO}_3 = \frac{\text{T x 1000 x 1.05}}{\text{Selected portion}}$$

Here, T= titrant volume (ml)

Magnesium (Mg): The magnesium hardness was estimated using the values of total hardness and calcium hardness. By putting the values in the following formula, the magnesium hardness was determined.

$$\text{Magnesium (mg/l)} = \text{(T-C) x 0.243}$$

where,

T is overall hardness,

C is calcium hardness

Chlorides: 500µl of K_2CrO_4 indicator was poured into the conical flask containing 50 ml of water sample. Then the sample was titrated against silver nitrate, after some time it started precipitating, indicating the end point.

$$Cl^- = \frac{(A-B) \times (N) \times (35.45)}{\text{Selected portion}}$$

where,

A is cubic measure of $AgNO_3$ utilized by the selected portion,

B is cubic measure of $AgNO_3$ used by the control,

N is Normality of $AgNO_3$ solution

Isolation of microorganisms from water: A serial dilution technique was performed for isolation of the bacterial strain. In serial dilution 1 ml of selected portion was poured into a test vial with 9 ml of sterile water to make microbial suspension and marked as stock. Serial dilution was made by pipetting out 1 ml from the stock and transferring it to a new test tube containing 9 ml distilled water and marked as 10^{-1}. Same way 1 ml sample from 10^{-1} was poured to the next test tube containing 9 ml distilled water and marked as 10^{-2} dilution. In the same way dilutions were made up to 10^{-6}

Agar plating method: Nutrient Agar medium (NAM) is the basal medium containing 5 gm Peptone, 3 gm Beef extract, 5gm Sodium chloride, 20 gm Agar / L.

Identification of the Bacterial Isolates: Bacterial identification was noted on the basis of visual physiological characters and morphological characters such as colour, shape, margin (entire, undulate, lobate, erose filamentous), elevation (flat, raised, convex, umbonate, pulvinate), gram's staining, arrangement of cell, motility and various biochemical tests.

RESULTS AND DISCUSSION

Analysis of water: The dairy effluent sample was collected from milk processing units of Parag dairy. Analysis of wastewater was performed through various physicochemical

characters and the observed values were compared with the values of ISI, WHO and Indian standards.

Colour: The colour of the dairy waste water was observed by visual comparison which was milky white when compared with distilled water (Fig1). This might be due to the discharge of milk and milk products in it giving it a whitish appearance.

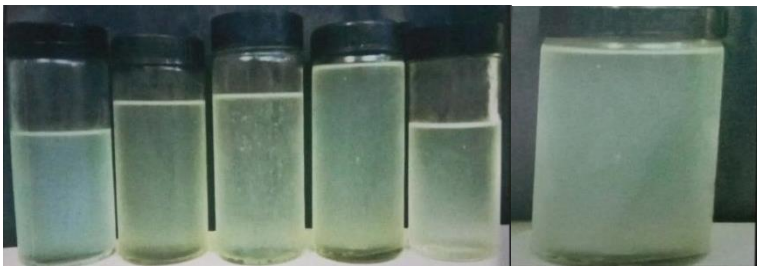

Fig 1: samples of dairy waste water (milky white in colour)

Temperature: Calculated temperature was 37.1°C, which was quite high as compared to pure water.

pH: The measured pH of the sample was7; with Universal indicator it was 7.5 which is almost similar Hence, concluding that the dairy water was neutral or slightly alkaline in nature.

Odor: The Odor of the sample was not foul. It was acceptable and generally indicated the typical dairy smell.

Dissolved oxygen: The DO was calculated by titration method. BOD bottles were used for measuring Dissolved oxygen. In BOD bottles, 2 ml of MnSO4 and alkali iodide was added, and a brownish cloud of precipitation was formed (Fig 2a). 2 ml sulphuric acid was added and the sample turned pale yellow in colour (Fig 2b). Sample was titrated with sodium thiosulphate. After addition of 2 ml of starch solution the sample turned blue in colour (Fig 2c). When again titrated, blue colour disappeared indicating end point (Fig 2d). The total volume of titrant used was 2.4 ml and sample used was 20 ml and DO was calculated (V. S. Shivsharan, et al., 2013).

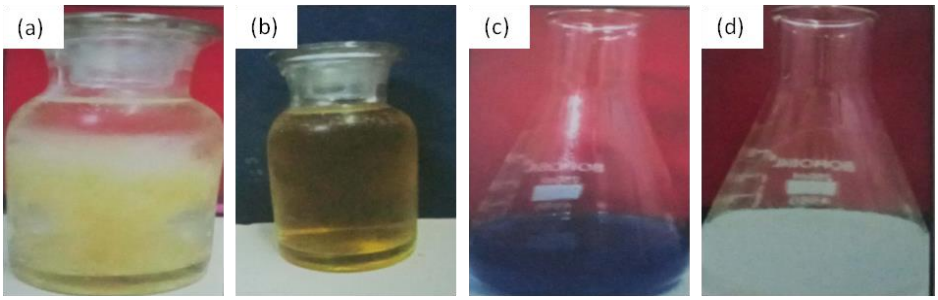

Fig. 2 (a) Formation of brownish cloud, (b) Sample after addition of sulphuric acid, (c) Appearance of blue colour and (d) Disappearance of blue colour indicating the end point

Biological oxygen demand: Two sets were prepared for calculating BOD. One blanks and one sample was taken in BOD bottles making one set. The DO of one set was calculated immediately; the DO of the second set was recorded for incubation time (five days) at 20°C. The DO of the immediately analysed sample was 26 mg/l and blank was 17.2 mg/l and the DO of the sample after five days of incubation was 18 mg/l and blank was 12.3 mg/l. From this BOD was calculated. BOD was calculated to be-sample 8 mg/l and blank was 4.9 mg/. When 2 ml MnSO4 and alkali iodide was added, a brownish cloud of precipitation was formed (Fig 3a). 2 ml sulphuric acid was added and the sample turned pale yellow in colour (Fig 3b). A separate flask was taken with 100 ml of sample and the sample was titrated against sodium thiosulphate. After addition of 2 ml of starch solution the sample turns blue in colour (Fig 3d). When again titrated, blue colour disappears indicating end point (Fig 4a).

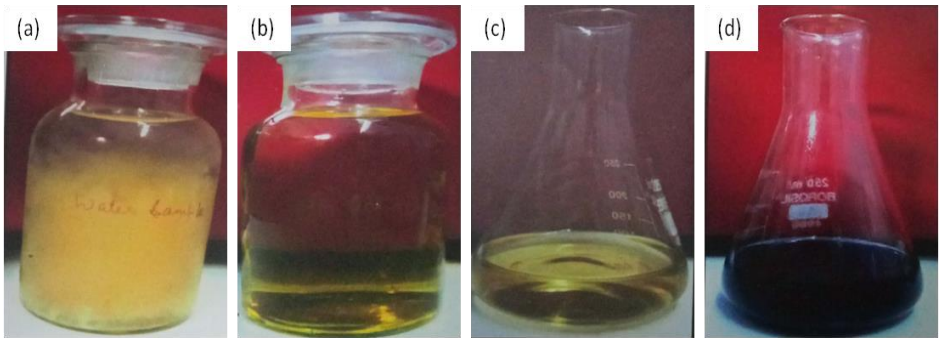

Fig. 3 (a) Formation of brownish cloud, (b) Sample after addition of 2 ml sulphuric acid, (c) Sample titrated with sodium thiosulphate and (d) Appearance of blue colour in the sample

Chemical oxygen demand (COD): It was calculated by using various chemicals including 2 ml of potassium dichromate, 2 ml of potassium iodide and 4 ml of H_2SO, in the water sample. When titrated with sodium thiosulphate pale yellow colour appeared (Fig 4b). On addition of

starch solution (0.4 ml) the solution turned bluish brown in colour (Fig 4c) and at point of titration it became colourless indicating end point (at that point 13.7 ml of the titrant used) and COD was calculated.

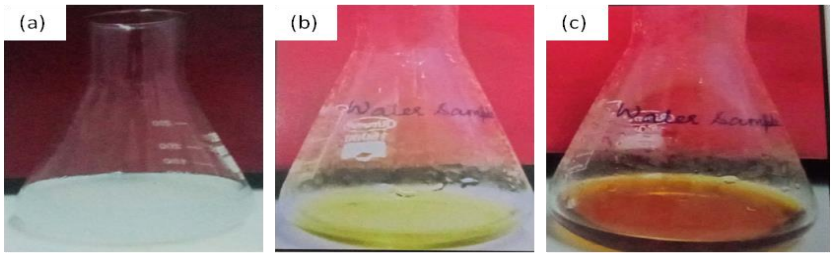

Fig. 4 (a) Blue colour disappeared indicating end point, (b) Pale yellow colour appeared after titration, (c) Yellow colour changed after adding starch solution

Total dissolved solids: For the measuring TDS, an empty porcelain dish which was 80.98 gm was taken. Afterwards, 100 ml of water sample was poured into it and kept in an oven. When the water sample was fully dried in a dish in a hot air oven and then again weighed the oven dried porcelain dish, which was 81.960 gm. From these values the total dissolved solids were calculated.

Total suspended solids: TSS was calculated with the help of filter medium. Firstly, the starting wt. of the filter medium was noted, which was 1 gm. a selected portion of water was strained via the filter medium. Furthermore, this final weight of filter medium was noted which was 1.1 gm. Total suspended solid was computed by deducting the starting wt. of filter medium from the final wt. of filter medium which was 0.1 mg/l.

Total solids: Total solids was calculated by adding TSS and TDS. The calculated value of TSS was 0.1 mg/l and TDS was 9.8 mg/l. The total solids, thus amounted to 9.9 mg/l.

Free carbon-di-oxide: The phenolphthalein indicator was used to measure free carbon dioxide. After this the sample was titrated however pink hue was continued showing the terminating point and the free carbon-di-oxide was calculated (fig 5a).

Alkalinity: The addition of phenolphthalein indicators developed a pink colour to the sample. Simultaneously few blobs of methyl orange solution were appended to the sample and it was volumetrically analysed against diluted HCl (Fig 5b). Pink colour reappeared indicating end point (Fig 5c). The total volume of the dil. HCI used was 3.6 ml and the value of the alkalinity calculated.

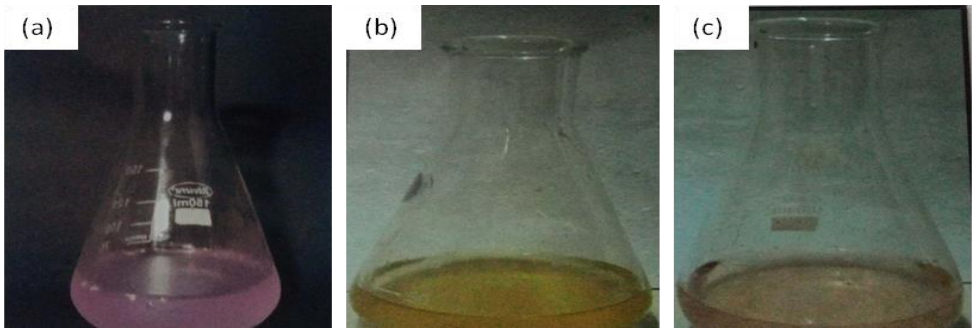

Fig. 5 (a) Persisting pink colour indicating end point, (b) After adding methyl orange, sample titrated with diluted HCL, (c) Pink colour appeared indicating end point

Acidity: 2-3 drops of methyl orange solution were poured into the water sample (100 ml) pink colour developed and titrated with sodium hydroxide (Fig 6a). After adding a phenolphthalein indicator, the sample was turned into pink colour (Fig 6b) the total quantity of the sodium hydroxide used was 1.2 ml and the value was calculated.

Hardness: a blob of EBT solution was mixed to the selected portion, after adding it produced wine red in colour (Fig 6c). Afterwards, the sample was titrated with EDTA solution, the colour changed in blue indicating end point (fig 6d). The total volume of EDTA consumed was 3.2 ml and the value of hardness was 80 mg/l.

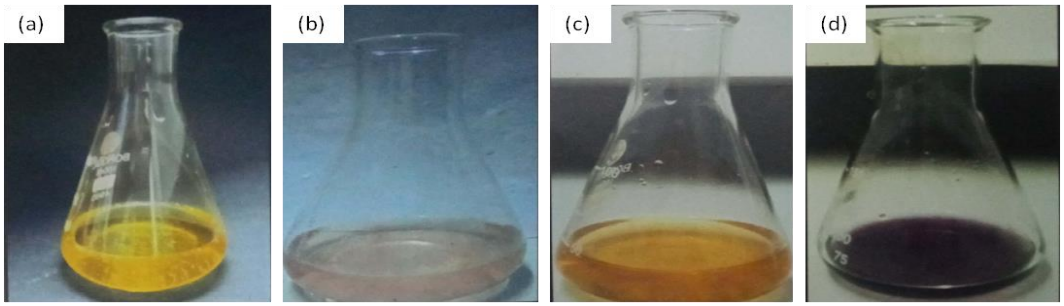

Fig. 6 (a) Appearance of yellow colour after titration, (b) Yellow colour changes to pink, (c) Samples turns wine red in colour and (d) Wine red changes to blue in colour

Calcium: 1 ml of Iso-propyl and 1000 µl of NaOH solution was appended into the 50000 µl of selected portion of water (Fig 7a). Pink colour developed after adding a pinch of murexide indicator (Fig 7b). The sample was titrated against EDTA, the total volume of EDTA used was 1.8 ml. pink colour turned purple indicating the end point (Fig 7c). The value of calcium calculated was 15.13 mg/l according to the formula.

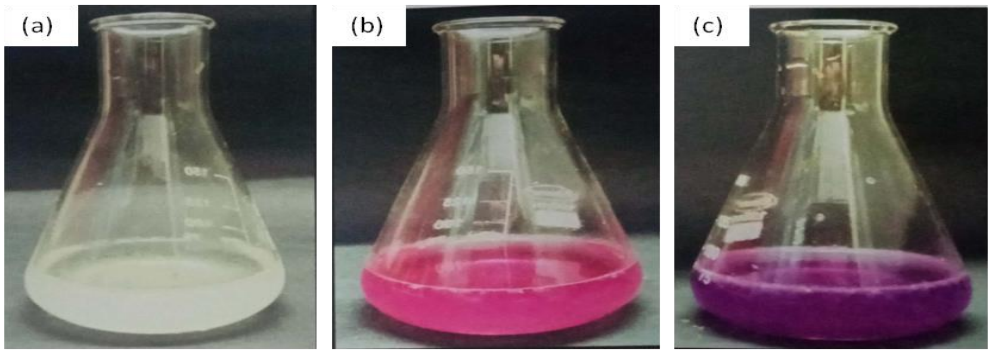

Fig. 7 (a) Water sample after adding sodium hydroxide and iso-propyl alcohol, (b) Pink colour developed after adding murexide indicator, (c) Pink colour changed to purple indicating end point

Magnesium: To calculate magnesium content in the wastewater, the values of total hardness and calcium hardness were utilized which was 160 milli gram/litre and 37.8 milli gram/litre individually. And values of magnesium hardness happen to be 29.69 mg/l.

Chlorides: In the 50 ml of water sample 500 µl of K_2CrO_4 indicator was appended, the sample showed lemon hue (Fig 8a). Sample was volumetrically analysed against $AgNO_3$ and at points where it precipitates indicate the end point, which was 3.5 ml (Fig 8b). The value of the silver nitrate consumed by the blank was 2.5 ml.

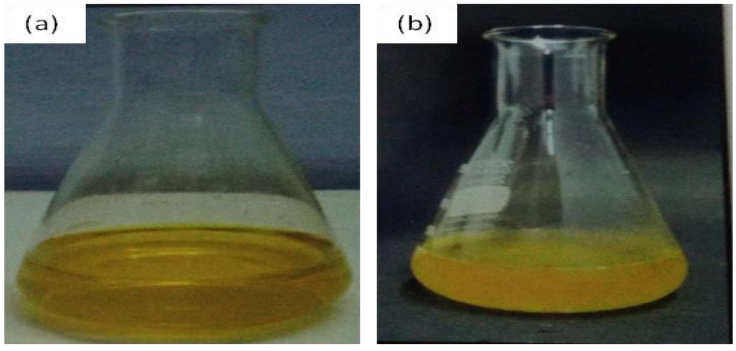

Fig. 8 (a) Sample turns yellow after 0.5 ml of potassium chromate indicator, (b) Precipitation starts after titrating with silver nitrate

The analysis of water samples through various parameters are summarized in table no. 1.

Table. 1: Laboratory analysis results of waste water samples.

S.No.	Parameter	Values of waste water sample

1.	Chlorides	0.012
2.	Free carbon-di-oxide	70.00 mg/1
3.	Magnesium	29.69 mg/1
4.	Calcium	15.13 mg/l
5.	Hardness	80.00 milli gram/litre
6.	Acidity	150.00 milli gram/litre
7.	Total suspended solids	1.10 milli gram/litre
8.	Total solids	9.90 milli gram/litre
9.	Alkalinity	900.00 milli gram/litre
10.	Total dissolved solids	9.80 milli gram/litre
11.	Biological oxygen demand	8 milli gram/litre
12.	Chemical oxygen demand	44.00mg/l
13.	Odor	Acceptable
14.	Dissolve oxygen	12.00 mg/1
15.	pH (Strips) Universal Indicator	7.0 7.5
16.	Temperature	37.1˚C
17.	Colour	Milky white

Isolation of Bacteria and study of their colony characters, morphology, gram staining etc.

The dairy waste contains a large number of microorganisms in it. The favourable medium for the isolation is the nutrient agar medium, which favours the growth of the bacteria. The bacteria were isolated by a plating technique (Agar plating technique). The different dilutions (1 to 10) show different bacterial isolates. From the isolated bacteria six isolates were considered and

studied for their different colony characters and morphology.

The shape of the colony of the first bacterial isolate was irregular, it showed clear and marked differentiation of the colour of the colony which was green. The margins of the first isolate were undulate (irregular) and the colony elevation was flat. The first isolate was gram positive in nature, the cells were spherical in shape and they were mostly single or sometimes in chains of two or three (streptococci). The shape of the colony of the second bacterial isolate was circular, the colour of the colony was white. The margins of the second isolate were continuous and the colony elevation was flat. The second isolate was gram positive in nature the cells are rod shaped and they occur in chains or in bunches. The colony shape of the third bacterial isolate was circular, the colour of the colony was off white. The margins of the third isolate were entire and the colony elevation was pulvinate. The third isolate was gram positive in nature, the cells were rod shaped and occured in chains. The colony shape of the fourth bacterial isolate was irregular, the colour of the colony was light brown. The margins of the fourth isolate arose and the colony elevation was raised. The fourth isolate was gram positive in nature, the cells were spherical shaped and they occured in chains of two (diplococci) or in short chains. The shape of the colony of the fifth bacterial isolate was circular, the colour of the colony was white. The margins of the fifth isolate were entire and the colony elevation was flat. The fifth isolate was gram positive in nature, the cells were spherical shaped and they occur in chains. The shape of the colony of the sixth bacterial isolate was circular, the colour of the colony was white. The margins of the sixth isolate arose and the colony elevation was flat. The fifth isolate was gram positive in nature; the cells were spherically shaped and they occurred as single (cocci) cells or in chains (small chains). When the gram staining tests were performed, all the isolates retained the colour of safranin and appeared pink in colour. Thus, all are gram positive in nature. The different colony characters and morphology of different bacterial isolates were summarized in table no. 2.

Table. 2: Colony characters and morphology of the isolated bacterial strains

Strains	**Colony morphology**	**Colour**	**Margin of colony**	**Acclivity**	**Gram character**	**Shape of cell**	**Arrangement of cell**

1.	Irregular	Green	Undulate	Flat	Gram Positive	Spherical	Single, in chain (streptococci)
2.	Circular	White	Entire	Flat	Gram Positive	Rod (bacilli)	In chain, bunches
3.	Circular	Off White	Entire	Pulvinate	Gram Positive	Rod	Chain
4.	Irregular	Light Brown	Erose	Raised	Gram Positive	Spherical	Diplococci, short chain
5.	Circular	White	Entire	Flat	Gram Positive	Spherical	Single (cocci)
6.	Circular	White	Erose	Flat	Gram Positive	Spherical	Single

A tentative identification was done of the bacterial isolates based on their colony characters and morphology and gram staining. The first isolate resembled *Nitrosomonas* -like and *Nitrospira* -like bacteria. Also, the colour of the medium turned green, gave gram positive tests which were similar to above mentioned species. The bacterial isolate with circular shape of the colony, white in colour and with entire margin, flat elevation, gram positive nature may belong to the *Corynebacterium sps*. Or may belong to *Bacillus sps.* Thus, a tentative identification of the bacterial isolates was done, but further for conclusive confirmation different biochemical tests will be performed and confirmed identification will be made later.

Table. 3: List of various scientific methods of water quality testing as per ISO and WHO

S. No.	**Physiological characters**	**Used procedure**	**As per WHO**	**As per ISO**
1.	**TSS**	Filtration	100 mg/L	-
2.	**Magnesium**	Titration method	150 mg/l	30 mg/l

3.	**Chloride**	Titration method	250 mg/l	250 mg/l
4.	**COD**	Incubation followed by titration	250 mg/l	-
5.	**BOD**	Incubation followed by titration	6	30
6.	**Acidity**	Acid – base titration	-	-
7.	**Alkalinity**	Acid – base titration	-	200
8.	**Total hardness**	Titration	200	300
9.	**DO**	Titration	5 mg/L	-
10.	**pH**	Litmus paper etc.	6.5-9.5	6.5-9.5
11.	**Temperature**	Temperature reader	NIL	NIL
12.	**Smell**	Sensory evaluation	Permissible	Permissible
13.	**Tincture**	Appearance	NIL	5 hue units

Conclusion: Industrial wastewater makes up the effluent that is delivered out of a particular manufacturing unit. Any type of contamination in water affecting its chemical, physical and biological properties, lead to water pollution. It can be concluded that waste-water is highly basic with good quality of dissolved oxygen and with acceptable odour. Production of odour is mainly due to gaseous decomposition from organic matter. Odour leads to more psychological stress than causing any direct harm. Foul odour reduces hunger, and also results in lower water consumption, and weakens respiration. The odour of the dairy water is not foul indicating typical dairy smell and it was acceptable. Colour change is visible from the naked eye and coloured water leads to doubt making it unacceptable for any purpose. Water released from dairy appears milky white in colour. It is not clean as compared with the pure water.

Temperature possesses consequences on most of the chemical reactions that happen in natural water systems. The temperature from the sample was reported to be 37°C which is quite high but upon reaching the temperature of 50°C the aerobic digestion stops. Temperature does not seem to have any greater influence on water quality. The dissolved solids in the water sample were very less, as the dissolved solids also affect the flavour of water. Alkalinity is the capability of water to counterbalance acids, while the basic nature of water sample was very high making it highly alkaline and pH of water sample (7.5 pH also indicated that in contrast to this the water sample is less acidic). High concentration of inorganic acids further reduces the pH value beneath 4.5 but the pH of the water sample is 7.5 (which is alkaline). The hardness of water is due to dissolved bicarbonates, chlorides and sulphates out of which the amplest amounts of calcium and magnesium are present. Water sample was moderately hard when compared with the range of hardness. The value of hardness is moderately hard (range of moderately hard was 75- 150 milligram/Liter). Organic and Inorganic particles remain suspended as solid in water. There are various inorganic solids composed of loam, silt, clay and other soil constituent regularly found in ground water and numerous organic constituents such as plant debris and other biological life forms such as algal cells and bacteria are quite frequent. The value obtained from suspended solids was 0.1 mg/l which was well within the limits. Dissolved solids may produce colour, taste and odour Distilled water are free from dissolved solids and preferred for different uses. Nevertheless, a concentration higher than 500-1000 mg/l of dissolved salts often gives rise to bad taste and imposes a laxative effect and the value of the dissolved solids in the present investigation has been reported as 9.8 mg/l which is very minimal. Hence, the dairy water is free from dissolved solids. Chlorides found in natural water are the consequences from percolation of chloride rocks as well as soils after coming in contact with water. The major origin of Cl^- in ground water accounts to agricultural, industrial and domestic wastewater discharge. The calculated estimate of chlorides came out to be 0.012 mg/l which was significantly lower in comparison to the standard values which accounts to be 250 mg/l. Oxygen is required by the living organism for their survival in one form or another. The available oxygen in fresh water extends from 14.6 mg/l to 7.6 mg/l at 30° C depending upon its solubility and the estimate received from the water analysis was 12 mg/l which lies within the permissible range of water quality. The aggregate volume of oxygen mandated by microbes to stabilize decomposable organic matter refers to BOD. The BOD of the selected portion was 8 mg/l and COD was 44 mg/l. The COD of the water was reported to be greater

than BOD, as the maximum number of compounds are chemically oxidized within a short span of time.

In dairy wastewater a number of gram-positive microbiotas is found predominantly. Their identification and morphological characteristics were measured via microscope and through biochemical tests. These characteristics revealed that bacteria probably belong to the genus *Bacillus*, *Corynebacterium* and *Nitrosomonas* More biochemical tests are required for the confirmation of the bacterial isolates from the dairy waste water. These biochemical tests indicate that the bacterial isolates from the dairy industry have the ability to utilize the components like nitrate, starch gelatine, sugar etc. Hence, these types of bacterial strains could be efficiently used to treat dairy wastewater.

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Synergistic effect of *Cymbopogon Citratus* and *Tecoma Stans* against some pathogenic bacteria

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ABSTRACT

Antibiotic resistance can be easily defined as when microbes change in response to the use of medicines, that is, it no longer responds to the use of medicines designed to devastate their cell structure. Plants possessing antimicrobial benefits could be utilized to derive useful medicines which will solve the purpose while imposing fewer side\piute effects. The present study was conducted to find an alternative in treating some common plant pathogenic bacteria by using plant extracts from commonly found plants in our locality. Various extracts using different solvent (Ethanol, Methanol) as well as aqueous extract of the *Tecoma stans* and *Cymbopogon citratus* (Leaves, Stem, and root) were prepared in microbiology lab, Dayal Bagh Educational Institute, Dayal Bagh Agra. The pathogens selected for this study included *Agrobacterium tumefaciens*, *Pseudomonas putida*, *Pseudomonas syringae*, *Pseudomonas fluorescens* and *Ralstonia solanacearum.* The microbial analysis was carried out by Disc-diffusion technique. Synergistic effects from the stem and leaves of the selected plants in methanolic extracts showed greater zones of inhibition in comparison to individual tests.

Keyword: Antibiotic resistance, antimicrobial activity, disc diffusion, Synergistic

INTRODUCTION

Natural plants are extensively used as primary health remedies due to their therapeutic properties. Since time immemorial plant and animal-based products and their derivatives have been exploited and explored for finding the remedy to many known and unknown diseases occurring to humans. Since the start of civilization humans have shown more interest in plant-based cure and tendency to use plants and their products as an herbal remedy for all types of illness. Thus, to explore the antimicrobial benefits of plants, its various parts such as roots, stems, leaves, flowers, and fruits were utilized. (Sowjanya *et. al.*, 2013). Besides, such plants having an aptitude to cure diseases and having ability to act against microbes are considered as a capable remedy possessing few side effects in comparison to other conventional medicines available today. Although a lot of the compounds inhabiting the plants have been discovered, scientists claim that a lot of such compounds which could bring in revolutionary changes in the field of medicine are yet to be discovered. Furthermore, after its discovery it is very essential to properly characterize them to obtain maximum output of the discovery and test its

significance against the copious number of microbes existing today. Although allopathy was discovered a long time ago, there has been a transition of people opting for natural cure of diseases. Allopathic medicines, though, could cure almost every condition in a limited period but they also accompany them with numerous side effects. Thus, a shift of choices has recently been reported where patients are opting for natural treatments, to be precise products that are obtained from plants. (Lutterodt *et. al.*, 1999). The microbial infections pose many health problems in the world. Use of synthetic antimicrobial drugs and antibiotics produce adverse effects; therefore, plants are used as the potential source of antimicrobial agents for the treatment of microorganisms.

Nearly 80% or even larger of the global population marks their dependency on plants providing us medicines. Our country India, is the originating place where most of a renowned system of medical facilities such as Siddha, Ayurveda, and Unani have been practiced successfully for over decades. Conventionally, medicines were formulated sometimes from a single plant and sometimes various combinations of different plants were used. All this knowledge of plants and herbs and their use and efficacy hinged to the understanding of its taxonomic features. The species of plant, the part of the plant to be consumed and the benefits it would impart made the ancient practitioners realize their worth.

