PEER REVIEWED JOURNAL

Volume 15, Issue 2, 2024 ISSN: 0976-4518

INTERNATIONAL JOURNAL ON BIOLOGICAL SCIENCES

Published by

NATIONAL ENVIRONMENTAL SCIENCE ACADEMY

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International Journal on Biological Sciences

Volume - 15 | Issue : 2 | July-December, 2024

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International Journal on Biological Sciences

Volume - 15 | Issue : 2 | July-December, 2024

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International Journal on Biological Sciences

International Journal on Biological Sciences 15 (2), July-December 2024, Pp. 77-79
ISSN No.: 0976-4518
https://doi.org/10.53390/IJBS.2024.15201

PHYSICO-CHEMICAL ASSESSMENT OF GROUNDWATER OF THE NORTHERN PART OF BUDHI GANDAK AREA AKBARPUR IN MUSHAHARI BLOCK MUZAFFARPUR DISTRICT, BIHAR

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Review Paper

Received: 20.6.2024 Revised: 05.07.2024 Accepted: 16.07.2024

ABSTRACT

During investigation, carried out the quality of water sample from tube wells at different places besides the said area Akbarpur in Mushahri Block Muzaffarpur District of Bihar state during June 2017 to May2018. Parameters such as pH, TDS, DO, EC, alkalinity, total hardness Ca, Mg, Po_4---, No_3-, So_4– and arsenic have been studied. Some samples exceeded the maximum permissible limit of TDS and Iron also according to medical science. Another water samples along Budhi Gandak area under examination which even exceeded the maximum permissible level. Arsenic contamination in the ground water of this belt is a serious concern about human health.

No. of Pages: 3 **References: 7**

Keywords: Budhi Gandak Area, Physico-chemical Parameters, Groundwater Quality, Tube wells.

INTRODUCTION

Water is essential for survival of all living organisms. Survival of human drinking water is life sustaining. Its' needed for metabolic processes and serving as a solvent for body solutes. Water is normally polluted by the activities of creatures. Nature disaster such as storms, earthquake and volcanoes also causes changes in water quality and the ecological standard of water. Ground water pollution is harder to recognize until after illness has occurred.

It has been recognized that water pollution is the vital cause of deaths and diseases, and that it concerns for death of more than 5 to ten people in this area. Testing of water samples regularly is the only way to be ensured that the groundwater is not contaminated.

In continuation of my work at 4-8 locations, I have, in the present research, studied quality of water samples from tube wells at different locations including the Akbarpur of Budhi Gandak area in Mushahari Block, Muzaffarpur of Bihar during the experimental year 2017-18 with respect to water quality Parameters, such as, total hardness, Ca, Mg, Po_4---,No_3-, So_4-- and Arsenic (Acharya, S.K., 2005) and as besides several Physico- chemical parameters such as pH, TDS, DO, EC, alkalinity and chloride comparisons have been made with a series of national and International standards for drinking water.

MATERIALS AND METHOD

Water samples were collected from 4 sites of different regions besides Akbarpur Budhi Gandak area from Mushahari from June 2017 to May 2018 in side District. The samples were collected in cleaned glass jar with necessary precautions. The pH and DO were measured at the sampling sites. The other parameters like total hardness, Ca, Mg, Po_4---,No_3-, So_4-- and

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arsenic were calculated by using standard method by me to determine the physico-chemical and metal parameters. Several informations are available on the Physico-chemical parameters of groundwater in India (APHA, 1996., Trivedi, R.K. & Goel P.K., 1984).

Table 1: Physico-chemical parameter of groundwater of Tube wells.

S.No.	Parameters Physico-chemical	June To August 2017	September To Nov 2017	December2017 To Feb 2018	March To May 2018
1	pH	7.54	7.12	7.00	6.76
2	DO	6.1	5.3	4.8	4.2
3	TDS	930	690	780	290 mg/L
4	EC	1560	750	650	1620
5	Alkalinity	211	190	154	120 mg/L
6	Ca	76	47	55	105
7	Mg	45	40	30	50
8	Phosphate	.173	.157	.160	.184
9	Sulphate	1.11	0.94	1.58	1.48
10	Nitrate	.26	.20	.15	.23
11	Arsenic	.006	.008	.009	.007

RESULT & DISCUSSION

In the course of research, marked variations were seen in water quality. The analysis of the ground water quality parameters revealed that there was wide variation in range of pH, Do, TDS, Ec, alkalinity along with total hardness, Ca, Mg, Po_4---,No_3-, So_4-- and arsenic .

The pH of ground water is indicator of it's' quality. Study area of pH value varied from 6.76 to 7.54. Values of the samples under examination are under the limits of Bureau of Indian Standards for all type of uses.

D.O. range shown in this work is 6.1 to 4.2 ppm. It was observed that dissolved oxygen in G. water is never a stress point. D.O. depends upon the dissolved organic matter.

TDS occurs due to large amount of fine clay particles or organic debris in the ground water. Its' range found in the research are 930 to 290 mg/L.

The presence of carbonates, bicarbonates and hydroxides is the main cause of alkalinity in natural water. The alkalinity value in the ground water varied from 154 to 211 mg/L.

When water goes through sand, soil and rock, it contains very small amounts of minerals and holds them in solution. Magnesium and calcium dissolved in water which makes water hard along with their carbonates, sulphates and chlorides in groundwater. Total hardness in the present research is varied.

CONCLUSION

Physico-chemical properties shown in this research revealed that the groundwater of Akbarpur in Mushahari block indicates the presence of ionic concentrations. Here some samples show high content of TDS which may cause aesthetic problems and other physic-chemical parameters which are well within the respective maximum limits. Arsenic is found in permissible limits in which one sample is a matter of deepest concern and is a potential health risk of the local residents.

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International Journal on Biological Sciences

International Journal on Biological Sciences 15 (2), July-December 2024, Pp. 80-88
ISSN No.: 0976-4518
https://doi.org/10.53390/IJBS.2024.15202

PRELIMINARY STUDY ON GREEN SYNTHESIS OF SILVER NANOPARTICLES USING CELL-FREE MICROALGAL EXTRACT

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Research Paper

Received: 28.7.2024 Revised: 10.08.2024 Accepted: 22.08.2024

ABSTRACT

Green synthesis of silver nanoparticles using microalgal suspension has been carried through bottom-up approach using silver nitrate as a precursor. Synthesis of Silver nanoparticles was observed by visual analysis followed by characterization using UV-Visible Spectroscopy. SPR spectra recorded were in range of 500-520 nm.However, comparatively sharp peaks at lower $AgNO_3$ concentration (0.1 mM) were obtained that could offer higher homogeneity whereas broad or flat peaks obtained at higher $AgNO_3$ concentration (0.5 mM and 1mM) indicates poly dispersed AgNPs. Thus, at preliminary level screening, lower silver nitrate concentration favours synthesis of silver nanoparticles.

No. of Pages: 9 **References: 28**

Keywords: Nanoparticles, Microalgal Suspension, Surface Plasmon Resonance and UV-Visible Spectroscopy.

INTRODUCTION

Nanotechnology plays an important role in design, synthesis and manipulation of nanoparticles, nanowires, and nanomaterials in the range between 1-100nm in dimension (Jain *et al.* 2009; Senthilkumar *et al.* 2015). Nanoparticle can be metallic, ceramic, polymeric, semiconductor, fullerenes and lipid based (Khan *et al.* 2017). Different metallic nanomaterials are being produced using copper, zinc, titanium, magnesium, gold, alginate and silver (Dubchak*et al.* 2010; Hasan. S, 2015). Materials developed in the nanoscale range were applied in different fields such as solar energy conversion, catalysts, medicine, and water treatment (Henglein, 1993).

There are various methods available for the synthesis of different types of nanoparticles by chemical, physical and biological means (Vanaja *et al.* 2013). According to Soleimani and Pirkoohi, (2017) these methods, though effective in producing metal nanoparticles suffer limitations due to environmental and health considerations (Edison *et al.* 2012). Therefore, biosynthesis of nanoparticles using microorganisms, enzymes, and plant extracts has emerged as a clean, cost-effective and efficient alternative to chemical methods (Ahmed *et al.* 2016). For the synthesis of AgNPs, biological methods are both economical and environmentally benign (Dhuper*et al.* 2012). Compared to other physiochemical synthesis, biogenic synthesis has a well-defined size, shape, and morphology and is free of contamination (Kumar *et al.* 2017). Vijayaraghavan (2010) asserts that slower kinetics of biologically synthesised nanoparticles provide more control over crystal formation and cheaper manufacturing costs (Aziz *et al.* 2014). Numerous researchers have shown the use of microalgal solution in the biological production of silver nanoparticles. Microalgae are regarded as cell factories for nanoscale particle

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production because of their rapid development and high biomass output in a short duration of time during culture (Ahmad *et al.* 2011; Mata *et al.* 2010).

In the present investigation, efforts have been made to synthesize Silver nanoparticles using microalgal suspension. Literature survey confirms the presence of secondary metabolites like Phenols (Jacob *et al.* 2007), Flavonoids (Sahu*et al.* 2016), Tannins (Soliwoda*et al.* 2017), Saponins (Geethalakshmi*et al.*2013), Vitamins (Qin *et al.*2010), Amino acids (Shankar *et al.* 2015) etc. Research studies showed that biomolecules, proteins and peptides present in Algae are mainly responsible for the formation and stabilization of AgNPs (Sharma *et al.* 2015). According to Ebrahiminezhad*et al. (*2016), proteins present in cell extract of *Chlorella vulgaris* were involved in the biosynthesis by providing dual function in reduction and shape-controlling of the synthesized AgNPs (Xie*et al.* 2007). The study aims to evaluate the synthesis of Silver nanoparticles (AgNPs) at different dilutions of cell free micro algal extract using different concentrations of $AgNO_3$ as Precursor and to characterize the synthesized Silver nanoparticles at the level of Preliminary screening (Optical properties).

MATERIALS AND METHODS

Chemicals/Reagents

All the chemicals/reagents used in the present study were of analytical grade. Triple distilled water was used to prepare microalgal nutrient media.

Preparation of Cell free Microalgae extract

Microalgae cultures [Consortia of *Chlorella sp., Scenedesmus sp., and Cosmarium spp.;* maintained in BBM medium (Nichols and Bold, 1965) under 16/8-hr light/dark cycle and 3000 lux intensity at 25 ± 1°C temperature (Shaker *et al.* 2017) were procured from departmental Algal Biotechnology laboratory. Microalgae culture was centrifuged at 10,000 rpm for 10 mins and pellets were discarded. The resulting supernatant was collected in eppendorf tubes and filtered twice with Whatman filter paper No.1 to eliminate any physical contaminants and stored at 4°C.

Sunlight-induced biological synthesis of silver nanoparticles

Silver nanoparticles (AgNPs) were synthesized by solution-based photo-irradiated biologically inspired reduction process (Fig. 1). Silver Nitrate was used as precursor and cell free microalgal suspension as reducing agent. In general, the synthesis of colloidal silver nanoparticles involved simple aqueous phase mixing of Precursor (AgNO3) with Reducing agent (microalgal suspension). Experiments were designed to study the effect of micro algal suspensions (1:5 & 1:10 dilutions) on synthesis of Silver Nanoparticles at different concentrations of Silver nitrate (0.1, 0.5 & 1 mM) (Table 1). Govindaraju*et al.* (2009) conduct extracellular Synthesis of Silver Nanoparticles by a Marine Alga, *Sargassum wightii* at 1:10 dilutions with 1mM AgNO3 solution. The synthesis of silver nanoparticles was carried out at different concentrations of precursor and reducing agent at variable exposure time in order to optimize the reaction parameters for better understanding and maximizing the yield of silver nanoparticles (Phatak and Hendre, 2015). The reduction reaction was carried out in presence of sunlight. The reaction mixtures were placed in direct sunlight on bright sunny days (March to June, 2018 at Institute's premises). The maximum and minimum temperature throughout the study was recorded as 45 °C and 28 °C respectively. The variation in light intensity was monitored after every 10 mins of interval throughout the experiment and recorded between ≈60,000 to ≈1, 10,000 Lux using Digital Lux Meter. The reaction time was extended up to 180 mins and observations were recorded after periodic time intervals (i.e. 20, 40, 60, 90, 120, 150, 180 mins) using UV-Vis spectrophotometer (ELICO SL-150) in order to record the SPR and to characterize the AgNPs. All the experiments were conducted in a completely randomised design, in duplicates. Mean ± Standard error was computed from raw data.

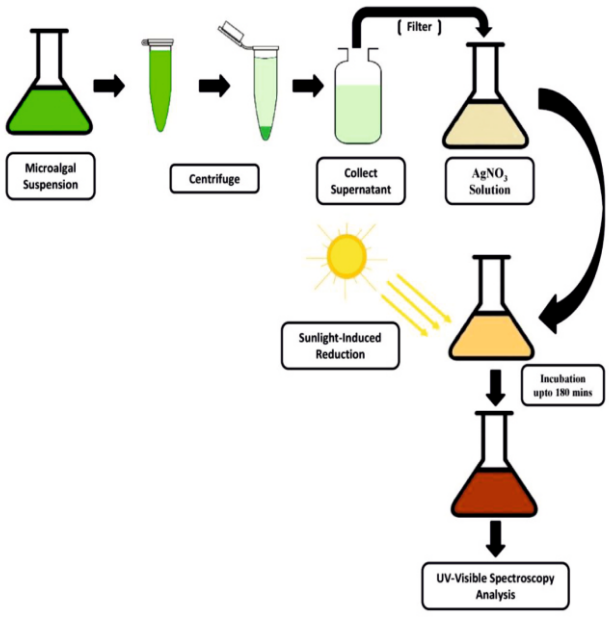

Fig 1: Schematic diagram of sunlight-mediated biological synthesis of AgNPs.

Table1: Experimental design:

Sample	Precursor	Microalgal Suspension Dilution
A_1	$AgNO_3$ (0.1mM)	1:5
A_2	$AgNO_3$ (0.1mM)	1:10
A_3	$AgNO_3$ (0.5mM)	1:5
A_4	$AgNO_3$ (0.5mM)	1:10
A_5	$AgNO_3$ (1mM)	1:5
A_6	$AgNO_3$ (1mM)	1:10

*All the treatments were performed in duplicates.

RESULTS & DISCUSSION

Observation of Colour Change

The preliminary analysis is the colour identification of the reaction mixture that confirms the synthesis of nanoparticles which is based on their optical properties for e.g., formation of characteristic brown colour indicates the synthesis of silver nanoparticles, and the acquired colour change is due to excitation of Surface Plasmon Resonance of metallic nanoparticles (Paulkumar*et al.* 2014). In the present investigation, the colour development from colourless to various shades of brown has been observed. Variations in colour of the reaction mixtures could be due to the active biochemical components present in the cell free extract of microalgal consortium. Experimental treatments performed at 0.1 mM $AgNO_3$ concentration, 1:5 (A_1) and 1:10 (A_2) dilution showed change in colour from colourless to light brown in 20 minutes of reaction time and further with the progress of reaction, not much significant colour development has been observed **(Fig. 8 &9)**. Treatments performed at 0.5 mM $AgNO_3$ conc., 1:5 (A_3) &1:10 (A_4) and at 1 mM $AgNO_3$ conc., 1:5 (A_5) & 1:10(A_6) showed distinct dark brown colours within 20 minutes of exposure time, thus indicates rapid synthesis of AgNPs **(Fig. 10 to 13)**.

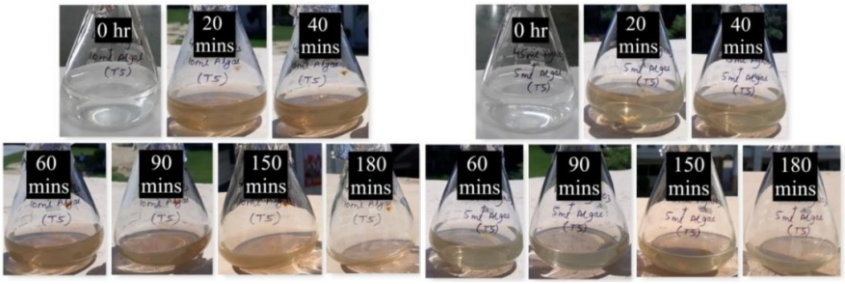

Fig 2: 0.1 mM $AgNO_3$ at 1:5 Broth Dilution (S_1) **Fig 3: 0.1 mM $AgNO_3$ at 1:10 Broth Dilution (S_2)**

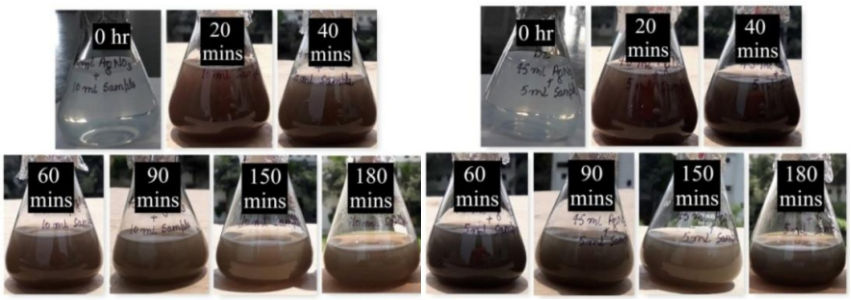

Fig 4: 0.5 mM $AgNO_3$ at 1:5 Broth Dilution (S_3) Fig 5: 0.5 mM $AgNO_3$ at 1:10 Broth Dilution (S_4)

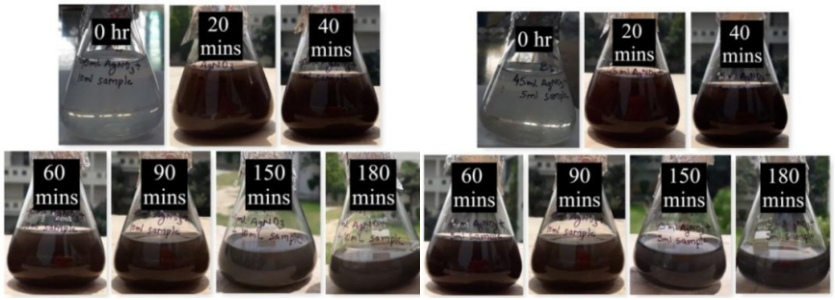

Fig 6: 1mM $AgNO_3$ at 1:5 Broth Dilution (S_5) Fig 7:1mM $AgNO_3$ at 1:10 Broth Dilution(S_6)

In a similar study on AgNPs synthesis using cell-free extract of *Brevundimonas spp*., Rajamanickam*et al.* (2013) observed appearance of dark brownish yellow colour indicating the synthesis of silver nanoparticles. Sharma *et al.* (2015) also observed appearance of dark brown colour of solution as an indicator of silver nanoparticles synthesis using cell free aqueous extracts of *S. platensis*. Visual observation of colour change in aqueous solution can also provide information about the size of synthesized AgNPs i.e., the smaller sized AgNPs results greater shift in colour towards red (Vadlapudi and Amanchy, 2017). However, observations leading to the growth and morphology of Silver nanoparticles need further investigations like SPR analysis, bandwidth analysis, etc.

Effect of Cell-free Microalgal Suspension and Silver nitrate concentrations on Synthesis of Silver Nanoparticles (AgNPs):

Green Synthesis of Silver nanoparticles (AgNPs) carried out using cell-free microalgal extract under sunlight as a reducing agent. The concentrations of Microalgal Suspensions were diluted at 1:5 & 1:10 in aqueous solution of $AgNO_3$ and reduction reaction was carried out in sunlight with periodic stirring. Continuous stirring facilitates availability of desired sites for developing silver nanoparticles (Raza *et al.* 2016). The reaction time was extended up-to 180 mins and observations were recorded periodically after 20 mins of intervals. The spectral data was recorded using UV-Vis spectrophotometer. The photo-irradiation based reduction was carried out based on the preliminary survey. Patel *et al.* (2015) in his study on different cell free microalgal and cyanobacterial cultures, observed AgNPs synthesis in light but not in dark. The Experimental design included variable concentrations of Silver nitrate (0.1, 0.5 and 1 mM) with Microalgal suspensions (1:5 and 1:10 dilutions). Total of 6 experiments were performed in duplicates (A_1 to A_6).