Simultaneously upon further investigations and findings it could be understood that when two compounds are mixed in synergy, their potential to combat any microbes have shown to drastically increase or decrease in comparison to when used individually. This synergy improvises and is beneficial in situations like treatment of patients and their clinical observations. In situations where patients are made to administer a required dosage of drug, synergistic medicine can prove to be a boon. Synergistic drug could serve the same purpose by lowering the dose requirement and achieving same health goals. This will eventually lower the cost of medical bills and simultaneously lower the risk of side effects on the patient by reducing the toxicity (Greco *et al.*,1995). For present study, *Tecoma & Cymbopogon* were selected to study the antimicrobial effects of their plant parts, individually and in synergy against *Pseudomonas syringae, Agrobacterium tumefaciens, Pseudomonas putida, Pseudomonas fluorescens, Ralstonia solanacearum.*

METHODOLOGY

Virulent bacteria were primarily inoculated in petri plates having nutrient agar medium (NAM) straightforwardly. It was then incubated at the temperature of 37°C (Optimum for bacterial growth) in the BOD incubator. Bacterial colonies that appeared on the petri plates were relocated to other petri plates containing (NAM) for further purification and removal of any other colonies if present to obtain pure cultures.

Revival of pathogens: The obtained colonies of pure bacteria were revived in the broth containing nutrient media suitable for them. They were then shifted in a BOD incubator for 24 hours at 37° C and then the solution had changed color signifying the bacterial growth. It was eventually maintained in glass slants at 4°C in the refrigerator. The leaves, stems and roots of *Cymbopogon citratus* & *Tecoma stans* were procured from the herbal garden situated in institutional premises. They were washed individually first by tap water, after which it was rinsed by sterilized distilled water. Removal of excess water using blotting sheets was done prior to shade drying. Preceding drying, dried plant parts were transformed into fine powder by using mortar pestle. The obtained powders were kept in separate airtight containers to prevent any sort of contamination for further use.

Preparation of various extracts:

i) Aqueous extract – To produce aqueous extract fresh plant parts of the selected plants were used. Extract was prepared by using mortar pestle and distilled water. To prepare individual plant parts extract 2 gm plant parts were crushed in 20 ml distilled water at room temperature and then strained by muslin cloth. The filtrate was carefully obtained and stored in a sterilized conical flask to be used within 24 hours.

ii) Ethanolic extract- To formulate individual extract of various plant parts that includes roots, stems, and leaves 2gm powder of each mentioned part was dissolved in 20 ml ethanol respectively. Further it was strained using muslin cloth, followed by careful storage in falcon tubes, and was utilized within 24 hours.

iii) Methanolic extract - To formulate methanolic extract which was prepared exclusively for investigating the synergistic activity. The combined plant extract 2gm (1gm of *Tecoma* parts + 1gm of *Cymbopogon* parts were solvated in 20 ml of pure methanol. Preceding 48 hours it was

strained with the help of muslin cloth. The residue was discarded and filtrate obtained was stored in sterilized conical flask to be used within 24 hours.

For the assessment of synergistic effect of plant extract against different pathogenic bacterial strains selected for this study:

The antimicrobial activity of plant extract that were prepared from *Cymbopogon citratus* and *Tecoma stans* against the selected bacterial cultures was analyzed using – *Paper disc diffusion technique (Pelezar et al, 1993; Okigbo et al, 2005):* To study the antimicrobial action experiments were performed using disc diffusion technique. Paper discs of size roughly 6 millimeter in diameter were nipped from Whatman no.1 filter paper with the help of a cork borer of defined diameter. Following this, the prepared sterilized discs were placed in different extracts for it to become saturated, having pre-assorted concentration. The discs were then carefully planted on a NAM medium petri dish already streaked with the test bacterial strains. Discs that were saturated with analogous solvent solitarily were selected to be used as control. These petri-plates were subjected to a BOD incubator where they were kept at suitable temperature i.e. 37 degrees Celsius and further careful observation for a presence or absence of zone of inhibition after 24 hours of incubation period was noted down.

RESULTS

Maintenance of bacterial cultures:

Bacterial cultures used were *Agrobacterium tumefaciens, Pseudomonas putida, Pseudomonas syringae, Pseudomonas fluorescens, Ralstonia solanacearum.* These plant pathogenic cultures were procured from the Microbiology laboratory, Department of Botany, Dairy campus, Dayal Bagh Educational Institute Agra. All these cultures were procured from the Indian Type Culture Collection (ITCC), IARI, New Delhi.

1.Resuscitation of bacterial pathogens: The bacteria were resuscitated in nutrient broth suitable for bacterial growth and cautiously placed in a Biological Oxygen Demand incubator for 24 hours at 37 °C. They were then transferred in slants and preserved in refrigerator at 4°C.

2. Assemblage and Production of Distilled water extract of roots, stems and leaves of *Tecoma stans* and *Cymbopogon citratus*.

Fresh distilled water extract prepared from different plant parts of the selected two plants was executed by the aforementioned method. Assemblage and production of ethanol-based extract of roots, stems, and leaves of *Tecoma stans* and *Cymbopogon citratus* were carried out. The ethanol-based extract of the two selected plants were produced using dried powder and following the methodology described. Methanol based extracts were utilized solely for assessing the synergistic effects of two predetermined plants against the chosen bacterial strains.

3. For **assessment of individual effect on above-mentioned parts of *Cymbopogon citratus* & *Tecoma stans* against selected bacteria by disc diffusion technique:**

Table I. (a) and (b) Antibacterial action of *Tecoma stans* against *A.tumefaciens, P.putida, P.syringae, P.fluorescence* and *R.solanacearum.*

Bacterial cultures used	**Part of plants involved**	**Solvent used**	**Results obtained**
(i) A.tumefaciens	roots	Distilled water	No zone of inhibition
	stems	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition
	control	Distilled water	No zone of inhibition
(ii) P.putida	roots	Distilled water	No zone of inhibition
	stems	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition

	control	Distilled water	No zone of inhibition
(iii) P.syringae	roots	Distilled water	No zone of inhibition
	stems	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition
	control	Distilled water	No zone of inhibition
(iv)P.fluorescens	roots	Distilled water	No zone of inhibition
	stems	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition
	control	Distilled water	No zone of inhibition
(v) R.solanacearum	roots	Distilled water	No zone of inhibition
	stems	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition
	control	Distilled water	No zone of inhibition

Table: 1(b)

Bacterial cultures used	**Part of plants involved**	**Solvent used**	**Results obtained**
(i) A.tumefaciens	roots	Ethanol	No zone of inhibition
	stems	Ethanol	No zone of inhibition
	leaves	Ethanol	No zone of inhibition
	control	Ethanol	No zone of inhibition
(ii) P.putida	roots	Ethanol	No zone of inhibition
	stems	Ethanol	No zone of inhibition
	leaves	Ethanol	No zone of inhibition
	control	Ethanol	No zone of inhibition
(iii) P.syringae	roots	Ethanol	No zone of inhibition
	stems	Ethanol	No zone of inhibition
	leaves	Ethanol	No zone of inhibition
	control	Ethanol	No zone of inhibition
(iv) P.fluorescens	roots	Ethanol	No zone of inhibition

	stems	Ethanol	No zone of inhibition
	leaves	Ethanol	No zone of inhibition
	control	Ethanol	No zone of inhibition
(v)R.solanacearum	root	Ethanol	No zone of inhibition
	stem	Ethanol	No zone of inhibition
	leaves	Ethanol	**1mm**
	control	Ethanol	No zone of inhibition

Zone of inhibition was not present in any distilled water and ethanolic extract of *Tecoma stans* against 1st four bacterial strains. Zone of inhibition was only found in ethanolic extract of leaf against *R.solanacearum*

Table II. (a) and (b) Antibacterial action of *Cymbopogon citratus* against *A.tumefaciens, P.putida, P.syringae, P.fluorescence* and *R.solanacearum.*

Bacterial cultures used	**Part of plants involved**	**Solvent used**	**Results obtained**
(i) A.tumefaciens	roots	Distilled water	No zone of inhibition
	stems	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition

	control	Distilled water	No zone of inhibition
(ii) P.putida	roots	Distilled water	No zone of inhibition
	stems	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition
	control	Distilled water	No zone of inhibition
(iii) P.syringae	roots	Distilled water	No zone of inhibition
	stems	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition
	control	Distilled water	No zone of inhibition
(iv) P.fluorescenns	roots	Distilled water	No zone of inhibition
	stem	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition
	control	Distilled water	No zone of inhibition
(v) R.solanacearum	roots	Distilled water	No zone of inhibition

	stems	Distilled water	No zone of inhibition
	leaves	Distilled water	No zone of inhibition
	control	Distilled water	No zone of inhibition

Table II (b)

Bacterial cultures used	**Part of plants involved**	**Solvent used**	**Results obtained**
(i) A.tumefaciens	roots	Ethanol	No zone of inhibition
	stems	Ethanol	No zone of inhibition
	leaves	Ethanol	No zone of inhibition
	control	Ethanol	No zone of inhibition
(ii) P.putida	roots	Ethanol	No zone of inhibition
	stems	Ethanol	No zone of inhibition
	leaves	Ethanol	No zone of inhibition
	control	Ethanol	No zone of inhibition

(iii) P.syringae	roots	Ethanol	No zone of inhibition
	stems	Ethanol	No zone of inhibition
	leaves	Ethanol	No zone of inhibition
	control	Ethanol	No zone of inhibition
(iv) P.fluorescens	roots	Ethanol	No zone of inhibition
	stems	Ethanol	No zone of inhibition
	leaves	Ethanol	No zone of inhibition
	control	Ethanol	No zone of inhibition
(v) R.solanacearum	roots	Ethanol	**2mm**
	stems	Ethanol	No zone of inhibition
	leaves	Ethanol	No zone of inhibition
	control	Ethanol	No zone of inhibition

Antibacterial activity of *Cymbopogon citratus* (2mm) was found only in ethanolic extract of root against *Ralstonia solanacearum.* Zone of inhibition was not noticed in ethanolic and distilled water extract of leaves as well as stems against other four bacterial strains.

Synergistic activity of stem and leaves of *T.stans* & *C.citratus* in combination by disc diffusion method against *A.tumefaciens* & *P. syringae*

Table III. Antibacterial activity of synergistic effect against *A.tumefaciens* and *P.syringae*

Bacterial cultures used	Part of plant involved	Solvent used	Results obtained
A.tumefaciens	stems	Methanol	2 mm
	leaves	Methanol	2 mm
P.syringae	stems	Methanol	2 mm
	leaves	Methanol	2 mm

Discrete plant parts extracts of the chosen 2 plants revealed negative outcomes against 4 out of 5 bacterial strains except ethanolic extract of leaves of *Tecoma stans* and ethanolic extract of root of *Cymbopogon citratus* against *R. solanacearum.* However positive synergism was seen in stem and leaves of *T. stans* and *C. citratus* against *A.tumefaciens* and *P. syringae* as they showed 2 mm zone of inhibition in methanolic extract of combined extract.

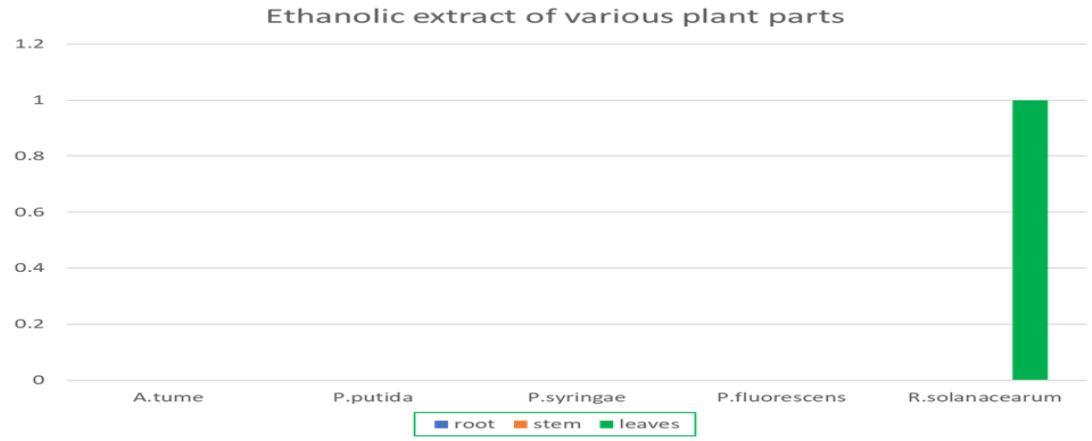

Fig. 1. Comparative study of individual ethanolic extract of different plant parts of *T. stans* against selected pathogenic bacteria

Preceding the analysis of ethanolic extract of various plant parts of *Tecoma stans* when tested against selected bacterial pathogens, it was noticed that no zone of inhibition was revealed

against *A.tumefaciens, P.putida, P.syringae, P.fluorescens* while inhibition zone of 1 mm was seen in ethanolic extract of leaves of *T.stans* against *R.solanacearum.*

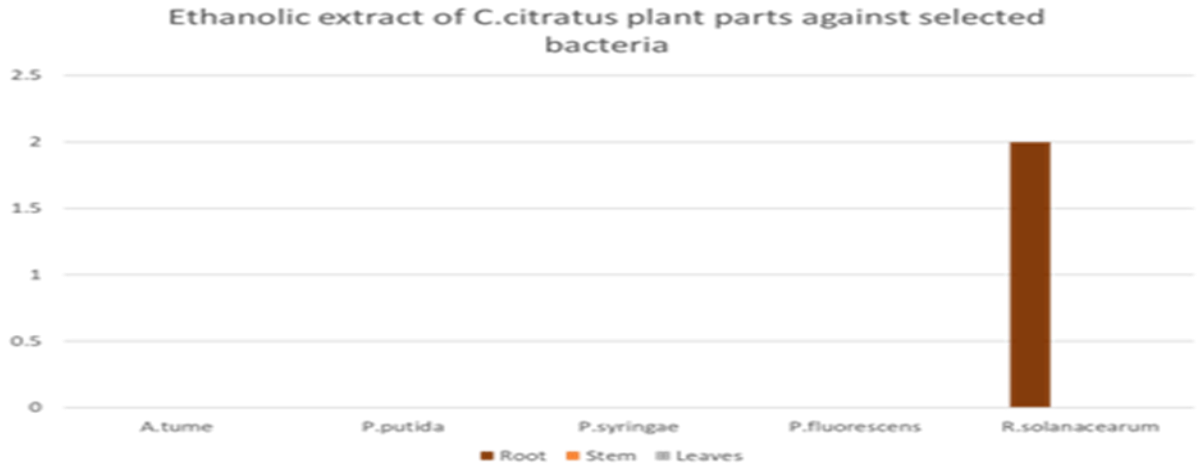

Fig. 2. Comparative study of individual ethanolic extract of *Cymbopogon citratus* against bacteria mentioned above

Preceding the analysis of ethanolic extracts of different parts of *Cymbopogon citratus* against the 5 chosen bacteria, absolutely null zone of inhibition was revealed against *A.tumefaciens, P.putida, P.syringae, P.fluorescens* root extract of *Cymbopogon citratus* solely indicated a 2 mm zone of inhibition against *R.solanacearum.*

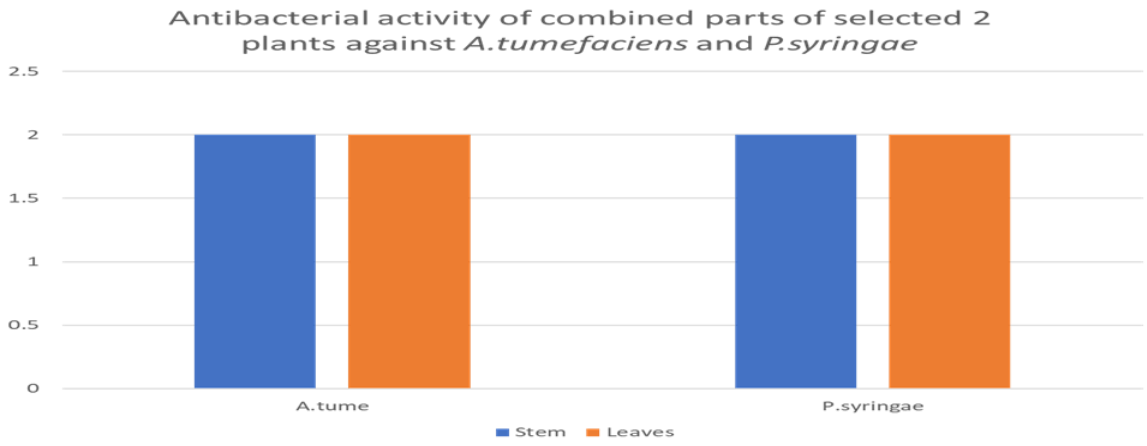

Fig. 3. Comparative investigation of synergistic effect against both bacterial strain (*Agrobacterium tumefaciens & Pseudomonas syringae*)

Aqueous extracts of various plant parts of *Tecoma stans* and *Cymbopogon citratus* was

totally ineffective against all selected bacterial pathogens but methanolic extract of both combined stem and leaves extracts of *Tecoma stans* and *Cymbopogon citratus* was observed effective against *A.tumefaciens* and *P.syringae*. Positive synergism was observed.

CONCLUSION

Natural plants are extensively used as primary health remedies due to their therapeutic properties. Plants naturally produce compounds that help them fight against a diverse range of pathogens like bacteria, fungi, viruses, and many more other threats. These compounds have proven to be helpful to mankind too. This information has been harnessed over for centuries by healers and medical practitioners to find remedy of the diseases occurring to humans (Sowjanya *et. al.*, 2013). Moreover, research has been going on to explore more and more such compounds from plants as they have lesser side effects and they can be a potential source for the development of medicines to rectify different medical conditions and infections. Development of such antibiotics could help in combating problems like drug resistance, a fast-growing concern of the medical field.

For the present experiment, selected bacterial strains were maintained on Nutrient Agar Medium (NAM). A mortar pestle was used for manual extraction of all the required extracts of plants selected and their parts simultaneously. To procure the powder from dried plant parts, a grinder was used. To prepare individual plant extract of various plant parts namely root, stem, and leaves of *Tecoma stans* and *Cymbopogon citratus*, 2 gm of dried powder was made to dissolve in 20 ml of sterile distilled water and ethanol in the order already mentioned.

Antimicrobial action was investigated by disc diffusion technique. Paper discs of size 06 mm in width were nicked out from Whatman no.1 filter paper by the help of a cork borer of measured diameter. The discs, fed with various extracts containing diverse concentrations were placed on petri plates containing Nutrient Agar Medium which had already streaked with selected microbes. Disc saturated with complementary solvent solely was treated as control. The plates were in incubation at required temperature and noted for the inhibitory zone after 24 to 48 hours.

Antibacterial activity in ethanolic extract of leaves of *Tecoma stans* and roots of *Cymbopogon citratus* was obtained against *R.solanacearum* only whereas almost null zone of inhibition was

noted in ethanol based extract of stem of *T. stans* as well as *C. citratus* against *A. tumefaciens, P. syringae. P. fluorescens and P. putida.* Aqueous extracts of stem, leaves, and root of *Cymbopogon citratus* did not show any positive against any of selected bacteria. Similar results were reported by Samah Noor in 2016 with aqueous extract of *Cymbopogon citratus*. She reported least activity in aqueous extract. In ethanol based extract of leaves as well as stem of *Tecoma stans,* only leaves showed positive results against *R.solanacearum*. Mohamed Z.M.Salem *et. al.,* in 2013 evaluated the antibacterial potential of leaves of *T.stans* in ethanolic extract against the growth of some human pathogenic bacterial strain using disc diffusion technique. However, in the present study, plant pathogenic bacteria were used.

In order to investigate the combination of 2 plant extracts 2 gm (1 gm of *Tecoma stans* plant parts + 1gm of *Cymbopogon citratus* plant parts) were dissolved in 20 ml of methanol. Methanol based extracts of both equally mixed stem and leaves solution obtained from *T.stans* as well as *C.citratus* were effective against *A.tumefaciens* and *P.syringae*. Based on the experimental observation of this current work, this merger of stem and leaves extracts of the dual plants has shown explicit synergism by demonstrating inhibitory effects. Results become significant as the individual extract did not result in any antimicrobial effect. Combination of methanolic stem and leaves extracts of *T.stans* and *C.citratus* showed positive synergism against *A.tumefaciens* and *P.syringae.*

Based on our literature survey there are no research disclosed about the synergistic effect of *Tecoma stans* as well as *Cymbopogon citratus* against *P.syringae, A.tumefaciens, P.putida, P.fluorescens* and *R.solanacearum.* Synergistic effect of *Tecoma stan*s and *Cymbopogon citratus* against *A.tumefaciens* and *P.syringae* is reported for the first time.

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Nanotechnology for Sustainable Development

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ABSTRACT

Nanotechnology has the potential to make substantial contribution to sustainable development in various ways. It can enable the development of more efficient and sustainable energy sources. Nanotechnology can be used to create solar panels that are much more efficient than traditional ones, making them more cost-effective and widely accessible. Nanotechnology can help to create new types of batteries that are more efficient and durable, enabling the storage of energy generated by renewable sources like wind and solar power. Nanotechnology can contribute to sustainable development by improving water quality and availability. Nanotechnology-based water treatment systems can remove pollutants and contaminants from water sources, making them safe for human consumption. Nanotechnology can be used to create membranes that can selectively filter out salt and other impurities, enabling the production of fresh water from seawater and other contaminated sources. Nanotechnology can have a notable impact in improving food security and sustainability. Nanotechnology-based diagnostic tools and therapies can enable earlier disease detection and more targeted treatments, reducing the burden of disease and improving patient outcomes. Nanotechnology can enable the development of more sustainable and eco-friendly medical products, such as biodegradable drug delivery systems and environmentally friendly medical devices.

INTRODUCTION

Background: Nanotechnology is a branch of science and engineering focusing on the design, production, and manipulation of materials at the nanoscale level. The applications of nanotechnology are diverse, ranging from electronics, medicine, energy, and the environment. In recent years, the use of nanotechnology has become popular in the area of sustainable development due to its potential to deal with the various challenges faced by society, such as pollution, climate change, and resource depletion. This research paper aims to discover the potential of nanotechnology for sustainable development by discussing its applications in various sectors and its impact on the environment, economy, and society.

An area of science and engineering called nanotechnology is concerned with the creation and manipulation of materials at the nanoscale. Nanotechnology has many different uses, including those in electronics, medicine, energy, and the environment. Due to its potential to address a number of societal issues, including pollution, climate change, and resource depletion, nanotechnology has recently acquired appeal in the field of sustainable development. This research paper discusses the uses of nanotechnology in numerous fields and how they affect the environment, the economy, and society in order to examine the possibilities of this technology for sustainable development.

Objectives: The targets of the studies that the paper holds are to: Explore the capacity packages of nanotechnology for sustainable improvement. This consists of figuring out the precise

regions wherein nanotechnology may be used to cope with sustainability demanding situations, inclusive of renewable energy, water purification, agriculture, and substances recycling. It assesses the influences of nanotechnology on sustainable improvement. This consists of thinking about the capacity blessings of nanotechnology, in addition to the capacity dangers and demanding situations. Identify the elements in an effort to impact the destiny improvement and use of nanotechnology for sustainable improvement. This consists of thinking about the technological, economic, social, and environmental factors in shaping the future of nanotechnology.

In this study, the paper will use a scientific literature evaluation to perceive and examine the prevailing literature on the packages and influences of nanotechnology for sustainable improvement. The findings of these studies may be of interest to an extensive variety of stakeholders, which includes scientists, engineers, coverage makers, and businesses. The paper will assist to tell the destiny improvement and use of nanotechnology for sustainable improvement. Here are a few precise questions that the studies will cope with:

What are the most promising packages of nanotechnology for sustainable improvement?

What are the capacity blessings/ dangers and demanding situations of nanotechnology for sustainable improvement, and What elements will impact the destiny improvement and use of nanotechnology for sustainable improvement? The studies will finish with a dialogue of the findings and their implications for the destiny of nanotechnology for sustainable improvement.

Scope of the Study: The cognizance regions of the study at will consist of applications and impacts. The study will discover the capacity packages of nanotechnology in every of these sectors. This will consist of a dialogue of the benefits, risks, and demanding situations of every application. The study will check the capacity effects of nanotechnology on every sector. This will consist of a dialogue of the economic, social, and environmental effects of nanotechnology. The study will discover the elements in order to impact the destiny improvement and use of nanotechnology in every sector. This will consist of a dialogue of the technological, economic, social, and environmental elements in order to form the destiny of nanotechnology.

NANOTECHNOLOGY APPLICATIONS FOR SUSTAINABLE DEVELOPMENT

Energy Sector:

(a) Enhancing Solar Energy Conversion: Nanomaterials like carbon nanotubes, graphene, and nanowires can improve the efficiency and cost-effectiveness of solar cells in a number of ways.

Increased light absorption: Nanomaterials have a large surface area to volume ratio, which means that they can absorb more light than their bulk counterparts. This can lead to an increase in the efficiency of solar cells, as more light is converted into electricity.

(b) Reduced reflection: Nanomaterials can also be used to reduce the reflection of light from solar cells. This is because they can interact with light in different ways, such as scattering and trapping. This can lead to an increase in the amount of light that is absorbed by the solar cell, which can also improve efficiency.

(c) Improved charge transport: Nanomaterials can also be used to improve the charge transport in solar cells. This is because they can provide a pathway for electrons to move more easily through the solar cell. This can lead to an increase in the current that is generated by the solar cell, which can also improve efficiency.

(d) Reduced cost: Nanomaterials can also be used to reduce the cost of solar cells. This is because they can be used to replace expensive materials, such as silicon. They can also be used to simplify the manufacturing process, which can also lead to cost savings.

Here are some specific examples of how nanomaterials are being used to improve solar cells:

(a) Carbon nanotubes: New type of solar cells which are more efficient, and durable are being created by carbon nanotubes. For example, carbon nanotubes can be used to create a transparent conducting layer for solar cells. This layer allows light to pass through it while also conducting electricity, which is essential for the operation of a solar cell.
(b) Graphene: Graphene is a new material that is being investigated for use in solar cells. Graphene has a number of properties that make it ideal for solar cells, including its high conductivity and its ability to absorb light over a wide range of wavelengths.
(c) Nanowires: New type of solar cells which are more efficient, and flexible are being created by nanowires. Nanowires can be used to create a network of interconnected wires that can absorb light and convert it into electricity. This network of wires is more efficient than traditional solar cells, and it is also more flexible, which makes it suitable for use in wearable devices and other applications.

Advanced Battery Technologies: Nanomaterials possess such properties that make them ideal for use in batteries, including:
(a) Increased surface area: Nanoparticles have a much larger surface area than their bulk counterparts, which means that they can store more ions and react more quickly.
(b) Improved conductivity: Nanomaterials can be made to be highly conductive, which helps to speed up the flow of electrons and ions in batteries.
(c) Enhanced stability: Nanomaterials can be made to be more stable than their bulk counterparts, which can improve the longevity of batteries.

Some of the specific ways in which nanotechnology is being used to develop high-performance batteries include:
(a) Using nanomaterials as electrodes: Nanoparticles can be used to make electrodes that have a higher surface area and improved conductivity. This can lead to batteries with a higher energy density and longer lifespan.
(b) Using nanomaterials as electrolytes: Nano Electrolytes are electrolytes that have been made with nanomaterials. Nano electrolytes have a number of advantages over traditional electrolytes, including improved conductivity, stability, and safety.
(c) Using nanomaterials to coat electrodes: Nanoparticles can be used to coat electrodes. This can help to improve the performance of the electrodes by preventing the loss of active material and by reducing the growth of dendrites.

Here are some specific examples of how nanotechnology is being used to develop high-performance batteries:

(a) Metal oxides: Metal oxides are a class of materials that have a high capacity for storing lithium ions. Nanoparticles of metal oxides are being used to make electrodes for lithium-ion batteries.

(b) Ceramics: Ceramics are a class of materials that are highly stable and can withstand high temperatures. Nanoparticles of ceramics are being used to make electrolytes for lithium-ion batteries. The development of high-performance batteries with increased energy storage capacity and longevity is a major research goal in the field of nanotechnology. Nanotechnology has the potential to revolutionize the battery industry and make batteries more affordable, efficient, and sustainable.

Environmental Remediation:

Nanoparticles for Pollution Control: Nanoparticles have a large surface area to volume ratio, implying that they can interact with a lot of pollutants at once. They are also very reactive, which means they can break down pollutants into less harmful substances.
There are a number of ways that nanoparticles can be designed to capture pollutants from air and water sources. One common approach is to use nanoparticles that have a specific affinity for the pollutant of interest. For example, gold nanoparticles have been shown to be effective at capturing mercury from air, while carbon nanotubes can be used to remove arsenic from water.
Another approach is to use nanoparticles that have a porous structure. The pores in the nanoparticles can trap pollutants, and the nanoparticles can then be easily removed from the air or water. This approach is often used to remove organic pollutants from water.
Nanoparticles can also be used to catalyze the breakdown of pollutants. In this approach, the nanoparticles act as a catalyst to speed up the chemical reaction that breaks down the pollutant. This approach is often used to eliminate pollutants from air, like volatile organic compounds (VOCs).

Here are some specific examples of how nanoparticles are being used to capture pollutants from air and water sources:
(a) Gold nanoparticles have been shown to be effective at capturing mercury from air. Mercury is a highly hazardous metal capable of causing various health problems, including neurological damage. Gold nanoparticles have a high affinity for mercury, and they can be used to remove mercury from the air before it can be inhaled.
(b) Carbon nanotubes can be used to remove arsenic from water. Arsenic is a naturally occurring element that can be found in groundwater. It is a highly toxic metal that can cause cancer. Carbon nanotubes have a porous structure that can trap arsenic molecules. The carbon nanotubes can then be easily removed from the water, leaving behind clean water.
(c) Zeolites are a type of mineral that can be used to remove organic pollutants from water. Organic pollutants are a broad group of chemicals that can come from a variety of sources, including industrial wastewater, agricultural runoff, and sewage. Zeolites have a porous structure that can trap organic pollutants. The zeolites can then be easily removed from the water, leaving behind clean water.

Sustainable Water Treatment:
Nanofiltration membranes are a type of membrane filtration process that uses pressure to separate molecules based on their size. The membranes have pores that are typically 1 to 10 nanometers in diameter, which is smaller than the size of most organic molecules and some ions.

This allows nanofiltration membranes to remove a wide range of contaminants from water, including:
(a) Organic matter: This includes dissolved organic carbon (DOC), which can contribute to taste and odor problems in water.
(b) Inorganic ions: This includes ions such as calcium, magnesium, and sodium, which can cause water hardness.
(c) Micropollutants: These are small, man-made contaminants that can be harmful to human health.
(d) Nanofiltration membranes offer a number of advantages over other water treatment methods. They are more efficient than traditional methods such as distillation and reverse osmosis, which require high temperatures or pressures. Nanofiltration membranes are also more sustainable, as they use less energy and produce less waste.

Nanofiltration membranes are increasingly being used for a variety of water treatment applications, including:
(a) Drinking water: Nanofiltration membranes can be used to produce high-quality drinking water that is free of impurities and contaminants.
(b) Industrial water: Nanofiltration membranes can be utilized for producing high-quality water for industrial processes, like food processing and power generation.
(c) Wastewater treatment: Nanofiltration membranes can be used to treat wastewater and remove pollutants before the water is discharged back into the environment.

Nanotechnology in Agriculture:
Nanosensors are devices capable of detecting and measuring physical, chemical, or biological properties at the nanoscale. Nanosensors can be used to monitor a range of parameters in soil, including:
(a) Moisture: Nanosensors can be used to measure the moisture content of soil, which is important for determining irrigation needs.
(b) Nutrients: Nanosensors can be used to measure the nutrient levels in soil, like nitrogen, phosphorus, and potassium. This information can help in determining the need for fertilizer applications.
(c) pH: Nanosensors can be used to measure the pH of soil, which is important for plant growth.
Salinity:Nanosensors can be used to measure the salinity of soil, which can be harmful to plants.
Pollutants: Nanosensors can be used to measure the levels of pollutants in soil, such as heavy metals and pesticides.

Nanofertilizers are fertilizers that are made of nanoparticles. Nanoparticles have a large surface area, implying that they can release nutrients more slowly and efficiently than traditional fertilizers. This can help to reduce the amount of fertilizer that is needed, which can protect the environment. Nanofertilizers can also be targeted to specific plant cells, which can help to improve crop yields. For example, nanofertilizers that are targeted to root cells can help to improve plant water uptake, while nanofertilizers that are targeted to leaf cells can help to improve photosynthesis. The use of nanofertilizers can contribute to increasing crop yields and mitigating the environmental impact of agriculture and promote sustainable agricultural practices.

Healthcare Advancements

Targeted Drug Delivery Systems: Nanoparticles are a promising new technology for drug delivery. They can be directed towards specific cells in the body, which can improve the efficacy of treatment. There are a number of different ways to target nanoparticles to specific cells. One way is to use ligands, which are molecules that bind to receptors on the cell surface. For instance, nanoparticles can be covered with ligands that bind to receptors on cancer cells. This allows the nanoparticles to be delivered directly to the cancer cells, where they can release their payload of drugs. Another way to target nanoparticles is to use magnetic fields. Magnetic nanoparticles can be made to accumulate in specific areas of the body by applying a magnetic field. This can be used to deliver drugs to tumors or other diseased tissues.
Nanoparticles can also be used to improve the stability and solubility of drugs. This is important for drugs that are unstable in the body or that are difficult to dissolve. Nanoparticles can encapsulate drugs and protect them from degradation. They can also increase the solubility of drugs, which makes them easier to deliver to the body.
Here are some specific examples of how nanoparticles are being used in drug delivery:

Doxil is a nanoparticle-based drug that is used to treat cancer. Doxil is made of a polymer that encapsulates the drug doxorubicin. The polymer coating protects the doxorubicin from being degraded in the body, and it also helps to target the drug to cancer cells.
Abraxane is a nanoparticle-based drug that is used to treat breast cancer. Abraxane is made of a protein that encapsulates the drug paclitaxel. The protein coating helps to protect the paclitaxel from being degraded in the body, and it also helps to target the drug to cancer cells.
Iron oxide nanoparticles are being used to deliver drugs to the brain. These nanoparticles can be made to accumulate in the brain by applying a magnetic field. This allows drugs to be delivered directly to the brain, where they can be used for treatment of diseases like Alzheimer's disease and Parkinson's disease.

Advanced Diagnostic Tools: Nanosensors are devices that can detect specific molecules or particles at the nanoscale. This makes them ideal for detecting diseases at an early stage, when they are often easier to treat. There are a number of different ways that nanosensors can be used to detect diseases. One way is to use them to detect biomarkers, which are molecules that are present in the body at higher levels when a disease is present. For example, nanosensors can be used to detect cancer biomarkers, such as tumor-associated antigens (TAAs).
Nanosensors can be used to detect diseases to detect changes in the electrical or optical properties of cells. For example, nanosensors can be used to detect changes in the electrical properties of cells that are infected with viruses. Nanosensors can also be used to detect diseases by imaging cells or tissues. For example, nanosensors that are coated with fluorescent molecules can be used to image cells that are infected with bacteria.

ECONOMIC AND SOCIAL IMPACT

Increased Productivity and Lower Production Costs: Nanotechnology field is rapidly developing and has the potential to revolutionize many industries. One of the most promising areas of nanotechnology is the development of efficient nanotechnologies. These nanotechnologies can be used to improve the efficiency of many processes, leading to enhanced productivity and reduced production costs. There are a number of different ways that efficient nanotechnologies can lead to enhanced productivity and reduced production costs. For

example, nanotechnologies can be used for development of new materials that are stronger, lighter, and more durable. This can lead to improved efficiency in manufacturing and transportation. Create new catalysts that can speed up chemical reactions. This can lead to improved efficiency in the production of chemicals and other products. Develop new sensors that can detect defects in materials or products. This can lead to improved quality control and reduced waste. Design new drug delivery systems that can target drugs to specific cells. This can lead to improved efficacy of treatments and reduced side effects.

Job Creation and Employment Opportunities: The nanotechnology industry has the potential to create new job opportunities and stimulate employment in a number of ways. The development of new nanotechnologies will require a workforce with specialized skills. This will create new job opportunities for scientists, engineers, technicians, and other professionals. The use of nanotechnologies in existing industries will create new jobs in those industries. For example, the use of nanotechnologies in manufacturing could create new jobs in the production of nanoscale materials and devices. The development of new products and services based on nanotechnologies will create new job opportunities in the commercialization of these products and services. A 2015 report by the National Nanotechnology Initiative estimated that the nanotechnology industry could create around 2 million new jobs in the United States by 2025. The report also found that the nanotechnology industry could contribute up to $3 trillion to the U.S. economy by 2025.

Some of the specific job opportunities that are expected to be created by the nanotechnology industry include: (a) Scientists and engineers who develop new nanotechnologies, (b) Technicians who manufacture nanoscale materials and devices, (c) Sales and marketing professionals who sell nanotechnologies to businesses and consumers, (d) Regulatory professionals who ensure that nanotechnologies are safe and effective, and (e) Lawyers who help businesses protect their intellectual property in the nanotechnology space

Here are some specific examples of how the nanotechnology industry is already creating new job opportunities:

(a) Nanoparticles are utilized to create new sunscreens that are more effective at blocking UV rays. This has created new job opportunities for scientists, engineers, and technicians who are developing and manufacturing these sunscreens.

(b) Nanosensors are being used to detect diseases at an earlier stage. This has created new job opportunities for scientists, engineers, and technicians who are developing and manufacturing these nanosensors.

(c) Nanocatalysts are being used to speed up chemical reactions. This has created new job opportunities for scientists, engineers, and technicians who are developing and manufacturing these nanocatalysts.

Social and Ethical Implications: Nanotechnology field is rapidly developing and has the potential to revolutionize many industries including healthcare industry. However, there are a number of social and ethical concerns related to nanotechnology, such as potential healthcare disparities and the need for equitable access to advanced treatments. One of the main concerns is that the benefits of nanotechnology will not be evenly distributed. This is because nanotechnology is a very expensive field, and it is likely that only the wealthy will be able to afford the most advanced treatments. This could lead to increase in wealth disparity and provoke social unrest. Another concern is that nanotechnology could be used to create new weapons or to enhance the capabilities of existing weapons. This could lead to an arms race, and it could also increase the risk of terrorism. It is also crucial to consider the environmental effect of nanotechnology. Nanoparticles can be very small, and they can easily enter the

environment. If the nanoparticles are not properly disposed of, it could have a negative effect on the environment.

ENVIRONMENTAL IMPACT

Potential Release of Toxic Substances: Due to their small size, they have unique properties which can be used in medicine, electronics, and manufacturing. However, there are also concerns about the potential environmental consequences associated with the production and disposal of nanomaterials. One of the main concerns is that nanomaterials could be emitted into the environment during their production or disposal, which could happen through air emissions, water discharges, or solid waste disposal. Once nanomaterials are released into the environment, they could potentially have a number of negative impacts, including: Pollution of air, water, and soil. Nanomaterials could pollute the air, water, and soil. This could lead to harm to human health and the environment.
Toxicity to organisms. Nanomaterials could be toxic to organisms. This could include plants, animals, and humans. Bioaccumulation. Nanomaterials could bioaccumulate in organisms. This means that they could build up in the bodies of organisms over time, which could lead to health problems. Genotoxicity. Nanomaterials could be genotoxic. This means that they could damage DNA, which could lead to cancer or other health problems. There are several ways that can be adopted to minimize the environmental impact of nanomaterials such as using nanomaterials in ways which involve minimal emission into the environment. For example, nanomaterials could be used in closed systems to prevent their release into the air or water.
Developing new methods for the disposal of nanomaterials that minimize their environmental impact. For example, nanomaterials could be incinerated or buried in landfills in ways that prevent their release into the environment. Educating the public about the potential environmental risks of nanomaterials. This will help ensure that individuals have awareness of the risks and can take measures to reduce their exposure.

Long-Term Environmental Consequences: there are also concerns about the potential environmental consequences of nanomaterials, including the accumulation of nanoparticles in soil and water systems. Nanoparticles can enter the environment through a variety of pathways, including:
(a) Production and use: Nanoparticles can be released into the environment during the production and use of nano-enabled products. For example, nanoparticles can be released into the air during the manufacturing of sunscreens or into the water during the use of laundry detergents that contain nanoparticles.

(b) Waste disposal: Nanoparticles can also be released into the environment through waste disposal. For example, nanoparticles can be released into the air when tires are burned or into the water when electronic waste is disposed of in landfills.
Natural sources: Nanoparticles can also be naturally occurring. For example, some plants produce nanoparticles as part of their defense mechanisms.

(c) Once nanoparticles enter the environment, they can accumulate in soil and water systems. This is because nanoparticles are very small and can easily be transported by water and air currents. The accumulation of nanoparticles in soil and water systems can have a number of potential long-term impacts on ecosystems and human health.

For ecosystems, the accumulation of nanoparticles can hange the composition of soil and water. Nanoparticles can change the composition of soil and water by altering the nutrient balance and the availability of oxygen. This can adversely affect the growth and survival of plants and animals. Interfere with the activities of microorganisms. Nanoparticles can interfere with the activities of microorgancisms, which are essential for the decomposition of organic matter and the cycling of nutrients. This can have a negative impact on the overall health of the ecosystem. For human health, the accumulation of nanoparticles can cause toxicity. Nanoparticles can be toxic to humans, depending on their size, shape, and composition. For example, some nanoparticles have been shown to cause cancer in animals. Interfere with biological processes- Nanoparticles can interfere with biological processes, such as cell growth and reproduction. This can result in various health issues such as cancer, reproductive problems, and neurological disorders.

CONCLUSION

Benefits of Nanotechnology for Sustainable Development:
Nanotechnology has the potential to address a wide range of sustainability challenges across various sectors, including:
(a) Energy: Nanotechnology can be used for development of new energy sources, such as solar cells and fuel cells and for improvement of the efficiency of existing energy sources, such as by making light bulbs more efficient or by developing new ways to extract oil and gas from the ground.
(b) Water: Nanotechnology can be used to develop new water purification technologies, such as filters that can remove pollutants from water. It can also be used to develop new ways to desalinate seawater, which could help to address the growing problem of water scarcity.
(c) Materials: Nanotechnology can be used to develop new materials which are stronger, lighter, and more durable. These materials could be in construction, transportation, and electronics.
(d) Healthcare: Nanotechnology can be used for development of new drugs, diagnostics, and medical devices. For instance, nanoparticles can be used to deliver drugs directly to target cells, which could improve the efficacy of treatments and reduce side effects.

(e) Agriculture: Nanotechnology can be used for development of new fertilizers, pesticides, and herbicides that are both more effective and environmentally safer. It can innovate methods for monitoring crop health and developing drought-resistant crops.
These are just examples of the potential benefits of nanotechnology in addressing sustainability challenges. As research progresses, we anticipate discovering even more applications of nanotechnology in the future.

Addressing Concerns and Promoting Responsible Use: Nanotechnology field is rapidly developing field and has the potential to revolutionize many industries. However, there are a number of ethical, regulatory, and environmental concerns which require attention to ensure the responsible and sustainable implementation of nanotechnology.

Ethical concerns: Some of the ethical concerns associated with nanotechnology include:
(a) The potential for discrimination: Nanotechnology could be used to create new forms of discrimination, such as by targeting specific groups of people with nano-enabled products or services.

(b) The potential for unintended consequences: Nanotechnology is a complex field with the possibility of unintended consequences associated with its use. For example, nanoparticles could be toxic to humans or the environment, or they could interfere with biological processes.
(c) The potential for misuse: Nanotechnology could be misused for harmful purposes, such as by creating new weapons or by developing new ways to exploit people.
(d) Regulatory concerns: There are currently no international regulations governing the development and use of nanotechnology. This means that there is a lot of uncertainty about how nanotechnology will be regulated in the future. It is important to develop clear and comprehensive regulations for nanotechnology to ensure that it is used safely and responsibly.

Environmental concerns: Nanoparticles can be very small, and they can easily enter the environment. This means that there is a risk that nanoparticles could pollute the air, water, and soil. It is important to develop methods for preventing the release of nanoparticles into the environment and for cleaning up any spills or releases that do occur. Some specific things that can be done to address these concerns:

a) Develop clear and comprehensive regulations for nanotechnology: This will help to ensure that nanotechnology is used safely and responsibly.
b) Fund research into the potential risks and benefits of nanotechnology: This will ensure better understanding of the potential impacts of nanotechnology and will aid in development of ways to eliminate any risks.
c) Educate the public about nanotechnology: This will ensure better understanding amongst the people as regards the potential benefits and risks of nanotechnology and to make informed decisions about its use. By taking these measures, we ensure that nanotechnology is used for good and that it does not pose a risk to humans or the environment.

Future Research and Development Needs: Nanotechnology field is rapidly developing and has the potential to revolutionize many industries. Here are some specific examples of how continued research could help to improve the safety and sustainability of nanotechnology: Research into the toxicity of nanoparticles could help us to develop methods for preventing exposure to nanoparticles and for treating people who have been exposed to nanoparticles. Research into the long-term effects of nanotechnology could help us to identify any potential risks associated with the use of nanotechnology and to develop ways to mitigate those risks. Research into the environmental impact of nanotechnology could help us to develop methods for preventing the release of nanoparticles into the environment and for cleaning up any spills or releases that do occur. Research into the ethical implications of nanotechnology could help us to establish ethical guidelines for the advancement and utilization of nanotechnology.

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Harmful effect of Plastics in marine life: A review

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ABSTRACT

Plastics have been reported as detrimental, particularly in relation to aquatic life forms. Aquatic species such as turtles, fishes, aquatic mammals like sea lions, dolphins, sharks and seabirds can become entangled in plastic debris, leading to injuries, suffocation, or death. Corals can be damaged when plastic debris becomes entangled and smother them, hindering their growth and reproductive capabilities. Fishing gear, plastic bags, and six-pack rings are common culprits. Marine organisms could not distinguish between floating plastic and food and thereby mistakenly eat plastic waste. Ingested plastic cause harm to internal organs that may result in nutrient deficiencies, clogging of blood vessels and reduced feeding capacity. It has been found that plastic matter less than five-millimeter dimensions, are commonly found in aquatic environments which can be consumed by aquatic species, comprising plankton, sea mammals, fishes, and seabirds. The effect of microplastic ingestion in aquatic animals as well as planktons over a prolonged period have the potential to impact reproductive capabilities, growth rates, and overall health of marine organisms. This problem affects species at various levels of the food chain. For instance, small fish may consume microplastics, which can then be passed on to larger predatory fish, and ultimately affect human health through seafood consumption. Plastics generally contain hazardous chemicals which are added at the time of processing, such as chemicals used to enhance flexibility, mechanical strength, durability and anti-flaming properties. These chemicals lead to toxic effects for marine animals and plants. When marine organisms ingest plastic, these chemicals discharge into their cells and lead to adverse health issues. The accumulation of toxins through the food chain, known as bioaccumulation, can have severe consequences for higher-level predators. Addressing the issue of plastics in marine life requires collective efforts from individuals, communities, governments, and industries. Reduction of plastic waste through recycling, waste management infrastructure improvement, promotion of sustainable initiatives and use of biodegradable plastics are essential for minimizing the harmful impact of plastics on marine ecosystem. The pathways by which plastics enter aquatic ecosystem and detrimental effects of plastics and microplastics on marine life from various reports have been reviewed in this paper to raise consciousness about the impact of plastics and microplastics.

INTRODUCTION

Marine life is massively affected by our intensive use of plastic.[1-4] The dreadful and fatal impact of plastics in marine ecosystems have been extensively documented and studied.[5-8] Plastics can cause physical harm to marine life. Sharp edges or fragments of plastic can lacerate or puncture organs, leading to infections and impaired swimming or mobility. Plastics contribute to the degradation of marine habitats. When large amounts of plastic waste accumulate in ocean bed, they can smother and suffocate communities like coral reefs and seafloor organisms.[9] This

disrupts the delicate balance of ecosystems and reduces biodiversity.[10]
Despite several cleaning drives by the governmental as well as non-governmental organizations and environmental laws restricting the discharge of plastic matter in water bodies, huge amount of plastic material is still discharged in the ocean every single day.[11-14] Extremely slow biodegradation of plastics make them stay in the water bodies for centuries.[15-17] Even the first plastic made by man is still present on this earth.[18-21] The production of plastics has seen an exponential rise and worldwide approximately 400 million metric tonnes of plastics had been produced in the year 2021.[22,23] And the production increases by 4% every year.[24-26] The amount of plastic waste accumulating on Earth is beyond imagination. And most of it is hidden in the depths of the ocean where it is wreaking havoc on aquatic life.[27-29]

Over eight million tons of plastic reach into ocean annually,[30,31] which under environmental impact disintegrates into extremely small, microscopic pieces regarded as microplastics. These microplastics having dimensions less than five millimetres, are very harmful for the aquatic species especially they enter in their internal organs. Reports show that these microplastics are omnipresent. Owing to their small size, they can travel throughout the expanse of the globe with winds and waves. It is reported in the recent literature that microplastics are present in the Arctic[32] and Antarctic regions. Presence of microplastics in the digestive system of gentoo penguins, in Antarctic region, have resulted in less consumption of food, thus affecting their growth and development.[33] These microplastics are formed by disintegration of large plastic materials or can be intentionally manufactured for use in cosmetics, cleaning agents, and industrial applications.[34] Further disintegration of micro-plastics leads to the formation of nano-plastics which have dimensions less than 100 nanometres. Due to small size of nano-plastics, they can easily enter the cellular membranes and disrupt the functioning of normal body tissues.[35]
Plastic waste in water bodies gets converted into microplastics and nanoplastics over hundreds of years by environmental weathering. These tiny plastic particles have high active lipophilic surface which can adhere heavy metals, toxic organic compounds and other pollutants, collectively known as persistent bio-accumulative toxic chemicals (PBTs) or persistent organic pollutants (POPs), from surrounding areas. Thus, these particles become the carriers of pollutants. At the same time, hazardous chemicals added at the time of processing of plastics leach out into the environment as toxic substances like lead, cadmium, zinc etc.[36] These microplastics when ingested by marine species hinder their physiological functions and sometimes lead to fatal consequences. Moreover, when such species are consumed by their predators, harmful pollutants get transferred to higher organisms/trophic levels. Thus, eventually the entire ecosystem gets distressed.[37-40]
The consumption of microplastics by the primary consumers is gradually being passed through the food chain to secondary consumers and the time is not far when it will ultimately get back to humans. There have been reports verifying the existence of microplastics in human placenta[41] and bioaccumulation of microplastics in various trophic levels.[42] The plastic itself is not the cause of concern but it is the toxic substances, the additives mixed during the production and harmful contaminants sorbed onto these plastic particles that cause serious consequences.[43]

Despite several environmental regulations, awareness programmes, recycling units and clean-up campaigns, plastic production is increasing rapidly and so is plastic waste. This detailed study covers the hazardous effect of plastic waste in the aquatic systems which have its alarming consequences.[44-48]

Pathways through which plastics enter water bodies

Plastics can enter water bodies through various pathways, contributing to the growing issues of plastic contamination. Incautiously discarding plastic waste contributes to the plastic contamination in water bodies. Absence of proper waste management infrastructure in under-developed regions of the world is a major cause of plastic contamination in oceans. Small scale industries and local authorities dump garbage in uncontrolled landfills. Mountains of plastics in these open dumps can be blown away and very often run into waterways. Due to extreme poverty waterways are the only option to transfer the garbage away from populated areas.[49] But this means that the garbage would be carried out into the oceans. At present, the low-income countries are carrying the burden of getting rid of the plastic waste while the richer countries pay these already overwhelmed countries, like Ghana and the Philippines, to accept garbage from the west.[50,51] This is creating a situation where the majority of plastic enter the ocean from just a few countries. So even though developed countries have advanced garbage collection systems, much of this garbage is simply shipped in third world countries to be dumped.[52] Plastics which are improperly managed can reach rivers, lakes, and finally reach oceans. Here we discuss three significant pathways, i.e., 1) Industrial effluents and sewage treatment plants; 2) Overflows as well as leachates from landfills and 3) Careless littering, which leads to around 80-85% of plastic waste in the ocean.

Industrial effluents and sewage treatment plants

Industrial waste has a huge impact on the oceans. The marine ecosystem is worst affected due to discharge from industrial waste. Industrial waste often contains toxic chemicals, heavy metals, and pollutants which pollute groundwater, lakes, rivers and other water bodies. When effluent is released, these contaminants can discharge into the water, rendering it unsafe for human consumption and detrimental to aquatic life. The release of industrial waste into water bodies can cause significant ecological damage. The toxic substances can harm aquatic plants, animals, and microorganisms, leading to population declines, biodiversity loss, and disruption of delicate ecosystems.[53] It can also result in the degradation of habitats critical for various species.[54] The bioaccumulation of hazardous metals like lead, mercury and copper also affects marine life.[55]

Industrial processes and activities also contribute to the discharge of plastic waste into aquatic systems. Manufacturing processes, like plastic production, can generate plastic pellets or nurdles that can be lost during transportation or handling and end up in waterways.[56] Similarly, industries that use plastic materials extensively, like fishing nets used by fishing industry, water pipes and nylon net cages in aquaculture, and discarded fishing gears in maritime sectors, can add to plastic pollution through the accidental loss or improper disposal of plastic items.[57] The use of microplastics in the manufacture of cosmetic products like microgranules in facial scrubs, toothpaste and also in textile industry like in clothing can pollute aquatic environments via drainage systems.[58,59] In addition, synthetic cloth industry generates microfibres during washing and sewage treatment.[60]

Preventing and mitigating the effects of industrial waste discharge requires strict regulations, effective waste management practices, and responsible industrial practices. Governments and regulatory bodies play a crucial role in enforcing environmental standards and monitoring industrial activities. Industries themselves need to prioritize sustainable practices, implement effective waste treatment and containment measures, and invest in cleaner technologies to minimize the risk of effluent water and reduce the environmental impact of their operations.

Landfills

While landfills are a common method of waste disposal, they have several harmful effects on the environment and water bodies. Open unmanaged landfills, with no physical barriers to control the flow of plastic carried by wind, flooding, runoff or stray animals, have the potential to carry plastic waste through waterways and eventually into the oceans. Additionally, landfills can release harmful chemicals and leachate, a liquid that forms as waste breaks down and percolates through the landfill.[61] Leachate contains pollutants that can seep into groundwater, potentially contaminating water sources. Leachate from landfills can infiltrate the soil and contaminate groundwater, affecting quality of local water which poses risk to ecological and human health. The pollutants present in leachate can include microplastics, heavy metals, organic compounds and toxic chemicals. Reports confirm that the amount of microplastics in leachate is 0.42−24.58 items per litre in Southern China[62] and 0−4.51 items per litre in Nordic countries.[63]

Plastics thrown into landfills and garbage dumps don't actually stay there forever. Over time, photodecomposition and environmental degradation of plastic debris in landfills break them down into microplastics. Thus, landfills are potential sources of microplastics leaching into groundwater.[64] Besides microplastics, chemical additives such as BPA, PBDEs, phthalates used during the synthesis of plastics have also been found in leachates. These chemicals are endocrine disruptors and therefore exhibit toxic effects when released in groundwater.[65]

Efforts are being made to minimize the ill effects of landfills through improved waste management strategies. Emphasizing on reducing and recycling initiatives can minimize the quantity of waste entering landfills, that decreases the impact on environment. Implementing appropriate engineering measures for collecting leachate and installation of liners, can help minimize water and soil pollution. Regular monitoring and maintenance of landfills are essential to ensure compliance with environmental regulations. Landfill gas, predominantly methane, can be collected and used as a renewable source of energy. This will reduce the emission of harmful green-house gases which are otherwise produced as by product in burning of fossil fuels.[66] Encouraging the use of alternative waste management methods, like waste-to-energy incineration or anaerobic digestion, can help divert waste from landfills and reduce their environmental impact.

Littering

Littering is an act of incautiously throwing waste in public places like beaches, parks, streets, lakes and rivers instead of throwing them in designated bins. Littering has numerous negative consequences for the environment, public health and marine life. Litter, particularly non-biodegradable items like plastics, can stay in the environment for hundreds of years. It can pollute natural habitats, including forests, rivers, and oceans, affecting wildlife and ecosystems. Litter may appear as food to animals that can be ingested or cause external injury leading to suffocation or sometimes death. Hazardous chemicals may also leach out from the litter and flows into water and soil, further contributing to environmental degradation. Due to lack of proper waste disposal infrastructure and inadequate public garbage bins, as well as incognizant attitude of the society, littering of plastic waste has become a serious concern to marine life.[67] Plastic items and debris on the ground, such as packaging materials, plastic bags, and bottles, can be carried by rainwater and wind into storm drains and water bodies.[68]Stormwater runoff is a major pathway for plastics to enter rivers, streams, and ultimately the ocean.[69] Plastic waste

can be generated from coastal activities such as tourism, beachgoers, and recreational boating. Marine vessels, including cargo ships, fishing boats, and cruise ships, can also be a cause of plastic pollution through the discharge of waste, including plastic items and fishing gear, directly into the ocean.