Observation of SPR spectra showed rapid synthesis (within 20 mins) of Silver nanoparticles in all the treatment samples (Fig 8-13). SPR spectra recorded were in the range of 500-520 nm. Variation in SPR peaks in different treatment samples indicates AgNPs of variable sizes and morphology. In treatment sample A_1 (0.1 mM $AgNO_3$, 1:5 broth dilution), peak sharpening increase with the time and maximum absorption was recorded after 180 mins of exposure time (Fig 8). There was not much variation in absorption values recorded after 40 mins of reaction time in treatment sample A_2 (Fig 9). After 20 mins of reaction, comparatively sharp peak was recorded in treatment sample A_4 (Fig 11) than A_3 (Fig 10) was observed. Experimental treatments A_5 and A_6 showed flat peaks, however maximum absorption was recorded after 20 mins of reaction in both the samples (Fig 12 & 13).

Overall, cell free microalgal suspension has played significant role in AgNPs synthesis, as rapid reduction was observed in all the treatment samples. Mi-Kyung and Jeune (2009) in his work on biochemical pool shifts analysis in *Chlorella ovalis* (cultured under different media composition) using FT-IR recorded the presence of carbohydrates, proteins, and lipid through functional group analysis. According to Mahdieh*et al.* (2012), presence of cellular reductases in *Spirulina platensis* is responsible for the synthesis of Silver Nanoparticles. Phenolic compounds present in plant extracts can be effective for the bio-reduction of silver ions to AgNPs (Bahararaet *al.* 2015). Sivathanu*et al.* (2011), reported presence of bioactive compounds such as alkaloids, flavonoids, carotenoids, saponins, fatty acids, amino acids and carbohydrates in organic solvent extracts of green algae *Chlorococcumhumicola*. Makarov *et al.* (2014) underlined the role of biomolecules (like different classes of flavonoids such as flavonols, flavones, flavanones, isoflavonoids, etc.) in nanoparticle synthesis. These bioactive molecules have various functional groups which can actively chelate and reduce metal ions into NPs through tautomeric transformations of flavonoids (Makarov *et al.* 2014).

Microalgal broth conc. doesn't affect peak intensity significantly. However, comparatively sharp peaks at lower $AgNO_3$ conc. (0.1 mM) was obtained that could offer higher homogeneity whereas broad or flat peaks obtained at higher $AgNO_3$ conc. (0.5 mM and 1mM) indicates poly-dispersed AgNPs. Jena *et al.* (2014) observed increase in peak intensity with increase in exposure time and suggested poly dispersed and aggregated AgNPs (SPR 430 nm) obtained from raw extract of *Scenedesmus* microalgae at 5 mM concentration of $AgNO_3$.

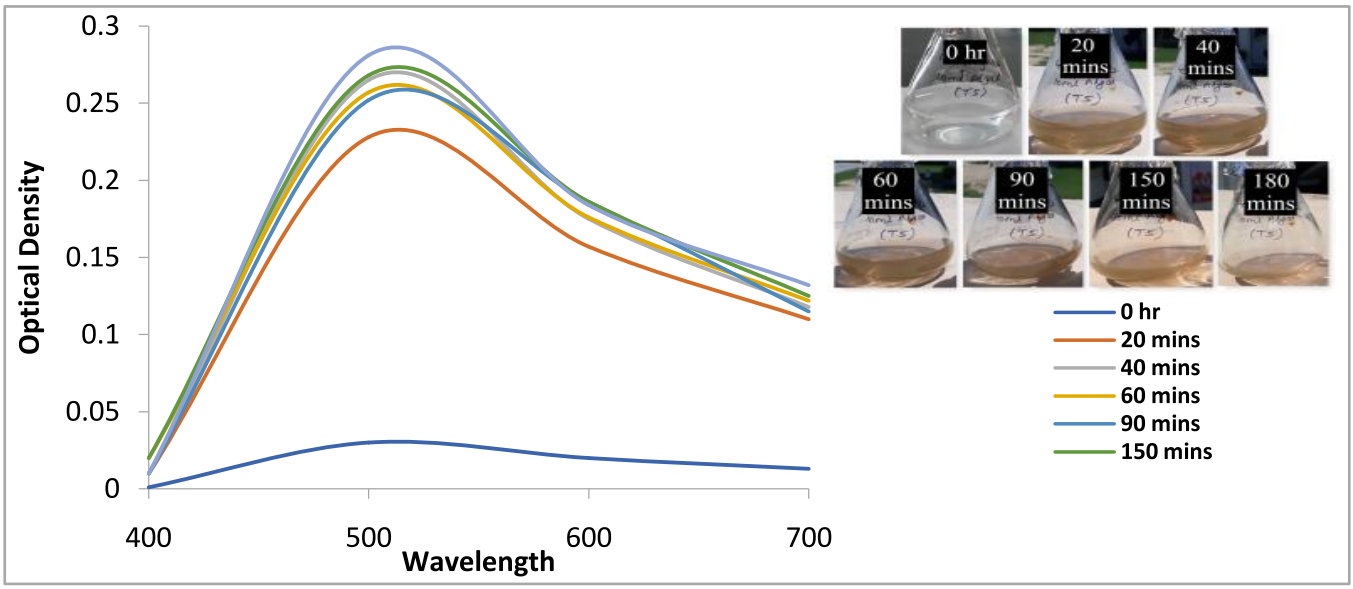

Fig 8: Visible spectra of Silver colloids at 0.1 mM $AgNO_3$ and 1:5 microalgal suspension dilution.

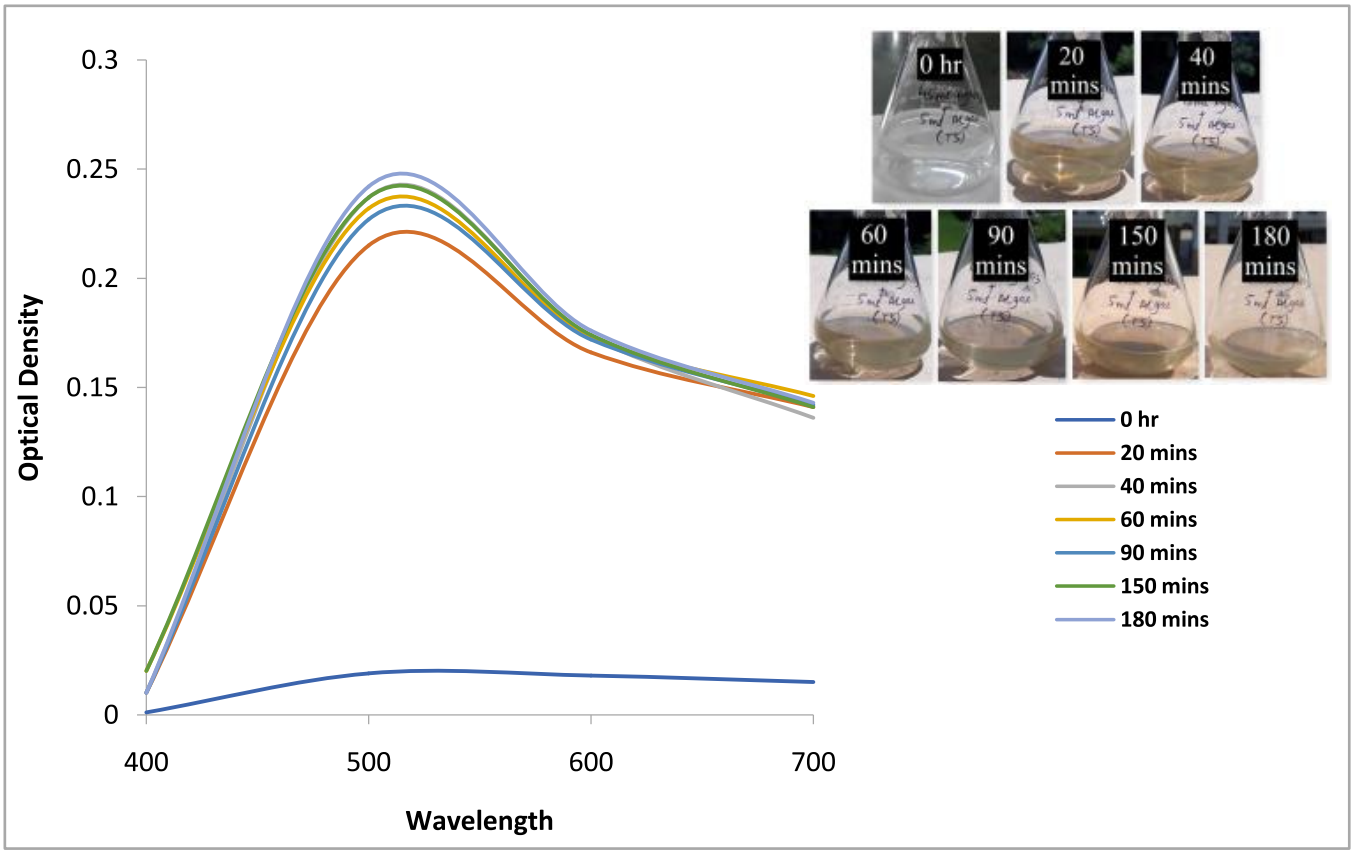

Fig 9: Visible spectra of Silver colloids at 0.1 mM $AgNO_3$ and 1:10 microalgal suspension dilution.

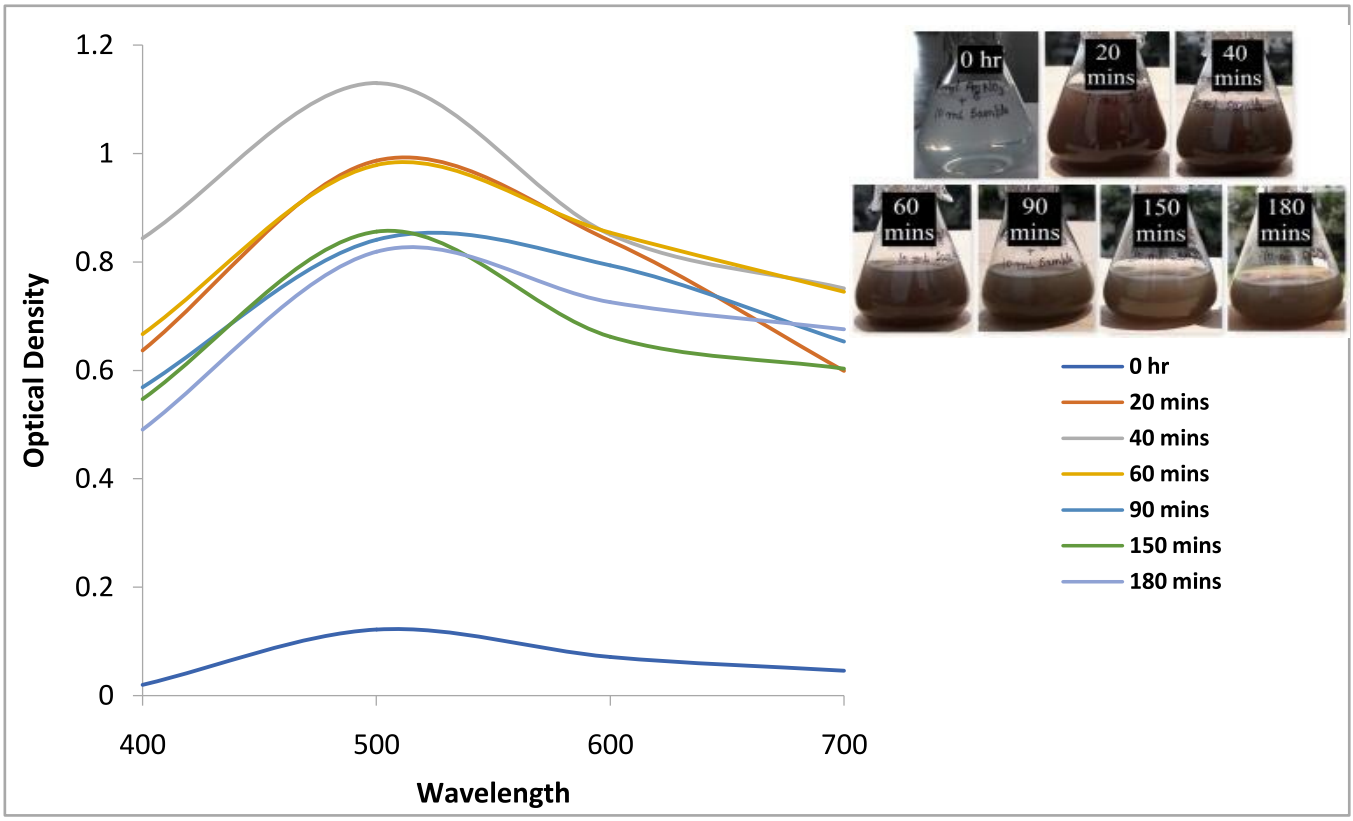

Fig 10: Visible spectra of Silver colloids at 0.5 mM $AgNO_3$ and 1:5 microalgal suspension dilution.

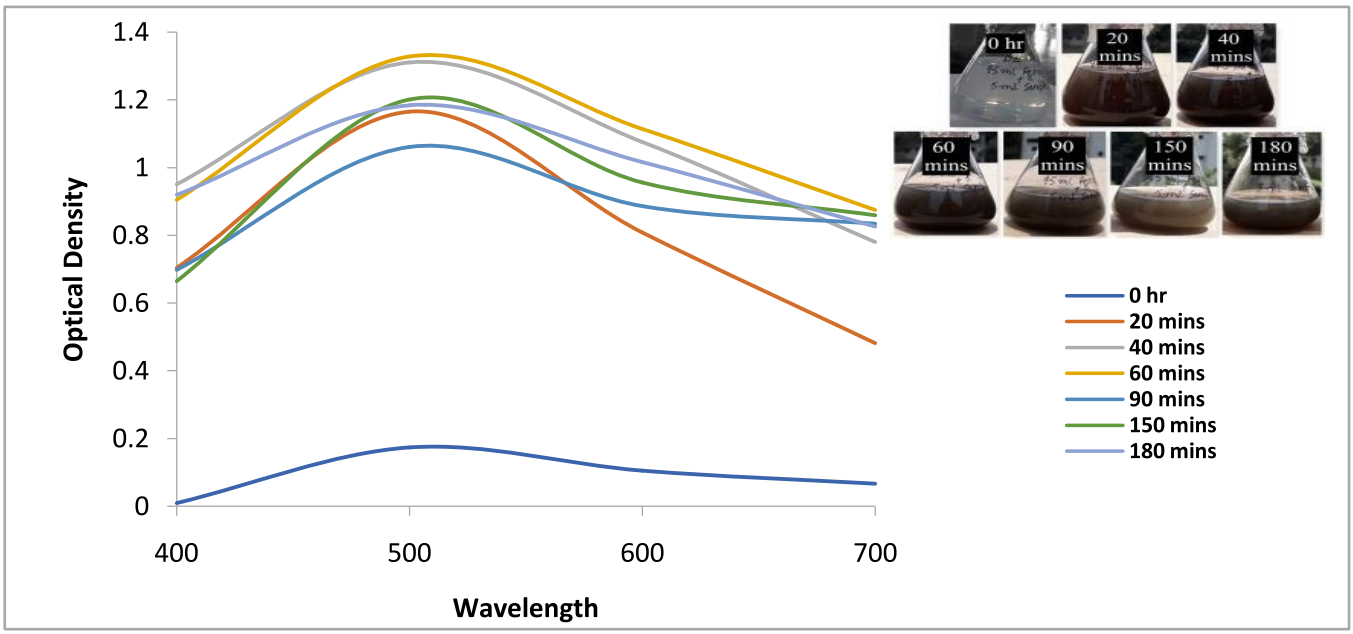

Fig 11: Visible spectra of Silver colloids at 0.5 mM $AgNO_3$ and 1:10 microalgal suspension dilution.

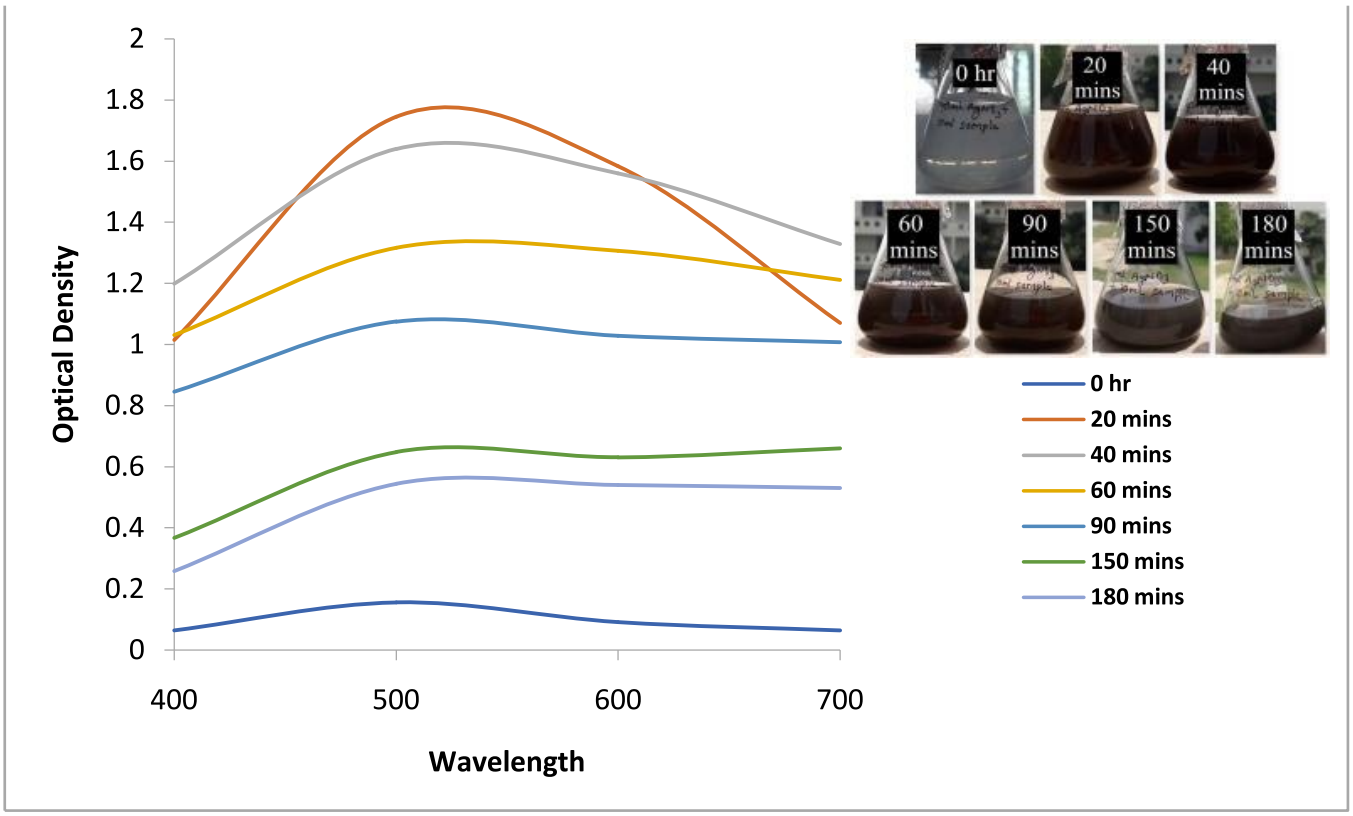

Fig 12: Visible spectra of Silver colloids at 1 mM $AgNO_3$ and 1:5 microalgal suspension dilution.

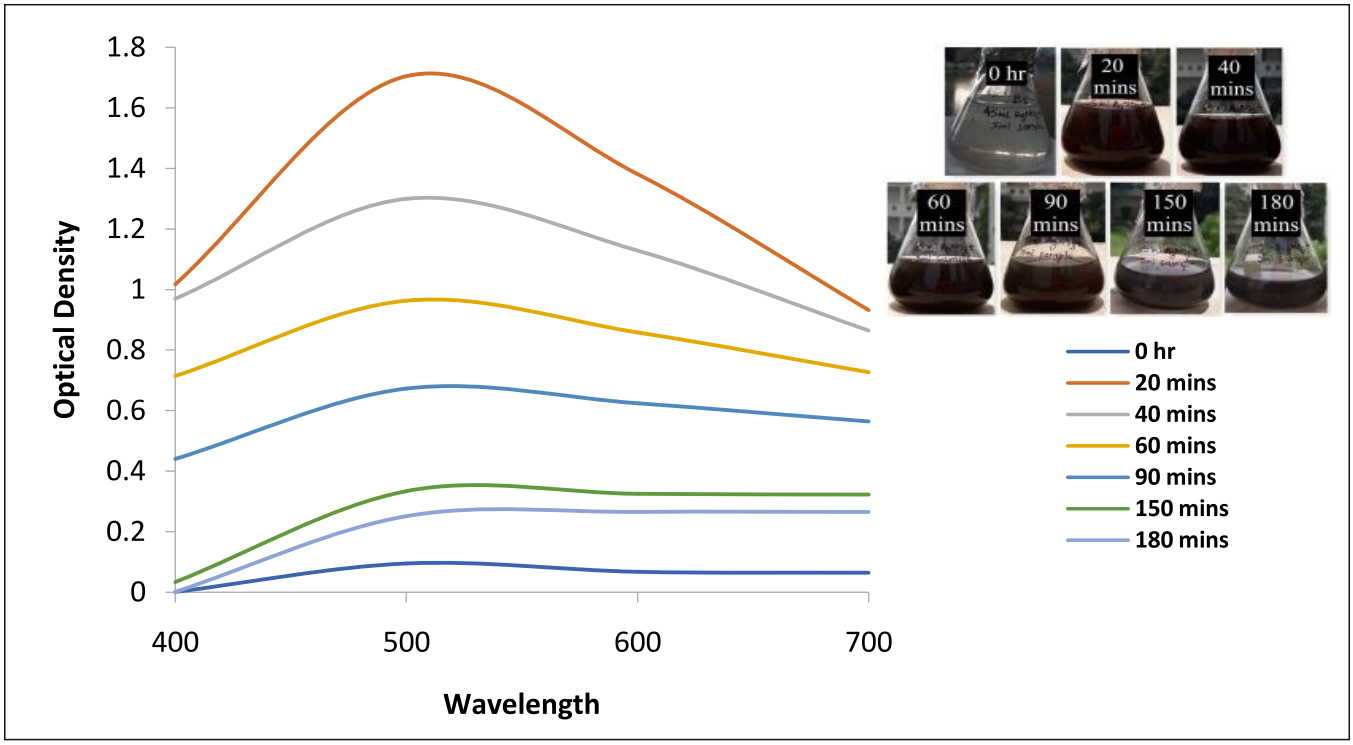

Fig 13: Visible spectra of Silver colloids at 1 mM $AgNO_3$ and 1:10 microalgal suspension dilution.

CONCLUSION

Algae are considered as an important source of carbohydrates, protein and lipids (Vincy*et al.* 2017). The use of algae in the synthesis of NPs has encouragd the designing of simple, green, cost and time effective approaches thereby, minimizing the use of chemicals and solvents (Vincy*et al.* 2017). In the present investigation, efforts have been made to synthesize silver nanoparticles in sunlight using Silver Nitrate used as precursor, cell free microalgae consortium as reducing agent and stabilizing agent. Visual analysis followed by UV-Vis Spectra results showed that the concentration of microalgal suspension and $AgNO_3$ plays a significant role in synthesis of silver nanoparticles. Observation of SPR spectra confirmed rapid synthesis of silver nanoparticles in all the treatment samples **(Fig 8-13)**. SPR spectra recorded were in the range of 500-520 nm. Although, cell free microalgal suspension has played significant role in AgNPs synthesis, as rapid reduction was observed in all the treatment samples but, microalgal broth conc. doesn't affect peak intensity significantly. However, comparatively sharp peaks at lower $AgNO_3$ conc. (0.1 mM) were obtained that could offer higher homogeneity whereas broad or flat peaks obtained at higher $AgNO_3$ conc. (0.5 mM and 1mM) indicates polydispersed AgNPs.

However, further studies pertaining to size, shape and distribution coupled with stabilization under variable conditions like stabilizing agents, different precursors, oxidizing agents, reaction time, pH, temperature, etc., to optimize the controlled synthesis of silver nanoparticles must be recommended.

ACKNOWLEDGEMENTS

The authors acknowledge the support of Director, Mewar Institute of Management, Ghaziabad affiliated to Choudhary Charan Singh University, Meerut, India for executing this research work. The authors are sincerely thankful to the staff and faculty of CCSU, Meerut, India for providing the continuous support for conducting the experiment.

DECLARATION

CONFLICT OF INTERESTS

The authors declare no competing interests.

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International Journal on Biological Sciences

International Journal on Biological Sciences 15 (2), July-December 2024, Pp. 89-95
ISSN No.: 0976-4518
https://doi.org/10.53390/IJBS.2024.15203

STUDY OF APPROACHES TO MICRONUTRIENT DISTRIBUTION IN SOIL WITHIN THE SHAHADA REGION OF NANDURBAR DISTRICT, MAHARASHTRA, INDIA

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Research Paper

Received: 20.09.2024 Revised: 18.10.2024 Accepted: 28.10.2024

ABSTRACT

In this research, soil sampling was conducted using a random sampling method, which led to the collection of five samples from each of the 116 villages, resulting in a total of 586 samples from the Shahada Region. The geographic coordinates of the sampling sites were recorded with GPS technology, and soil was extracted from a depth of 0 to 22.5 cm in agricultural fields. All necessary precautions were taken during the laboratory analysis of the soil samples, which were assessed following standardized protocols for pH (1:2.5), electrical conductivity EC (dSm^{-1}) and organic carbon content. Fertility maps for the Shahada Region in the Nandurbar district were developed using Arc-4 software, guided by GPS-GIS data.

The predominant soil types in this area are classified as medium black to deep black cotton soils, belonging to the inceptisol and vertisol orders, and are characterized by a flat topography. Consequently, the primary crops cultivated in this region include sugarcane, cotton, chili, papaya, maize, wheat, and gram. The soils in the Shahada Region exhibited a saline to alkaline reaction. Based on their electrical conductivity, these soils were classified as moderately saline, with values ranging from 0.06 to 2.90 dSm^{-1} and an average of 0.60 dSm^{-1}. Additionally, the average organic carbon content in the Shahada Region was found to be 0.57 g kg^{-1}. This information, along with the fertility maps, will be essential for the strategic planning and management of soil fertility, crop yield, and overall agricultural practices.

No. of Pages: 7 **References: 22**

Keywords: Micronutrient, Soil Characteristics, Shahada Region, GPS, GIS, Mapping.

INTRODUCTION:

The decline in micronutrient levels has become a pressing issue for soil productivity and sustainability, largely driven using high-yielding crop varieties, intensive farming practices, and an increased dependence on high NPK fertilizers. Micronutrients are vital for maintaining soil health and boosting crop yields (Rattan et. al., 2009). For optimal plant growth and food production, it is imperative that soils supply sufficient micronutrients. The heightened extraction of these essential elements, stemming from the implementation of high-yielding varieties (HYVs) and intensive agricultural methods, coupled with a preference for high-analysis NPK fertilizers, has resulted in diminished soil micronutrient levels, ultimately jeopardizing crop productivity. Poor nutrient management has led to the rise of various nutrient deficiencies in Indian soils (Sharma and

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Chaudhari, 2007). Recognizing the strong relationship between soil properties and micronutrient availability, this study seeks to explore how soil characteristics influence micronutrient levels in the Shahada Region soil series of North Maharashtra, as current knowledge on this subject is both limited and fragmented (Bafna and Thorat, 2009).

The utilization of GPS and GIS technologies, particularly the global positioning system and geographical information system, is essential for developing fertility maps that illustrate the distribution of macro- and micronutrients. In agriculture, the global positioning system serves multiple functions, including land surveying, the construction of infrastructure such as dams and canals, and research into animal behaviour and aquatic ecosystems. Additionally, the integration of GPS and GIS supports the creation of digital road maps for transportation. Analysing soil samples in conjunction with GPS data is crucial for making informed nutrient management decisions (Shubham Jadhav and Kartik Jadhav, 2023). It is crucial to identify the specific fertilizer needs to accurately assess the required quantity of straight fertilizers, rather than depending on pre-mixed, complex formulations. Utilizing fertility maps created through GPS-GIS technologies can greatly enhance the efficiency of fertilizer application. This method enables a more judicious use of financial resources allocated for fertilizers, ensuring that the nutrients provided to the soil are in accordance with the requirements of the cropping systems.

Furthermore, fertilizer application can be customized to meet the specific needs of various sections of fields, thereby improving nutrient management practices. The collection of soil samples via GPS technology is essential for generating thematic soil fertility maps. This technology assists in determining the precise latitude and longitude of sampling locations, which is vital for continuous monitoring of soil nutrients across different areas. It also yields important data regarding elevation, road networks, proximity to urban centres, and movement speed. The Nandurbar district is located at coordinates 21.228° N latitude and 74.1422° E longitude, covering a total area of 5035 km^2. The district receives an average annual rainfall of 769 mm, with recorded maximum and minimum temperatures of 43.3 °C and 11.9 °C, respectively. Nandurbar is subdivided into six regions, with Shahada being the primary focus of this research. The Global Positioning System (GPS) is a satellite-based navigation and positioning system managed by the United States military, which allows for the accurate determination of an object's location on the Earth's surface through geographical coordinates. Bharat Chaudhari et. al., 2022. Conversely, the Geographical Information System (GIS) functions as a computational framework for the collection, storage, querying, and visualization of geographical data. Once soil fertility maps are created, it becomes feasible to adjust information regarding the fertility status of specific areas.

These maps offer customized guidance and assessments for the management of soil fertility in the future. The adoption of high-yield crop varieties and more intensive agricultural methods, along with a growing dependence on high NPK fertilizers, has resulted in diminished levels of soil micronutrients, which have now dropped below the levels required for sustainable crop production. This deficiency in micronutrients has become a critical obstacle to both soil productivity and sustainability. In the Shahada Region, the main crops grown are cotton, sugarcane, banana, wheat and papaya.

MATERIALS AND METHODS:

The integration of GPS and GIS technologies, namely the global positioning system and geographical information system, plays a pivotal role in the creation of fertility maps that depict the distribution of both macro and micronutrients in the soil. By utilizing GPS data for the collection of soil samples, agricultural professionals can make informed decisions regarding nutrient management strategies. The development of thematic soil fertility maps necessitates a systematic approach to soil sampling, supported by GPS technology, which is vital for the ongoing assessment of soil nutrients across various regions and communities. The Nandurbar district, situated between 21.228° N and 74.1422° E, consists of six regions, with the Shahada Region, located at coordinates 21.5429691° N and 74.44691462° E, chosen for this investigation. Shahada, found between 21.54296910° N and 74.44691462° E, is one of the six regions in the Nandurbar district and lies in the northwestern part of the area, approximately 30 km northeast of Nandurbar. The town is flanked by the Tapi and Gomai Rivers and is noted for its grain market, cooperative dairy farming, sugar production, and cotton spinning industries, encompassing 172 villages and four Revenue Circles.

According to the census data from 2011, Shahada, a town in India, had a population of 61,376, with males constituting 52 percent and female's 48 percent. The literacy rate in Shahada is impressively high at 86.62%, surpassing the national average of 74.04%. Male literacy is recorded at 90.67%, while female literacy is at 82.40%. Additionally, 12.95 percent of Shahada's population consists of children under six years of age. The region exhibits significant linguistic diversity, featuring a range of local and tribal languages, including Bhilu, Ladshi, Dogari, and Bayadi, alongside Marathi, Ahirani, and Gujarati. The Shahada Region was selected for a project aimed at developing thematic soil fertility maps utilizing GPS and GIS technologies. During the soil sampling process, latitude and longitude data were gathered using a GPS device. Soil samples were collected from agricultural fields at depths of 0 to 22.5 cm, resulting in a total of 588 samples from the area. These samples were mixed thoroughly, air-dried in a shaded environment, and ground using a wooden mortar and pestle. The ground samples were then sieved through a two-millimetre mesh for analytical purposes. Walkey and Black, (1934). For subsequent analysis, the sieved soil samples were stored in appropriately labelled cotton bags. Throughout the laboratory analysis of the soil samples, all necessary safety protocols were strictly followed. The analysis utilized standard methodologies, specifically measuring pH (1:2.5), EC (dSm-1) and organic carbon content as a percentage.

RESULTS AND DISCUSSION:

Soil fertility maps for the Shahada Region, located in the Nandurbar district of Maharashtra, were developed utilizing Arc-4 software, which integrates GPS and GIS technologies. The soils in this region exhibited a saline to alkaline reaction. Based on assessments of electrical conductivity, the soils were classified as moderately saline, with conductivity values ranging from 0.06 to 2.90 dSm−1 and an average of 0.60 dSm−1. The organic carbon content in the soils varied from 0.01 to 2.42 g kg−1, with an average concentration of 0.54 g kg−1 across the Shahada Region. Detailed information regarding the range and average values of the soil's chemical properties is presented in Table 1, while Figure 1 illustrates thematic maps that depict soil fertility. Table 2 provides an overview of the number of samples collected and the percentage distribution of various soil chemical properties. The prevalence of alkaline conditions in many soil samples can be attributed to the extensive cultivation of sugarcane, where irrigation is primarily conducted through flood methods, and the use of organic materials to enhance soil structure is minimal. The observed alkalinity in the Shahada Region is likely a result of salt accumulation, exacerbated by high temperatures and the application of high-analysis fertilizers. Additionally, the cultivated soils in this area are classified as medium to deep black soils, which impede drainage and contribute to elevated pH levels.

Table 1: Physico-chemical characteristics and nutrient composition.

Sr. No.	**Chemical Properties**	**Range**	**Average**	**SD +**
1.	pH (1:2.5)	5.09 to 8.98	7.66	0.54
2.	EC (dSm^{-1})	0.04 to 2.88	0.58	0.38
3.	Organic carbon ($g\ kg^{-1}$)	0.02 to 2.36	0.54	0.30
Available Micronutrient ($mg\ kg^{-1}$)				
Sr. No.	**Soil Characteristics**	**Range**	**Mean**	**% sample deficient**
4.	DTPA-Fe	1.42-5.46	3.40	70
5.	DTPA-Mn	2.48-7.80	4.75	Nil
6.	DTPA-Zn	0.22-0.76	0.53	58
7.	DTPA-Cu	0.21-0.45	0.31	Nil
8.	Hot water soluble - B	0.22-1.53	0.65	36

The concentrations of DTPA-extractable iron (DTPA-Fe) in the soil samples analysed ranged from 1.42 to 5.46 mg kg^{-1}, resulting in an average concentration of 3.40 mg kg^{-1}. Analysis of the available iron indicated that 72% of the samples were deficient in DTPA-Fe, while 26% met the sufficiency criteria, which is set at a critical threshold of 4.48 mg kg^{-1} (Katyal and Rattan 2003). A significant positive correlation was identified between iron availability and clay content (r = 0.640**), organic carbon (r = 0.712**), and cation exchange capacity (CEC) (r = 0.644**). Conversely, the availability of iron decreased with increasing sand content (r = -0.766**), calcium carbonate ($CaCO_3$) (r = -0.510**), pH (r = -0.680**), and electrical conductivity (EC) (r = -0.122), as presented in Table 2. The levels of DTPA-extractable manganese (DTPA-Mn) in the soil samples varied from 2.48 to 7.80 mg kg-1 (Table 1). Given that the critical threshold for manganese deficiency is 1.98 mg kg^{-1}. Arunachalam et. al. (2013), all samples were classified as sufficient in manganese. The available manganese exhibited a significant positive correlation with clay (r = 0.655**), organic carbon (r = 0.705**), CEC (r = 0.517**), and silt (r = 0.694**), while it showed a negative correlation with increasing levels of $CaCO_3$ (r = -0.396**) and pH (r = -0.564**). The concentration of available zinc in the soil samples ra-ranged from 0.22 to 0.76 mg kg^{-1} (Table 1). Among the analysed samples, 36% were classified as sufficient, while70% were deficient in DTPA-extractable zinc, with a critical deficiency threshold of 0.58 mg kg^{-1} (Katyal and Rattan 2003).

The presence of zinc exhibited a significant increase in relation to higher clay content (r = 0.546**), organic carbon (r = 0.614**), and silt (r = 0.702**). Additionally, a strong positive correlation was identified among the micronutrients zinc, copper, iron, manganese, and boron with the levels of organic carbon (Table 2). The incorporation of organic matter markedly enhances soil structure and introduces chelating agents that improve the bioavailability of vital micronutrients (Bafna and Thorat, 2008; Tale and Ingole., 2015). Studies have shown that the retention of applied boron rises from 48% to 60% as organic carbon content increases from 0.50% to 0.75% (Jadhav and Jadhav, 2023). Moreover, a negative correlation was noted between the concentrations of zinc, copper, iron, manganese, and boron and the levels of $CaCO_3$ (Table 2). The increase in metal concentrations associated with higher $CaCO_3$ levels may be attributed to the conversion of available metal ions into insoluble hydroxides or carbonates, or their binding by the free $CaCO_3$ present in the soil (Venkatesh et. al., (2003). The application of lime has the potential to diminish the availability of hot water-soluble boron due to the formation of calcium borate and boron silicate compounds (Mulani, et. al., 2019).

Table 2a: The relationship between soil characteristics and the presence of accessible micronutrients in the soil.

Sr. No.	Soil Characteristics	Available Micronutrients				
		Fe	Mn	Zn	Cu	B
1.	pH	-0.680**	-0.564**	-0.582**	-0.586**	-0.554**
2.	Electrical Conductivity	-0.122	-0.105	-0.084	0.194	0.090
3.	CEC	0.644**	0.652**	0.631**	0.677**	0.625**
4.	Sand	-0.766**	-0.745**	-0.675**	-0.652**	0.606**
5.	Silt	0.770**	0.694**	0.702**	0.652**	0.517**
6.	Clay	0.640**	0.655**	0.546**	0.548**	00.564**
7.	$CaCO^3$	-0.510**	0.396** -	-0.442**	-0.504**	-0.404**
8.	Organic Carbon	0.712**	0.706**	0.614**	0.732**	0.505**

Table 2b: The quantity of samples and the percentage distribution of soil chemical characteristics across various categories.

Sr. No.	Chemical Properties	Category	Value	No. of Samples	Percentage Distribution
9.	pH (1:2.5)	Acid	<6.5	26	02.72
		Neutral	6.5 to 7.5	180	01.90
		Alkaline	7.5	374	62.26
10.	EC (dSm^{-1})	Safe	<0.5	292	48.32
		Moderately Safe	0.5 to 1.25	242	40.64
		Unsafe	>1.25	45	06.92
11.	Organic carbon (g kg^{-1})	Low	<0.5	275	46.42
		Medium	0.5 to 0.75	152	25.34
		High	>0.75	150	25.18

A significant positive relationship was observed between the concentrations of zinc, copper, iron, manganese, and boron and the silt and clay fractions present in the soil. The presence of finer soil particles enhances the surface area available for ion exchange, which can facilitate an increase in DTPA-extractable metal ions. Soils characterized by finer textures exhibit a greater capacity to retain boron (B) compared to their coarser counterparts, thereby reducing the likelihood of boron loss due to leaching in fine-textured soils. This observation aligns with the findings of Chakraborty et. al., 1982 and Sharma et. al., 2003. The research underscores that the deficiency of iron (Fe) and zinc (Zn) is particularly significant among the micronutrients (Fe, manganese (Mn), copper (Cu), Zn, and B) in the Mokala series soils. The highest levels of DTPA-extractable Fe, Mn, Cu, and Zn were recorded in fine-textured soils with elevated organic carbon content. Conversely, coarse-textured soils were found to be more susceptible to deficiencies in Fe, Mn, Cu, Zn, and B. Among various soil properties, organic carbon, cation exchange capacity (CEC), and the ratios of silt and clay positively influence the availability of micronutrients, while factors such as sand content, pH, and calcium carbonate ($CaCO_3$) content have a detrimental effect on their availability.

Soil fertility maps for the Shahada Region, located in the Nandurbar district of Maharashtra, were developed utilizing Arc-4 software, which combines GPS and GIS technologies. The soils in this region exhibited a reaction ranging from saline to alkaline. Based on electrical conductivity measurements, the soils were classified as moderately saline, with values spanning from 0.04 to 2.88 dSm^{-1} and an average of 0.58 dSm^{-1}. The organic carbon content in these soils varied between 0.02 and 2.36 g kg^{-1}, with an average concentration of 0.54 g kg^{-1} in the Shahada Region. Detailed information regarding the range and average values of soil chemical properties is presented in Table 1, while Figures 1, 2, and 3 illustrate the thematic maps that represent soil fertility in the studied area. Furthermore, Table 2b provides information on the number of samples collected and the percentage distribution of different soil chemical properties.