Packaging is the largest market for plastic that includes items like food containers, cling films, beverage bottles, poly bags and much more. All these items are largely seen littered in drains, streets, tourist's places, water bodies and dumping sites and thus is largest source of plastic pollution. The volume of plastic items entering in oceans is evident from the growing dimensions of garbage patches in the ocean.[70] It is estimated that single use plastics (SUPs) are responsible for 60-95% of world's marine plastic pollution.[71] It is unfortunate to know that we are choosing to make something that will be used just once from the material that lasts forever. Low production cost, durability and other unique properties have probably made plastics the material of choice for decades. However, increasing plastic pollution and its harmful consequences are forcing us to reconsider our choice and take measures to combat the global plastic problem.

Besides creating unsanitary conditions, litter places a financial burden on communities. Local governments and municipalities must allocate resources for litter clean-up, waste management, and infrastructure maintenance. Littering reflects an irresponsible human behaviour towards the environment due to lack of awareness about its detrimental consequences. Promoting awareness drives about systematic waste disposal and highlighting negative impacts of littering through educational programs, advertising, and community engagement can help change behaviour. Providing sufficient and conveniently located waste bins, recycling facilities, and appropriate disposal options can encourage responsible waste disposal and reduce the likelihood of littering. Enforcing anti-littering laws and imposing fines or penalties for littering can act as a deterrent and encourage compliance with proper waste disposal practices. Encouraging community participation in clean-up initiatives, organizing litter-free campaigns, and fostering a sense of ownership and pride in public spaces can help reduce littering and create a cleaner environment. Engaging non-governmental organizations, government bodies, business communities, resident welfare associations and individuals, is crucial to developing comprehensive strategies and implementing effective solutions to combat littering.

FACTORS AFFECTING SURGE OF MICROPLASTICS IN THE ENVIRONMENT

The surge of microplastics in the environment is influenced by various factors. Understanding these factors is crucial for assessing and managing microplastic pollution. The consumption and production of plastics all over the world have increased significantly in recent years resulting in generation of huge amount of plastic waste. This further increases the probability for microplastics to reach various ecosystems. The abundance of microplastics is associated with the amount of plastic waste generated and the inadequate management of this waste. Large plastic items, like bags, pet bottles and packaging materials, can disintegrate with time due to weathering processes like UV radiation, mechanical stress, and wave action. This disintegration phenomenon generates micro-plastics and nano-plastics. The abundance of microplastics can thus be associated with the presence and disintegration of macro size plastic debris. Improper disposal and inadequate waste management practices significantly contribute to microplastic pollution. Areas where waste management systems are inadequate or inefficient, more plastic waste tends to reach the environment, including water bodies. Inadequate recycling and high rates of littering add to the problem. Regions with high population density and urbanization have witnessed a surge of microplastics because of greater

consumption of plastics, waste generation, and lack of waste management. Urban runoff and stormwater systems can transport microplastics from urban areas into nearby water bodies. Microplastic abundance can vary depending on the proximity to pollution sources. For example, areas near industrial facilities, wastewater treatment plants, shipping routes, or coastal tourism activities may experience higher levels of microplastic pollution due to direct inputs or transport from these sources.[72] Environmental conditions can also influence the abundance of microplastics. Wind and water currents can carry microplastics to distant areas, distributing them across different regions. Local hydrodynamics, tides, and river systems can affect the accumulation and dispersal of microplastics in specific areas. Different types of plastics have varying degrees of durability, weathering resistance, and propensity to fragment into microplastics. Plastics, like polypropylene and polyethylene are more prone to fragmentation and may contribute to a higher abundance of microplastics compared to other plastics.[73]

INHERENT TOXICITY OF MICROPLASTICS AND ADSORBED HARMFUL SUBSTANCES

Knowing how plastics are made will make this discussion easier to understand. The raw material for plastics comes from crude oil which is rich in carbon compounds. Simple as well as more complex carbon compounds are used as monomeric units for building polymer chains using chemical processes. The molecular weights of the polymers depend upon degree of polymerization. The chain length can be controlled by controlling the number of monomeric units linked together in the chain. For example, low density polyethylene may contain as many as 1500 monomeric units with a molecular weight of less than 50 kg/mol while high density polyethylene may contain 2000 - 12000 monomeric units with molecular weight of 200 kg/mol. Thus, the structure as well as composition of polymers varies greatly.

To make plastics with desired properties, these polymers are mixed with different additives such as colorants, stabilizers, fillers, plasticizers, etc. It is these additives that make plastics more harmful to aquatic species. When plastic is consumed by the species, these harmful chemicals can leach out inside their bodies and cause disorders.[74-78] Through the food chain, these additives travel to higher hierarchical levels in an ecosystem and thus lead to biomagnification.[79]

Huge amount of harmful organic chemicals like condensed aromatic hydrocarbons, organohalogenated pesticides, hexachlorocyclohexane and chlorinated benzene including heavy metals, accumulate on the lipophilic surface of microplastics and result in local concentration of these chemicals on a smaller surface making them more toxic.[80] These persistent bioaccumulative toxic chemicals (PBTs) such as polybrominated diphenylethers, polychlorinated biphenyls (PCB), bisphenol A, plasticisers (phthalates) etc. mimic hormones leading to endocrine disruption and reproduction disorders in aquatic species.[81] It is reported that South China Sea's coral reef fish has been significantly affected by microplastics combined with pollutants like polycyclic aromatic hydrocarbons (PAHs).[82] Bioaccumulation of flame-retardant chemicals like polybrominated diphenyl ethers have been reported in crickets due to polyurethane foam ingestion. Crickets may therefore be regarded as the carriers of polybrominated diphenylethers from consumer products to terrestrial food webs.[83] C.M. Rochman et al.[84] demonstrated that medaka fish when subjected to adsorbed contaminants over microplastics including PAHs, PCBs and polybrominated diphenylethers exhibited hepatic stress and altered endocrine function. Consumption of PBTs adsorbed on microplastics by marine species leads to biomagnification of these chemicals in aquatic food chains.[85,86] Effects

of exposure to contaminants such as per-fluoro octane sulfonic acid and benzo[a]pyrene adsorbed on low-density polyethylene exhibited mechanical injury to the gills of Scrobiculaplana in the papery furrow shell clam.[87] The ingestion of microplastics adsorbed with per-fluoro octane sulfonic acid and benzo[a]pyrene also showed a negative effect on the biomarkers estimated in the tissue of S.Plana. Thus, plastics act as carriers of hazardous substances to fish and other marine species.

Besides their chemical composition and sorbed contaminants, the shape of plastic particles can also control the extent of toxicity. It is reported that microfibers of plastics cause severe intestinal toxicity in comparison to microplastic in the form of beads and fragments in zebrafish.[88]

IMPACT OF PLASTICS/MICROPLASTICS ON AQUATIC SPECIES

Plastics and microplastics have been shown to have toxic effects on fish and other aquatic life, interfering with their physiological functions like low food intake, oxidative damage, slow development and abnormal behaviour. In our study we will discuss three aspects of interference of plastics and microplastics with aquatic life, 1) Swallowing and Entanglement of plastics, 2) Ill-effects of the chemical additives that leach from plastics and 3) Detrimental effects of adsorbed harmful chemicals.

Swallowing and Entanglement

Many aquatic species, ranging from small zooplankton to large marine mammals, mistakenly ingest plastics and microplastics. These particles can resemble food items, such as plankton or small fish, and are often consumed as a result. Physical damage of the digestive tract can be caused by sharp or rigid plastic fragments, which lead to wounds, lacerations, or obstructions. This can result in internal injuries, impaired digestion, and even death. Ingesting plastics causes a fallacious feeling of being satisfactorily fed in animals, leading them to take less nutritious food. This can result in malnutrition and reduced fitness, affecting growth, reproduction, and overall health. Plastics can contain additives and pollutants, such as flame retardants, persistent organic pollutants and plasticizers. When ingested, such toxic chemicals may leach into the cells or tissues of aquatic species, causing to life-long health issues, including hormonal disruptions, reproductive problems, and impaired immune function.[89-93]

Plastics, particularly larger objects like packaging materials, lines and fishing nets present a consequential entanglement threat to aquatic species. Entangled animals may suffer from severe injuries due to constrictions, abrasions, or lacerations caused by the entangling material. These injuries can lead to infections, reduced mobility, or even amputations, ultimately impacting the survival and well-being of the affected species. Entangled animals may experience restricted movement or impaired swimming capabilities, making them more vulnerable to predation and hindering their ability to search for food. This can lead to reduced foraging success, weight loss, and diminished energy reserves. Entanglement can cause significant stress and distress to aquatic species, disrupting their natural behaviours and causing prolonged suffering. Stress-related health issues can weaken individuals and increase their susceptibility to disease and other environmental pressures.[94-98] Younger seals, who are unaware and curious towards plastic objects frequently become targets of entanglement.[99] It is also reported that entanglement causes amputation of limbs in marine turtles.[100]

The animals often mistake plastic for food or swallow it while swimming or feeding. A detailed report confirmed that several hundreds of aquatic species including fish, sea mammals, turtles

and seabirds have ingested plastic.[101] This raises an alarm to control the plastic waste entering oceans else the number will continuously increase. Once consumed, plastic can tear or clog their intestines or block the passage of food through their bodies. When plastics or microplastics are ingested by marine species, their stomach feels full and they lose their appetite, leading to starvation or death. It has been reported that a sperm whale was found dead on a beach in Scotland and the cause of its death was found to be several hundred pounds of litter inside its body.[102]

Of more serious concern is the extent to which plastics and these tiny microplastics and nanoplastics have spread through the food web. It is reported that micro-plastics and nano-plastics have entered various organs in fish like gills, muscles and liver.[103] Consumption of nano-polystyrene particles by fish via aquatic food chain cause crucial impact on their metabolic parameters like cholesterol to serum triglyceride ratio, muscle cholesterol content, liver cholesterol content and body weight.[104] Consumption of micro-polystyrene beads by veligers of Crepidula onyx led to retarded growth rates. It was experimentally established that the larvae of Crepidula onyx was stagnated at smaller size when fed with micro-polystyrene in comparison to the larvae that were not fed by micro-polystyrene.[105] Nano-sized polystyrene particles also decrease viability of algae cell and concentration of chlorophyll.[106]

Additives Leaching

There are various ingredients like flame retardants, plasticizers, colorants, incorporated in the plastics during manufacturing process to enhance their properties. When plastics are ingested by aquatic species, there is a potential for the leaching of additives from the plastic particles. The by-products of plastic manufacturing create ill-effects to species who consume microplastics or plastic products.[107]

There is physical bond (and not chemical bond) between plastic and ingredients in the polymer products. When plastics come in contact with water, especially under certain climatic conditions like rise in temperature, exposure of sunlight, or acidic conditions, these ingredients can migrate from plastic and leach into the surrounding environment. The leached additives from plastics can be toxic to aquatic organisms. Different additives can have different toxicological properties, and their effects can vary depending on the concentration, duration of exposure, and sensitivity of the species involved. Some ingredients have been associated with endocrine disruption, neurotoxicity, reproductive issues, and immune system impairment in aquatic organisms.

When additives leach into the water, they can be consumed by aquatic organisms through various routes, including ingestion, respiration, and absorption across the skin or gills. These additives accumulate in the cells of organisms over time by the process known as bioaccumulation. As predators consume smaller organisms containing additives, the concentration of these substances can increase at higher trophic levels, posing a greater risk to top predators. The prolonged effects of additive leaching on aquatic flora and fauna are still to be evaluated. However, it is known that chronic exposure to certain additives can lead to physiological and reproductive abnormalities, impaired growth and development, reduced fertility, and compromised immune function. These effects directly influence the dynamics of population and health of the ecosystem.

To mitigate the leaching of additives from plastics and its impact on aquatic ecosystems, it is imperative to address the root cause of contamination by reducing plastic waste and promoting the use of more sustainable materials.[108] Additionally, stricter regulations on the utilization of harmful ingredients in plastic production and proper waste management practices can help

minimize the contact of aquatic flora and fauna to these potentially harmful chemicals.[109-113]

Adsorption of harmful chemicals

Plastics, including microplastics, are prone to adsorb harmful organic materials from the surroundings. The adsorption process occurs when toxic substances available in the water, like heavy metals, POPs and hydrophobic organic compounds, stick to the surface of plastic fragments. Plastic fragments have a large surface area which make them attractive surfaces for the adsorption and the hydrophobic nature of plastics makes them attract hydrophobic organic chemicals.[80] The chemical compounds adhere to the plastic surface due to inter-particle attractions, like Van der Waals forces. The adherence capacity of plastics relies on several factors, including the nature of plastic, contact duration, concentration of the organic contaminants in the surroundings and the surface properties.[114] POPs are non-biodegradable and toxic chemicals that stay in the environment for long periods.[86] Certain pesticides, PCBs and PAHs are examples of a few POPs. Plastics, especially microplastics, can act as a reservoir for POPs, effectively concentrating and transporting these chemicals in marine ecosystems. Adsorption of POPs onto plastics can increase their bioavailability and potential toxicity when ingested by aquatic organisms. Plastics can also adsorb heavy metals, like mercury, lead, copper and cadmium from water. Such toxic heavy metals may leach into aquatic environments from industrial activities, urban runoff, and other sources.[115] When plastics adsorb heavy metals, they can become carriers of these toxic substances, potentially increasing their bioaccumulation in aquatic organisms upon ingestion. The adsorption of harmful chemicals onto plastics can have several ecological implications. When aquatic organisms ingest plastic particles, they can also ingest the adsorbed toxic compounds, which may lead to adverse health effects, including reproductive disorders, developmental abnormalities, and impaired immune function. Additionally, the ingestion of plastic particles with adsorbed chemicals can facilitate the transfer of these toxic substances up the food web, leading to contamination in higher trophic levels, including fish, aquatic mammals and even human beings through seafood consumption.[116]

MICROPLASTICS IN FOOD WEB

Microplastics and nano-plastics have been found in various components of food chain, from producers to higher levels in food chain hierarchy, including humans.[117]Microplastics that enter aquatic ecosystems, through various pathways, can be consumed by a broad range of marine organisms, comprising shellfish, plankton, fish and aquatic mammals. Planktonic organisms, such as copepods, krill and zooplanktons, which are at the base of ocean's food web can inadvertently swallow microplastics while feeding on suspended particles in the water.[118] Additionally, filter-feeding organisms like mussels,[119] oysters,[120] and clams[121] can accumulate microplastics through the water column while filtering large amount of water for food. Microplastics can be carried through the food chain as organisms consume other organisms containing microplastics. For example, small fish that consume plankton containing microplastics can be preyed upon by larger fish, leading to the transfer of microplastics up the food web. As larger predators continue to consume smaller ones, this process potentially results in the accumulation of microplastics in top predators. Microplastics can accumulate in the cells, tissues and organs of varied species throughout the food web. They can be found in the digestive tracts, gills, and various organs of marine animals.[122]Microplastics have been found in the bellies and intestines of fish, shellfish, and marine mammals, and can even relocate to other organs, like liver or the muscle tissues.

Humans may also be affected by microplastics by consuming contaminated seafood. Seafood, such as fish and shellfish, store microplastics in their body tissues, and when consumed by humans, they can potentially introduce microplastics into the human body. Microplastics are reported in various human food items, like seafood, salt, honey, potable water, and some air-borne particles.[123] The potential consequences of microplastics on organisms and health of human beings are still being studied.

THREATS POSED TO HUMAN HEALTH

Microplastics are a potential threat to human life and health, although the full extent of these risks is still being studied. Entry of microplastics into the human body through ingestion is primarily by the intake of polluted food and beverages. Microplastics have been discovered in many food items, for example in seafood, salt and even bottled water. While the exact health effects of ingesting microplastics have not been fully comprehended, there are concerns about their potential to deposit in the alimentary canal and potentially induce physical or chemical harm. Microplastics can also be absorbed through the skin, although the extent of dermal absorption is still a topic of research.[124] Certain cosmetics and beauty products containing microbeads, such as exfoliating scrubs, can introduce microplastics directly onto the skin. Microplastics are the carriers for chemicals and additives that are associated with their manufacturing or present in the immediate environment such as heavy metals, organic pollutants and other toxic substances. These chemicals have the potential to leach out from microplastics and be released into the body upon ingestion or absorption. The long-term exposure to such chemicals through microplastics could pose health risks, including endocrine disruption, developmental issues, and other adverse effects.

Microplastics can trigger inflammatory responses in the body. Studies have shown that when microplastics interact with immune cells or tissues, they can induce an immune response, leading to the release of inflammatory mediators.[125] Prolonged or chronic inflammation is associated with various health problems, such as cardiovascular diseases, autoimmune disorders, allergies and asthma. Microplastics in the environment can provide lipophilic surfaces for the microorganisms, including potentially harmful bacteria to form a colony. This microbial colonization on microplastics could increase the risk of infections if contaminated microplastics are ingested or come into contact with open wounds. It's important to note that while microplastics are present in various environmental sources and have been detected in the human body, the present scientific knowledge about the health risks related to microplastics are still evolving. Further research is required to better comprehend the potential health impacts, including the mechanistic aspects of toxicity, the dose-response relationship and the effects of prolonged exposure to microplastics. To mitigate potential risks to human health, it is imperative to work towards the root cause of microplastic pollution such as reduction in plastic waste, better management of waste, promotion of sustainable substitutes, and implementation of stricter laws on the manufacture and use of plastics.

SUGGESTED WAYS TO MITIGATE POTENTIAL HAZARDS OF MICROPLASTICS IN MARINE ENVIRONMENT

Mitigating the probable hazards of micro-plastics in the aquatic environment requires a multi-dimensional approach that involves various stakeholders, encompassing individuals,

governments and industries. Reduce plastic consumption: Reducing overall plastic consumption is crucial for minimizing the generation of waste plastic and, consequently, its release into the aquatic environment. Individuals can make a difference by adopting habits like using reusable plastic items such as bottles, containers and bags, and opting for less plastic packaged products. Governments and businesses can play a role by implementing policies that promote alternatives to one-time use plastics and encouraging sustainable consumption and manufacturing practices. Proper management of waste is essential for preventing plastic waste to enter the aquatic environment. Implementing effective waste collection systems, recycling infrastructure, and waste disposal facilities can help reduce plastic leakage into water bodies. Governments should prioritize investments in waste management infrastructure and promote recycling initiatives.

Encouraging the recycling of plastics can help reduce the demand for virgin plastic production. Governments and industries should invest in recycling technologies and facilities to increase plastic recycling rates. Additionally, transitioning towards a circular economy model, where plastics are designed for recyclability and multiple lifecycles, can help minimize plastic waste and the associated risks of microplastic pollution. Investing in research and development of eco-friendly materials and alternatives to plastics can help reduce the production and accumulation of microplastics. This includes exploring biodegradable or compostable materials that have less effect on the human health and environment.[126]Governments can support innovation and provide incentives for the development and adoption of sustainable materials. Increasing public awareness about the consequences of microplastic pollution is crucial for driving behavioural change. Education campaigns can inform individuals about the ill-effects of microplastics on the marine ecosystem as well as on humans. These campaigns can also promote responsible utilization of plastic products and proper management of plastic waste. Environmental organizations, schools, and governments can collaborate to raise awareness through outreach programs, workshops, and educational materials.

Upgrading wastewater treatment plants can help capture microplastics and prevent their discharge into oceans, seas and lakes. Advanced treatment equipment, such as membrane filtration and activated carbon filters, can be effective in removing microplastics from wastewater.[127] Implementing and enforcing stricter regulations on industrial wastewater discharge can also help minimize microplastic inputs into the environment. Continued research and monitoring are crucial for understanding the sources, pathways of distribution, and ill-effects of microplastics. International organizations, research institutions and governments should support scientific studies to evaluate the intensity of microplastics pollution, its ecological effects, and probable human health risks. This knowledge can inform policy decisions and guide effective mitigation strategies. Combating microplastic pollution requires a collaborative effort from all sectors of society. By taking proactive measures to promote sustainable choices, technologically advanced waste management practices and reduction in plastic consumption, it is possible to mitigate the potential hazards of microplastics in aquatic environment.

CONCLUSION

The steady surge in plastic pollution in aquatic ecosystems is now attracting serious attention as cases are being reported of harmful effects of plastic toxicity to marine life at all the trophic levels of aquatic food web. Of greater concern are micro-plastics and nano-plastics that result from the disintegration of larger plastic particles in water bodies due to environmental degradation. The tendency of micro- and nano-plastics to attract toxic pollutant particles makes

them even more dangerous to aquatic species that perceive them as food. Plastic waste causes physical harm to various species such as sea turtles, oysters, mussels, plankton, fishes, penguins, whales, dolphins, etc. It also destroys the natural habitat of these species.

Statistics show that if current rates of plastic production are followed, four times more plastic than today will be produced by the middle of the 21st century, creating a pandemic of microplastics. Although many reports attest to the harmful effects of micro-plastics, nano-plastics are little documented because these particles are even smaller and require more sophisticated techniques to detect. The potential damage caused by these nano-plastics to the food web is yet to be explored in depth. Also, the adverse effects of micro and nano-plastics on human health are still in their initial stages and research is needed in this direction to control its impact at an early stage.

Plastic pollution from aquatic ecosystems cannot be addressed without appropriate environmental monitoring and database collection at regional and national levels. Financial incentives to promote the use of bioplastic can be an advantageous alternative.[108,128]Better analysis of the composition, sources and distribution of marine litter is necessary. Regulatory steps are strongly advocated to prevent and reduce environmental damage of microplastics as well as the potential environmental consequences of microplastics.

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Analysing India's Nuclear Progress as an alternative Source of Energy: from Nehru to Modi

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ABSTRACT

Energy is the buzzword for the development of any nation. At present, around 60-% energy demand of India is met by thermal power plants leading towards polluted air and water. The realization of the impact is not recent. The fathers of modern India envisaged the need for alternative sources of energy. In this regard, nuclear power was seen as a reliable source. Pandit Jawaharlal Nehru, Vikram Sarabhai, Homi Jahangir Bhabha, Former PM Indira Gandhi, Former PM Atal B. Vajpayee, and Former PM Dr Manmohan Singh are the pioneers who have worked tirelessly to enhance India's nuclear capacity despite international pressure. However, the expectations are not yet met due to socio-economic and political circumstances. The paper explores the process of developing nuclear power as a substitute energy source since independence and highlights the journey with foreign policy scenarios developed in the process. The paper cites various civil society agitations for setting up nuclear power plants. Another aspect with which the paper deals is that dwelling upon the nuclear waste management issues and radiations around the surrounding regions. Nuclear power can be both a boon or bane depending upon the caution. There have been several disasters such as Chernobyl whose aftermaths are realised to date. The paper dwells into the scope and challenges for nuclear energy in India and how far the country has reached in realising its potential.

KEYWORDS: Energy, Nuclear, Foreign policy, Power, Sustainable

INTRODUCTION

It has been 75 years since India gained Independence. India has today grown economically, militarily and in various fields which include Space technology, nuclear power capability, etc. Along with all these developments taking place, what also grew was India’s energy demand, owing to the rapid growth in population, industrialization and urbanization.

However, this growth in the energy demand was foreseen by our scientists as well as the political leadership soon after we got independence. One important aspect of fulfilling this energy demand is nuclear energy. Though nuclear energy at the time of Independence was not an option for satisfying the immediate energy demand as India lacked resources as well as technical capabilities, a long-term plan was put in place to develop nuclear energy. This is known as the “Three-stage nuclear program” given by Dr Homi Jehangir Bhabha. The program forms the basis of India’s program for nuclear energy.

This paper seeks to understand and analyze India’s historical progress in the development of nuclear energy. The paper focuses on how different government played their role in developing India’s indigenous program for nuclear energy. The paper seeks to analyze the prospects and challenges in the implementation of the program.

HISTORICAL OVERVIEW: NEHRU TO MODI

India was a young nation, not even one year has passed since its independence but the visionaries already had a plan in mind. On 26th April 1948, Dr Homi Jahangir Bhabha gave a note entitled 'Organization of atomic research in India' to then PM Pt. Jawahar Lal Nehru. It asked that the development should take place in an organized manner. The Atomic Energy Commission of India (AEC) was established on August 10, 1948.

The first mention of atomic energy officially in a policy in independent India came in the Industrial Policy Resolution, 1948 where it was mentioned as the exclusive monopoly of the central government.

Dr Homi Bhabha is considered the father of the nuclear program in India. He established Atomic Energy Establishment, Trombay (AEET) in January 1954 and it was named Bhabha Atomic research centre when he died in 1966.

Later that year, a "Conference on the Development of Atomic Energy for Peaceful Purposes on India" was organized on 26th November 1954 in the presence of India's first PM Pt. Jawaharlal Nehru. He gave the opening speech where he started by reiterating the 1948 stance that the development of atomic energy shall be the exclusive responsibility of the state. Being a visionary, he emphasized the importance of power that power is the basis of the modern Industrial Revolution. At this conference, Dr Homi Jehangir Bhabha gave the three-stage nuclear plan for the first time. (National Archives of India)

The three-stage nuclear program:

Dr Homi Bhabha was the chief architect of India's three-stage nuclear program. This India-specific plan was made on the basis of what indigenous resources are available and how to harness their maximum potential. India has limited Uranium reserves while at the same, time it has rich Thorium deposits. This gives Thorium a prominent position in the program and utilisation of the country's abundant Thorium reserves becomes its long-term objective. (Parekh 2014)

Table I:

Stage	Reactor	Fuel	Progress
First	Pressurized Heavy Water Reactors (PWHR)	Indigenous Natural Uranium	Commercial Stage
Second	Fast Breeder Reactors (FBRs)	Plutonium–239 (a by-product from PHWRs)	Technology demonstration stage
Third	Advanced nuclear power systems	Thorium	Technology Development stage

The First Stage: The Pressurised Heavy Water Reactors (PHWR) are fuelled with natural uranium. In the process, electricity is generated as the product while Plutonium-239 is a by-product. (Bucher 2009)

The Second Stage: The second stage aims to breed uranium-233 (U-233) and more plutonium-239 for the 2nd and 3rd-stage reactors, as well as generating electricity to fulfil India's energy needs. Furthermore, after there is a sizable stockpile of plutonium-239, thorium will be used in the reactor to produce uranium-233. This uranium is necessary for the third stage. (Bucher

2009)
The Third Stage: Stage 3 aims to create thorium-uranium 233-based fuel cycle systems that make use of India's substantial thorium stocks to achieve a sustainable nuclear fuel cycle and offer long-term energy security through atomic power. (Bucher 2009)
This three-stage nuclear program was formally adopted by the Government of India in 1958.

Asia's first research reactor to achieve criticality: APSARA & beyond
In the meanwhile, APSARA, an indigenous research reactor became the first research reactor in Asia to reach criticality, when it did so on August 4, 1956. As per the definition given by the Nuclear Energy Agency, Criticality in the context of a nuclear reactor occurs when the rate of neutron production from fission reactions balances out with losses due to leakage or absorption, resulting in a stable number of neutrons generated. The development of the 40 MW research reactor CIRUS that reached initial criticality in July 1960, came next. It was built with Canada's assistance under Dr. Bhabha's leadership. (BARC)
In 1962, India came up with THE ATOMIC ENERGY ACT, 1962 which put in place more stringent rules including Regulation of the extraction or enrichment of materials containing uranium, power to the Government to obtain information, entry and inspection etc.

India's first Atomic Power Stations: BWR - TAPS 1,2; PHWR – RAPS 1,2 and beyond
India's first Atomic power station came up in Boisar, Maharashtra is known as Tarapur Atomic Power Station (TAPS 1,2). These were BWR. Though, as discussed in the Three-stage program above that Pressurised Heavy water reactors (PHWR) remain central to India's nuclear program, The choice of a BWR as its first plant was made as part of a carefully devised strategy to obtain nuclear technology, build up the workforce, and foster a nuclear culture. International General Electric (IGE) of the US was given the contract to construct these units in 1964. Both of them started commercial operations in October 1969. (Bohra and Sharma, 2006)
The first Pressurised Heavy Water Reactors came up in Kota, Rajasthan (RAPS 1,2). The development of these two units was a joint endeavour with Atomic Energy of Canada Limited. Canada provided India with technical assistance as well as critical components. These reactors contained rigid safeguards so that the possibility of application of these reactors for a military program could be ruled out. In the building of RAPS 1, an indigenisation rate of roughly 55% was attained, increasing to nearly 75% for RAPS 2. (Bohra and Sharma, 2006)
In the meanwhile, the work to set up two other units of PHWR was taken up in Kalpakkam, Tamil Nadu known as Madras Atomic Power Stations (MAPS 1,2). This marked a significant step towards indigenisation as India bore the sole responsibility for the design, engineering and construction of these atomic power stations.