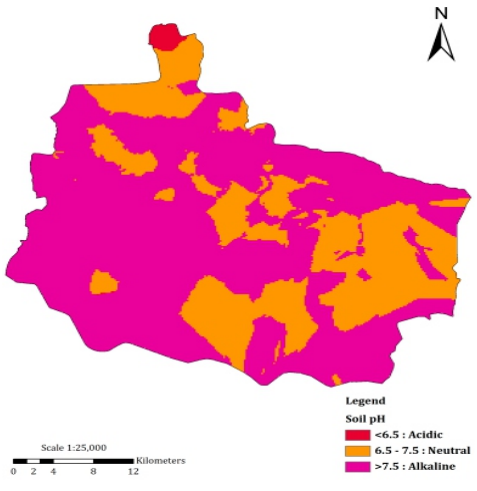

Figure 1: Showing map of soil pH of shahada.

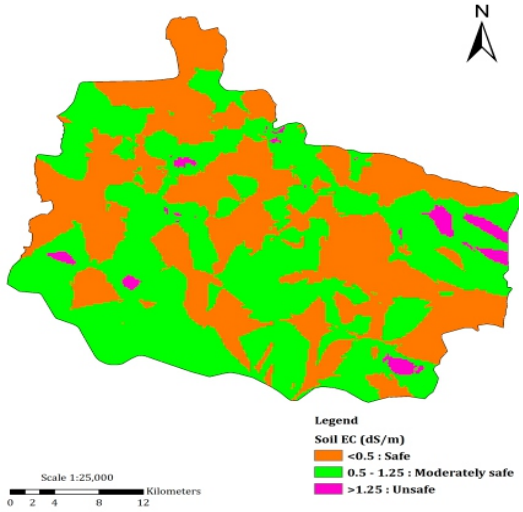

Figure 2: Showing map of soil electrical conductivity (EC) of shahada.

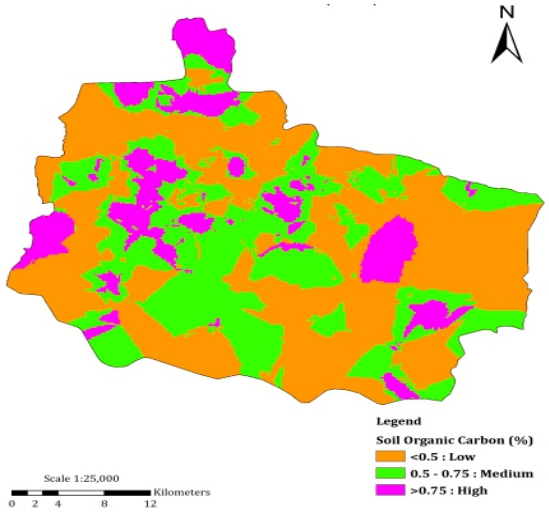

Figure 3: Showing map of soil organic carbon of shahada.

The occurrence of alkaline conditions in various soil samples can be attributed to the common agricultural practice of sugarcane cultivation, which generally employs flood irrigation techniques and minimal addition of organic matter to enhance soil structure. The observed alkalinity in the Shahada Region is likely a result of salt accumulation, exacerbated by elevated temperatures and the use of high-analysis fertilizers. Additionally, the soils in this region are categorized as medium to deep black soils, characterized by inadequate drainage, which further elevates pH levels. Numerous researchers have conducted studies on Micronutrients within their respective fields, with notable contributions from authors such as Arunachalam et. al. (2013), Bharat Chaudhari et. al., (2022), Bafna and Thorat, (2008), Bafna and Thorat, (2009), Gowda et. al., (2004), Gupta (2005), Isirimah et. al., (2003), Katyal and Rattan (2003), Kumar and Babel (2011), Mathur et. al., (2006), Mulani et. al., (2019), Qureshi et. al. (1996), Rattan et. al., (2009), Sharma and Chaudhary (2007), Sharma et. al., (2003), Shubham and Kartik (2023), Solanki and Chavda (2012), Tale and Ingole (2015), Venkatesh et. al., (2003), and Yadav (2011).

CONCLUSION:

The analysis of the maps indicated that a significant portion of the Shahada study area exhibited alkaline characteristics, showed moderate stability in terms of EC (dSm^{-1}), and had low levels of organic carbon. This methodology is suggested as a viable means for assessing sustainable soil management practices. The fertility maps produced can serve as tools for forecasting the potential and limitations of land for crop cultivation. Additionally, the results from soil testing were employed to formulate fertilizer recommendations aimed at improving crop yields while preserving soil fertility, productivity, and sustainability, as well as enhancing the quality of crops in the examined region. The generated data and fertility maps will support the strategic planning and management of soil fertility, productivity, and quality for various crops, including banana, papaya, sugarcane, onion, cotton, and chili, within the Shahada Region.

ACKNOWLEDGMENTS:

We express our sincere appreciation to the Director, School of Environmental and Earth Sciences at KBCNMU, Jalgaon, for providing the vital resources necessary for the execution of our research.

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International Journal on Biological Sciences

International Journal on Biological Sciences 15 (2), July-December 2024, Pp. 96-101
ISSN No.: 0976-4518
https://doi.org/10.53390/IJBS.2024.15204

DETECTING YELLOW RUST OF WHEAT AT VILLAGE LEVEL USING SENTINEL-2 SATELLITE IMAGES

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Research Paper

Received: 22.09.2024 Revised: 24.10.2024 Accepted: 22.11.2024

ABSTRACT

Yellow rust is a destructive disease that adversely impact the growth and production of wheat. Previous studies shown that the parts of Rupnagar district, the foothill district of Punjab, is the most severely affected area for yellow rust of wheat because climate conditions in this area are favourable for its growth. Therefore, a study was planned to demonstrate the potential of Sentinel-2 images in detecting the yellow rust of wheat at village level (Nangal Nikku and Dukli villages of Rupnagar District of Punjab). The time series Normalized Difference Vegetation Index (NDVI) values from 27 January, 2024 to 08 February, 2024 were extracted from Sentinel-2 images to distinguish the diseased from healthy crop in the two villages. Compared with the NDVI values of healthy wheat, a decrease in NDVI by 17.9 -19.4% was observed in the disease stressed crop during this period. The rule-based classification effectively identified the yellow rust areas of wheat in the two villages. These results showed that Sentinel-2 may be used for detection of diseased crop at village level and this may assist in taking the contributing to improved crop health and yield sustainability.

No. of Pages: 6 **References: 24**

Keywords: Normalized difference vegetation index, Sentinel-2 data, Yellow rust.

INTRODUCTION:

Wheat is one of the extensively grown crops but highly susceptible to pests and diseases (Yuan et al., 2014). Yellow rust caused by Puccinia striiformis f. sp. tritici poses a serious threat to wheat yield and frequently occurs in moderately low temperature and high humid regions (Ren et al., 2021). The distinctive symptom of yellow-colored stripes on wheat leaves, facilitates easy diagnosis. These stripes, typically 2 or 3 mm wide and running parallel to leaf veins, signify the presence of the disease (Nguyen et al., 2023). The farmers usually use the size of the diseased area on the leaves to determine the extent of damage. However, this method is prone to error and may occur in excessive use of pesticides or fails to achieve the optimum level of pest control. Further, this will lower crop productivity and result in economic losses (Wellings, 2011; Sabença et al., 2021; Biel et al., 2021; Chai et al., 2022). Therefore, timely and precise disease monitoring is crucial to mitigate economic losses in farming.

The conventional visual inspection method for detecting wheat yellow rust in the field, has major limitations including small coverage and the inevitable subjectivity of analysts (Zheng et al., 2018;

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Guo et al., 2021). In the recent years, remote sensing technology has emerged as a viable alternative for the identification of diseased crop, offering cost effective monitoring, and allowing better disease control (Moshou et al., 2004; Franke et al., 2005; Su et al., 2018; Su et al., 2019; Abdulridha et al., 2020). The variability in plant pigments and their corresponding spectral signatures allows researchers to employ visible imaging techniques for effective plant disease detection (Ashourloo et al., 2014). Yellow rust induces changes in physiology of plants, altering their photosynthesis patterns accordingly. This alteration is measurable through changes in radiant energy absorption and reflectance rates, detectable by multispectral and hyperspectral satellite imageries (Thirugnana Sambandham et al., 2022, Guo et al., 2020). Previous studies have proven the potential of spectral vegetation indices for detecting the changes in plant physiology, and phenology (Hillnhütter & Mahlein, 2008; Mahlein, et al., 2013; Dutta et al., 2013; Nguyen et al., 2023). Dutta et al. (2013) utilized remote sensing derived indices to identify the yellow rust on wheat in different areas of Punjab. Singh et al. (2023) suggested the use of Sentinel-2 satellite imagery for monitoring yellow rust of wheat. However, there are very few studies in which yellow rust of wheat has been identified at village level. Based on the effectiveness of vegetation indices in sensing physiological changes, the current research was aimed to explore the ability of Sentinel-2 images (Spatial resolution of 10 m in visible and near infrared bands) in determining the yellow rust of wheat in the selected villages of Rupnagar District of Punjab using a rule-based classification approach.

Study Area and Dataset Used

This study was focused on mapping of yellow rust affected wheat in Nangal Nikku and Dukli Villages of Rupnagar District of Punjab as represented in Fig. 1. The Roopngar district is divided into four main physiographic units namely: Siwalik Hills, Valleys, Piedmont plain and Alluvial/Flood plain. This region characterized by diverse landscapes including flood plains, fertile alluvial plains. The river Satluj forms the main drainage system in the area and flows in general from north east towards west. This region experiences distinct seasons, with dominant south-easterly rains between July and September. The remaining months are generally dry with occasional winter showers. The climate exhibits extremes summers reaching up to 48°C and chilly winters dipping to very low levels in December and January.

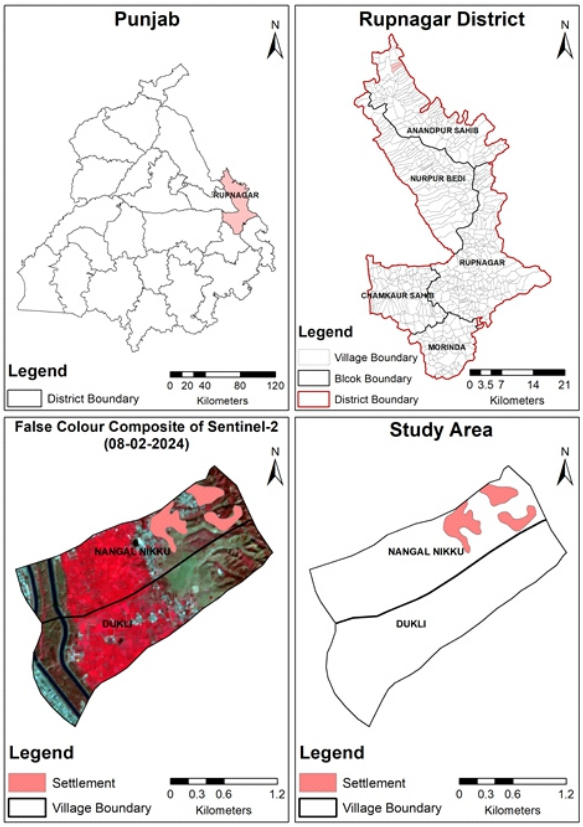

Figure 1: Study area.

The cloud free Sentinel-2 satellite images acquired from November 2023 to February 2024 were used to identify the diseased crop. This satellite offers several key advantages for mapping of biotic stress like vast areas coverage with 10-meter spatial resolution of visible and near infrared bands, which provide sufficient detail to distinguish between stress induced fields. The 13 spectral bands of Sentinel-2 capture information across various wavelengths. This information is crucial for differentiating between stress induced vegetation based on its unique spectral signature, which varies across the electromagnetic spectrum throughout its growth cycle. The two Sentinel-2 satellites have a combined revisit period of 5 days. Field survey was conducted in multiple wheat field's locations having yellow rust disease during February, 2023.

Methodology

In this study, Sentinel-2 time series images between November 2023 and February 2024 were used to cover the growth stages of wheat from sowing to disease infestation stage (2023-24). Normalized Difference Vegetation Index (NDVI) was derived from the pre-processed images to understand the spatio-temporal dynamics of the wheat crop. The formula for computing NDVI is:

Where ρNIR is the spectral reflectance in the near-infrared band, and ρred is the spectral reflectance in the red band of the multispectral Sentinel-2 satellite image.

Ground-truth locations of yellow rust affected wheat fields were collected through field visits in the Nangal Nikku and Dukli Villages of Rupnagar District during February 2024. For these locations, the temporal variation of NDVI was computed. A rule-based classification was employed to distinguish between yellow rust affected wheat crops from healthy crops based on the time series NDVI profile. Wheat sowing in the study area typically starts in October to November, while the diseases has been identified in January to February.

Results and Discussion

The false colour composite (FCC) of Sentinel-2 facilitated the visual identification of diseased crops in dark red tone and healthy crops in light red tone. The examples of diseased crop areas are shown with blue boundary and healthy crop areas with white boundary in Fig. 2. The NDVI spectral profile recorded during November, 2023-February, 2024 is shown in Fig. 3. The spectral profile revealed the occurrence of yellow rust in early January 2024 and the disease progressed towards February, 2024. A sudden decline in NDVI values (17.9-19.4%) was observed from 27 January, 2024 to February 8, 2024. This was mainly due to moist climate with high humidity in mountainous region that favored the growth of yellow rust (IMD, 2024; Dutta et al., 2013).

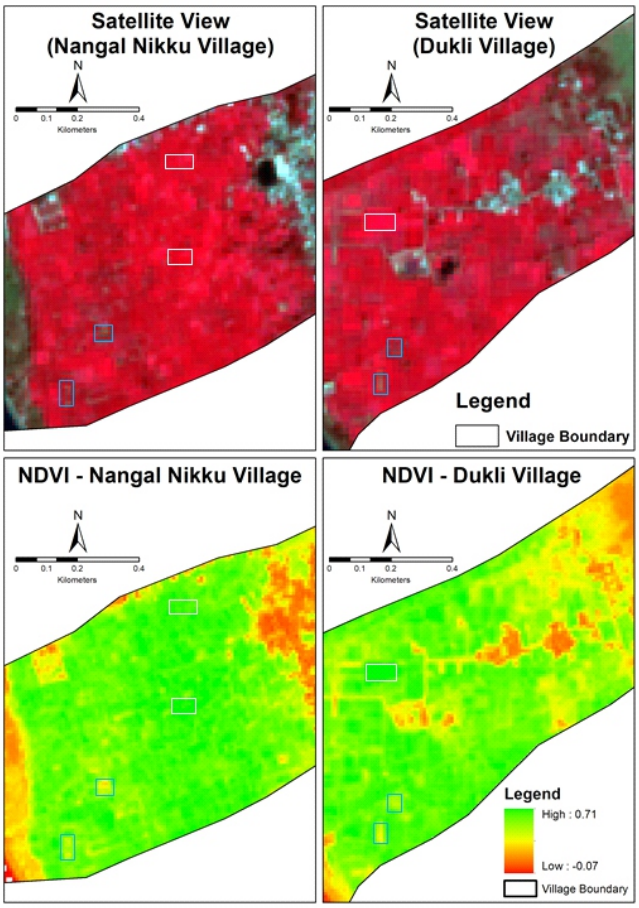

Figure 2 False Colour Composite of Sentinel-2 and NDVI of the study area.

The optimal threshold range of NDVI was obtained based on the trial-and-error method. The wheat pixels having NDVI values greater than 0.5 and lesser than 0.6 are considered as diseased crop, whereas, the wheat pixels with NDVI values greater than or equal to 0.6 were categorized as healthy crop (as represented in Fig. 4). It was found that nearly 51% of the total wheat area in the two villages was affected by yellow rust disease.

In this study, the influence of wind condition was included that likely favor the dispersion of yellow rust spores over long distance (Sánchez Espinosa, 2023). Indian Meteorological Department (IMD) reported

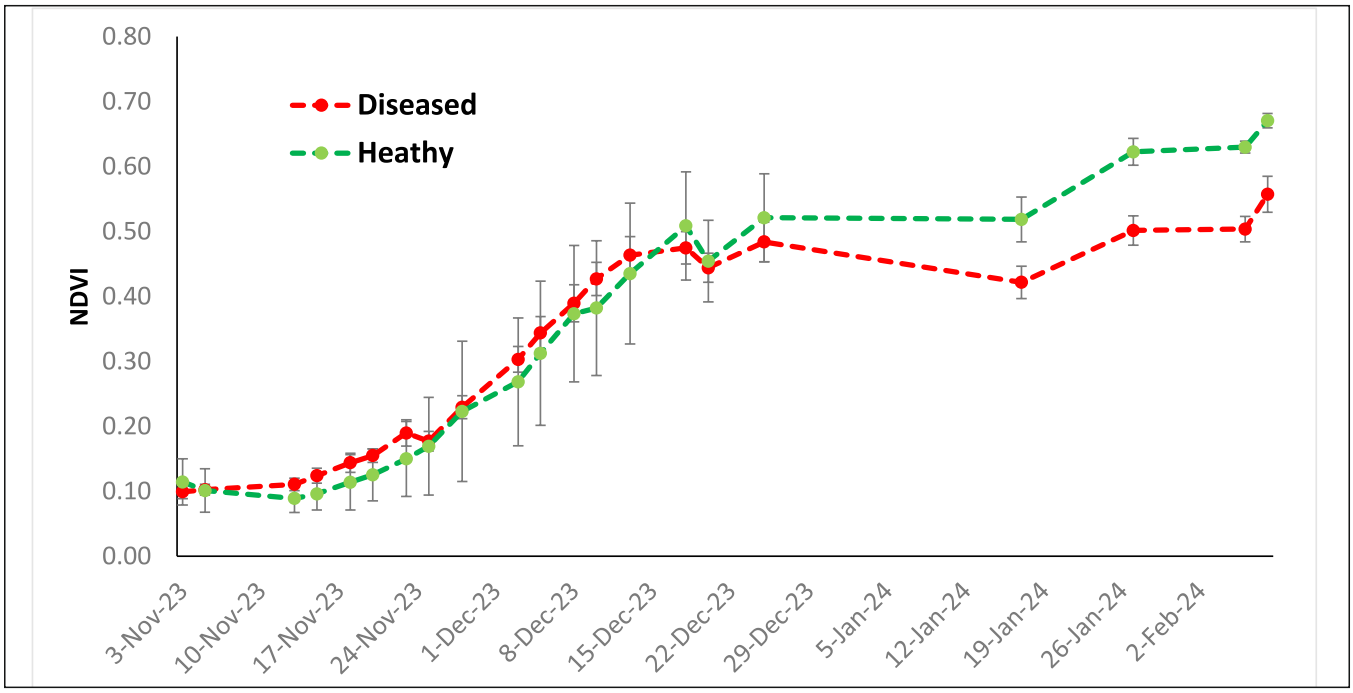

Fig. 3: Spectral profile of NDVI for diseased and healthy crop. Vertical lines indicate standard error of the mean.

strong and chilly surface wave warning conditions over Punjab during January-February, 2024 (IMD, 2024). The wind speed and wind direction data obtained from ERA5 Daily Aggregates (Muñoz Sabater, 2019) showed that the winds speed remained up to 30-40 kmph which contributed to the rapid dispersal of the disease, leading to increased incidence in wheat fields across the district. This, in turn, posed a significant threat to the region's wheat production, potentially resulting in yield losses and economic consequences for farmers.

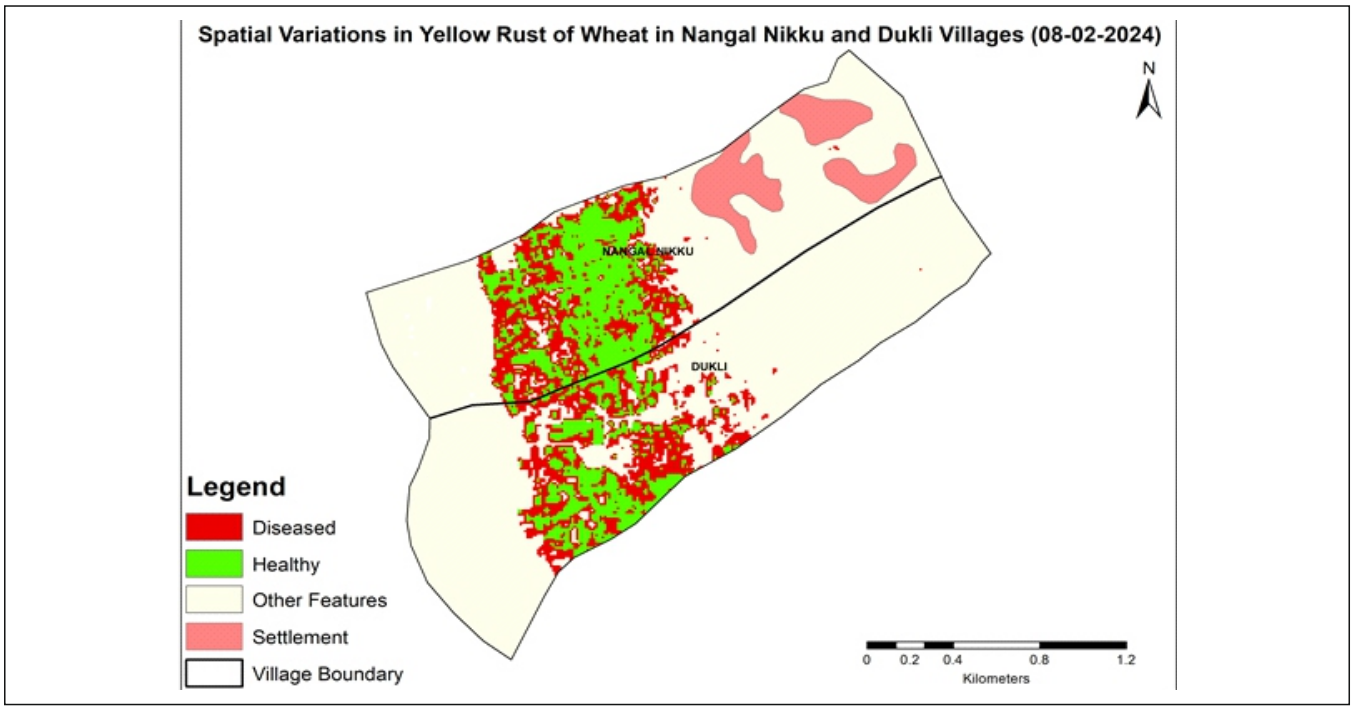

Fig. 4: Classified yellow rust affected and healthy wheat in Nangal Nikku and Dukli Villages of Rupnagar District of Punjab.

CONCLUSIONS

The results of this study showed the efficacy of NDVI time series data derived from Sentinel-2 for detecting yellow rust of wheat and NDVI data provided a clear distinction between healthy and infected areas, supporting its application as an effective tool for early detection and monitoring at village level. Additionally, climatic conditions (i.e., low temperature and high humidity) and wind speed data has greatly influenced the onset and spread of yellow rust. Furthermore, Sentinel-2 images offer a cost-effective solution for large-scale disease monitoring, potentially reducing the economic impact of yellow rust on wheat production. Future research should focus on improving the spatial resolution and incorporating other spectral indices to further refine disease identification and extend its application to other crop diseases.

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International Journal on Biological Sciences

International Journal on Biological Sciences 15 (2), July-December 2024, Pp. 102-112
ISSN No.: 0976-4518
https://doi.org/10.53390/IJBS.2024.15205

CONSUMER PURCHASE BEHAVIOR FOR CHICKEN MEAT PRODUCTS IN ISLAND GARDEN CITY OF SAMAL

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Research Paper

Received: 18.08.2024 Revised: 22.09.2024 Accepted: 27.10.2024

ABSTRACT

Yellow rust is a destructive disease that adversely impact the growth and production of wheat. Previous studies shown that the parts of Rupnagar district, the foothill district of Punjab, is the most severely affected area for yellow rust of wheat because climate conditions in this area are favourable for its growth. Therefore, a study was planned to demonstrate the potential of Sentinel-2 images in detecting the yellow rust of wheat at village level (Nangal Nikku and Dukli villages of Rupnagar District of Punjab). The time series Normalized Difference Vegetation Index (NDVI) values from 27 January, 2024 to 08 February, 2024 were extracted from Sentinel-2 images to distinguish the diseased from healthy crop in the two villages. Compared with the NDVI values of healthy wheat, a decrease in NDVI by 17.9 -19.4% was observed in the disease stressed crop during this period. The rule-based classification effectively identified the yellow rust areas of wheat in the two villages. These results showed that Sentinel-2 may be used for detection of diseased crop at village level and this may assist in taking the contributing to improved crop health and yield sustainability.

No. of Pages: 6 **References: 24**

Keywords: Consumer, Chicken, Meat, Products, Purchase Behaviour, Broilers, Native.

THE PROBLEM AND ITS SETTING

Background of the Study

The chicken industry in the Philippines has various components. The commercial sector is characterized by large-scale, industrial production systems of broilers and layers of exotic breeds. On the other hand, the backyard sector is made up of many small holders who keep a few native or crossbreed chickens mainly for their own consumption. Chicken meat was regarded as one of the Filipinos' favorite foods. Recent food industry trends have given consumers the opportunity to expect more from the products they buy. However, their purchase behavior is influenced by a variety of factors. This means that in the food market, consumers can buy products that do more than just meet their basic nutritional needs. Instead, they can look for differentiated products that meet a variety of safety and quality requirements.

The main problem is that consumers' selection of food is governed by many factors, including culture, religion, lifestyle, diet, knowledge, health concerns and food trends, often influenced in the advertisement, news and personal take by the media (Popa et al., 2011). This usually entails adhering to

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ethical guidelines during the product's breeding, growth, and processing.

The country's total chicken population as of 01 October 2021 was estimated at 190.74 million birds or 2.4 percent more than the previous year's same period count of 186.33 million birds. Of the total chicken inventory, native/improved chicken contributed 45.2 percent, followed by broiler chicken with 31.1 percent share and layer chicken with 23.7 percent share. (PSA, 2021). Population and income are factors other than prices that affects the country's chicken meat demand. Hence, as the Philippines population continue to increase, total chicken consumption also increases. It is important that the consumers consumed chicken meat products since it is one of the most nutritious animal products because of proteins, vitamins and fats content which gives nutrient for human health. Native chicken is normally raised in many rural areas of the country and takes considerable time to mature and usually they are rarely provided with feed and water on a daily basis but they hunt for their survival. Whereas broiler is characterized by a rapid growth within a short period of time of approximately 6 weeks under commercial breeding farms who use the advanced intensive fattening systems. Apparently, inefficiency and competition with imported meat products are some of the problems faced by the local meat industry according to (Balogbog, 2018). Hence, it is on the point that this study was conceptualized in order to know the consumer purchase behavior for chicken meat products in Island Garden City of Samal. This study will help the suppliers and retailers of chicken meat products to improve their strategy by understanding the purchasing behavior of the consumers.

Broiler and native chicken meat has a significant contribution in the chicken industry. In spite of its critical role in household economics and food security, there is no any published research yet in Samal Island that can assess chicken meat producers as well as the retailers on the consumers purchase behavior. Therefore, it is imperative to conduct comprehensive studies that can cover the entire chicken meat products on consumer purchase behavior for chicken meat.

Statement of the Problem

The study aims to look into the purchase behavior of consumers in terms of chicken meat products in Island Garden City of Samal. Specifically, it seeks to answer the following questions;

1. What is the level of socio-demographic profile of chicken meat buyers in Island Garden City of Samal in terms of:
   a. age;
   b. gender;
   c. civil status; and
   d. ethnicity?

2. What is the level of socio-economic profile of the chicken meat buyers in Island Garden City of Samal?
   a. education;
   b. working status;
   c. no. of employed members; and
   d. household income?

3. What are the practices of consumer in buying chicken meat products in Island Garden City of Samal?

4. Which chicken meat product is most preferred by the consumers from different income classes in Island Garden City of Samal.

Theoretical Framework

This research study is anchored on the theory of Consumer behavior theory developed by Kassarjian in 1982. This theory aims to understand how consumers make decisions and behave when purchasing and using products and services. It uses a variety of disciplines, including sociology, psychology, economics, and marketing, to investigate the factors that affect consumer behavior. The decision-making process, consumer attitudes, perception, motivation, learning and memory, social and cultural effects, and marketing and advertising are some important concepts and theories in consumer behavior. Businesses and marketers may create efficient marketing strategies and products that satisfy the wants and preferences of customers by knowing these aspects. Customer behavior theory's ultimate objective is to assist businesses and marketers in better comprehending and anticipating customer behavior in order to produce goods that satisfy the demands and preferences of their target market and effective marketing campaigns (Piacentini and Szmigin, 2018). Thus, this theory is suitable for this research since it investigates the consumers purchase behavior for chicken meat in Samal Island by identifying the consumer's socio-demographic profile, socio-economic profile, practices of consumer in buying, and most preferred chicken meat product in different income class in the Island.

Moreover, as this study assess the consumers purchase behavior, this study is also supported by the theory of reasoned action (TRA) is a general theory of behavior that was first introduced in 1967 by Martin Fishbein, and was extended by Fishbein and Icek Ajzen in 1980. According to this theory, customers' intentions to buy a product are influenced by their perceptions of the product and arbitrary standards (Montano and Kasprzyk, 2015). In the context of chicken meat products, the perspectives of consumers may be impacted by elements including flavor, cost, health advantages, and food safety. The cultural and societal expectations around meat intake may have an impact on subjective norms.

Conceptual Framework

As perceived in figure 1, this paper utilizes the IPO model or the Input, Process and Output model in conceptualizing the idea of this study. The IPO model refers to the specific potential to examine the moderating effect of context-related constructs to explain how inputs are transformed into outputs through a process. (Dulebohn, James H., and Julia E. Hoch, 2017). In this study, the input stage involves identifying the socio-demographic profile of chicken meat buyers in Samal Island, their socio-economic profile, practices used in buying chicken meat products, and their preferred chicken meat products form different income class. Meanwhile, in the process stage, this study will utilize a specific approach in collecting the data, analyzing the data, interpreting the data and presenting the data. And, lastly in output process, the researchers present the result or output generated by the process in response to the input factors. This stage also includes the researcher's recommendation of the study based on the findings.

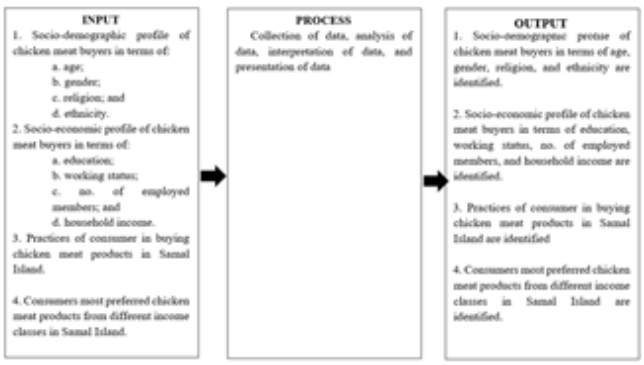

Fig. 1: Conceptual Framework.

Significance of the Study

The study will provide baseline information to businessmen, firms and organizations as far as the chicken industry and its various stakeholders based on the consumer's purchase behavior.

For the Producer

This research will give them an idea as to what type of chicken meat are mostly being consumed by the consumers. They will be able to consider also the different demands of the consumer towards chicken meat products. This would allow them to better satisfy consumer expectations, demands and needs.

Retailers

For the retailers of chicken meat products, they will understand their different consumers since it will identify the different factors which significantly affecting consumer purchase behavior for chicken meat products and evaluate the effects of those factors on the decision of consumer to purchase chicken meat products. Further, the seller will have an idea as to what chicken meat product is most preferred by consumers from different income classes in Island Garden City of Samal.

Consumers Through this study we will be able to understand how the consumers respond with the chicken meat products since this study will lay down the why, where, when, and how in terms of consumer purchase behavior for chicken meat products.

Suppliers

For chicken meat suppliers, this research will give them the idea as to the different attributes that the consumer usually considers in the purchase products. This will help them to fulfill the consumer's expectation on chicken meat products.

Students and Future Researchers

For students and academic researchers, this study will serve as a guide to those who will be conducting similar studies and further studies on consumer purchase behavior for chicken meat.

Definition of Terms

For a better and clearer understanding of this study, the following terms are conceptually and operationally defined.

Consumer Behavior

It refers to the buying behavior of the ultimate consumer and the process by which individuals search for, select, purchase, use, and dispose of goods and services, in satisfaction of their needs and wants.

Chicken Meat

Any chicken grown specifically for consumption as meat after processing.

Socio - Demographic Factors
Refer to age, sex, place of residence, religion, educational level and marital status.

Socio – Economic Factors
An individual's or group's position within a hierarchical social structure. Socio – economic status depends on a combination of variables, including occupation, education, income and wealth.

METHODOLOGY

Research Design
This study used quantitative research design to obtain the research questions. The study used descriptive method of research. According to (McCombes and Shona, 2020) descriptive research aims to accurately and systematically describe a population, situation or phenomenon. It can answer what, where, when and how questions, but not why questions. A descriptive research design can use a wide variety of research methods to investigate one or more variables. Unlike in experimental research, the researcher does not control or manipulate any of the variables, but only observes and measures them. Descriptive research is usually defined as a type of quantitative research, though qualitative research can also be used for descriptive purposes. The research design should be carefully developed to ensure that the results are valid and reliable.

Structured survey questionnaire was used for quantitative research in order to generate responses from the respondents. Furthermore, the designed questionnaire gathered only relevant information and included questions that were a necessity of meeting the research objectives. This means that the researchers randomly select respondents from three districts of Island Garden City of Samal, Babar, Samal and Kaputian District.

Respondents of the Study
The respondents of the study are the chicken meat consumers in Island Garden City of Samal. Specifically, there are 150 respondents and are randomly selected in three different barangay, Barangay Villarica for Babak district, Barangay Peñaplata for Samal district, and Barangay Poblacion for Kaputian district.

Research Locale
This research study was conducted in Island Garden City of Samal. The Island Garden City of Samal is composed of Main Island and 7 islets with 118.5 kilometers of long continuous coastline and 30,130 hectares of total land area that lavishes ample mountain ranges, a number of isolated hills and uneven distribution of lowlands. The entire island including Talikud and the rest of the islets has thirty-one (31) coastal barangays out of the 46 barangays. Kaputian District has the greater number of coastal barangays with 12 barangays out of its 15 barangays. There are 5 major urban areas in the city namely; Barangay Pichon and Villarica of Babak District, Barangay Peñaplata of Samal District and Barangay Poblacion and Sta. Cruz of Kaputian District. Specifically, the research study was conducted within three (3) specified locations namely; Barangay Villarica for Babak district, Barangay Peñaplata for Samal district, and Barangay Poblacion for Kaputian district.

Table 1: Research Respondents.

Location	No. of Respondents
Babak District	50
Samal District	50
Kaputian District	50

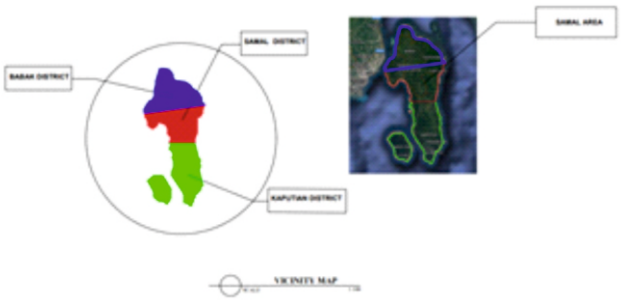

Figure 2. Map or Research Local.

Sampling Design
Sampling is the process of drawing a sample from a larger population to make conclusions about the whole population, where the population stands for a target group to be studied (Krishnaswami, O., & Satyaprasad, B., 2010). The study will use random sampling. Random sampling only takes few forms of large population that makes the researcher possible to begin the process of data collect in faster than other forms of data collection.

Research Instrument
The researchers will use structured survey questioners. The first part of the questionnaire

contained socio-economic and demographic questions in a closed-ended type of questions and multiple-choice formats. The second parts of the questionnaire are the practices of consumer in purchasing chicken meat questions in a closed-ended type of questions and multiple-choice formats. With the help of a questionnaire, the researcher will be able to determine the relationship between independent and dependent variables regarding the study.

Data Gathering Procedure

The researcher divided the respondents into three locations and printed same number of questionnaires which was used during the interview. The researcher used the random sampling interview with the structured survey questionnaire to the respondents present in the meat shop and public market in Island Garden City of Samal. In collection of the data using the survey questionnaire, the researcher asked permission on the respondents by giving them the informed consent form before they answer the survey questionnaire. The researchers personally handed the questionnaire and explained the researcher tool and its purpose to the respondents. Furthermore, the researcher retrieved the survey questionnaires after the respondents answered all the items. Finally, the researcher tallied and tabulated all the data, analyzed and interpreted the statistical results with the help of statistician. Lastly, the researcher formulated recommendations based on the findings of the study.

Statistical Treatment

The data gathered was tabulated and analyzed using statistical tools such as frequency and percentage. This will be used to analyze the effects of socio – demographic and socio – economic factors on the purchase behavior of consumers for chicken meat products.

Ethical Consideration

The Samal Island City College ethical board was consulted for approval before the research could begin. Following an appropriate presentation of the study's goal to the target population, time was given for any questions or requests for clarification. Every respondent underwent the necessary informed consent processes. This was done during the debate, just before a real personal interview. Research ethics Committee (SICC-REC) for the full board review of the investigation's ethical aspects in light of the research ethics dimensions of social value, informed consent, vulnerability issues, privacy and confidentiality of information, transparency, qualification of the researchers, adequate facilities, and community involvement.

Social Value

The researchers carefully analyze the Consumer Purchase Behavior for Chicken Meat Products in Island Garden City of Samal. they will understand their different consumers since it will identify the different factors which significantly affecting consumer purchase behavior for chicken meat products and evaluate the effects of those factors on the decision of consumer to purchase chicken meat products. Further, the seller will have an idea as to what chicken meat product is most preferred by consumers from different income classes in Island Garden City of Samal.

Informed Consent

All study participants provided their informed consent, which was obtained in this case. The chosen respondents were given a thorough and in-depth explanation of the study's objectives by the researcher. The researcher made sure that the consent requirement was a voluntarily chosen requirement. The participants understood the concept and the ramifications of taking part in the study with sufficient clerical information and understanding.

Vulnerability of Research Rarticipants

The researcher safeguarded the subjects against being tricked, threatened, or coerced into taking part. They were treated with the utmost respect by the researcher. As a result, the respondents were notified by the researchers that they were not required to participate in the survey or respond to the questionnaire. Despite being of legal age, the volunteers are nonetheless at risk because the researcher is a student from one of the study's chosen research locations. The participants in the study were taken into account by the researcher since they were informed enough to choose whether or not to participate in the study.

Privacy and Confidentiality of Information

The current study ensured the privacy and confidentiality of the information of the respondents. The researcher adhered to the principles of Data Privacy Act of 2012 or Republic Act 10173 which mandates transparency, legitimate purpose, and proportionality in the collection, retention and processing of personal information (Ramos, D. P. , 2019). The fundamental human rights to information privacy were protected by this law, ensuring the free

flow of information that fosters innovation and development. The respondent's or participants' right to privacy was safeguarded by the researcher, who treated their responses with the utmost care. To protect their identities and to provide them the opportunity to participate without worrying that their participation in the study would be made public, other personal information won't be requested during the study.

Qualification of the Researcher

The research is ultimately the researcher's responsibility and accountability. The researchers are equipped with the knowledge and abilities required to do the research. They must be mindful of their own research competency limitations. They gained the knowledge and abilities required to conduct the research through their two years of earning academic units for their bachelor's degree, participation in research-related seminars and training, assistance from their adviser and peers, readings from a variety of books and literatures, and the supervision of SICC-REC. Additionally, the panelists assisted in improving the research study under the supervision and guidance of their adviser.

Adequacy of Facilities

The researcher makes sure that the study will be conducted with the necessary funding and tools. This is to guarantee that the researchers get the best resources to finish their work. The researcher must privately own the necessary equipment—a laptop, printer, and internet connection—while other college provisions ensure that the facilities are adequate and easily accessible. Additionally, there are readily available library materials, both offline and online, including books and Google Docs. As a result, the resources included experts who gave the researcher the direction they required for the conduct of this research. These experts included the panel members who served as expert validators and the adviser, SICC—Research Adviser.

Community involvement

The researcher is actively involved in the communities of Babak, Samal, and Kaputian. Because the population of Island Garden City of Samal is so diverse, the researcher is sensitive to and respectful of the cultural, traditional, and religious practices of the area. The academic community at Samal Island City College contributed to the revision, validation, and correction of the study's manuscript. The academic community at SICC gave the researcher instructions based on its norms and procedures for doing research. Parents, teachers, and school administrators' participation is also very important

From the creation of the survey questionnaire until the results of the first phase of the study, school administrators, teachers, and parents all contributed. In the second phase, the guiding questions were the tool used to collect qualitative data. On the other hand, the researchers saw that proper protocol was followed and that the respondents gave their consent. Moreover, the significant personas and other stakeholders may benefit from the output of the study because they are the recipients of the data regarding knowledge about Consumer Purchase. Behavior for Chicken Meat Products of Island Garden City Samal. Further, the result would be presented to the egg retailers and wholesalers to serve as their guide and ideas to address the problems or challenges that the respondents encountered.