NPT, Pokhran 1, CTBT and Pokhran 2: Impact on the Nuclear Energy Program
In 1968, India was under tremendous pressure to join the NPT which stated that no country other than the 5 Nuclear weapon states (who had acquired nuclear weapons by then) will ever acquire atomic weapons. As part of the accord, nuclear weapon states agreed to share civil nuclear technology. India saw this as discriminatory and refused to sign the treaty. As of today, 190 countries are signatories of the NPT while India has not signed the treaty.
In May 1974, PM Indira Gandhi led the mission which undertook an explosion of a nuclear device, labelling it as a Peaceful nuclear explosion, code name - Smiling Buddha (Pokhran 1). This rocked the entire non-proliferation regime. The plutonium utilised in the detonation was produced in the CIRUS reactor supplied by Canada, using heavy water provided by the United States. Consequently, both countries responded strongly. Canada ceased its nuclear energy

assistance for two heavy water reactors then being built, citing a breach of their 1971 agreement. The US, however after a brief interruption, determined that the test did not contravene any agreements. The United States proceeded with the delivery of enriched uranium intended for the Tarapur reactor in June 1974. (O'Mahoney 2020)

In reaction to India's test, the Nuclear Suppliers Group (NSG) was established in 1974, initially referred to as 'The London Club'.

The "Comprehensive Test Ban Treaty" (CTBT) was adopted by UNGA in 1996. (Mistry 1998) This time again India faced significant international pressure to ratify the treaty, however, it continued to refuse, India in its statement expressed its firm resolve that we would "never sign this unequal Treaty, not now, nor later."

In less than 2 years of the adoption of CTBT in UNGA, in May 1998, India conducted nuclear weapon tests at Pokhran under the leadership of PM Atal Bihari Vajpayee. US imposed sanctions on India that included economic sanctions, pressurising India to sign NPT, CTBT etc. and also pressurising India and Pakistan to improve their relations and resolve the Kashmir Issue. US sanctions were replied to by a hard-line Indian stance with India claiming itself a nuclear weapon state and hence no negotiation can take place on NPT without accepting India's nuclear status. However, just after the Pokhran 2 nuclear tests, India changed its stance on CTBT and showed a willingness to sign. Moreover, the Indian Prime Minister stated in his 1999 address to the UN General Assembly that India was ready to see the CTBT negotiations through to a successful conclusion. (Pant 2002)

Rounds of Indo-US negotiation started. There were eight rounds of talk in eight months which included the waiver of economic sanctions after the third round of negotiation in 1998 itself. An intense diplomatic engagement continued thereafter. (Pant 2002)

On July 18, 2005, a joint statement was released by Indian PM Manmohan Singh and US President George W. Bush. This landmark declaration was significant because the United States acknowledged India as a country with advanced nuclear technology and committed to comprehensive civil nuclear energy cooperation. In return, India agreed, among other things, to distinguish between its civilian and military nuclear facilities and voluntarily place them under the safeguards of the International Atomic Energy Agency (IAEA). (Bano, 2015)

IAEA Safeguards, NSG Waiver and a Series of Civil Nuclear Cooperation Agreements

Following the July 2005 statement, India in May 2006 tabled a separation plan for Civil and Nuclear facilities in the parliament and communicated the same to IAEA (International Atomic Energy Agency). India did not satisfy the conditions of the US Atomic Energy Act; India was still a country outside the NPT. Therefore, to sign a Nuclear Cooperation Agreement with India US on its part had to enact the 'India Peaceful Atomic Energy Act' (H.R. 5682) in December 2006 to provide a waiver to India. (Grover 2016)

In August 2008, an agreement with the IAEA about the India-specific safeguards was approved by the Governors of the IAEA. This allowed for the NSG to provide a waiver to India which came in September 2008. India had already conducted negotiations for a Nuclear Cooperation Agreement (NCA) with the USA, France, and Russia. On September 30, 2008, an NCA was signed with France. On October 10, 2008, with the USA and on December 5, 2008, with Russia. This marked a significant step towards India's civil nuclear cooperation. (Grover 2016)

Barack Obama, the then President of the United States, declared the US support for membership of India to the NSG during a state visit to India in November 2010.

Civil Liability for Nuclear Damage act of 2010

However, the cooperation faced a challenge with the UPA government enacting the act in 2010.

The section 17(b) of the Act became a matter of controversy. The section held that after compensating for nuclear damage as per Section 6, the operator of the nuclear installation should have the right to seek recourse if the nuclear incident was caused by the actions of a supplier or their employee, including the provision of defective equipment or materials, or sub-standard services. The suppliers claimed that such a provision is not in line with international conventions in effect that assign sole liability to the operator. (Sengupta and Ambast, 2012)
It was further asserted that this provision is directly opposed to Article 10 of the annexe to the Convention on Supplementary Compensation for Nuclear Damage (CSC), an international treaty that India has signed.

RECENT PROGRESS

India's nuclear energy program has seen more continuity than change as far as domestic politics is concerned. The impact of geo-political, geo-strategic and geo-economic factors has been more profound. Since 2014, PM Narendra Modi-led NDA government has pursued the goal of joining the Nuclear Suppliers Group (NSG). The joint statements during the state visits of PM Modi have a long list of countries that have extended support for India's entry to NSG. India submitted the formal application in 2016 to join the NSG. The NDA government has also led to a series of Nuclear Cooperation Agreements for peaceful uses with Bangladesh, Sri Lanka, Japan, the United Kingdom, Australia etc. Among these, the agreement with Japan is significant in two aspects. Firstly, Japan has a hard-line stance on nuclear non-proliferation, Japan signing an agreement with India showcases the trust in India's peaceful nuclear program. Secondly, Japan is the manufacturer of several key components of Western nuclear reactors. The agreement with Bangladesh becomes significant as it fulfils India's objective of becoming a supplier. (ORF 2019)

PROSPECTS OF NUCLEAR ENERGY IN INDIA

India presently operates 22 nuclear reactors with a combined operational capacity of 6,780 MW, constituting only 1.6% of India's total capacity of 411 Gigawatts.

The 12th five-year plan (2012-17) called for 63 GW of total installed capacity of nuclear energy by 2031. However, the government stated in March 2018 that its 63 GW target for nuclear capacity will not be met and that by the year 2031, The total nuclear capacity is estimated to be approximately 22.5 (GW).
In March 2022, Minister of State, Dr Jitendra Singh reiterated that India will reach a total nuclear energy generating capacity of 22.5 GW by 2031. He added that this aid in achieving the Prime Minister's announcement at UNFCCC's COP26 in Glasgow, UK that by 2030, India aims to achieve a non-fossil energy capacity of 500 gigawatts (GW) and intends to fulfil 50% of its energy needs from renewable sources. (PIB, 2022).
This means that India is going to increase its nuclear energy generating capacity to almost three times in a span of fewer than 10 years.
On 18th Feb 2023, Union Minister of State Dr Jitendra Singh said that the 1st plant in North India is coming up in Haryana in the town of Gorakhpur, which is located roughly 150 km north of the capital city of New Delhi. (PIB 2023)
The long-term ambitious target of the Government of India is to achieve 25% of total energy generation through nuclear by the year 2050. This also becomes important as India needs to fulfil another important announcement by PM Modi at COP 26 that India will become Net a zero emitter by 2070.

Nuclear Power Plants under commercial operation in India

The Indian nuclear power sector has seen significant growth since the commissioning of its first reactors in the late 1960s. Tarapur Atomic Power Plant-1 (TAPS-1) and Tarapur Atomic Power Plant-2 (TAPS-2), both located in Boisar, Maharashtra, commenced operation in October 1969 with 160 MWe each, utilizing Boiling Water Reactor (BWR) technology. These were among the pioneering nuclear facilities in the country, setting the stage for subsequent developments. (AERB, 2023)

Rajasthan emerged as another key location with the Rajasthan Atomic Power Plant-1 (RAPS-1) commencing operations in December 1973 in Kota, Rajasthan, utilizing 100 MWe Pressurized Heavy Water Reactor (PHWR) technology. It was followed by Rajasthan Atomic Power Plant-2 (RAPS-2) in April 1981, generating 200 MWe, further solidifying Rajasthan's position in India's nuclear power landscape. Moving southwards, the Madras Atomic Power Plant-1 (MAPS-1) and Madras Atomic Power Plant-2 (MAPS-2) started operations in January 1984 and March 1986, respectively, in Kalpakkam, Tamil Nadu, each with a capacity of 220 MWe using PHWR technology. Similarly, the Narora Atomic Power Plant-1 (NAPS-1) and Narora Atomic Power Plant-2 (NAPS-2) began operations in January 1991 and July 1992 in Narora, Uttar Pradesh, each generating 220 MWe with PHWR technology. (AERB, 2023)

The Kakrapar Atomic Power Plant-1 (KAPS-1) and Kakrapar Atomic Power Plant-2 (KAPS-2), located in Tapi, Gujarat, commenced operations in May 1993 and September 1995, respectively, contributing another 220 MWe each through PHWR technology. In Karnataka, the Kaiga Generating Station-1 (KGS-1) and Kaiga Generating Station-2 (KGS-2) started operations in November 2000 and March 2000, generating 220 MWe each using PHWR technology, followed by additional units in subsequent years. Expansion continued with Tarapur Atomic Power Plant-3 (TAPS-3) and Tarapur Atomic Power Plant-4 (TAPS-4) in Boisar, Maharashtra, starting operations in August 2006 and September 2005, respectively, each with a capacity of 540 MWe using PHWR technology. Rajasthan Atomic Power Plant-3 (RAPS-3) and Rajasthan Atomic Power Plant-4 (RAPS-4) in Kota, Rajasthan, began operations in June 2000 and December 2000, adding 220 MWe each with PHWR technology. (AERB, 2023)

The most recent additions include the Kudankulam Nuclear Power Station-1 (KKNPS-1) and Kudankulam Nuclear Power Station-2 (KKNPS-2) in Kudankulam, Tamil Nadu, starting operations in December 2014 and March 2017, each generating 1000 MWe using Pressurized Water Reactor (PWR) technology. These facilities mark India's entry into larger capacity reactors, enhancing its nuclear power generation capabilities significantly. (AERB, 2023)

Nuclear Power Plant Projects under development

The landscape of India's nuclear power sector is poised for expansion with several significant projects at various stages of development across different regions. The Kakrapar Atomic Power Project (KAPP) in Gujarat, for instance, includes KAPP-3, a 700 MWe Pressurized Heavy Water Reactor (PHWR) unit that has been commissioned, contributing to the country's nuclear energy grid. KAPP-4, also a 700 MWe PHWR unit, is currently under construction, enhancing the capacity of the Kakrapar site to meet future energy demands. In Haryana, the Gorakhpur

Haryana Anu Vidyut Pariyojna (GHAVP) is progressing with GHAVP-1 and GHAVP-2, both 700 MWe PHWR units currently under construction. Additionally, GHAVP-3 and GHAVP-4 are in the siting stage, indicating further expansion plans at this location to augment nuclear power generation in northern India. In Rajasthan, the Rajasthan Atomic Power Project (RAPP) at Rawatbhata is advancing with RAPP-7 and RAPP-8, both 700 MWe PHWR units currently under construction. These projects aim to bolster the state's nuclear energy infrastructure, ensuring reliable electricity supply to the region. Moving southwards to Karnataka, the Kaiga Atomic Power Project (KAIGA) has proposed KAIGA-5 and KAIGA-6, both 700 MWe PHWR units in the siting stage, highlighting the state's strategic role in India's nuclear power development efforts. In Tamil Nadu, the Kudankulam Nuclear Power Project (KKNPP) continues to expand with the construction of KKNPP-3, KKNPP-4, KKNPP-5, and KKNPP-6, each featuring 1000 MWe Pressurized Water Reactors (PWR). These additions underscore Tamil Nadu's growing importance as a hub for nuclear power generation in southern India. (AERB, 2023)

Additionally, the Prototype Fast Breeder Reactor (PFBR) in Kalpakkam, Tamil Nadu, with a capacity of 500 MWe, has been successfully commissioned, marking a significant milestone in India's pursuit of advanced nuclear technologies. (AERB, 2023)

Overall, these projects represent India's ambitious plans to diversify and expand its nuclear energy capacity, contributing to the nation's energy security and sustainable development goals.

Table II Installed capacity (in mw) of power stations in India

	Capacity (MW)	Percentage
Total Fossil Fuel	236468.911	57.40%
Renewable Energy sources (including Hydro)	168400	40.90%
Nuclear	6780	1.60%
Total Installed Capacity	411649	100%

Source: Central Electricity Authority. Installed Capacity Report. January 2023

Table III Comparison with the world

	COUNTRY	% Nuclear of total electricity generated
1	France	69
2	Ukraine	55
3	Slovakia	52.3
4	Belgium	50.8
5	Hungary	46.8
6	Slovenia	36.9

7	Czech Republic	36.6
8	Bulgaria	34.6
9	Finland	32.8
10	Sweden	30.8
11	Switzerland	28.8
12	South Korea	28
13	Armenia	25.3
14	Spain	20.8
15	Russia	20

Source: Nuclear Energy Institute

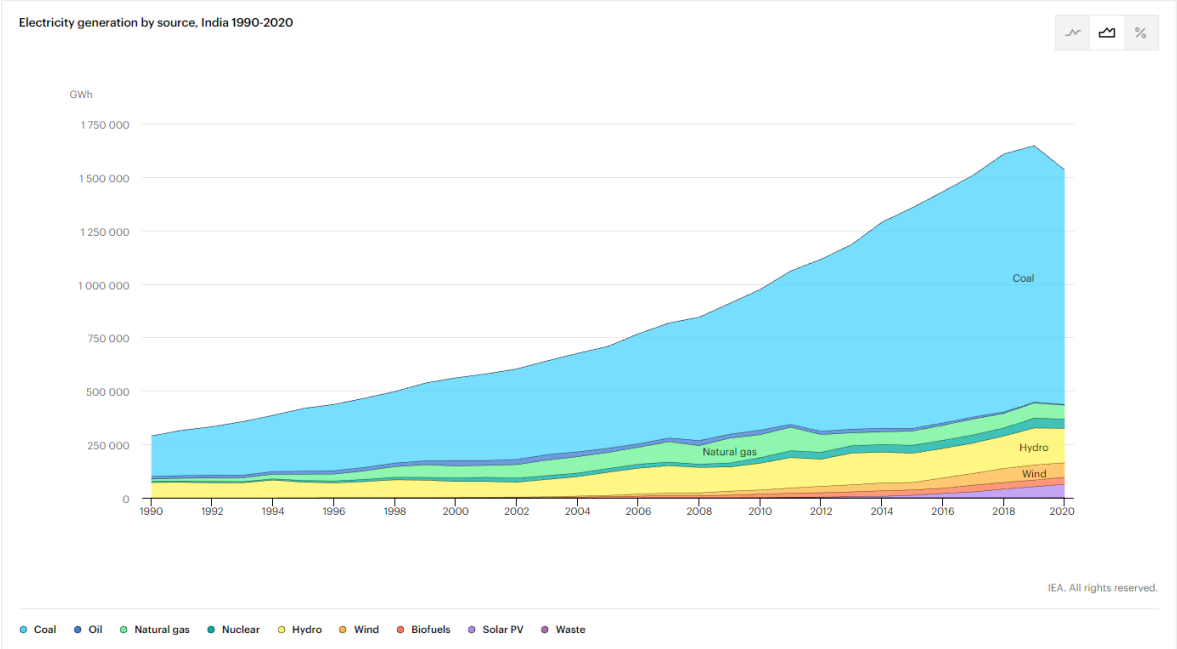

Fig 1. India: Generation of electricity as per source
Source: International Energy Agency (IEA)

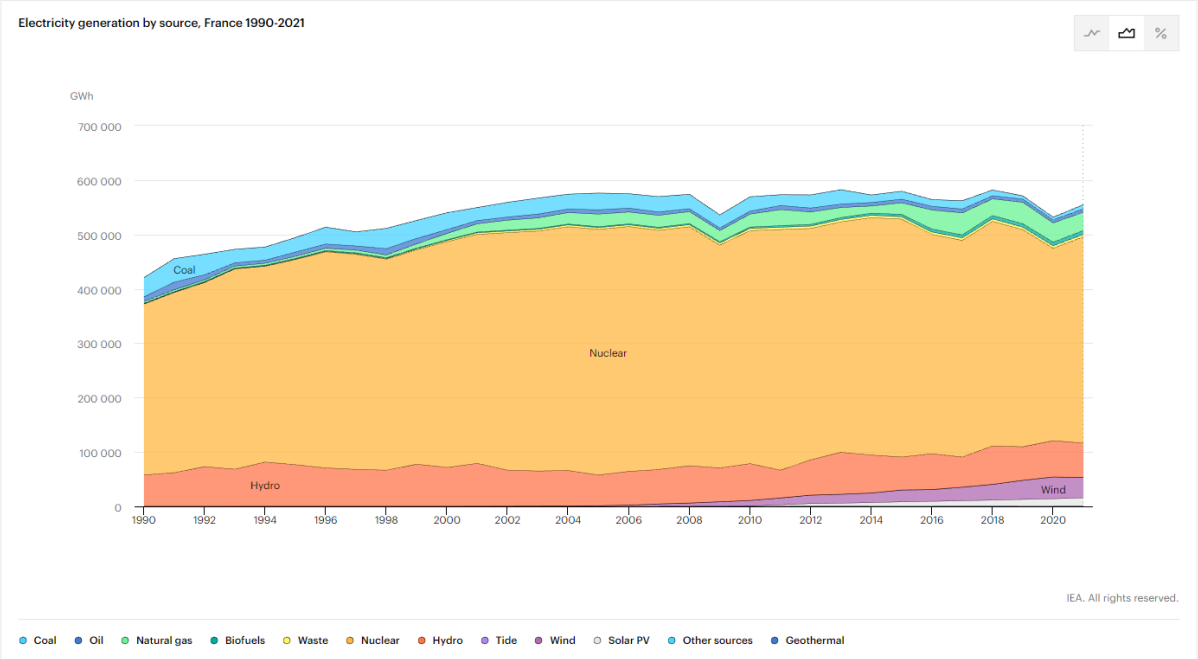

Fig 2. France: Generation of electricity as per source
Source: International Energy Agency (IEA)

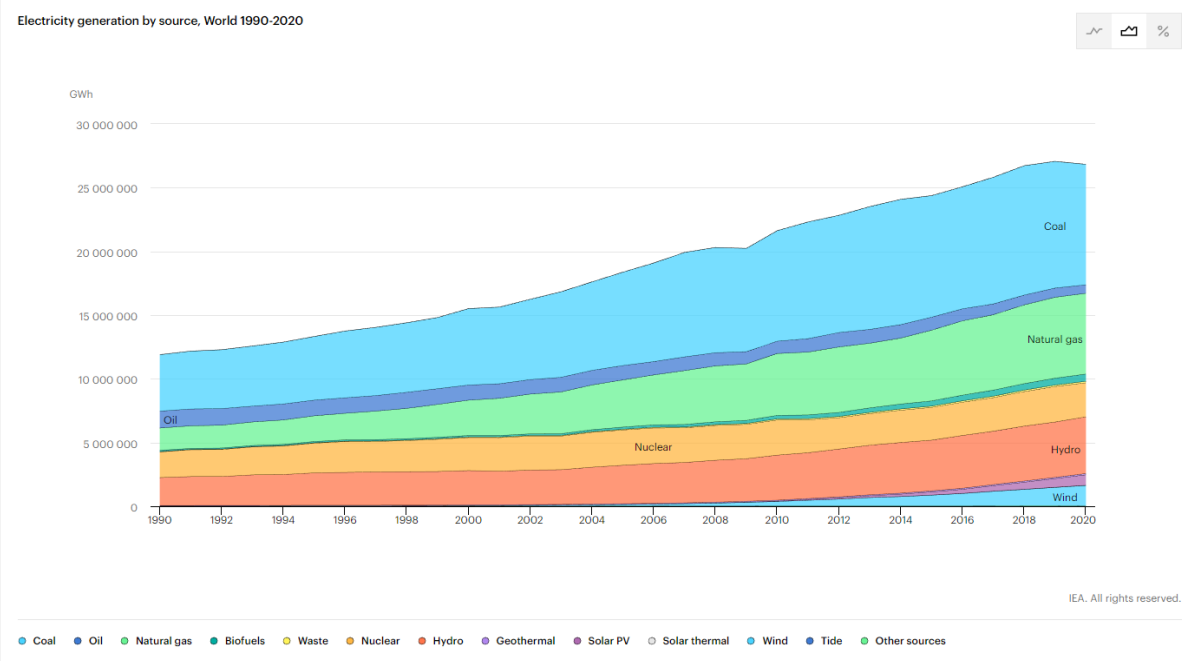

Fig 3. World: Generation of electricity as per source
Source: International Energy Agency (IEA)

CHALLENGES TO INDIA'S NUCLEAR ENERGY PROGRAM

The program faced the issue of a lack of technological assistance, fuel and components for nearly 30 years of its nuclear program. The reason for this was India's nuclear tests in 1974 and its reluctance to sign NPT. However, things improved in the 21st century with a landmark Nuclear Cooperation Agreement with the United States in 2008. However, that does not end

the challenges India faces in implementing its nuclear program.

Land Acquisition

A large land area is required for the setting up of such a plant. The Atomic Energy Regulatory Board (AERB) code establishes that there must be an exclusion zone—a region with any human habitation is prohibited within a radius of 1.5 km. This increases the required area of land. The acquisition of land is not easy in India and at times faces protests from civil societies and the public. There are primarily two reasons for this. First is the fear of nuclear waste leading to radiation in nearby areas. Secondly, fair compensation for the acquired land becomes a bone of contention.

Nuclear Waste Management

Waste management facilities have been successfully and safely running for around 6 decades at several nuclear installation locations. India has extensive and best-in-class experience managing nuclear waste from power plants, fuel reprocessing, and related equipment. India's nuclear waste management system is comparable to best International Practices. However, the fear of radiation persists leading to protests by public. (Prasad and Bansal, 2006)

Fuel requirements

India has rich reserves of Thorium that would last hundreds of years. However, the use of Thorium is a long-term plan and will come into the picture in the third stage. (Vijayan et al, 2017) As of now, India's nuclear program is heavily dependent on Uranium and as discussed above India has limited Uranium. Hence, its fuel requirements are met by importing Uranium. However, with a series of Nuclear Cooperation Agreements taking place in the past 15 years, the challenge of fuel requirement can be easily dealt with.

Resources: Human and Financial

To scale up India's nuclear power program, it is required to have a skilled workforce in nuclear technologies. At the same time developing and operating power plants is a costly affair, hence, the funding of the nuclear program also poses a challenge.

Protests Hampering the pace of the nuclear program

As discussed above, land acquisition and concerns regarding the waste management of radio-active materials remain a matter of concern for the general public. This has led to various protests in the past. One prominent example is the PMANE group, it is founded by S P Udayakumar. The group aims to the permanent shutdown of the Kudankulam Nuclear Power Plant site. Around 1,000 anti-nuclear protestors attempted to march towards the plant on September 10, 2012. The police had to use tear gas shells to disperse the protestors.

CONCLUSION

Despite India's Nuclear program starting in the late 1950s, the progress is yet to meet the expectations of the potential that India offers. This potential comes from various factors. First, India is blessed with one of the largest reserves of nuclear fuel of the future i.e., Thorium. Second, India's strategic relationship with the US has improved by leaps and bounds in the 21st century which can cater to Indo-US civil nuclear cooperation. Though the expectations are not met as of now, with the projects under development, India's nuclear program is now ready to take off.

At the UNFCCC's COP 26, in Glasgow, UK, Prime Minister Narendra Modi declared that India would cut its carbon emissions by one billion tonnes by 2030. He also declared that by 2070, India will have net zero emissions. Regarding the generation of energy from more renewable energy sources, including hydro, wind, solar, etc., India is among the top 10 countries. However, this is not the case with nuclear energy. India is a 1.3 billion people country and is still growing. To fulfil the growing energy demand and aim to cut carbon emissions simultaneously, nuclear energy can play a very critical role.

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CONSTRAINTS TO WOMEN'S FINANCIAL INCLUSION INDIA

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ABSTRACT

Financial Inclusion of women is crucial for achievement of fifth SDG, of Gender equality. Among Indian women, every one in five does not have access to a bank account. Even while the number of women with bank accounts has increased due to government-run initiatives to promote financial inclusion, there are still significant disparities in account activity, credit availability, and savings rates. Due to a number of factors, including their higher likelihood of defaulting on debt, lack of access to mobile phones or identity documentation, distance from a bank branch, ask of comparatively larger amounts of collateral, and need for assistance opening and managing a bank account, women encounter barriers to accessing financial services. This study examines the barriers and the gender disparities in financial inclusion in India.

Keywords: Financial Inclusion, Gender gap, Digital financial Inclusion, Women Economic Empowerment

INTRODUCTION

History is the proof of the fact that poverty and inequality are intertwined. Women are known for earning less, learning less and owning less and yielding less autonomy over their lives and choices. Women's Economic Empowerment (WEE) "is a weapon to stand against the denied right to make strategic life decisions." To gain the strength of economic empowerment, women should find a way out to achieve economic security for themselves and their families, resultantly giving them a say in markets, governance system as well as ability to meet the void of necessities that adversely impacts their livelihood. Financial services easy access encourages social as well as economic empowerment with options for earning income, building assets, and engaging more fully in the economy.

Financial inclusion ensures the spine from startling events like COVID-19 pandemic, which made realization of importance of accessibility to formal financial services to the poorest. A gallery of researches approves that rise in financial inclusion of women, impacts in boasting economy. Women have higher propensity to save, improvement in women's earnings can positively raise proportions of domestic savings. Factually, increasing the propensity of women to enter and to be active in formal financial system. As a result of rise in household deposits, the capital accessibility in the market will increase.

National Strategy for Financial Inclusion (2019-2024) released by RBI, defined financial inclusion as "the process of ensuring access to financial services, and timely and adequate credit for vulnerable groups and low-income groups at an affordable cost." Financial inclusion expands overall economic output, lowers income inequality and poverty, and advances gender equality and women's empowerment.

LITERATURE REVIEW

Women Economic Empowerment is critical to attainment of fifth SDG, i.e. gender equality. OECD (2015) report about Women's Economic Empowerment states that for sustainable development as well as pro-poor growth majorly of developing countries, economic management of women is pre-requisite. To achieve the same, a sound public policy having a comprehensive approach with long-term commitment is required. Countries are understanding of the importance of gender disparity in economy in use of financial resources, as realization the developing and underdeveloped countries in the world are framing policies to obtain universal financial inclusion. Financial exclusion of minority groups of society is a concern for developed and developing countries. Even a 'well-developed' financial system has not successful in bringing universal financial inclusion in many countries(Bhatia & Singh, 2019).

Gender focused schemes for women financial inclusion will foster participation of women in financial services. Women with accessibility to bank accounts, savings mechanisms, and other financial services will be enabling them to control their earnings and incur personal and productive expenditures(Alam, 2012; Ashraf et al., 2010; Islam et al., 2015). Women's labour market participation rose in India after workfare payments were transferred to their personal bank accounts rather than the accounts of their spouses(Field et al., 2021).Women will also have freedom of choice of utilizing their time, in employment or leisure, self-employment or education. They have autonomy of making fundamental decisions related to marriage, employment, as well as contraception. Women will have alternatives to end abusive relationships and feel relatively less vulnerable to intimate partner. (Hendriks, 2019) have created a strategy dubbed "D3," which consists of digitizing social protection programs, directing money to women's accounts, and designing the program to increase the economic prospects available to women.Studies have shown that matriarchal houses are more likely to make greater investments in economic assets and productive investments as they often lack in financial resources to invest, due inability to save as well as unemployment (Gammage et al., 2017).

Individual-level traits are just as important as household-level economic factors like wealth, the gender of the household head, and the household's location between a rural and an urban area. The ability of women to get loans and open bank accounts is significantly impacted by unofficial gender norms that control their economic activity and mobility (Govindapuram et al., 2023).

OBJECTIVES

1. To evaluate the disparity between genders in terms of financial service and resource access in India.
2. To outline agents of impediments to financial inclusion of women in India.

GENDER AND FINANCE

Theoretically, there are various methods to link gender and finance. First, gender equality boosts human capital stock. A highly educated female labour force results

in a bigger accumulation of skills and competence, increasing total demand for finance. Furthermore, highly educated women are less likely to have children and may devote more time to work. This not only reduces reliance and generates a demographic dividend, but also improves their financial management. Several recent studies have investigated these correlations.