RESULTS AND DISCUSSION

This chapter deals with the presentation of analysis and interpretation of the data gathered in this research study. The various results are presented in the succeeding tables with the corresponding discussions and explanations. It also answered specific problems stated in previous chapter.

Socio - Demographic Profile of Chicken Meat Buyers in Island Garden City of Samal.

The various factors under demographic are the following; age, gender, ethnicity, and civil status.

Table 2: The distribution of respondents according to demographic factors.

SOCIO-DEMOGRAPHIC PROFILE											
AGE			GENDER			ETHNICITY			CIVIL STATUS		
Variable	Frequency	Percentage	Variable	Frequency	Percentage	Variable	Frequency	Percentage	Variable	Frequency	Percentage
18-24	51	34%	Male	83	55%	Tagalog	4	3%	Single	67	45%
25-32	32	21%	Female	67	45%	Cebuano	145	97%	Lived in	30	20%
32-38	16	11%				Tausug	1	1%	Separated	3	2%
39-45	15	10%									
46-52	8	5%									
53-59	15	10%									
60-66	5	3%									
67-73	3	2%									
74-80	2	1%									
81-87	3	2%									

The table above shows the age of the respondents. Majority of them were 18-24 (34%) years old, 25-32 (21%), 32-38 (11%), 39-45 and 53-59 (10%). This implies that the consumer buying chicken meat products were relatively young. Further, this is true in the case of broiler meat since age is significant in buying chicken meat product. This finding aligns to the study of (Menozzi et al. , 2021) which argue that in considering age, younger people had a more favorable attitude towards eating a poultry product. Also, as

perceived in table 1, majority of the consumers who buys chicken products were male with 55% while female consumers are 45%. This finding is supported by the study of (Neima et al., 2021). The study revealed that there were 55.2% male and 44.8% female consumers who constantly buys poultry products particularly chicken products. This implies that male consumers are more likely to buy chicken products than females.

Additionally, as depicted in table 2, majority of the respondents were single 45%. Some were married 29% and few others were live in 20%, widowed 4% and separated 2%. This means that majority of the consumers who purchased chicken meat products are single. However, Doolin et al (2005) suggest that there is no relation between civil status and the consumer's purchase behavior.

Furthermore, the table also shows that majority of the respondents were Cebuano 97% and few others were Tagalog 3% and Tausug 1%. This means that majority of the consumers who purchased chicken meat products are Cebuano whom are commonly the local residents in the Island. This result affirms to the study of the researchers (Nayeem, 2012) which suggest that marketing communication messages may influence consumers' purchase decisions through recognising the cultural differences that have discussed previously. Since Asian-born consumers generally give preference to group goals over individual goals or interests, it may be more effective for marketers to communicate with them at a group-level rather than at an individual level.

Socio-Economic Characteristics of Respondents in Island Garden City of Samal.

The various factors under demographic are the following; education, working status, no. of employed members, and household income.

Table 3: The distribution of respondents according to economic factors

SOCIO-ECONOMIC PROFILE												
EDUCATION			WORKING STATUS			NO. OF EMPLOYED HOUSEHOLD			MONTHLY HOUSEHOLD INCOME			
Particular	Frequency	Percentage	Particular	Frequency	Percentage	Particular	Frequency	Percentage	Particular	Frequency	Percentage	
Elementary Level	2	2%	Employed	41	41%	1	45	45%	9,000 and Below	61	61%	
Elementary Graduate	2	2%	Unemployed	34	34%	2	28	28%	9,001 - 13,000	19	19%	
High School Level	11	11%	Self-employed	15	15%	3	14	14%	13,001 - 18,000	14	14%	
High School Graduate	31	31%	Others	10	10%	4	6	6%	18,001 - 23,000	5	5%	
College Level	31	31%				5	2	2%				
College Graduate	28	28%				6	1	1%				
						Others	1	1%				

The above table shows that 31%, 31%, and 28% of the respondents were high school graduate, college level and college graduate respectively. With these given set of data, it shows that consumers are educated. Hence, they have the capacity to work and have their business as sources of income resulting to increase in their individual purchasing power. This finding affirms to the study of (Chien et al., 2019) which argue that in particular, awareness and knowledge factors have a greater influence on purchasing behavior in northern regions. These findings suggest that enhancing consumer awareness of organic rice and providing more purchasing channels could contribute to increasing organic rice consumption. Consumer education is viewed as the process by which people learn the workings of the-marketplace so that they can improve their ability to act as purchasers or consumers of those products and services they deem most likely to enhance their well-being. On the contrary, some studies, knowledge about a product by consumers through educating them does not change consumer beliefs and self-assessments, which determines their preferences. This implies that consumer beliefs and preferences may not be altered no matter the level of education attained by the consumers (Balogbog, 2018).

Additionally, the table shows that most of the respondents are employed (41%) and unemployed (34%). The self-employed is only 15%. This means that majority of the respondents have a source of income to purchase chicken meat products. Also, the above table shows that 45% of the respondents have (1) employed household member. The others were 2 members (28%), 3 members employed (14%), others (6%), 4 members employed (4%), 5 members employed (2%) and 6 members employed (1%). This means that every family has the capacity to purchase chicken meat products since in every family there are one and two members who are working. This might be a reflection that every week they can consume meat products. Furthermore, as perceived in table 2, 61% of the respondents have an average monthly income of P19, 000 and below which indicates that majority of the respondents belong to income class BC. This implies that these group of income class can purchase chicken meat products especially broiler when the price will decrease. There are 30% of income class D and 9% of income class The results align to the case study of (OECD, 2018) which concluded that meat consumption particularly chicken products have increased steadily over the past few decades. The main

reasons are the increases in the population and in their level of income. As the purchasing level improves, consumers move from grain-based diets to ones in which meat consumption is higher. Hence, it implies that there is a connection between the working status and no. of employed members of the household to the purchasing power that influence the purchasing behavior of the consumer in buying chicken products.

Practices of consumers in buying chicken meat products

This section shows the practices and different approach used by the consumers in purchasing chicken products in different settings.

Table 4. The distribution of respondents according to who decides to purchase chicken meat products.

PRACTICES		
Particular	**Frequency**	**Percentage**
Father	10	7%
Mother	29	19%
Father and Mother	61	41%
Children	23	15%
Others	27	18%

The above table shows that father and mother predominantly make the decision in buying chicken meat products with 41% next to children who also influences the purchasing decision. This finding affirms to study of (Aleti, 2009) which argue that at any stage of socialization, children impact their parents' purchase decisions and behavior. On the contrary, a previous study found that in five of the 18 cases studied children reported a greater effect on parental purchase decisions than their parents perceived. at any stage of socialization, children impact their parents' purchase decisions and behavior (Dikčius et al. , 2019).

Table 4.1: The distribution of respondents according to where consumers purchase chicken meat products.

Chicken Products	Public Market	Meat Shop	Others
Broiler	107	33	10
Native	34	28	88

Table 4.1 shows that the respondents mostly buy broiler at public markets and native at others. It can be observed also that consumers also prefer to purchase chicken in the public market. These results aligned to study of (Dusaran and Pabulayan, 2015) which mentioned that the income of the native chicken growers is relatively low since native chicken production is still a backyard family economic undertaking with limited marketable product volume. Thus, native chicken's availability results for some consumer to purchase native chicken outside public market and meat shop. However, nowadays, native chicken is being displaced in some of the supply chain by broiler or hybrid chickens. This is, an opportunity for small-scale farmers to raise native chicken and generate incremental benefits by supplying the emerging market for this commodity.

Table 4.2. The distribution of respondents according to when consumers purchase chicken meat products.

Meat Type	Everday		2-4 times a week		Once a week		Twice a week		Once a month		Others	
	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage	Freq.	Percentage
Broiler	1	2%	59	39%	43	29%	26	17%	15	10%	4	3%
Native	1	2%	17	11%	37	25%	33	22%	53	35%	7	5%

The above table shows that for broiler there are 59 (39%), 43 (29%), 26 (17%), 15 (10%) of the respondents usually purchase 2-4 times a week, once a week, twice a week and once a month respectively, while 3% and 2% of the respondents purchase others and every day.

Meanwhile, in native, 53 (35%), 37 (25%), 33 (22%), 17 (11%) of the respondents usually purchase once a month, once a week, twice a week and 2-4 times a week respectively, while 5% and 2% of the respondents purchase others and every day. This implies that most consumers purchase broilers or hybrid chicken more often than the native chickens. This is due to the availability of native chickens in the market. As researchers of (Dusaran and Pabulayan, 2015) argue that the income of the native chicken growers is relatively low since native chicken production is still a backyard family economic undertaking with limited marketable product volume unlike broilers or hybrid chickens that are locally available in public markets.

Table 4.3. The distribution of respondents according to attitude

Particulars	Class A		Class BC		Class D	
	Broiler	Native	Broiler	Native	Broiler	Native
Specific parts that are readily available	3	1	59	12	28	20
Choose specific and let it be sliced/chopped/grinded	3	1	9	6	11	16
Others	7	11	24	36	6	9

It can be observed from the table above that majority of the respondents from income classes BC and D buy meat parts that are commonly sold in the market or that are pre-cut into different forms while respondents in income class A choose either of the two. This implies that majority of the consumers mostly buy pre-

cut chicken meat products than readily available cuts of meat. This result affirms the study of

Preferred chicken meat products by the consumers from different income classes in Island Garden City of Samal.

Table 5: The distribution of respondents according to Chicken Meat Purchase Choice.

Response	Broiler			Native		
	Class A	Class BC	Class D	Class A	Class BC	Class D
	(n=13)	(n=92	(n=45)	(n=13)	(n=92	(n=45)
Yes	11	68	9	2	24	36
No	2	24	36	11	68	9

As depicted in table 5, out of the 150 respondents, 88 (59%) respondents buy broiler chicken meat and 62 (41%) respondents buy native chicken meat. This implies that most of the respondents choose to consume broiler meat. This is due to its availability in the market. According to of (Dusaran and Pabulayan, 2015) native chicken growers have low income since native chicken production is still a backyard family economic undertaking with limited marketable product volume unlike broilers or hybrid chickens which are available in any local markets. Thus, this implies that consumer's preference in buying chicken meat products also influenced by its availability in the market although consumers concludes that carcass characteristics, quality and unique flavor of indigenous chicken are higher than that of broiler chicken (Choo et al., 2014).

SUMMARY, FINDINGS AND RECOMMENDATIONS

This chapter presents the summary, findings, and corresponding recommendations about the consumer purchase behavior for meat products in Island Garden City of Samal. This study was conducted in the meat shops and public markets in Island Garden City of Samal. The general objective of this study is to determine the consumer purchase behavior for meat products in Island Garden City of Samal. Specifically, the study aims to identify the socio – demographic profile of meat buyers, to identify practices of consumers in buying meat products, and to know the meat product most preferred by consumers from different income classes in General Santos City.

SUMMARY OF FINDINGS

The following summary of the findings is based on the results of the study:

1. First, result reveals that majority of the respondents were relatively young, most of them are males, single, and are Cebuano whom are local residents in the Island.

2. Secondly, as to education, most of the consumers has higher educational attainment in which most of them are employed which means that they have sources of income to purchase chicken meat products.

3. Thirdly, both mother and father predominantly in purchasing decision with the influence of the children's choices. Meanwhile, most of the respondents purchase chicken meat products in public market for broilers and others such as family backyards for native chicken. Findings also revealed that broilers are purchased 2-4 times a week while native is once a month. In distribution of respondents according to attitude, most of the consumers prefer pre-cut chicken meat products than readily available cuts of meat.

4. Lastly, most of the respondents choose to consume broiler meat than native chicken. Although consumers concludes that carcass characteristics, quality and unique flavor of indigenous chicken are higher than that of broiler chicken, its availability in the market influence the consumers preference.

CONCLUSION

Based on the above discussion, it may be concluded that multiple determinants shape the consumer purchase behavior toward chicken meat products. The findings indicate that the majority of the respondents were young, male, single, and local residents of the Island, specifically Cebuano. They were generally well-educated and employed, suggesting they have the means to purchase chicken meat products. The purchasing decisions were primarily influenced by both parents, taking into consideration the preferences of their children. The respondents typically bought broilers from public markets 2-4 times a week, while native chicken was purchased once a month, often from family backyards. In terms of attitude, most consumers preferred pre-cut chicken meat products over readily available cuts. Although the respondents acknowledged the higher carcass characteristics, quality, and unique flavor of native chicken compared to broilers, the preference for broiler meat was influenced by its availability in the

market. Thus, consumer purchase behavior for chicken meat products in Island Garden City of Samal are dependent on socio – demographic and socio – economic aspects.

RECOMMENDATIONS

The following recommendations are based on the findings of the study.

Chicken Meat Retailers/Vendors

Improve their place especially in practicing proper sanitation. Engaged in selling chicken meat by products with proper branding and labeling. Maintain the quality of chicken meat products

Chicken Meat Producers

Engage in selling broiler chicken meat. There is a good business in producing broiler for income class BC.

Government Sector (NMIS)

Increase nutrition benefits information to the consumer in order to increase food safety and consumption. Proper government food safety enforcement.

Meat Shops

Provide proper labeling and packaging of meat products.

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International Journal on Biological Sciences

International Journal on Biological Sciences 15 (2), July-December 2024, Pp. 113-117
ISSN No.: 0976-4518
https://doi.org/10.53390/IJBS.2024.15206

MAPPING THE SOWING WINDOWS OF WHEAT IN LUDHIANA DISTRICT USING SENTINEL-2 SATELLITE IMAGES

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Research Paper

Received: 16.9.2024 Revised: 14.10.2024 Accepted: 19.11.2024

ABSTRACT

Yellow rust is a destructive disease that adversely impact the growth and production of wheat. Previous studies shown that the parts of Rupnagar district, the foothill district of Punjab, is the most severely affected area for yellow rust of wheat because climate conditions in this area are favourable for its growth. Therefore, a study was planned to demonstrate the potential of Sentinel-2 images in detecting the yellow rust of wheat at village level (Nangal Nikku and Dukli villages of Rupnagar District of Punjab). The time series Normalized Difference Vegetation Index (NDVI) values from 27 January, 2024 to 08 February, 2024 were extracted from Sentinel-2 images to distinguish the diseased from healthy crop in the two villages. Compared with the NDVI values of healthy wheat, a decrease in NDVI by 17.9 -19.4% was observed in the disease stressed crop during this period. The rule-based classification effectively identified the yellow rust areas of wheat in the two villages. These results showed that Sentinel-2 may be used for detection of diseased crop at village level and this may assist in taking the contributing to improved crop health and yield sustainability.

No. of Pages: 5 **References: 11**

Keywords: Wheat mapping, NDVI, Sowing cycle & Crop classification.

INTRODUCTION

Punjab's wheat crop is a significant contributor to the nation's food grain production. The favourable climatic conditions along with soil conditions and agronomic factors create a thriving environment for wheat cultivation in Punjab (Sandhu et al., 2023). The state's high wheat yield is a result of modern farming practices including irrigation and mechanisation. However, identification of sowing dates of wheat is crucial in crop modeling that determines how weather in addition to abiotic and biotic stress will affect wheat yield (Qiao et al., 2023). Remote sensing emerged as a powerful tool providing the invaluable insights into many facets of the wheat cultivation cycle. This technology encompasses diverse methods like multispectral and hyperspectral sensors, and unmanned aerial vehicles (UAVs) to extract the sowing dates of wheat. By leveraging the spectral properties of wheat at different wavelengths, these techniques enable accurate crop classification and the identification of key parameters such as crop health, water stress levels, nutrient deficiencies, and potential pest infestations (Choudhury and Bhattacharya, 2018; Skendzic, et al, 2023). This information empowers farmers and agricultural experts to make informed decisions regarding irrigation scheduling, fertilizer

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application, disease and pest management, ultimately leading to optimized resource utilization and increased crop yields (Lee *et al*., 2010).

Several studies have demonstrated the effectiveness of remote sensing in various aspects of wheat production (Gao, 2024; Pan et al., 2021). Lobell et al. (2013) used the Moderate Resolution Imaging Spectroradiometer (MODIS) and Satellite Pour l' Observation de la Terre Vegetation (SPOT) sensors to measure the sow dates in the Indian section of the Indo-Gangetic plains. Dinesh kumar et al. (2019) mapped the crop phenology using time series MODIS data in the parts of Tamilnadu. Singh et al. (2022) derived the phonological metrics of crop from Landsat data. Yue et al. (2024) used the Sentinel-2 images for wheat planning and harvesting area in the North China Plain. There are few studies in which Sentinel-2 imageries have been used form mapping the sowing windows of wheat in Punjab. Therefore, a study was carried out to evaluate the efficacy of Normalized Difference Vegetation Index (NDVI) derived from Sentinel-2 satellite imagery for mapping the sowing windows of wheat in the Ludhiana district of Punjab.

MATERIALS AND METHODS

Study area: The sowing windows of wheat were extracted in the Ludhiana district of Punjab (**Fig.1).** Ludhiana district is situated in the centre of the Punjab plain region which is devoid of major topographic features and is conspicuously a flat terrain. The major physiographic units are: flood plain, alluvial plain and sand bars or dunes. The elevation of the Ludhiana plain varies from about 268 m in the east to about 216 m in the western part. The topography of the district is shaped by Satluj River and its tributaries. The river course changes from time to time. The total rainfall of the district averages 660 mm (average of 40 years). About 70 per cent of the rainfall is received between July and September and coincides with most of the growth period of the *Kharif* crops. From October to the end of June, generally dry conditions prevail except for a few light showers received owing to westerly depressions. The district represents the extremes of climate. The summer temperatures are severely high, with May to June temperature ranging from 45 ^{0}C to 48 ^{0}C. The winters are fairly cold, with temperature touching very low on a few days during December to January. Frosts are fairly common during these months.

Satellite data: This study utilizes data from the Sentinel-2 mission, specifically the Sentinel-2A and

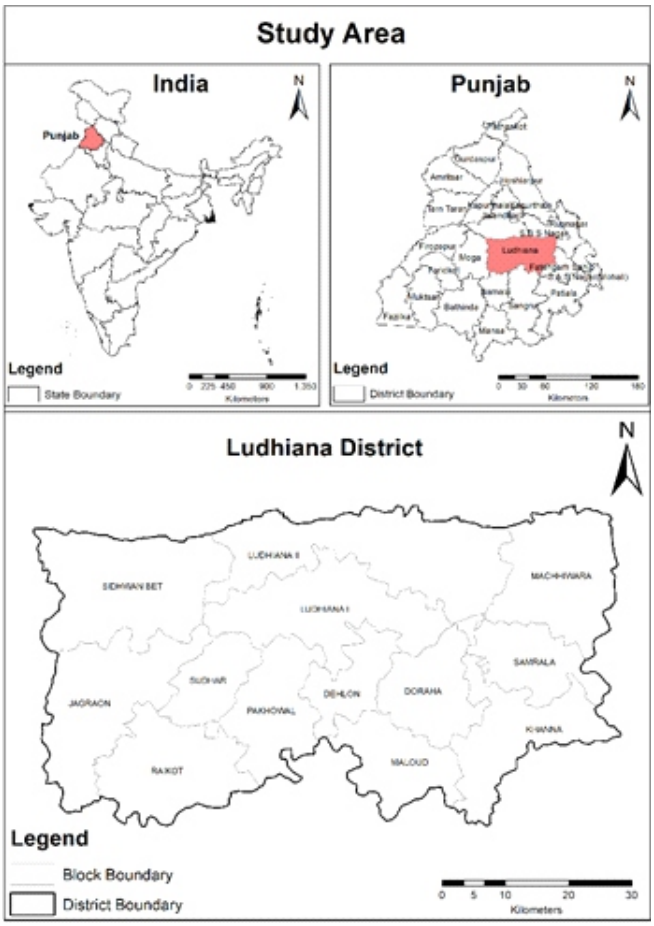

Fig. 1: Study area.

Sentinel-2B satellites. These satellites cover vast areas in a single pass and useful for wheat mapping projects on district /block scale. With a 10-meter spatial resolution in the visible and near-infrared (NIR) regions, they provide sufficient detail to distinguish between wheat fields and other land cover types. Their 13 spectral bands capture information across various wavelengths. This information is crucial for differentiating wheat from other vegetation based on its unique spectral signature, which varies across the electromagnetic spectrum throughout its growth cycle. The two Sentinel-2 satellites have a combined revisit period of 5 days. This frequent data acquisition allows for capturing critical changes in wheat crops throughout the growing season.

Methodology

In this study Sentinel-2 time series images from November 2022 to April 2023 were used to cover the wheat crop's growth stages from sowing to harvesting seasons. Normalized Difference Vegetation Index (NDVI) was derived from the pre-processed images to

understand the spatio-temporal dynamics of the wheat crop, and is calculated using the following formula.

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Where, NIR is the spectral reflectance in the near-infrared band, and Red is the spectral reflectance in the red band of the multispectral Sentinel-2 satellite image.

Ground-truth locations of wheat fields were collected through field visits in the Ludhiana district to identify the spectral signature of wheat fields and the variation of the spectra. For these locations, the temporal variation of NDVI was computed. A rule-based classification was performed to distinguish from other crops based on the time series NDVI profile.

RESULTS AND DISCUSSION

Classification of wheat

In this study, Normalized Difference Vegetation Index (NDVI) analysis showed a distinct temporal patterns for wheat in the Ludhiana district. During the sowing period (late October to November), wheat fields exhibited the lower NDVI values (< 0.2) due to sparse vegetation cover. As the crop enters its vegetative growth stage, the NDVI values progressively increase (> 0.5), reaching a peak when the leaves and shoots are fully developed. Following harvesting in April and May, NDVI values again drop significantly (< 0.2) due to the removal of plant biomass. Using these variations in NDVI values observed at ground-truth locations, a rule-based masking technique was implemented. This technique identified regions exhibiting specific temporal patterns in NDVI: below 0.2 during sowing, above 0.5 during full growth, and below 0.2 after harvest (Fig. 2).

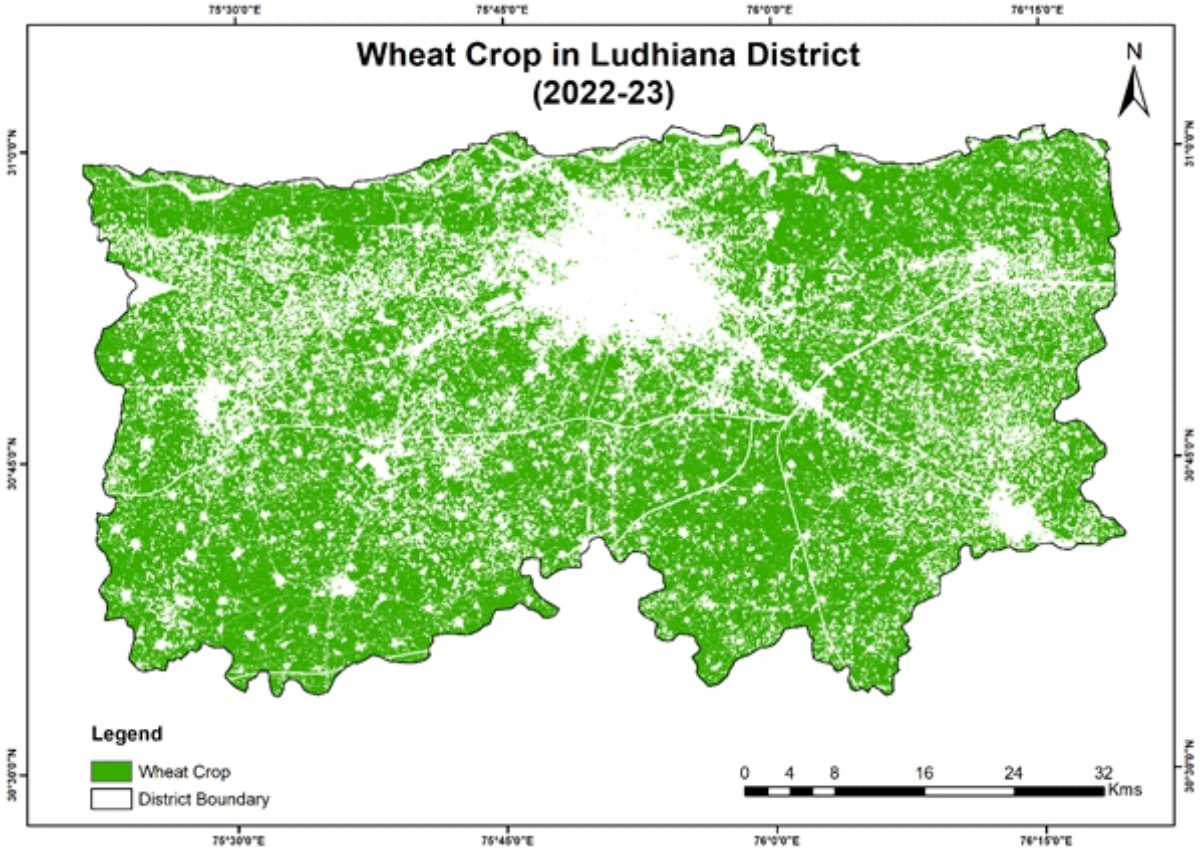

Fig. 2: Wheat sowing in the Ludhiana district of Punjab during 2022-2023.

Cycle-wise sowing dates of Wheat crop:

Using time-series NDVI data from October to December, the cycle wise sowing data was generated at 10-m spatial resolution for the crop season 2022-2023. Figure 3 showed that wheat sowing started form 1st October 2022 which covered 8% of the sowing area. There was an increase by 4% in sowing area from 11-20 October 2022, however, sowing area decreased by 5.9% between 21 and 30 October 2022. The area under wheat sowing was 27.8% between 1 and 20 November 2022. Highest wheat (49% of the sowing area) sowing took place from 21 to 30 November followed by 28% sowing in between 1 and 10 December 2022 (Fig. 4). The wheat sowing area over the three months was in the order: November 2022 (77.2% of the sowing area) > October 2022 (28.0% of the sowing area)> December 2022 (26.8% of the sowing area). The distinct temporal patterns observed in NDVI values across the wheat sowing over three months showed the crop classification with an overall accuracy of 86%.

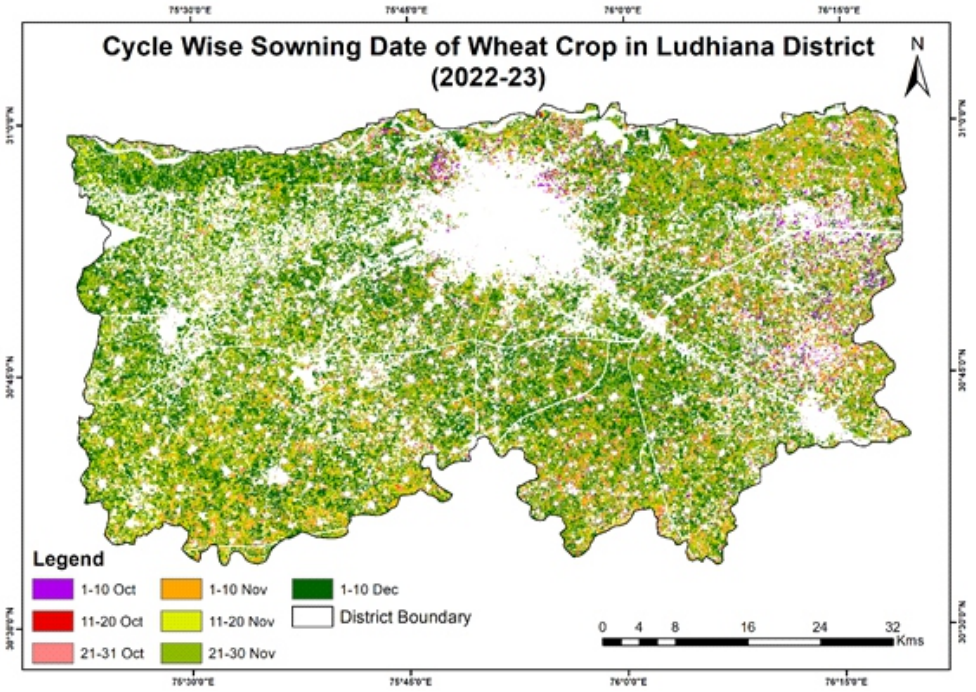

Fig. 3: Cycle wise wheat sowing in the Ludhiana from October to December 2022.

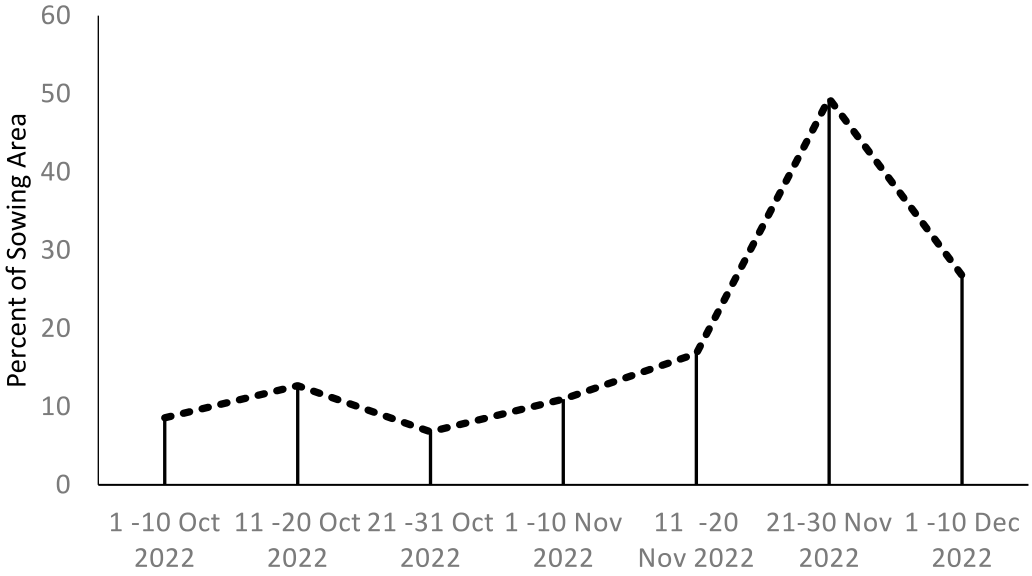

Fig. 4: Area under wheat sowing in the Ludhiana district of Punjab from October to November of the year 2022.

CONCLUSIONS

The results of this study showed the effectiveness of NDVI values extracted from Sentinel-2 satellite data for mapping the sowing dates of wheat in Ludhiana district (Punjab) on spatial scale. The rule-based classification model based on NDVI values provided the accurate mapping and classify the wheat area according to different sowing dates. The maximum sowing area in the district was observed between 1 and 30 November 2022. The replication of this study is useful for planning precision agricultural operations, agronomic practices and understanding the spatio-temporal dynamics of crop in an area.

ACKNOWLEDGEMENT

We acknowledge the *European Space Agency* for providing open access Sentinel data.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship and publication of this article.

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International Journal on Biological Sciences

International Journal on Biological Sciences 15 (2), July-December 2024, Pp. 118-125
ISSN No.: 0976-4518
https://doi.org/10.53390/IJBS.2024.15207

INNOVATIVE METHODS OF CHEMICAL SCIENCE COMMUNICATION: MAKING CHEMISTRY ACCESSIBLE TO ALL

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Research Paper

Received: 20.09.2024 Revised: 22.10.2024 Accepted: 17.11.2024

ABSTRACT

Effective communication in chemical science is essential for enhancing public understanding and engagement with the subject, particularly given its significance in addressing contemporary global challenges. This study investigates innovative methods for communicating chemical science to diverse audiences, including students and the general public. By employing a mixed-methods approach that includes a literature review, bibliometric analysis, a survey, and expert interviews, the research identifies key challenges in chemistry education and communication. Findings indicate that the complexity of chemical concepts, insufficient hands-on experiences, and the abstract nature of the subject hinder comprehension. The study highlights the importance of using visual aids, real-world applications, and technology integration to make chemistry more accessible. Recommendations for improving communication strategies are provided, aiming to foster greater appreciation for chemistry and its relevance to everyday life.

No. of Pages: 9 **References: 10**

Keywords: Chemistry, biology, geology, education, communication, space.

INTRODUCTION

The need for effective science communication has never been more critical, especially as scientific literacy becomes increasingly important in addressing global challenges such as climate change, public health, and technological advancement[1]. In the common public opinion, Chemistry is often perceived as a complex and abstract subject matter leading to less engagement and understanding. However, the integral role Chemistry plays in our daily lives, influences everything from the food we eat to the clothes we wear. Perhaps the complexity lies more in the chemical concepts that often the general public can't relate to. In such a case, effective communication of chemical science is the key! It can help bridge this gap, fostering a greater appreciation for chemistry and its relevance to social issues. As science becomes increasingly integrated into policy decisions and mainstream public discourse, the ability to communicate scientific concepts clearly and effectively is essential.

This study aims to explore innovative methods of chemical science communication that can make chemistry and related topics more accessible to all audiences including students and the common people. The research focuses on identifying effective strategies for communicating chemistry, explore the challenges faced by chemistry educators and communicators and provide recommendations for improving chemical science communication. The study is based on a combination of scientific literature review, bibliometric

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analysis, and empirical data collection via surveys and expert interviews. By examining the current landscape of chemical science communication, the study aims to inform the development of new strategies and resources that can enhance public engagement with the central science i.e. Chemistry.

Methodology

The data has been collected using 4 main sources. They included:

1. **Scientific Literature Review:** To identify existing methods and strategies in chemistry education and science communication, a comprehensive review of peer-reviewed articles was conducted. This review focused on studies that highlighted innovative approaches to teaching and communicating chemistry[2].

2. **Bibliometric Analysis:** Using VOSviewer (version 1.16.19), a software tool for creating and visualizing bibliographic networks, a bibliometric analysis was performed on articles indexed in the PubMed database related to search keyword combination "Chemistry" AND "Science Communication" from 1980 to 2024. This analysis aimed to identify key themes, trends, and influential works in chemistry science communication.

3. **Survey:** A survey was designed to gather insights from students with chemistry and non-chemistry backgrounds and the general public. The survey collected inputsregarding their experiences and opinions on challenges they faced and improvements they can suggest in chemistry education and effective communication methods.

4. **Expert Interviews:** In-depth call interviews were conducted with Experts in Chemistry Education and Chemical Science Communication. Qualitative insights were gained from their experiences and best practices in chemistry communication. The interviews aimed to explore the nuances of effective communication strategies and the contextual factors that influence their implementation.

Participants of the Survey and Experts were approached through professional networks, social media platforms, and academic institutions. A total of 57 survey responses were collected, and 2 in-depth interviews were conducted.Quantitative data from the survey were analyzed and the most important and relevant ones have been listed in tabular form in this paper, while qualitative data from interviews were analyzed thematically. This mixed-methods approach allowed for a comprehensive understanding of the current landscape of chemical science communication.

RESULTS AND DISCUSSIONS

- **Results from Scientific Literature Review**

The literature review revealed several key themes in effective chemical science communication.

Methods in Chemical Science Communication	Brief description
1. Visual Aids and Hands-On Activities	Studies indicate that using visual aids, such as diagrams, videos, and interactive simulations, significantly enhances understanding of complex chemical concepts [2]. For example, Hofstein and Mamlok-Naaman (2007) highlighted the benefits of laboratory activities in enhancing students' understanding of chemistry and developing their scientific skills [3].
2. Relate to Real-World Scenarios	Research demonstrates that connecting chemistry to real-world issues, such as environmental sustainability and health, increases student motivation and interest [1]. Eilks and Hofstein (2015) found that using socio-scientific issues (SSIs) as a context for teaching chemistry can significantly enhance students' engagement and understanding of the subject [1]. Holman (1987) emphasized the importance of relating chemistry to everyday life and personal experiences to make it more meaningful and memorable for learners.

3. Technology Integration	Technology-enhanced teaching, including online resources and digital simulations, has been found to facilitate interactive learning experiences [4]. The use of social media and online platforms for science communication has also gained traction, allowing educators to reach wider audiences. Barak (2017) noted that technology can enhance collaborative learning environments and provide access to resources that may not be available in traditional classroom settings [4].

· **Results from the Bibliometric Analysis**

The bibliometric analysis conducted using VOSviewer software is as below and highlighted the following trends:

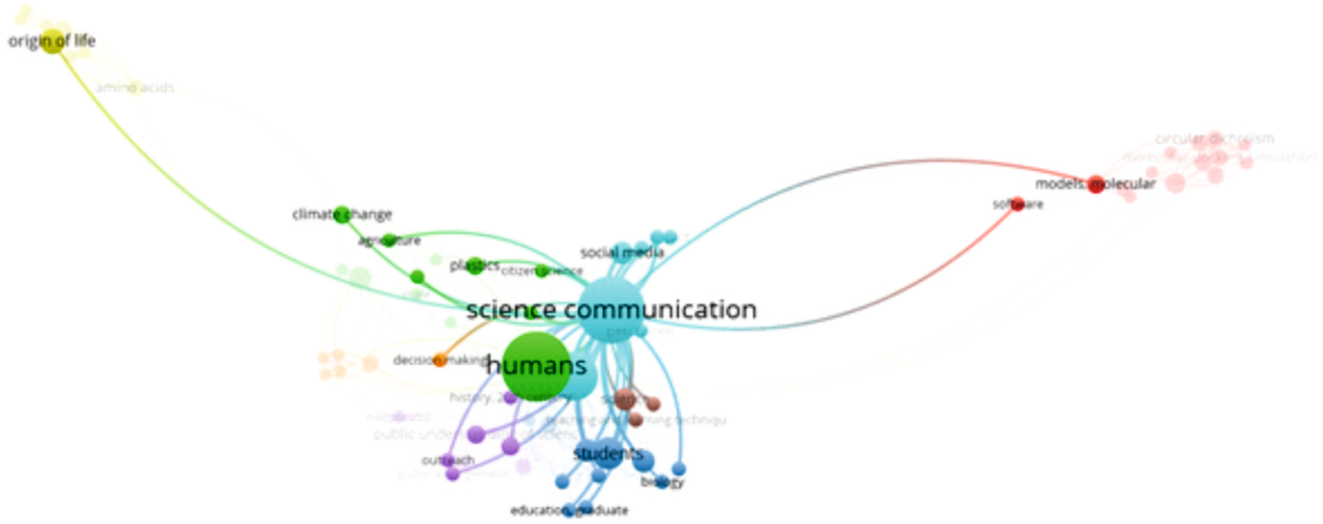

Figure 1: The figure shows the Bibliometric Network generated using VOSviewer- version 1.6.19 with the keyword combination "Chemistry" AND "Science Communication" based on the literature on the PubMed database published between 1980 and 2024 (Keyword Threshold count-2). This Bibliometric Network serves three purposes: 1) Validates the study showing the connections between "science communication" and popular topics related to chemistry like "models, molecular", "origin of life", "climate change", and more. 2) Reduces Bias during literature review (software generated). 3) Helps find loopholes directing future research based on connections in the Bibliometric Network.

NOTE: In a bibliometric network visualization, circle size denotes entity importance based on citation counts, while line thickness indicates connection strength. Colours differentiate clusters or categories, aiding in identifying research fields or collaboration groups within the network.

The Bibliographic Network generated, in Figure 1 implies that Chemical Science Communication is more often done citing concept examples or applications from physical or life sciences. Chemistry is a point of connection among various fields and finds more relevance to the readers and students through its role in physical or life science topics like the origin of life, climate change, plastics, thermodynamics, molecular models, DNA, spectrometry, biomedical research, and many more. Furthermore, this was even shared as an insight by an Expert Interviewee, Ms. Sanjukta Mondal, mentioned later in the paper. She thinks that sharing about Chemistry by connecting it to trending topics or daily-used objects or applications or through stories of inventions and stalwarts in the field is more appealing to her audience.