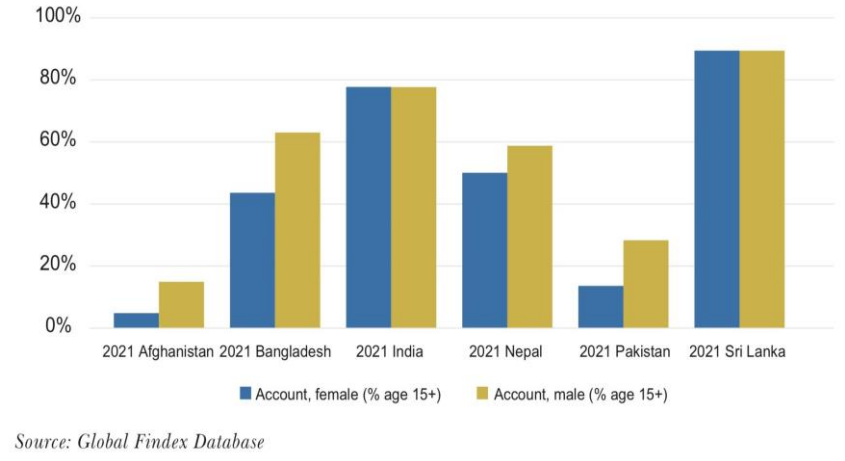
Gender equality also counts as factor contributing as an impact on capacity enhancement. Upgrading of the overall labour force skillset results in raising labour productivity and attracts investment. This will contribute to enhancement in women's income, as well as causing an increase in the domestic savings. It can boost women participation in formal financial system, and this is found proven that a percentage point increase in the female share of salaries raises aggregate savings by 0.25% of GDP. This suggests that women are more likely to save, which might lead to an increase in household savings if income is shifted from males to women. Increased domestic savings can be channeled through the banking sector, giving money to industries for expansion. According to the Food and Agriculture Organisation (FAO), increased access to farming resources for women can boost agricultural productivity on women's farms in developing nations by 4%. This is expected to empower women in accessing the official banking systems, as long as some of the income derived from it goes to them(Ghosh & Vinod, 2017).

GLOBAL FINANCIAL INDEX 2021

The World Bank's worldwide Findex Database provides data on worldwide borrowing, payments, and savings in the context of financial services. For the 2021 survey, 128,000 individuals from 123 economies worldwide were surveyed in the midst of the COVID-19 pandemic. Data on savings, payment methods used, and accessibility and usage of official as well as informal financial services are also included. Poll indicates that 13% of the world's unbanked population is female. The term "account ownership" in this index refers to the ownership of an account in any of the following institutions: banks, credit unions, microfinance organizations, post offices, and mobile money accounts; all are governed by local laws. They can be used by account holders for remittances, deposits, bills, loans, and payments.

Developing economies have made headway, with the gender gap in account ownership narrowing from 9 percent to 6 percent between 2011 and 2021. In emerging economies, 68% of women and 74% of men were banked in 2021. India demonstrated no gender disparities in account ownership.

Just seven economies—China and India included—have more than half of the world's adult unbanked population. China and India make up a substantial proportion of the world's unbanked population with 130 million and 230 million, respectively., in spite of having high rates of bank account ownership.



Source: Global Findex Database

Fig. 1. South Asian Bank Account Ownership (2021)

India and Sri Lanka being the exceptions, all the countries in the South Asian region are facing a vast gender gap in account ownership.

Points of Focus:

1) A significant population of women is lagging behind in account ownership for a range of reasons. These comprise the costliness of the majority of financial services, the inability to produce identity proofs, lack of knowledge of relevant paperwork, and lack of financial confidence. Other contributors are, being from financial institution, which can affect women way more in comparison to males because of limitations on their movement, faced by women frequently.

2) COVID-19 depicts a soaring rise in the adoption of digital payments globally, in turn widening financial inclusion. Digital payment use has a substantial gender disparity of 17 percentile points. In developing countries, the number of adults sending or accepting digital payments increased from 35% in 2014 to 57% in 2021, a rise that left behind the increase in account ownership in the same time period.

Energy and telecommunications access, including mobile phones, as well as the availability and dependability of enabling infrastructure, such as identification papers, must be taken into account in any endeavor to boost use for banked adults and inclusion for unbanked adults.

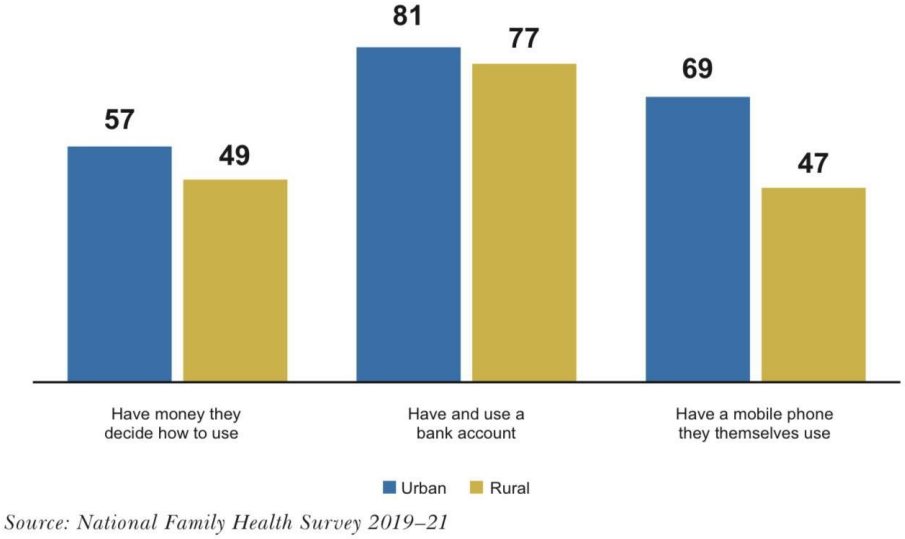
NATIONAL FAMILY HEALTH SURVEY (NFHS) 2019-21

Latest NFHS-5 survey 2019-21 included new domains, to study women economic empowerment. In terms of employment, earnings, control over earnings, proportions of women earnings in comparison of their husbands, ownership of assets and access to bank account and mobile phones.

I. There has been a noteworthy rise in the percentage of women who own their own bank and utilize it for personal use, standing at 79% in NFHS 5 from 53% in NFHS 4.

II. Despite an increase in awareness of microcredit programs from 41% in NFHS-4 to 51% in NFHS-5, women continue to have limited access to credit. Merely 11% of women have ever taken advantage of microfinance facility ever. Women use microcredit programs at a rate of 12% in rural and 9% in urban regions, respectively, in contrast to urban areas.

III. With 53.9 percent of women possessing smartphones and 71 percent of those women being able to read text messages, there is still a significant gender gap in digital technology. This suggests that there is still a divide in literacy and access. The percentage of women who use their mobile phones for financial transactions is only 22.5%.



Source: National Family Health Survey 2019–21

Fig 2.

Note: This addresses to the women as individuals rather than as a collective because SHGs handle the majority of microcredit borrowing.

IV. Only 18% of working married women made individual judgments about their financial spending. 67% percent decided with their partners.

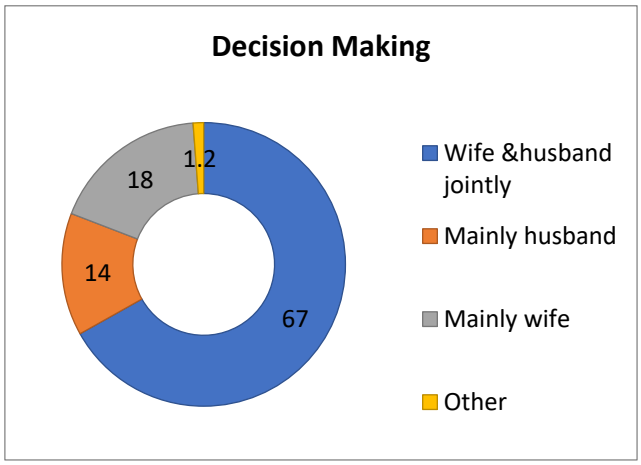


Fig 3.

Note: percentage of married women (ages 15 to 49) who earned money in the 12 months before to the poll, as reported by the person who typically makes choices on their usage

Gender Based Behavior Norms

Women's and men's behavior is mostly determined by social and gender conventions. The majority of suppliers create goods and services based on the behaviors of the customers they observe—men in the marketplace, women additionally, they adapt to their behavior by developing gender-conscious services that, although acknowledging women's lower skill or income levels, do not address the underlying causes of this discrepancy. Financial service providers, as well as the industry as a whole, should go one step further and begin to question "why." Why are males in the market and women closer to the house? Why do more men than women carry phones? Why do women labor primarily in the unorganized sector? Addressing these issues will help financial inclusion go closer to realizing its aims of empowerment. Sector players include donors, providers, and legislators.

Table I

MEN		WOMEN	
Behavior	**Norm**	**Behavior**	**Norm**
Handles the money	Men are the financial providers	Cares for children and elderly parents/ in-laws	Women are the caregivers
Speaks with vendors	Men can talk to strangers, other men	Household chores (cooking, cleaning, laundry)	Household duties are a woman's job
		Restricted mobility	
Makes household and business decisions	Men are the head of household	Makes the pots and cups (impacts time use)	Women support spouse in all activities
Primary phone user	Men need information and technology to provide for the family	Responsible for petty cash	Women don't need phones to manage their responsibilities
	Women have no need for technology, and mobile phones expose them to risky interactions	Women value being part of informal savings groups, MFIs	

Reasons of Women Left Stranded

Socio-economic and Cultural Factors:

- Education and Income Inequality: Lower literacy levels and income disparities between men and women restrict access to formal financial systems.
- Social Norms and Patriarchal Structures: Limited decision-making power within households and traditional gender roles often create barriers to financial independence.

- Caste and Rural-Urban Divide: Caste discrimination and limited access to financial infrastructure in rural areas exacerbate exclusion for women from marginalized communities.

Product and Service Gaps:

- Limited Availability of Gender-responsive Products: Lack of microloans, savings accounts with flexible options, and insurance targeted at women's needs hinders financial security.
- Informal vs. Formal Systems: Reliance on informal financial systems like moneylenders can lead to high interest rates and debt traps, particularly for women.
- Digital Financial Literacy Gap: Limited digital literacy and access to technology can exclude women from the benefits of mobile banking and digital financial services.

Systemic and Regulatory Barriers:

- Land Ownership and Collateral: Lack of land ownership for many women limits their ability to access credit and participate in formal financial markets.
- Legal Frameworks and Property Rights: Unequal inheritance rights and discriminatory financial laws can impede women's financial autonomy and control over resources.
- Lack of Consumer Protection: Inadequate awareness and protection against unfair practices and predatory lending can disproportionately harm women.

Psychological and Behavioral Factors:

- Financial anxiety and lack of confidence: Negative societal perceptions and internalized gender norms can instill fear and distrust in formal financial systems among women.
- Time constraints and workload: Women's multiple roles as caregivers and income earners limit their time to engage with financial services or seek financial guidance.
- Lack of awareness and financial literacy: Limited knowledge about financial products and services can hinder women from making informed financial decisions.

COVID-19 AND DIGITAL GENDER DIVIDE

Information about the effect of COVID-19, pandemic on digital financial inclusion is scarce. According to World Bank research from 2021, the epidemic made contactless financial goods and services more necessary, hastening the transition of many economies to digital banking. Many governments adopted digital payments as a crisis reaction to help companies and consumers. But not everyone has access to the knowledge and abilities needed to use digital financial goods and services, which has highlighted the digital split that disproportionately impacts women. During the pandemic, the advancement India has initiated in encouraging females to use mobile internet for the first time was halted. 83% of men and 71% of women own mobile phones, which indicate a 14% gender gap in mobile ownership. Even with high ownership rates, the statistics on mobile internet use are dismal. With 51% of men and 30% of women using mobile internet, there was a 41% gender gap. (Shanahan, 2022)

The percentage of women who own and use a mobile phone increase with years of age, from

32% among women aged 15-19 to 65% among women aged 25-29, and then drops among older women, according to NFHS-5 data that maps digital access and literacy. With respect to literacy, the proportion of women who possess a mobile phone and are able to read text messages declines as they become older, with the 15–19 age group's percentage standing at 89 percent and the 40–49 age groups at 53 percent. The difference between the male and female populations is in ability, facility, and accessibility.

CONCLUSION

Financial inclusion is essential to both sustainable development and economic progress because it gives women a way to achieve social and economic empowerment. Research has shown that improving women's financial access boosts household earnings by benefiting the women themselves.
The acceleration of the transition to digital services and the legislative reactions to the pandemic have opened a window of opportunity to narrow the gender divide in India's journey of financial inclusion. Women confront a range of gender-specific obstacles, including constrictive social standards, limitations on their mobility, identity issues, inadequate financial literacy, lack of assets for collateral and lower level of internet literacy. To address the issues, a women-focused model for financial inclusivity is necessary, presenting with equal opportunity for women to a range of financial services that are offered to the male population, should be the first priority. It will be a step towards promoting their full involvement in economic activities by giving them the same chances as men.

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Application of Artificial Intelligence in United States Political Marketing: A Case Study

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ABSTRACT

Artificial intelligence (AI) has become a transformative force in numerous industries, and political marketing in the United States is no exception. This case study investigates the application of AI in political campaigns, focusing on its impact on voter engagement, data-driven decision-making, and personalized outreach. The research delves into the deployment of AI-driven algorithms to understand huge amounts of voter data, which includes social media activity, demographics, and previous voting behaviour. Leveraging machine learning, political campaigns can identify key issues and sentiments prevalent among different voter segments, enabling them to tailor their messages more effectively. Moreover, AI-powered chatbots and virtual assistants have been integrated into political marketing strategies to engage with potential voters in real-time. These conversational interfaces can provide instant responses to queries, disseminate information, and even simulate candidate interactions, enhancing the overall voter experience. Ethical concerns surrounding AI in political marketing are also addressed, as this technology raises questions about privacy, algorithmic bias, and data security. The case study examines how campaigns balance the benefits of AI with safeguarding citizens' rights and maintaining electoral integrity. By analyzing the success and challenges of prominent AI-driven political marketing campaigns, this case study highlights the growing significance of AI in shaping modern electoral processes. Ultimately, it emphasizes the need for responsible and transparent AI implementation in political marketing to ensure fair and informed voter engagement in the United States.

Key words: Artificial Intelligence; United States; Political Marketing; chatbots; machine learning

INTRODUCTION

In the contemporary landscape of political campaigning, the fusion of technology and strategic

communication has become increasingly indispensable. Amid this evolution, artificial intelligence (AI) emerges as a game-changing force, reshaping the contours of political marketing in the United States. This case study embarks on an exploratory journey into the dynamic realm where AI intersects with the intricacies of political engagement and voter persuasion [1]. As political campaigns vie for attention in a digitally saturated world, the application of AI introduces a new dimension of sophistication. Artificial Intelligence techniques ability to analyze vast troves of data with unprecedented speed and accuracy offers a transformative paradigm for campaign strategists. By dissecting demographic trends, social media interactions, and historical voting patterns, AI empowers campaigns to tailor messages with remarkable precision, amplifying resonance among diverse voter segments.

The case study delves deeper, shedding light on how AI-driven tools, such as chatbots and predictive analytics, revolutionize voter interaction and outreach strategies. These technological innovations not only enable real-time engagement but also predict voter preferences, allowing campaigns to adapt and respond dynamically to evolving sentiments. However, the infusion of AI into political marketing is not devoid of ethical considerations. The potential for algorithmic bias, the manipulation of public perception, and data privacy concerns underlines the need for careful scrutiny and responsible implementation. Against this backdrop, the case study navigates through a specific instance, illuminating the strategic incorporation of AI in a prominent United States political campaign. By dissecting the methods, successes, challenges, and ethical implications of this case, we glean valuable insights into the ever-evolving relationship between AI and the democratic processes that underpin the United States political landscape [2-3].

Artificial Intelligence (AI) stands as a transformative paradigm within the realm of computer science and technology. It represents the simulation of human intelligence processes by machines, allowing them to learn, reason, and execute tasks that generally require human cognitive efficiency. At its core, AI includes a wide range of techniques, from machine learning and natural language processing to robotics and supervised systems. One of AI's central tenets is machine learning, a subset that empowers systems to learn from data rather than being explicitly programmed. Through algorithms, machine learning models detect patterns, make predictions, and continuously refine their performance. This capability finds applications across various domains, from predicting stock market trends and diagnosing medical conditions to personalizing online content recommendations [4]. Natural language processing

(NLP), another vital facet of AI, enables computers to comprehend, interpret, and generate human language. NLP underpins virtual assistants like Siri and chatbots, facilitating seamless human-machine interactions and information retrieval. AI's impact reverberates across industries. Healthcare sector evolve using AI in diagnosing diseases, analyzing medical images, and even suggesting treatment plans. The automobile sector leverages with self-driving cars, enhancing road safety and transportation efficiency. Financing sector evolve with AI algorithms sift through vast datasets for fraud detection, risk assessment, and algorithmic trading. Ethical considerations intertwine with AI's advancement. Concerns encompass algorithmic bias, where machine learning models inadvertently perpetuate societal prejudices present in training data. Privacy concerns arise from AI's ability to process and interpret personal information, raising questions about data security and ownership. Looking forward, the trajectory of AI holds immense potential [5-6]. AI-driven innovations could revolutionize education through personalized learning experiences, amplify renewable energy solutions, and pave the way for more sophisticated space exploration. However, navigating AI's trajectory also demands thoughtful regulation and policies to ensure responsible and equitable implementation. In essence, AI is an ever-evolving technological frontier that reshapes how we interact with machines and the world around us. Its capacity to learn, reason, and adapt opens doors to unprecedented possibilities, positioning it as a cornerstone of the digital age and a driving force behind future innovations.

Artificial Intelligence (AI) is rapidly revolutionizing marketing surveys across various industries, redefining how businesses gather, analyze, and act upon consumer insights. With its remarkable ability to process vast amounts of data and extract meaningful patterns, AI-driven marketing surveys enhance the accuracy, efficiency, and depth of understanding in diverse ways. In consumer sentiment analysis, AI-powered natural language processing (NLP) algorithms dissect textual responses from surveys, social media, and online reviews, capturing nuanced sentiments and opinions. This offers marketers a comprehensive view of public perceptions, enabling them to refine strategies and respond to evolving trends. Personalization is a hallmark of modern marketing, and AI elevates this aspect in surveys. By analyzing individual preferences, purchase history, and behavior, AI tailors survey questions to each respondent, ensuring relevant and engaging interactions. This not only improves response rates but also generates more accurate and actionable insights [7-8].

Predictive analytics, fueled by AI, empowers marketers to forecast trends and consumer

behavior. By analyzing historical data, AI models can identify patterns, allowing businesses to anticipate market shifts and adjust their strategies proactively. AI-driven image and video analysis play a pivotal role in understanding visual content shared by consumers. Marketing surveys can leverage AI to analyze images, logos, and videos associated with products or brands, unveiling insights that traditional surveys might miss. Market segmentation, a cornerstone of targeted marketing, is further enhanced by AI. Clustering algorithms process survey data to identify distinct consumer segments based on shared characteristics, enabling marketers to tailor their approaches for maximum impact. Incorporating AI into marketing surveys isn't without challenges. Ethical considerations, such as data privacy and algorithmic bias, require careful attention. Striking a balance between automation and maintaining a human touch in survey interactions is also a key consideration [9-10].

POLITICAL MARKETING

Political marketing encompasses the strategic and targeted efforts of political candidates, parties, and organizations to communicate their messages, ideals, and policy proposals to the electorate. It mirrors the principles of commercial marketing, adapting them to the unique context of the political arena. In a democracy, political marketing having a crucial role in shaping public perception, mobilizing voters, and ultimately influencing election outcomes. Candidates utilize various channels, such as speeches, debates, social media, and advertising, to engage with constituents and convey their platforms. Through skillful branding and messaging, political marketing seeks to establish an emotional connection between candidates and voters. Effective political marketing involves market segmentation, where different voter segments are identified based on demographics, interests, and values. Tailoring messages to resonate with these segments enhances the likelihood of connecting with diverse constituencies. Moreover, political marketing extends beyond elections, serving as a continuous process of building relationships and maintaining public trust. It involves careful reputation management, crisis communication, and the cultivation of a strong political identity. However, political marketing also raises ethical concerns, including the potential for manipulation, misinformation, and the influence of money on political discourse. As technology evolves, the digital landscape introduces new dynamics, demanding adaptability in campaign strategies. In sum, political marketing is a dynamic and influential practice that shapes the way citizens engage with politics and make informed decisions. It underscores the

importance of effective communication, strategic positioning, and ethical considerations in the democratic process.

METHODOLOGY

In the context of political marketing, a robust methodology is essential to generate credible insights into the complex interplay between political strategies and public engagement. While studying the uses of artificial intelligence (AI) in political marketing through a case study, the methodology should encompass several key components:

1. Research Design: Determine whether the study will be exploratory, descriptive, explanatory, or a combination of these. In the case of AI in political marketing, an explanatory approach might be suitable to understand how AI tools are integrated into campaign strategies and how they impact voter engagement.
2. Data Collection: Define the data sources, which may include campaign materials, social media interactions, surveys, and voter demographic data. The data should be relevant to the specific case study and aligned with the research questions.
3. Sampling Strategy: Specify the criteria for selecting the case study, such as the political campaign to be analyzed. Ensure that the selected case is representative and provides a comprehensive view of AI's application in political marketing.
4. Data Collection Methods: Detail the methods used to collect data, such as content analysis of campaign materials, sentiment analysis of social media posts, and interviews with campaign strategists. These methods should be chosen to capture both quantitative and qualitative aspects of AI's impact.
5. Data Analysis: Describe the techniques for analyzing the collected data. For AI in political marketing, this might involve machine learning algorithms for sentiment analysis, coding schemes for content analysis, and thematic analysis for qualitative interviews.
6. Issues of ethical consideration: Discuss the ethical issues regarding data privacy, informed consent, and potential biases in data collection and analysis. Ensure that the study adheres to ethical standards and guidelines.
7. The Reliability and Validity: Address measures taken to ensure the validity and reliability of the findings, such as inter-coder reliability in qualitative analysis or cross-validation in machine learning algorithms.

8. Limitations: Acknowledge the limitations of the selected methodology, such as potential biases, data constraints, and few others challenges faced during the research process.

SUMMARY OF THE U.S. PRESIDENTIAL ELECTION 2020

The 2020 U.S. Presidential election was a closely watched and highly contested political event. The incumbent President Donald Trump, a Republican, sought re-election, while former Vice President Joe Biden, a Democrat, challenged him. The election took place against the backdrop of Pandemic of COVID-19, led to a significant increase in mail-in and early voting. After a contentious campaign marked by debates on healthcare, the economy, racial justice, and the pandemic response, Joe Biden emerged as the victor.

Table I: Summary of the U.S. Presidential Election 2020

Candidate	Party	Popular Vote (Millions)	Electoral Votes
Joe Biden	Democrat	81.2	306
Donald Trump	Republican	74.2	232

1. Voter Turnout: The 2020 election saw the highest voter turnout in over a century, with more than 158 million people casting their votes.
2. Electoral College vs. Popular Vote: Although Biden won the Electoral College decisively, the popular vote was still closely contested, reflecting the ongoing debate about the U.S. election system.
3. Pandemic Impact: The COVID-19 pandemic prompted many states to expand mail-in and early voting options to ensure voter safety.
4. Battleground States: Several key battleground states played a pivotal role in determining the outcome, with close margins in states like Pennsylvania, Michigan, and Wisconsin.
5. Historic Vice President: Kamala Harris create a history as the first Black woman and first person of South Asian origination to be elected as a Vice President.
6. Legal Challenges: The election faced legal challenges and allegations of voter fraud, leading to heightened scrutiny and recounts in certain states.

7. Transition of Power: Despite legal battles and disputes, Joe Biden was inaugurated as the 46th President of the United States on January 20, 2021.
8. The 2020 U.S. Presidential election highlighted the significance of voter engagement, the role of key swing states, and the ongoing debates surrounding the U.S. election process.
9. Please note that the data provided is based on available information up to September 2021.

Major challenges faced by the candidate in US election

U.S. presidential candidates face a multitude of challenges throughout their campaigns, navigating a complex landscape shaped by political, social, and technological factors. Some major challenges include:

1. Public Perception and Image: Candidates must manage and shape their public image, addressing controversies, personal histories, and public perceptions that could affect their electability and credibility.
2. Primary Competition: Within their own party, candidates often face fierce competition during primary elections, where they must differentiate themselves from other contenders while appealing to their party's base.
3. Policy Positioning: Articulating clear policy positions on a wide range of issues while maintaining consistency and appealing to various voter demographics can be challenging, especially as public sentiment evolves.
4. Media Scrutiny: The media closely examines candidates' every move, from policy proposals to personal actions, which can both shape public perception and create challenges if misrepresented or misinterpreted.
5. Negative Advertising: Opponents often use negative advertising to attack a candidate's record or character. Responding effectively to these attacks without appearing defensive is a delicate balance.
6. Debates and Public Speaking: Debates and public appearances offer candidates an opportunity to showcase their knowledge and charisma, but they can also expose weaknesses, gaps in knowledge, or missteps.
7. Ground Game and Voter Outreach: Candidates must build effective ground campaigns to mobilize supporters, register voters, and ensure a strong presence in key states.

8. Social Media and Online Influence: The rise of social media introduces opportunities for direct voter engagement but also makes candidates susceptible to misinformation and viral controversies.
9. Changing Demographics: The U.S. is becoming more diverse, and candidates must address the concerns of various demographic groups while navigating issues related to identity and representation.
10. COVID-19 and Crisis Management: The 2020 election highlighted the challenges of campaigning during a crisis, such as the COVID-19 pandemic, requiring candidates to adapt their messaging and campaign methods.

Solution by AI in US political marketing

Artificial intelligence (AI) is emerging as a powerful solution to address various challenges in U.S. political marketing, revolutionizing how campaigns engage with voters, refine strategies, and navigate complex dynamics. AI-driven solutions offer:

1. Targeted Messaging: AI analyzes vast datasets to identify voter preferences, enabling campaigns to craft personalized messages that resonate with specific demographics. This level of customization enhances voter engagement and response rates.
2. Sentiment Analysis: AI-powered sentiment analysis scours social media and online platforms to gauge public sentiment toward candidates and issues. Campaigns can swiftly adjust their messaging in response to real-time feedback.
3. Predictive Analytics: AI models forecast voter behavior, allowing campaigns to allocate resources strategically. Predictive analytics identify key battleground states and predict shifts in voter sentiment, informing campaign strategies.
4. Data-Driven Insights: AI processes massive amounts of data to extract actionable insights, enabling campaigns to make informed decisions based on voter demographics, issues of importance, and local trends.
5. Optimized Ad Placement: AI optimizes ad placement and targeting, ensuring campaign messages reach the right audience at the right time, thereby maximizing the impact of advertising spending.
6. Real-Time Chatbots: AI-driven chatbots engage with voters 24/7, answering queries, disseminating information, and simulating candidate interactions, enhancing voter experience and accessibility.

7. Issue Prioritization: AI analyzes public discourse to identify emerging issues and concerns, allowing campaigns to address relevant topics and stay ahead of voter interests.
8. Resource Efficiency: AI streamlines campaign operations, from volunteer management to event scheduling, improving resource allocation and campaign coordination.
9. Ethical Considerations: AI can help identify and mitigate algorithmic bias, ensuring fair and equitable representation in voter outreach and messaging.

By harnessing AI's capabilities, U.S. political campaigns can refine their strategies, optimize resource utilization, and engage with voters in a more targeted and impactful manner, ultimately contributing to a more informed and participatory democratic process.

Impact of AI

The use of AI in the 2020 U.S. Presidential Election brought several notable impacts:

1. Personalized Engagement: AI-driven voter targeting and messaging ensured that campaigns could engage with individuals on issues that resonated with them, fostering a more personalized voter experience.
2. Real-Time Adaptation: AI-powered sentiment analysis and predictive analytics allowed campaigns to adapt quickly to changing voter sentiments and tailor their strategies accordingly.
3. Efficiency and Resource Optimization: AI streamlined campaign operations, saving time and resources by automating tasks and optimizing resource allocation.
4. Data-Informed Decision-Making: AI provided data-driven insights into voter behavior, enabling campaigns to make informed decisions about strategy and resource allocation.
5. Wider Outreach: Automated chatbots and AI-driven social media interactions expanded voter outreach beyond traditional methods, engaging younger and tech-savvy demographics.

In the complex and rapidly evolving landscape of the 2020 U.S. Presidential Election, AI emerged as a powerful tool that enabled campaigns to navigate the intricacies of voter engagement, data analysis, and strategic decision-making. While AI offered substantial benefits, its ethical implications underscored the importance of responsible and transparent usage to preserve the integrity of the democratic process.

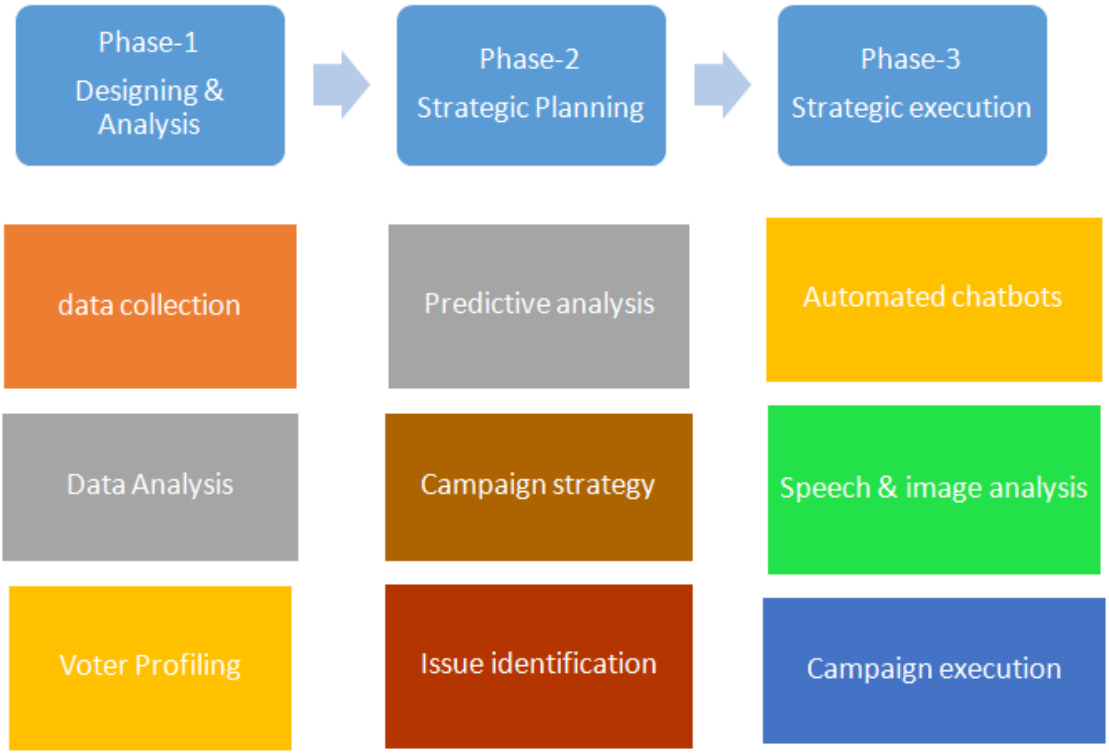

Fig 1. Flowchart of use of artificial intelligence in US election

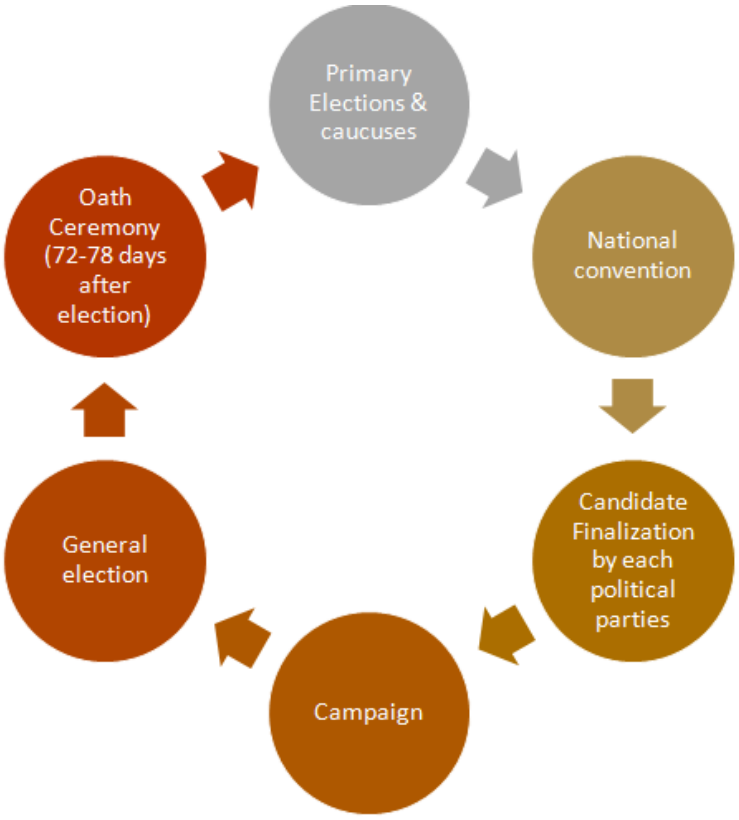

Figure 2: US Election Process Diagram

CONCLUSION

In the landscape of political marketing, evolution of AI has undergone a profound transformation, reshaping the very landscape of how candidates engage with voters, craft messages, and navigate the complexities of modern electoral processes. The journey of AI in political marketing has transcended mere technological innovation, ushering in a new era marked by data-driven precision, real-time adaptability, and enhanced voter engagement. As AI algorithms became more sophisticated, their integration into political campaigns evolved from basic data analysis to encompass intricate predictive models that forecast voter behavior and sentiment. This evolution has enabled campaigns to strategize with an unprecedented level of foresight, optimizing resource allocation and honing messages to resonate with specific voter segments. The power of AI-driven sentiment analysis, which dissects public opinion from social media and online platforms, has equipped campaigns with the ability to adapt swiftly to emerging trends and refine their strategies in real-time. Furthermore, the rise of AI-powered chatbots and personalized interactions has democratized political engagement, allowing voters to access information and interact with campaigns on their own terms. This evolution has strengthen the connect of voters and candidates, cultivating the sense of inclusivity and participation in the democratic setup. However, with this evolution also come ethical considerations. The potential for algorithmic bias, data privacy breaches, and the manipulation of public opinion raise crucial questions about the ethical concerns of use of AI in political marketing. Striking the right balance between uses of AI's capabilities and protecting the integrity of democratic discourse remains an ongoing challenge.

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India's G20 Presidency: The Emerging Multi-polar World Order and Great Power Politics

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ABSTRACT

The 18th G-20 summit concluded in New Delhi on the 8th and 9th of September, 2023. India is hosting the presidency of this developed and emerging economies grouping for the first time. The timing of India's presidency is crucial, especially in light of the world's ongoing tensions on a wide range of challenges. In the 21st century, the power dynamics and global order have shifted dramatically. This century is witnessing an emergence of a multi-polar world order. In this new global landscape, the power is distributed with various state and non- state actors. The United States, Russia, China, European Union, India and other influential nations are the major state actors of this new global order. Along with its various non- state actors has also plays a significant role in global power politics. In the current global scenario, the world has been divided on many matters, and the power politics between the states has risen to new heights. The Russia- Ukraine (2022) conflict has further fuelled the division between West and East. The North-South divide already separated the globe, and neo-colonialism continues to penetrate the developing and underdeveloped worlds.

Along with it, Great Power politics has reached new heights, influencing world order in multiple ways. The strengthening of Russia-Chinese relations, NATO's tendency to expand, and China's potential as a rival to the US and the Russia-Ukraine conflict substantially contribute to the Great Power Politics. The Soviet disintegration of 1990's had driven the global power dynamics from a bipolar to a unipolar world order. However, the 21st century has witnessed the the power shift away from a unipolar world to a multi- polar world order and this power shift has a significant implication on global economy, geopolitics, new alliance mechanisms and so on. The emergence of new economies like India too has got an opportunity to navigates its global aspirations in this new global landscape. The successfull G20 presidency of India had shown the its diplomatic capability and global diplomatic interests. This paper examines how the G20 presidency of India has become very significant in the emergence of a new multi-polar world order and the rising great power rivalry.

Keywords: Great Power Politics, Multi-polar World Order, Neo-Colonialism, North-South divide

INTRODUCTION

India commemorated its 75th anniversary of independence in 2022, signifying the culmination of a protracted liberation struggle that commenced in 1947. This era coincided with a surge of decolonisation throughout Asia, Africa, and South America as nations endeavoured to extricate themselves from colonial domination. The formulation of foreign policies for these newly sovereign states proved particularly challenging, given the prevailing context of the Cold War. Nevertheless, India garnered support from other recently emerged nations when it introduced

the Non-alignment Movement (NAM) in 1955. Throughout the Cold War, India's foreign policy heavily relied on non-alignment principles. In 1983, Prime Minister Indira Gandhi spearheaded India's hosting of the NAM summit in New Delhi, thereby reinforcing their unwavering commitment to non-alignment (Kumar, 2010). In 2023, the city of New Delhi served as the venue for the 18th G-20 meeting, during which India played a prominent role in extending a warm reception to the African Union (AU) as the 21st member of the group.

In the 20th and 21st centuries, India has played an active role in amplifying the representation of the global South within the established global order (Aulakh & Prasad, 2023). Over the past 75 years, India's position in the international arena has undergone significant transformations, coinciding with substantial shifts in the global order. The assumption of the G-20 Presidency marks a pivotal moment for India, enabling it to showcase its power, potential, and significance in global affairs to the international community. The global geopolitical landscape underwent a significant transformation following the conclusion of the Second World War, culminating in the dissolution of the Soviet Union in the 1990s. Initially, the post-Cold War era witnessed a unipolar world order dominated by the United States. However, over time, this US-led global order has experienced a shift, leading to the emergence of a multi-polar world order in the 21st century. This shift can be attributed to various factors, including the rapid growth of China, the relative decline of the US economy, the ascent of emerging economies, the deepening divisions between the East and West, as well as the North and South, and the increasing influence of multi-lateral organisations such as the BRICS, SCO, AU, among others. No single entity possesses the capacity to manipulate or modify the geopolitical and socioeconomic structure of the emerging global arena. The present multi-lateral global system encompasses diverse mechanisms to uphold the prevailing power equilibrium and deter any single actor from establishing hegemonic dominance. Examples of these mechanisms include the NATO alliance, the QUAD, AUKUS, BRICS, and SCO, among others. These multi-lateral forums effectively counteract any attempts at hegemonic interference in the international system. John Mearsheimer's offensive realistic theory highlights the competition among nation-states for a dominant position in the global order. However, the multi-lateral world order mitigates this potentially destabilising scenario. Nevertheless, there is an ongoing power struggle between the Western and Eastern powers to secure a hegemonic position in the international arena (R, 2023).

The phenomenon of Great Power Politics has been a significant aspect of international political history. According to Mershemeir, this form of politics was prevalent during the 19th and 20th centuries and is expected to persist in the 21st century as well. The concept of Great Power Politics falls within the Realistic paradigm, as these powerful nations consistently engage with the global arena due to their strong economies, proficient military capabilities, and extensive global interests (Zimmern,1939). The ongoing crisis between Russia and Ukraine (2022) has emerged as a significant arena for competition among major global powers. China, Russia, and the United States are continuously struggling to establish their dominance in global politics, with various socio-political and economic factors contributing to the intensification of this situation. The ongoing Ukrainian crisis, disputes in the South China Sea, the formation of alliances by both Western and Eastern powers, and the trade war between China and the United States are among the prominent manifestations of the prevailing rivalry among major powers in the contemporary world. India's foreign policy has adopted a more pragmatic and realistic approach under the leadership of Prime Minister Modi. The government is trying to align itself with Western and Eastern powers strategically. Notably, India has assumed the leadership of

the G20 grouping during a time of increasing great power rivalry within the multi-polar world order (R, 2023).

The Dynamic G-20 Presidency of India

India marked an important milestone in 2023 when it took the helm of the Group of Twenty (G-20), an organisation made up of the biggest economies of the globe. In 1999, against the backdrop of the Asian financial crisis, the G-20 was established. It includes representatives from both the developed North and the emerging South. Its relevance has grown over time—primarily since it represents 80% of the world's population and 85% of the global GDP. India's G20 presidency unfolded against the backdrop of an emerging multi-polar world. With shifting power dynamics and evolving geopolitical interests, India navigated skilfully through the complexities of great power politics. It sought to bridge the gap between developed and developing nations, advocating for a more inclusive and equitable global order. India's presidency of the G20 is characterised by a dynamic approach that addresses pressing global challenges, showcasing its diplomatic finesse and strategic vision. In 2022, New Delhi succeeded Indonesia as G-20 president. In February 2022, the Russia-Ukraine conflict also broke out, making the post-covid period of the world political structure particularly difficult. In this challenging circumstance, India has taken on the G-20 presidency (Kakoti& Sing, 2023). On December 1, Indian Prime Minister Narendra Modi expressed India's priority regarding its term, and his political message was, "Our G-20 priorities will be shaped in consultation not only with our G-20 Partners but also with fellow travellers in the global South, whose voice often goes unheard" (Dhar, 2023).

One of India's fundamental priorities during its G20 presidency was fostering economic resilience and innovation. By promoting digitalisation, sustainable investment, and robust financial systems, India aimed to fortify the global economy against future shocks. India took proactive steps towards addressing climate change and promoting sustainable development. Recognising the urgent need for collective action, India emphasised partnerships focusing on clean energy, environmental conservation, and climate resilience. India's presidency also highlighted its outreach to emerging markets and developing nations. The game-changing decision made during the 18th presidency was to include the African Union, and as a result, the forum has expanded its diversity. With the welcoming of AU as the 21st entity in the G-2O, India took the initiative to amplify the voice of the global South and enhance South-South cooperation. The G-20 meeting underlined India's dedication to a more inclusive and equitable world order.

The Emerging Multi-polar World Order and India

India has completed its 75 years of independence in 2022. It gained independence in 1947 after hundreds of years of freedom struggle. The second war period was a period of decolonisation, and different countries in Asia, Africa and South America gained independence. The formulations of the foreign policy of newly independent nations were challenging at that point, especially in the background of the Cold War. The newly emerged countries stood with India after introducing the Non-alignment Movement (NAM) in 1955. The non-aligned policy was crucial to India's foreign policy during the Cold War. In 1983, India even hosted the NAM summit in New Delhi under the leadership of Prime Minister Indira Gandhi (Kumar,2010). New Delhi hosted the 18th G-20 meeting in 2023, and India led the welcoming of the African

Union (AU) to the grouping as a 21st entity. During the 20th and 21st centuries, India has actively enhanced the voice of the global South according to the existing world order (Aulakh& Prasad, 2023). In the last 75 years, India's position in the world has changed significantly, and global order has changed drastically. The G-20 Presidency is a significant turning point that allowed New Delhi to demonstrate to the rest of the world its strength, potential, and importance in global affairs.

The world became bipolar after the Second World War, which ultimately ended in the 1990s with the fall of the Soviet Union. The world saw a unipolar world run by the United States at the beginning of the post-Cold War period. However, the US-led world order has eventually started to change, and in the 21st century, the world order has become a multi-polar world order. A multi-polar world has emerged as a result of the growth of China, the decline of the US economy, the rise of emerging economies, the widening of the East-West and North-South divides, and the growing influence of multi-lateral organisations like the BRICS, SCO, AU, and others. In this new global sphere, no single power can potentially affect or change the global geopolitical and socioeconomic framework. The prevailing multi-lateral global order also includes different power balance mechanisms which have maintained the status quo and prevented a hegemonic intervention by a single actor. The NATO alliance, the QUAD, AUKUS, BRICS, SCO, etc., are the multi-lateral forums that prevail over any actor's hegemonic interference in the international system. In his offensive realistic theory, John Mearsheimer clearly illustrates that nation-states are fighting for a hegemonic position in the global order. The multi-lateral world order avoids this thrilling scenario; however, the West and East are engaged in a phenomenal power politics struggle to get the hegemonic position in the international domain (R, 2023).

India's approach to global affairs has undergone significant changes from the period of independence to the present day. This evolution is evident in the transition from non-alignment to multi-alignment, as well as in the shift from the Panchasheel principles to the Panchamrith policy. India's foreign policy has experienced substantial transformations over time, reflecting shifts in its strategic priorities and geopolitical circumstances. The dynamics of global power rivalry have also exerted influence on India's global approach (Walton, 2007). During the Cold War, India pursued a non-aligned stance and refrained from aligning with any power bloc. However, this policy has gradually lost its relevance and significance. The post-Cold War era ushered in a new global order, prompting India to adapt to the evolving international landscape (Ganguly, 2004). Since 2014, India's global approach has undergone a paradigm shift, with the new government asserting a strong and independent foreign policy due to its parliamentary majority. India's standing in the global arena has evolved significantly, leading to a transformation in its global diplomacy (Mahida & Chauhan, 2023).

The foreign policy of the Modi government has adopted a more pragmatic and realpolitik approach, aligning with the principles of the Realistic school of thought. However, India seeks to balance its previous idealistic global outlook through enhanced global cooperation, increased participation in multilateral forums, and efforts to boost trade. The Realistic school of thought prioritizes national interest and security, which is also reflected in the Panchamrit policy. This policy emphasizes two key pillars: Samman, which underscores dignity and honour, and Suraksha, which aims to enhance regional and global security (Barik, 2021). The Realistic school acknowledges global insecurity, conflict, and anarchy, representing the competitive and conflictual aspects of international politics (Heywood, 2019). India's participation in the

QUAD grouping, military agreements with the USA, Russia, and other countries, and the increase in defence budget underscore its adoption of the Realistic paradigm in its global approach (Jaishankar, 2020; Kukreja, 2020; Pant, 2021).

India's presidency of G-20 shows how India is navigating its global outlook. India has made a joint statement at the summit, especially since the globe has been divided on many matters, including Russia- the Ukraine war. The joint statement shows India's diplomatic success and is much closer to India's approach to the Ukrainian conflict. However, the 2022 Bali G20 summit had a much tougher language for the conflict, but in the Indian summit, it was adopted in the Indian way. Regarding the Russia- Ukraine war statement compared to the 2022 Bali statement, EAM Jayashankar replied, 'Bali was Bali, and New Delhi is New Delhi'. The minister's reply illustrates how much India's global approach has shifted (Mahida& Chauhan, 2023., Aulakh& Prasad, 2023). Along with this, India has announced joining the Europe-Middle East and India corridor, which can potentially challenge China's Belt and Road Initiative. At the Esat Asia summit of 2023, PM Modi talked about the code of conduct of the South China Sea in accordance with the UNCLOS agreement. These actions demonstrate the country's global strategic change and ability to make decisions independently (Chaudhury, 2023; Aulakh& Prasad, 2023).

CONCLUSION

In the aftermath of the COVID-19 pandemic, there has been a noticeable division between the West and East, particularly exacerbated by the Russia-Ukraine conflict that began in 2022. This has further exacerbated global political tensions and deepened the North-South divide. Concurrently, India has strengthened its global position and has emerged as a leader among developing nations (Pande, 2017). The global geopolitical landscape has shifted towards a multipolar world order in the twenty-first century, with India assuming a unique and significant role in global affairs. India's foreign policy has undergone significant changes, emphasizing strategic autonomy, particularly in the context of the growing rivalry between the Western and Eastern powers. Under the Modi administration, India has pursued a pragmatic and realistic approach, contributing to global peace, cooperation, and security. India's new global strategy combines realistic and liberal perspectives, as evidenced by its diplomatic efforts at the G20 Summit in 2023, which emphasized strategic autonomy and enlightened national interests (Aulakh & Prasad, 2023). In this emerging multipolr world order, India's position in the global politics undoubtedly influences great power rivalry and the G-20 presidency has demonstrated India's navigation for its global interests and aspirations.

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Environmental Crisis

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ABSTRACT

Climate change has not only posed health hazards but is making life difficult on this planet. On the one hand, the glaciers are melting, resulting in flood situations in many places, and on the other, the deserts are facing torrential rains. There are many ways in which humans are causing this damage to the environment, and it has taken the form of a crisis. Governments are doing their best, but what we need to do most is spread awareness amongst the masses, and that is the only way we can save the environment from further damage. The present study portrays mundane chores where humans are harming the environment and what little effort on their part can save the entire planet.

Fig. 1.

INTRODUCTION

The thing that gives life to everything is called the environment. We reside in the natural world or the whole of a geographical location. This allows us to say that the environment is responsible for the existence of life. This is because the interaction between the various types of living beings and nonliving beings like animals, humans, plants, water bodies, air, soil, etc., is what creates the perfect combination to sustain life. This combination of life is solely responsible for the existence of the world we reside in today. This coexistence of humans and nature has been in harmony since immemorial. This is the beauty of the environment because it creates life and allows it to grow, which is something that can't be done by anyone mortal. Every single thing and every single being in the environment is a reflection of such beauty. This is regardless of how big and small that thing is.

This same beauty has been the source of inspiration for many successful poets who craved to have a piece of this indispensable environment. Poets such as William Wordsworth often wrote about nature and the environment. He personified it to show his love and appreciation for it as if it were alive on its own. It was almost as if loving it as a nonliving thing wasn't enough. Instead, he wanted to love it like it would understand that love like someone who was alive would. In one of his famous poems, he says

"Knowing that Nature never did
Betray the heart that loved her tis
Her privilege, through all the years of
This is our life, to lead from joy to joy:
(William Wordsworth, Tintern Abbey)

THREATS TO OUR ENVIRONMENT

This shows that the environment is not something that is only appreciated in modern times after years of scientific research; instead, it has always been enjoyed ever since life came into being. Without the combination of air, water, and Earth, no life is possible. Our planet Earth has been blessed to have all these elements in appropriate proportion hence life has been possible. Even after recognizing such qualities of the environment, we as a society have not been able to prevent the current threats against it. We have identified the elements that are responsible for its degradation. Still, many of us are in the denial mode of recognizing those threats as real and need to do more to save the environment. Over the past decades, these problems have only increased and left negative impacts on us that are now currently affecting the lives of millions of people. These threats are related to abnormal occurrences in the environment. For example, global warming, pollution, problems related to plastic, overconsumption of resources, etc. We can still combat these changes to not only save the environment but also to positively impact the lives of people who are being affected.

Fig. 2.

Global warming is currently one of the biggest threats to our environment. It is the extreme increase in the temperature of our planet that occurs at an abnormally high rate. This can negatively affect our environment by causing glaciers to melt, which would lead to floods in areas located near water bodies, and it can even cause droughts in certain regions due to the extremely high temperature. All of us are aware of the reasons and the factors leading to global warming. Burning fossil fuels causes global warming as it emits greenhouse gases that significantly increase the temperature of the Earth at an abnormally high rate. For many decades, we've been using fossil fuels as a source of energy for multiple things in our day-to-day lives, such as using it for petrol in our vehicles, producing electricity, or using it as a fuel

for heating. We can fight back against global warming and save the environment by using alternatives to fossil fuels. Some ways of doing this are: using electric vehicles, using solar panels for energy, or using windmills as the primary source of producing electricity, etc. Fossil fuels are more dangerous as they emit a considerable amount of carbon dioxide when they are burnt. It is not only carbon dioxide, but it also emits nitrogen and sulfur oxide. Pollution created by cars is very harmful and is responsible for significant global warming. The greenhouse gases are emitted, and they trap the heat in the atmosphere, causing global warming. The world's largest glaciers are melting because of this phenomenon. In turn, this causes respiratory diseases among humans and causes smog in the environment. Alternate fuel should also be looked upon as a possibility in the right direction. Scientific production of biogas can be one such step in the right direction. All these environment-friendly alternatives may prove to be a little expensive on the pocket, but the expense of the environment is boundless.

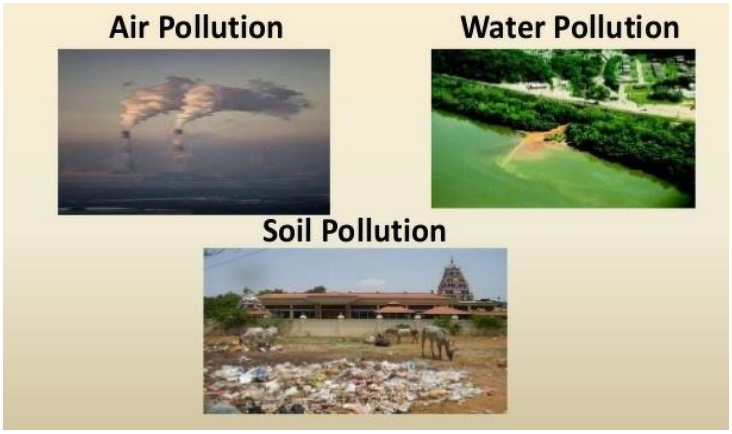

Fig. 3.

Pollution is another problem that people are struggling with in their environments. Not only does this cause harm to human life, but it also causes harm to all kinds of other living beings. For example, water pollution has caused large amounts of marine life to die in recent years. Pollution exists in many forms and is equally deadly in all of them. Be it land pollution, water pollution, or air pollution. Since pollution is the presence of toxins and contaminants that can be extremely harmful to all living beings, it negatively affects our environment by being a severe threat to life in many areas that are highly polluted. Some instances where this can be seen are humans getting diagnosed with severe health conditions such as asthma due to breathing in polluted air or animals unintentionally eating leftover waste from landfills and getting seriously ill to the point of death or almost dying. We can save the environment by controlling the pollution levels and bringing it down through some easy steps. One such step that we all can take is to be mindful of producing, buying, or throwing away anything that is toxic and may end up adding to air pollution, land pollution, or water pollution. Industrial waste creates a lot of water pollution, making aqua life too turvey. The fish are dying, and the underwater vegetation is completely diminished. Air pollution is causing a threat to human lives. People are suffering from various undetectable health problems, and life expectancy in industrial cities is getting shorter with each passing year

Fig. 4.

Plastic was invented for people's convenience. It was cheap, easy to produce, use, and versatile. These pros of plastic were all those producers focused on until decades later when we first started to see the horrifying cons that came with using plastic. Plastic is non-recyclable and nearly impossible to dispose of. It is produced with very harmful chemicals and is highly toxic when burnt. Most of our landfills are filled with this harmful plastic waste. More and more plastic waste is generated by it, and most products are only for one-time use. We, as humans, should shun such products completely. When this one-time-use plastic waste is burnt, it emits the most toxic fumes in the air, making the air poisonous for the passive breathers. The best and only way to reduce the toxic harms that are caused by plastic is to say no to as much of it as possible. There isn't a specific solution to disposing of plastic that has been invented till now, which is effective. Therefore, the best way individuals can help fight against plastic waste is by reducing their use of it as much as possible and saying no to plastic. Easy and cost-effective replacements for plastic are steel bottles, bamboo toothbrushes, paper bags, reusable cups, etc.

Fig. 5.

Over the past two centuries, the population worldwide has increased manifold. With the increase in population, the consumption of natural resources has also increased. Today, in many places, the world is facing scarcity, even for drinking water. A time will come in the future when there will be no water on Earth. Can we imagine our planet without water? If we do not take drastic steps to save water, we will not be able to save life on Earth. Overconsumption of resources is another threat to our environment. It is when humans consume limited resources

found in the environment at an unnaturally large amount that negatively impacts the environment. These resources take multiple centuries and even millennia to replenish themselves, which is much slower than the rate at which we consume them. Therefore, when we consume them, we are taking too much from the environment without giving it any time to replenish that loss.

Deforestation is another threat to the environment. The felling of trees has posed a serious environmental issue. Plants are directly responsible for the production of oxygen, which all living beings breathe. Without or even less oxygen is leading to the severity of air, resulting in heart and lung diseases. The rainfall also gets affected by deforestation, resulting in water scarcity. The entire ecosystem is being affected.

Fig. 6.

CONCLUSION

The various threats to the environment have been discussed in the present study. These threats need to be addressed as a priority. People should wake up from denial mode and realize no such threat exists. Humanity at large should become judicious when it comes to the consumption of natural resources or the degradation of the environment. We should start following the zero-waste policy. No water, food, or fuel is to be wasted. No one-time use of plastics. The public transport system should be smooth and affordable for the masses; people should start using shared transport. This would help curb the pollution in many ways. It would save fuel and less carbon emissions, resulting in the improvement of the air quality. Even while cultivating gardens, a new possibility is being explored. It is the new age of farming called Hydroponics. It is a vertical garden that can be grown even if there is land scarcity; a garden grown hydroponically requires less water, and the chances of soil erosion are zero. In the long run, it will be economical, viable, and more environmentally friendly.

Fig. 7.

All should follow the 3Rs policy, i.e.
Reduce- this is for minimizing the use or consumption of any resource right from the beginning due to the belief that if we consume less, then we will waste less.
Reuse- this stands for the practice of reusing the same resources repeatedly instead of using new ones for every single purpose that is different from each other and producing more waste.
Recycle- when reusing the same resources is insufficient, that is when recycling is brought into the picture. This allows us to give our discarded products a new shape and form to use again for similar purposes.
Finally, it is essential to recognize that to maintain the beauty of this environment, we should always be grateful for it and be wise in our actions to make sure that we don't negatively impact the environment.
It Is also the duty of every individual to be responsible for their environment and not push this responsibility on any political leader, government, big corporation, climate activist, etc. It is vital that we recognize the impact of our environment in our everyday lives and treat it as such.

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वेदों में विश्व की उत्पत्ति की अवधारणा

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विश्व साहित्य के सर्वप्रथम ग्रन्थ है 'ऋग्वेद', जिसमें देवताओं के स्तुतिपरक मंत्र हैं। इन मंत्रों के द्वारा देवताओं का यज्ञ करना ही वैदिक धर्म है।[i] यह देवता प्रकृति के ही तत्त्व हैं। जैसे इन्द्र वर्षा का देवता है, रूद्र झंझावात का, सविता प्रातःकालीन सूर्य है इत्यादि। यह देवता मनुष्य के इष्ट की प्राप्ति तथा अनिष्ट का परिहार करने में समर्थ हैं। निघंटु के व्याख्याकार यास्क 'देव' शब्द का लक्षण करते हैं- **"देवो दानाद् वा दीपनाद् वा द्योतनाद् वा द्यूस्थाने भवति इति वा।"**[ii] देवता वह है जो दान देता है, प्रकाशित होता है, अन्यों को प्रकाशित करता है तथा द्यूलोक में रहता है। मूल रूप से देखें तो देवता वह है जो हमें हमारा अभीष्ट फल दे । वैदिक व्याख्याकार 'सायण' ऋग्वेद के मंत्रों की यंत्रवत् व्याख्या के सिद्धान्त को मानते हैं। उनके अनुसार मनुष्य देवताओं को यज्ञ में आहुति देता है, जिससे देवता पुष्ट होते हैं तथा प्रसन्न होकर प्रतिकार स्वरूप मनुष्य को उसका अभीष्ट फल देते हैं। सायण वेद का लक्षण भी इसी आधार पर करते हैं- '**इष्टप्राप्त्यनिष्टपरिहारयोरलौकिकमुपायं यो ग्रन्थो वेदयति स वेदः**।[iii] प्रकृति के तत्त्व अनेक हैं अतः देवता भी अनेक हैं। इससे स्पष्ट है कि वेदों में 'बहुदेववाद' प्राप्त होता है। धीरे-धीरे यह बहुदेववाद 'एकेश्वरवाद' की ओर अग्रसर हुआ और धर्म का स्थान दर्शन ने ले लिया । ऋग्वेद में कई दार्शनिक सूक्त हैं, जिनमें जगत् की उत्पत्ति विषयक चर्चा प्राप्त होती है। ऋग्वेद के दशम मंडल में ऋषि पूछता है कि वह कौन सा पेड़ था? वह कौन सी लकड़ी थी, जिससे स्वर्ग और पृथ्वी को बनाया गया? **"कि स्विद्वनं क उ स वृक्ष आस यतो द्यावापृथिवी निष्टतक्षुः ।"** इस समस्या के समाधान स्वरूप ऋग्वेद में पुरुष सूक्त (10.90), हिरण्यगर्भ

सूक्त (10.121) तथा नासदीय सूक्त (10.129) सबसे महत्त्वपूर्ण सूक्त हैं।

पुरुष सूक्त के अनुसार पुरुष का शरीर ही मूल सामग्री है। वही उपादान कारण है, जिससे जगत् की उत्पत्ति हुई। भूत- भविष्य सब वह पुरुष रूप ही है- "**पुरुष एवेदं सर्वं यद्भूतं यच्च भव्यम् ।**"[iv] वह पुरुष इतना विशाल है कि पुरुष सूक्त के प्रथम मंत्र में ही यह कहा गया कि वह हजारों शीर्ष, हजारों नेत्र तथा हजार पैरों वाला है। वह इस भूमि को सब ओर से व्याप्त करके इससे भी दस अंगुली अधिक है- "**सहस्रशीर्षा पुरुषः सहस्राक्षः सहस्रपात्, स भूमिं विश्वतो वृत्वाऽत्यतिष्ठद्दशाङ्गुलम् ।।**"[v] उसकी शक्ति असीम है। समस्त दृश्यमान् जगत् उसका एक चरण है। उसके तीन चरण द्युलोक में हैं।

उस विराट् पुरुष से विराट् ब्रह्मांड उत्पन्न हुआ । पुरुष ही इस विराट् ब्रह्मांड का अधिष्ठाता है। यह विराट् ब्रह्मांड विस्तृत हुआ तो उसमें आकाश, भूमि आदि ग्रह उत्पन्न हुए । उसके पश्चात् उसमें रहने वाला प्राणी जगत् प्रसारित हुआ- "**तस्माद्विराळेजायत विराजो अधि पूरुषः । स जातो अत्यरिच्यत पश्चाद्भूमिमथो पुरः**"[vi]

पुरुष सूक्त में सृष्टि-रचना एक यज्ञ के रूप में वर्णित है। सृष्टि की रचना में देवताओं ने भी सहायता प्रदान की । इस यज्ञ में वसन्त ऋतु ने घृत अर्थात् घी का कार्य किया, ग्रीष्म ऋतु ने ईंधन का तथा शरद् ऋतु ने हवि का कार्य किया- "**यत्पुरुषेण हविषा देवा यज्ञमतन्वत । वसन्तो अस्यासीदाज्यं ग्रीष्म इध्मः शरद्धविः ।**"[vii] यज्ञ से सकल भोज्य पदार्थों का संपादन किया गया । उसके पश्चात् वायु में उड़ने वाले, अरण्य में रहने वाले तथा ग्राम में रहने वाले समस्त प्राणियों को बनाया ।

उस विराट् पुरुष के मन से चंद्रमा उत्पन्न हुआ । नेत्रों से सूर्य का उद्भव हुआ तथा मुख से इंद्र एवं अग्नि का जन्म हुआ । प्राणों से वायु उत्पन्न हुआ । नाभि से अंतरिक्ष हुआ । सिर से द्युलोक हुआ । पैरों से भूमि हुई । कानों से दिशाएं हुई- "**चन्द्रमा मनसो जातश्चक्षोः सूर्यो अजायत मुखादिन्द्रश्चाग्निश्च प्राणाद्वायुरजायत ।। नाभ्यो आसीदन्तरिक्षं शीर्ष्णो द्यौः समवर्तत । पद्भ्यां भूमिर्दशः श्रोत्रात् तथा लोकाँ अकल्पयन् ।।**"[viii]

पुरुष सूक्त का पुरुष उपनिषदों में ब्रह्म कहलाया तथा पुरुष सूक्त का यह विचार कि 'पुरुष ही जगत् है' उपनिषदों में विकसित हुआ ।

श्रीमद्भागवत पुराण जो कि पंचम वेद कहा जाता है, उसमें भी इसी प्रकार की सृष्टि रचना का वर्णन प्राप्त होता है। श्रीमद्भागवत पुराण में कहा गया है कि सृष्टि रचना से पूर्व एकमात्र वह परमात्मा ही था जोकि आत्माओं का भी आत्मा था । वह विभु अर्थात् सर्वव्यापी था । [ix] एकमात्र वही दृष्टा था, परंतु उसे कोई दृश्य दिखाई नहीं पड़ा - "**स वा एष तदा द्रष्टा नापश्यद् दृश्यमेकराट्** ।" [x] उस समय उसने स्वयं को असत् माना परंतु वस्तुतः वह असत् नहीं था क्योंकि उसकी शक्तियाँ ही सोई थी परंतु उसके ज्ञान का लोप नहीं हुआ था । इस दृष्टा की 'माया' नाम की एक सदसदात्मिका शक्ति हुई, जिसके द्वारा विभु परमात्मा ने विश्व का निर्माण किया- "**सा वा एतस्य संद्रष्टुः शक्तिः सदसदात्मिका । माया नाम महाभाग ययेदं निर्ममे विभुः ।।**[xi] यह त्रिगुणात्मिका माया जब कालवृत्ति से क्षोभ को प्राप्त हुई, तब पुरुष रूप परमात्मा ने उसमें बीज स्थापित किया ।[xii] तब काल की प्रेरणा से उस माया से महत् तत्त्व प्रकट हुआ । महत् तत्त्व से अहंकार की उत्पत्ति हुई । अहंकार तीन प्रकार का है- वैकारिक (सात्विक), तैजस (राजस) और तामस । वैकारिक अहंकार से मन तथा इंद्रियों के अधिष्ठाता देवता उत्पन्न हुए । तैजस अहंकार से ज्ञानेंद्रियों और कर्मेंद्रियों की उत्पत्ति हुई । तामस अहंकार से शब्द तन्मात्र उत्पन्न हुआ । शब्द से आकाश की उत्पत्ति हुई । भगवान् की दृष्टि जब आकाश पर पड़ी, तब आकाश से स्पर्श तन्मात्र उत्पन्न हुआ ।

स्पर्श तन्मात्र के विकृत होने पर उससे वायु की उत्पत्ति हुई । अत्यंत बलवान् वायु ने आकाश के सहित विकृत होकर रूपतन्मात्र की रचना की और उससे संसार का प्रकाशक 'तेज' उत्पन्न हुआ । फिर परमात्मा की दृष्टि पड़ने पर वायुयुक्त तेज ने काल, माया और चिदंश के योग से विकृत होकर रसतन्मात्र के कार्य 'जल' को उत्पन्न किया । तदनंतर तेज से युक्त जल ने ब्रह्म का दृष्टिपात होने पर काल, माया और चिदंश के योग से गंधगुणमयी 'पृथ्वी' को उत्पन्न किया ।[xiii] इन महाभूतों में पूर्व पूर्व उत्पन्न होने वाले महाभूत के गुण पश्चात् उत्पन्न होने वाले

महाभूतों में भी अनुगत समझने चाहिए ।[xiv] इस प्रकार भागवत पुराण में महत् से अहंकार, अहंकार से इंद्रियों की उत्पत्ति का वर्णन ठीक उसी प्रकार से किया गया है जिस प्रकार सांख्य दर्शन में । सांख्य दर्शन के अनुसार जगत् की रचना चेतन पुरुष एवं जड़ प्रकृति के संयोग से होती है। यह संयोग पंग्वन्ध न्याय से होता है। जैसे एक पंगु एवं एक नेत्रहीन व्यक्ति अकेले अपने गंतव्य तक पहुंचने में असमर्थ होने पर एक दूसरे की सहायता से अपने कार्य में सफल होते हैं। उसी प्रकार अकेली जड़ प्रकृति सृष्टि रचना नहीं कर सकती एवं अकेला चेतन सृष्टि रचना नहीं कर सकता । जब दोनों का संयोग होता है तब सृष्टि रचना होती है- "**पवन्धवदुभयोरपि संयोगस्तत्कृतः सर्गः** ॥"[xv] प्रकृति से महत्, महत् से अहंकार, अहंकार से सोलह तत्त्व । यह सोलह तत्त्व हैं- एकादश इंद्रियाँ (पांच ज्ञानेंद्रियाँ, पांच कर्मेंद्रियां और एक मन) तथा शब्द, स्पर्श, रूप, रस, गंध- यह पंच तन्मात्राएं । इन पंच तन्मात्राओं से पंचमहाभूत उत्पन्न होते हैं- **प्रकृतेर्महांस्ततोऽहङ्कारस्तस्माद्गणश्च षोडशकः । तस्मादपि षोडशकात्पञ्चभ्यः पञ्च भूतानि ।।**[xvi] इस प्रकार सांख्य दर्शन में पच्चीस तत्त्वों से यह जगत् बना है । सांख्य दर्शन और भागवत पुराण में मौलिक अन्तर यह है कि सांख्य दर्शन में ईश्वर के बिना ही सृष्टि की उत्पत्ति हो जाती है तथा भागवत दर्शन में सृष्टि की उत्पत्ति, स्थिति एवं लय सब कुछ ईश्वर पर आश्रित है।

भागवत पुराण के अनुसार ईश्वर के अतिरिक्त देवगण भी हैं, जो सृष्टि की उत्पत्ति में सहयोग प्रदान करते हैं। सृष्टि प्रक्रिया में वैकारिक अहंकार से जो चेतन अंश विशिष्ट इंद्रियों के अधिष्ठाता देवता उत्पन्न हुए, वे भगवान के ही अंश थे । परंतु पृथक् पृथक् रहने के कारण वे विश्व रचना करने में सफल नहीं हुए- इस प्रकार का उल्लेख भागवत में मिलता है । [xvii] तब उन्होंने हाथ जोड़कर भगवान् से कहा कि विभिन्न स्वभाव वाले होने के कारण हम आपस में मिल नहीं पाते अतः ब्रह्मांड की रचना करने में हम असमर्थ हैं।[xviii] तब सर्वशक्तिमान् भगवान् कालशक्ति को स्वीकार कर एक साथ ही महत् तत्त्व, अहंकार, पंचभूत, पंचतन्मात्र, मन सहित एकादश इंद्रियाँ - इन तेइस तत्त्वों के समुदाय में प्रविष्ट हो गए [xix] तथा उस तत्त्व समूह को

अपनी क्रियाशक्ति के द्वारा आपस में मिला दिया । तब इन तेइस तत्वों के समूह ने भगवान् की प्रेरणा से अपने अंशों द्वारा विराट पुरुष को उत्पन्न किया ।[xx] अतः भागवत पुराण के अनुसार विश्व रचना करने वाला महत् तत्त्व आदि का समुदाय एक दूसरे से मिलकर जिस परिणाम को प्राप्त हुआ वह परिणाम ही 'विराट् पुरुष' है, जिसमें समस्त चराचर जगत् विद्यमान है।[xxi] यह विराट पुरुष हिरण्यमय है जोकि जल के भीतर एक हज़ार वर्षों तक विद्यमान रहा - **"हिरण्मयः स पुरुषः सहस्रपरिवत्सरान्। आण्डकोश उवासाप्सु सर्वसत्त्वोपबृंहितः ॥"**[xxii] इस प्रकार के स्वर्णमयी अण्ड का वर्णन सर्वप्रथम ऋग्वेद के दशम मंडल के हिरण्यगर्भ सूक्त में प्राप्त होता है, जिसमें कहा गया है कि सृष्टि की उत्पत्ति हिरण्यगर्भ से हुई। सृष्टि से पूर्व सर्वत्र जल ही जल व्याप्त था। उस जल में एक बहुत बड़ा स्वर्णमयी अण्डाकार तत्त्व उत्पन्न हुआ, जो हिरण्यगर्भ कहलाया। सायण के अनुसार हिरण्यगर्भ के दो अर्थ हैं-

- "**हिरण्यमयस्य अण्डस्य गर्भभूतः प्रजापतिः हिरण्यगर्भः"** अर्थात् हिरण्यमय अण्डे का गर्भभूत प्रजापति । सरल शब्दों में- जो प्रजापति हिरण्यमय अण्डे में गर्भरूप में स्थित था। तैतरीय संहिता में भी कहा गया है- "**प्रजापतिर्वै हिरण्यगर्भः प्रजापतेरनुरूपत्वाय"**[xxiii]
- "**हिरण्यमयोऽण्डो गर्भवद्यस्योदरे वर्तते सोऽसौ सूत्रात्मा हिरण्यगर्भ इत्युच्यते"** अर्थात् सुवर्णमय अण्डा जिसके गर्भ में है ऐसा सूत्रात्मा हिरण्यगर्भ ।

इसी हिरण्यगर्भ से समस्त ब्रह्माण्ड की सृष्टि हुई । समस्त ब्रह्माण्ड उसके गर्भ में विद्यमान था । हिरण्यगर्भ के द्वारा आकाश उन्नत किया गया, पृथ्वी स्थिर की गई तथा स्वर्ग स्तब्ध किया गया । हिरण्यगर्भ के द्वारा ही सूर्य स्थापित किया गया । यही अंतरिक्ष में विद्युत का निर्माता भी है- **"येन द्यौरुग्रा पृथिवी च दृळहा येन स्वः स्तभितं येन नाकः । यो अन्तरिक्षे रजसो विमानः कस्मै देवाय हविषा विधेम ॥"**[xxiv] यह हिरण्यगर्भ स्वयं उस जल से उत्पन्न हुआ, जो सृष्टि से पूर्व सर्वत्र व्याप्त था- "**आपो ह यद् बृहतीर्विश्वमायन् गर्भं दधाना । ततो देवानां समवर्ततासुरेकः"**[xxv] यह हिरण्यगर्भ प्रजापति का पर्याय है। अतः हिरण्यगर्भ सूक्त के अनुसार प्रजापति इस संसार का कर्ता है।

ऋग्वेद के दशम मंडल में एक अन्य सूक्त है जिसमें सृष्टि की उत्पत्ति का वर्णन किया गया है वह है 'नासदीय सूक्त' । 'नासत्' शब्द से प्रारंभ होने के कारण इसे नासदीय सूक्त कहा जाता है। इसमें कहा गया है कि जब सृष्टि का आरंभ भी नहीं हुआ था, उस अवस्था में न सत् था, न असत् था । वस्तुतः यहाँ सत् और असत् का क्या अभिप्राय है- यह विवेचन का विषय है। इतना अवश्य है कि यह प्रलयावस्था थी जिसमें समस्त जगत् प्रपंच का अभाव हो गया था । "**अधुना ततः प्रागवस्था निरस्त-समस्त-प्रपञ्चा या प्रलयावस्था स निरूप्यते**"[xxvi]

सूक्त के पहले मन्त्र की पहली ही पंक्ति में कहा गया कि प्रलयावस्था में "असत् नहीं था"; सायण के अनुसार इसका अर्थ है कि प्रलयावस्था में इस जगत् का मूल कारण नहीं था । परंतु यह असत् 'शशशृंग' की भांति सत्ता से रहित नहीं था । क्योंकि इस प्रकार के असत् तत्त्व से सृष्टि की रचना नहीं हो सकती । आगे कहा गया है

कि उस समय "सत् भी नहीं था ।" सत् शब्द यहाँ 'कार्य' का वाचक है।[xxvii] वेंकट माधव के अनुसार भी असत् शब्द 'कारण' का वाचक है तथा सत् शब्द 'कार्य' का वाचक है। महाप्रलय की अवस्था में यह दृश्यमान कार्य-समूह तथा कारण-समूह कुछ भी नहीं था ।[xxviii] रज: अर्थात् पृथ्वी नहीं थी । यास्क रज: का अर्थ 'लोक' करते हैं। [xxix] पृथ्वी नहीं थी तो पृथ्वी के नीचे पाताल आदि लोक हैं- वह भी नहीं थे । व्योम अर्थात् अंतरिक्ष नहीं था । वेदों में अंतरिक्ष के ऊपर द्युलोक, सत्यलोक आदि लोक भी हैं।[xxx] प्रश्न उठता है कि क्या वहाँ पर प्रलयावस्था नहीं थी? सायण के अनुसार प्रलयावस्था में वह भी नहीं थे । इससे चौदह भुवन वाले ब्रह्मांड का स्वरूप से निषेध हो जाता है।[xxxi] जब ब्रह्मांड का निषेध हो गया, तो उस ब्रह्मांड को आवृत करने वाले आकाश आदि पंचभूत भी नहीं थे । ऐसी अवस्था में **गहन गंभीर जल** के होने की संभावना दिखाई गई है- "**अम्भः किमासीद् गहनं गभीरम् ।**" विज्ञान भी जल से भूमि की उत्पत्ति को स्वीकार करता है। यजुर्वेद की तैतरीय संहिता भी प्रलयावस्था में सब ओर जल होने की संभावना बताता है- "**आपो वा इदमग्रे सलिलमासीत् ।**" [xxxii]

इस प्रकार का प्रतिसंहार होने पर संहर्ता की अपेक्षा होती है। संहर्ता मृत्यु है परंतु अगले

ही मंत्र में कहा गया कि उस समय मृत्यु भी नहीं थी- "**न मृत्युरासीत् ।"** प्रश्न उठता है कि यदि मृत्यु नहीं थी तो उसके अभाव में क्या अमृतत्व था? उत्तर है "**अमृतं न तर्हि ।**" पुनः आशंका होती है कि सभी का आश्रयभूत 'काल' तो होगा; तो इस विषय में कहा गया "**न रात्र्या अह्न आसीत्प्रकेतः ।"** अर्थात् दिन और रात्रि का ज्ञान भी नहीं था । सातवलेकर के अनुसार इसका कारण है कि दिन और रात्रि के हेतुभूत सूर्य और चंद्रमा का भी अभाव था ।[xxxiii] इस अहोरात्र के निषेध से इससे संबंधित मास, ऋतु, संवत्सर आदि समग्र काल का निषेध हो गया । जब सब कुछ नहीं था, तब क्या था? इसका उत्तर है कि अपनी सृजनात्मक शक्ति से युक्त, बिना वायु के सांस ले रहा वह एक ही था ग्रिफिथ के शब्दों में "That One Thing, breathless. breathed by its own nature: apart from it was nothing whatsoever."[xxxiv] उस परम तत्त्व अथवा चैतन्य के अतिरिक्त किसी का अस्तित्व नहीं था- "**तस्माद्धान्यन्न परः किञ्चनासे ।"**

सृष्टि के पूर्व प्रलयावस्था में अज्ञान से आवृत गहन अंधकार था । सब ओर सलिल था । सातवलेकर सलिल का अर्थ 'जल' करते हैं। परंतु दुर्गाचार्य के अनुसार "**सलिलं सद्भावे लीनं सर्वमिदं जगत् सन्मात्रस्यैव भावस्योपरि लीनमासीत् ।"** यह सारा जगत् सद्भाव में लीन था । सायण भी सलिल का यही अर्थ लेते हैं। "**सृष्टेः प्राकृ प्रलयदशायां भूतभौतिक सर्व जगत्तमसा गूळ्हम्"** उस अज्ञान रूपी अंधकार से सब ओर जो यह विशाल जगत् छिपा हुआ था, वह तप की महिमा से उत्पन्न हुआ । मुंडकोपनिषद् में भी कहा गया है "**तपसा चीयते ब्रह्म ।**"[xxxv] तब सर्वप्रथम परमेश्वर के मन में सृष्टि को उत्पन्न करने की कामना उत्पन्न हुई "**एकोऽहं बहु स्याम प्रजायै ।**"

यह कामना ही जगत् की उत्पत्ति का प्रथम बीज रूप थी । अर्थात् कामना इसका प्रथम विकास थी जो चेतना का प्रथम बीज है। यह कामना ही उसका 'तप' कहलाई। तैतरीय आरण्यक में भी इसी सिद्धान्त का प्रतिपादन किया है **'सोऽकामयत बहु स्याँ प्रजायेयेति स तपोऽतप्यत् । स तपस्तप्तवेदं सर्वमसृजत यदियं कि च ।"** [xxxvi] वैदिक ऋषि यह कहता है कि कोई इस सृष्टि

की उत्पत्ति के बारे में वास्तव में जानता भी है या नहीं? **"को अद्धा वेद क इह प्रवोचत्कुत आजाता त इयं विसृष्टि: । अर्वाग्देवा अस्य विसर्जनेनाथा को वेद यत आ बभूव ।।"**[xxxvii] अर्थात् कौन सचमुच जानता है कौन यहाँ घोषणा कर सकता है कि यह विशिष्ट सृष्टि कहाँ से उत्पन्न हुई, कहाँ से आई ? इसकी सृष्टि के पश्चात् देवता उत्पन्न हुए पर कौन जानता है कि स्वयं इस उद्भव कहां से हुआ है ?

निष्कर्ष रूप में कहा जा सकता है कि परस्पर भिन्न होते हुए भी इन सूक्तों तथा सिद्धांतों के अनुसार सृष्टि का कर्ता एक ही है जिसका अंश प्रकृति की प्रत्येक वस्तु में विद्यमान है। इस शक्ति को पुरुष, हिरण्यगर्भ या प्रजापति आदि किसी भो नाम से पुकारें अन्ततोगत्वा ये सब उसी एक शक्ति के विभिन्न रूप हैं। जैसा कि ऋग्वेद में कहा गया है-

"इन्द्रं मित्रं वरुणमग्निमाहुरथो दिव्यः स सुपर्णो गरुत्मान् ।

एक सद्विप्राः बहुधा वदन्यग्निं यमं मातरिश्वनमाहुः ॥[xxxviii]

इस सर्वशक्तिमान ने अपनी माया से सृष्टि की रचना की इस सृष्टि रचना का एक निश्चित नियम है जिसका पालन किया गया तब ही प्रत्येक प्रलय के पश्चात पुन्हा उसी प्रकार की।

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[1] [1] "यागादिरेव धर्म:" अर्थसंग्रह

[2] [ii] निरुक्त यास्क द्वारा किया गया 'देव' शब्द का निर्वचन

[3] [iii] कृष्ण यजुर्वेद की तैतरीय संहिता भाष्य भूमिका

[4] [iv] ऋग्वेद संहिता पुरुष सूक्त (10.90) का द्वितीय मंत्र पूर्वार्ध

[5] [v] वही प्रथम मंत्र

[6] [vi] वही, पंचम मंत्र

[7] [vii] वही, मंत्र 6

[8] [viii] वही मंत्र 13-14

[9] [ix] भगवानेक आसेदमग्र आत्माऽऽत्मनां विभुः । भागवत पुराण 3.5.23 पूर्वार्ध

[10] [x] भागवत पुराण 3.5.24 पूर्वार्ध

[11] [xi] भागवत पुराण 3.5.25

[12] [xii] कालवृत्त्या तु मायायां गुणमय्यामधोक्षजः । पुरुषेणात्मभूतेन वीर्यमाधत्त वीर्यवान् ॥ भागवत पुराण 3.5.25

[13] [xiii] भागवत पुराण 3.5.27-35

[14] [xiv] भूतानां नभादीनां यद्यद्भव्यावरावरम्। तेषां परानुसंसर्गाद्यथासंख्यं गुणान् विदुः ॥ भागवत पुराण 3.5.36

[15] [xv] सांख्यकारिका, कारिका 21 उत्तरार्ध

[16] [xvi] सांख्यकारिका, कारिका 22

[17] [xvii] भागवत पुराण 3.5.37

[18] [xviii] भागवत पुराण 3.5.47

[19] [xix] वही, 3.6.1-2

[20] [xx] वही, 3.6.4

[21] [xxi] वही, 3.6.5

[22] [xxii] वही, 3.6.6

[23] [xxiii] तैतरीय संहिता 5.5.12

[24] [xxiv] ऋग्वेद, हिरण्यगर्भ सूक्त (10.121) मंत्र 5

[25] [xxv] वही मंत्र 7

[26] [xxvi] नासदीय सूक्त के प्रथम मंत्र पर सायण भाष्य

[27] [xxvii] तदानीं प्रलयदशायामवस्थितं यदस्य जगतो मूलकारणं तदसच्छशविषाणवन्निरुपाख्यं नासीत् । न हि तादृशात्कारणादस्य सतो जगत उत्पत्तिः सम्भवति। सायण भाष्य

[28] [xxviii] .....महाप्रलयावस्थायाम् असच्छब्दः कारणवचनः। सच्छब्दः कार्यवचनः ।अयं परिदृश्यमानः कार्यवर्गः कारणवर्गश्च न अभूत्। ऋग्वेद 10.129 पर वेंकट माधव का भाष्य

[29] [xxix] लोका रजांस्युच्यन्ते। निरुक्त 4.19

[30] [xxx] विष्णु पुराण के अनुसार लोकों की संख्या 14 हैं पृथ्वी से आरंभ करते हुए 7 लोक ऊपर हैं और 7 नीचे। पृथ्वी के ऊपर के लोक हैं- भूर्लोक, भुवर्लोक, स्वर्लोक, महर्लोक, जनलोक, तपोलोक और ब्रह्मलोक। पृथ्वी के नीचे वाले लोक हैं- अतल, वितल, सतल, रसातल, तलातल , महातल और पाताल।

[31] [xxxi] परो व्योम्नः परस्तादुपरिदेशे द्युलोकप्रभृति सत्यलोकान्तं यदस्ति तदपि नासीदित्यर्थः । अनेन चतुर्दशभुवनगर्भं ब्रह्माण्डं स्वरूपेण निषिद्धं भवति ।

[32] [xxxii] तैतरीय संहिता 7.1.5.1..

[33] [xxxiii] ऋग्वेद संहिता, हिंदी अनुवाद, संपादक सातवलेकर

[34] [xxxiv] ऋग्वेद संहिता, अंग्रेजी अनुवाद पीएच ग्रिफिथ मोतीलाल बनारसीदास प्रकाशित

[35] [xxxv] मुंडकोपनिषद् 1.8

[36] [xxxvi] तैतरीय आरण्यक 8.6

[37] [xxxvii] ऋग्वेद, नासदीय सूक्त, मंत्र 6

[38] [xxxviii] ऋग्वेद 1.164.36

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