- **Survey Results**

The survey was able to collect a total of 57 responses. Please note that all the survey participants have provided us with their consent allowing us to use their survey data inputs for Research purposes only without revealing their identities. The following are the key findings:

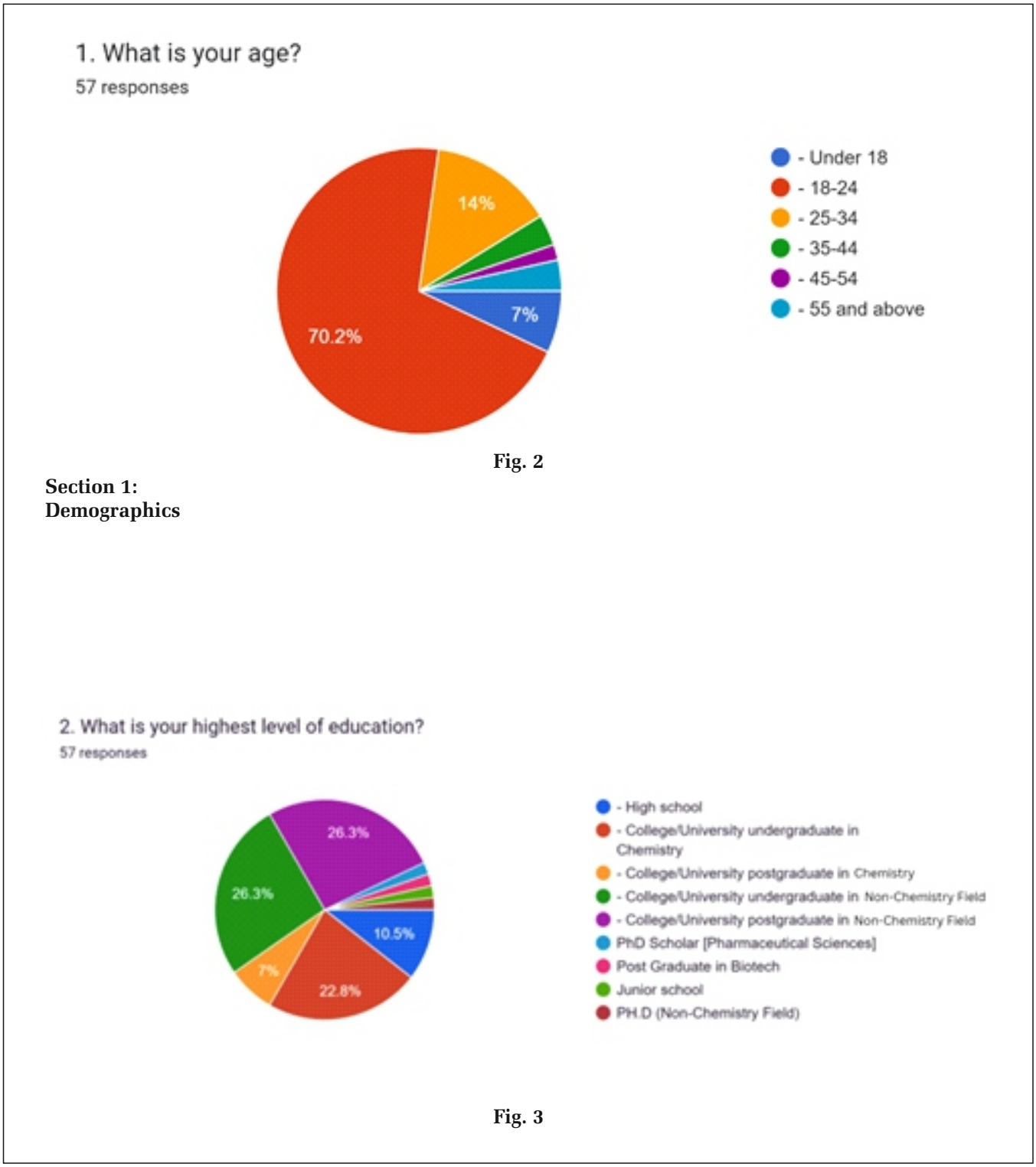

Fig. 2

Section 1:
Demographics

Fig. 3

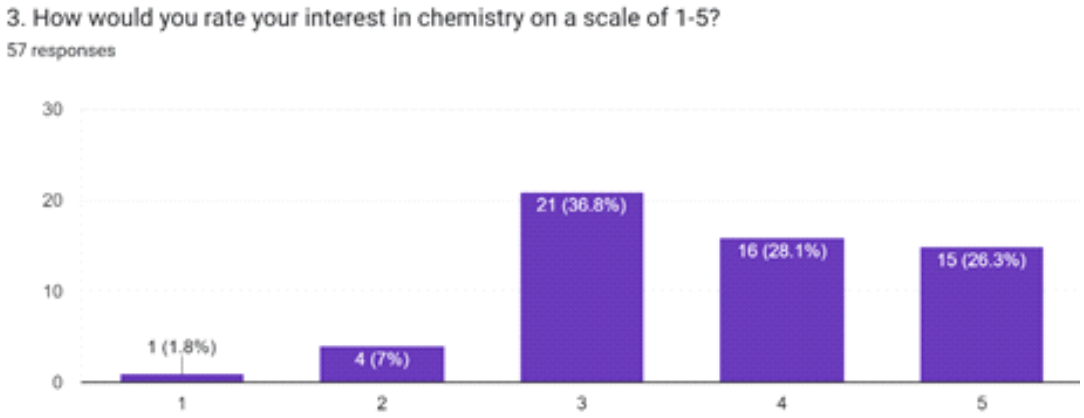

Fig. 4

Section 2: Interest in Chemistry

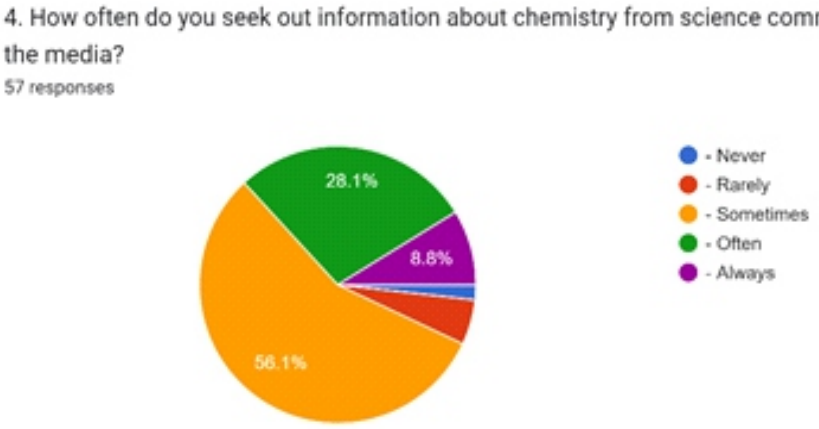

Fig. 5

Section 3: Learning Preferences

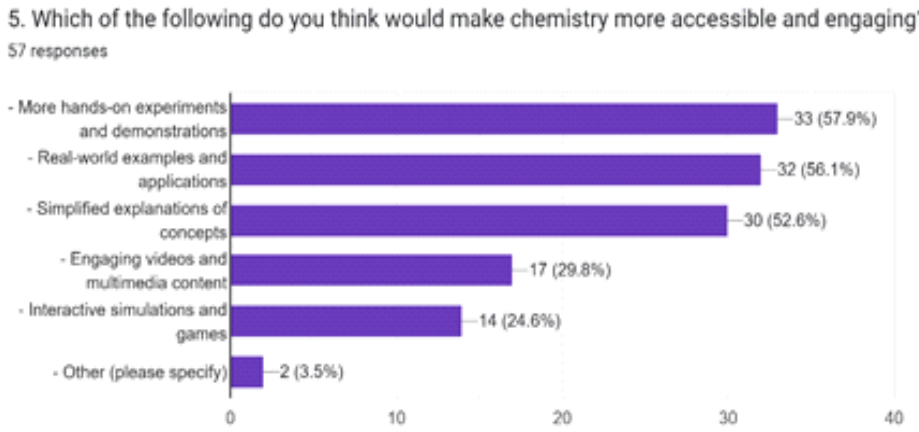

Fig. 6

6. What are some of the challenges you face in understanding chemistry concepts? *(Only the most important and relevant inputs have been considered)*

- Understanding Complex Chemical Reactions
- Difficulty in Remembering Formulas
- Lack of Hands-on Experiments
- Chiral Centers and Stereochemistry
- Poor Conceptual Understanding from Early Education
- Interconnected Nature of Concepts
- Visualization and Abstract
- Limited Multimedia Resources for Advanced Topics
- Mathematical Requirements
- Insufficient Practical Application

7. Do you have any suggestions for how chemistry can be made more accessible and engaging for students and the general public?

(Only the most important and relevant inputs have been considered)

- ✓ Real-World Applications
- ✓ Hands-On Experiments
- ✓ Interactive Learning Tools
- ✓ Simplified Explanations
- ✓ Use of Multimedia
- ✓ Focus on Experimental Learning
- ✓ Community Engagement
- ✓ Visual Representation
- ✓ Encouraging Curiosity
- ✓ Access to Resources

- ***Expert Interview Insights***

Two Chemical Science professionals were interviewed [5][6][7].A balance of inputs was ensured by interviewing [8][9][10] a Chemistry Researcher and Educator more relevant to student education and a Freelance Science Journalist involved with public understanding of chemical science. Dr. Maya Gupta (Teaching Faculty, Department of Education, Jadavpur University, Ph.D. and Post Doctorate in Chemistry) was interviewed as a Chemistry Researcher and Educator. Ms. Sanjukta Mondal (Freelance Science Writer, Journalist, and Consultant) was approached to receive inputs on Chemical Science Communication with relation to the general public. They provided additional insights into the challenges and best strategies in chemistry education and science communication:

1. *Personal inspiration pointers on taking up Chemistry as a field of study.*

   - o For Dr. Maya it was more the colourful chemical reactions, observation of nature, and her desperation to learn a subject generally considered hard by her peers that inspired her to take up Chemistry as a career path.

   - o For Sanjukta it was her School Chemistry Teacher who made the subject more fun and relatable to her. The hands-on laboratory work she was involved in high school also was a motivating factor behind going for further study in Chemistry.

2. *Effective methods of chemical science communication and tailoring it as per target audience.*

   - o Dr. Maya emphasized more on fostering observation of nature and its changes among the students like in leaf or flower (colour changes with chemical reactions, slow and fast with time). Hands-on activities and Application-based learning can help a student better understand the subject matter. The Five E-Model (Engage, Explore, Explain, Elaborate, and Evaluate) and Learning through collaboration, brainstorming, by-doing, project-based, group discussion, debate, wall magazines, etc. can be helpful on a case-to-case basis.

     She believes storytelling methods and traditional media like, nukkadnatak (a traditional Indian street play), and anti-superstitioncampaigns can be instrumental in making chemistry more relatable to the common people.

   - o Sanjukta believes in communicating about Chemistry with better storylines and visuals rather than just facts and figures. Connecting to popular Science shows or movies (like Breaking Bad) and the stories of people involved with the invention, discoveries, or historical context helps make the content more human and interesting for the people. She doesn't use chemical symbols or

reactions in her science communication works unless essential with supporting lucid explanation.

In Inreach, scientific communications can include a bit more jargon and facts given the target audience is more familiar with the fundamentals of the subject. However, for outreach science content storytelling and connecting to daily life activities can help gain a better appreciation for the topic. Being open to feedback from different kinds of audiences (without bias) and improving accordingly is the key!

3. Challenges in chemical science communication.

- A decline in the student interest in chemistry in recent times, corruption in the education system, lack of funds for fostering creative learning, and digital media addiction are some of the challenges faced by Dr. Maya in chemistry education.

- Sanjukta mentions that while simplification of facts is important, oversimplification which may lead to misinterpretation of the facts is not desirable. Over-explanation of a topic also stands out as a challenge at times.

4. Role of Chemistry educators and science communicators.

- Both Dr. Maya and Sanjukta agree that the role of a chemical science communicator lies in making the content more engaging and accessible to various kinds of audiences. This can foster an appreciation for the subject and most importantly promote ethics and scientific temperament.

Conclusion

The study validates the need for innovative communication strategies in chemical science to enhance student education, public understanding, and engagement. Key challenges identified include the complexity of chemical concepts, difficulties in memorization, and insufficient practical experiences, which affect effective learning. To address these issues, it is recommended to increase hands-on experiments, utilize technology for interactive learning, and connect chemistry to real-world applications. Additionally, employing visual aids and fostering community engagement can make chemistry more accessible. Future directions should focus on policy changes toward developing tailored communication strategies that resonate with diverse audiences, ultimately promoting a deeper appreciation for chemistry and its relevance in everyday life.

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Appendix A: Survey Questionnaire

The survey was collected using a Google Form. All questions marked with * were mandatory. The questions included.

Section 1: Demographics

1. What is your age?*
   - Under 18
   - 18-24
   - 25-34
   - 35-44
   - 45-54
   - 55 and above

2. What is your highest level of education?*
   - High school
   - College/University undergraduate in Chemistry
   - College/University postgraduate in Chemistry
   - College/University undergraduate in Non-Chemistry Field
   - College/University undergraduate in Non-Chemistry Field
   - Other

Section 2: Interest in Chemistry

3. How would you rate your interest in chemistry on a scale of 1-5?*

   (1 being not interested at all, 5 being extremely interested)

4. How often do you seek out information about chemistry from science communicators online or in the media?*
   - Never
   - Rarely
   - Sometimes
   - Often
   - Always

Section 3: Learning Preferences

5. Which of the following do you think would make chemistry more accessible and engaging?* (Multiple Choices)
   - More hands-on experiments and demonstrations
   - Real-world examples and applications
   - Simplified explanations of concepts
   - Engaging videos and multimedia content
   - Interactive simulations and games
   - Other (please specify)

Please specify here (if you have chosen others in the above question)

6. What are some of the challenges you face in understanding chemistry concepts?*(open-ended question)
7. Do you have any suggestions for how chemistry can be made more accessible and engaging for students and the general public?*(open-ended question)

Section 4: Final Thoughts and Consent

8. Any additional comments or feedback?
9. Please provide us your consent that you allow us to use your data provided in this survey for Research purposes only without revealing your identity.*
   - Yes sure!

Appendix B: Expert Interview Questions

Common questions:

1. What inspired you to become a science communicator and/or educator in the field of chemistry?
2. What are some of the most effective methods you have used to make chemistry accessible and engaging for your audience?
3. How do you tailor your communication style and content to different age groups and educational backgrounds?
4. What are some of the challenges you face in communicating complex chemistry concepts to a non-expert audience?
5. What message would you like to give to chemical science educators and science communicators in terms of making chemistry more accessible to all?

Miscellaneous (asked on case-to-case basis):

For Chemistry Educator: Name some organizations that help or can help cater to the greater audience in terms of chemical science education.

For Chemistry Science Communicator: How do you collect audience feedback based on your chemical science communication content?

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International Journal on Biological Sciences

International Journal on Biological Sciences 15 (2), July-December 2024, Pp.126-131
ISSN No.: 0976-4518
https://doi.org/10.53390/IJBS.2024.15208

A LITERATURE REVIEW ON BIOACCUMULATION OF HEAVY METALS IN AQUATIC ECOSYSTEM WITH SPECIAL REFERENCE TO INDIA

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Review Paper

Received: 22.10.2024 Revised: 18.11.2024 Accepted: 07.12.2024

ABSTRACT

Fish is a popular choice for its nutritional benefits, but it is also important to be aware of potential risks associated with chemical contamination, Monitoring and regulating these contaminants are crucial for ensuring safe consumption of aquatic foods. The increasing risk of toxicity due to heavy metal accumulation in fish poses significant global dangers, particularly in aquatic ecosystem. Development projects have been a subject of study for their environmental impact, altering not just geometry but also natural hydrological and sedimentological processes. Our research aims to assess the impact of such projects on heavy metal accumulation in aquatic-origin fish, crucial for ensuring both fish and human health safety.

No. of Pages: 9 **References: 10**

Keywords: Fish, Human health, Heavy Metals, Bioaccumulation, Toxicity.

INTRODUCTION

Water is a very crucial component of life it is an abundantly found material in nature. It is a critical constituent of all living forms. Adequate water quality is vital for all living beings including humans who use it for drinking as well as for other purposes. Drinking water is supplied through groundwater sources like rivers, lakes, ponds, dams and so on (Dwivedi, 2020). These sources are always being contaminated with different types of pollutants (Kalal et al., 2020). So, these essentially need the quantitative analysis of pollutants in water (Momin Shaziya, 2018). Aquatic pollution is world's biggest problem and continues to threaten both public health and quality of life. India is a developing country near about 70% of industrial wastes is dumped untreated into local water bodies. These activities pollute usable water. Industrial wastes including electronic wastes, microplastics contain toxic chemicals, metallic waste, oil, and acids and along with these numbers of metals are released in an aquatic environment that harms the aquatic biodiversity (Verma and Prakash, 2020 & 2022). Some such substances are Arsenic (AS), cadmium (Cd), chromium (or), copper (Cu) lead (Pb), mercury (Hg), Zinc (Zn), Nickel (Ni) etc. (Khillare, 2018). Effects of arsenic on fishes are well studied by Prakash and Verma (2019 & 2020).

All the water resources are contaminated with sewage waste, industrial waste, toxic inorganic and organic

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pollutants. The anthropogenic activities are not only creating biodiversity threats but also various types of pollution Prakash and Verma (2022). Aquatic pollution results in a water quality that affects the aquatic organisms which in turn can affect human health through the food chain. And all these things can cause unpredictable changes in the ecosystem (Shinde et al., 2019). Aquatic life is totally dependent on the ecosystem for growth, reproduction and survival. Fishes are secondary consumers in the aquatic food web providing food for other trophic levels and human beings. The waters contaminated with heavy metals and sediments can bring many physiological, histological, haematological, behavioural, and other different changes in the fish community (Nandan, 2012).

A systematic literature review on the accumulation of heavy metals in fish and their impacts on human health would involve gathering and analysing relevant studies on this topic. The review would likely explore factors such as the sources of heavy metal contamination in aquatic environments, the uptake and accumulation of heavy metals in fish tissues, and the potential health effects on humans consuming contaminated fish. A systematic literature review with a specific emphasis on selecting and analysing relevant studies published in various databases like Scopus, Google scholar, and shodhganga. This type of review aims to provide a comprehensive summary of existing scientific knowledge on the topic.

Normal methodology

Preserving fish samples properly and then analysing them based on various criteria like sex, species, and size helps researchers understand their characteristics and potential health implications, such as heavy metal exposure. Dissecting the samples into muscle and liver tissues allows for specific analysis of heavy metal storage and exposure pathways. It is a thorough process to ensure accurate results. The process outlined involves thorough washing of fish samples with purified distilled water to remove any contaminants. After dissection, specific tissues like muscle, liver, and gonads are collected, dried, and stored for analysis. The samples are packaged, sealed, and frozen for future use. Determinations are made within a set timeframe to ensure the integrity of the samples. Further preparation involves homogenizing the dried samples, followed by lyophilisation, and finally, acid digestion for liquefaction. This detailed procedure ensures accurate analysis of the fish samples for various purposes.

For heavy metal analysis in fish organs, researchers often utilize either inductively coupled plasma optical emission spectrometry (ICP-OES) or atomic absorption spectrometry (AAS). Both methods are commonly employed for their sensitivity and accuracy in detecting and quantifying heavy metals in biological samples like fish tissues. Each method has its advantages and may be chosen based on factors such as the specific heavy metals being analysed or the laboratory's equipment and expertise

Historical Reviews:

The table below represents classification and comparative study between different articles on heavy metal accumulation in fish species, especially from India.

Author	Species	Study Area	Heavy Metal	State	Year
S. Biswas et al.	*Sarda Orientalis, Siganus Javus S. Commerson*	Kalpakkam	Cu, Mn, Mn, Fe, Cr, Pb	Tamil Nadu	2010
S. Jasuja	*M.Singhala, C. Mrigala, C.Carpio, L. Rohita*	Satlaj River	Cd, Cu, Zn, Pb, Cu	Panjab	2011
G. Ambedkar & M. Muniyan	*Mystrus vittatus, Tilapia, H. fossilis, Ctenopharyngodon idella,Saurida undosquamis*	Collidam River	Cu, Pb, Cd, Zn	Tamil Nadu	2011
K. Yadri et.al	*Etroplus suratensis, Tetradonv nigroviridis, Ambasis commersoni*	Savitri River	Pb, Cd, Hg	Maharashtra	2012
Bhupendra Kumar et. al.	*Bombe duck, Scolidon, Bhola, Pomfret, Hilsa, Markrel.*	Mandipur	Fe, Zn, Cu, As, Hg, Cd	West Bengal	2012
R.M. Patil		Ratnagiri	Cu, Zn, Cd, Hg	Maharashtra	2012
Kandasami D.	*Clibanarius infraspinatus, Maretrix casta, Mugil cephalus*	Arasalar Estuary	Cu, Zn, Cd	Tamil Nadu	2012
Ciji P.P.	*Puntius parrah*	Paraiyar river	Cu, Zn	Kerala	2012
M.J. Shaikh	*Labeo rohita*	Nathsagar Dam	Cd, Cr	Maharashtra	2013
N.S. Pimple & S.S. Kharat	*Osteoberma vigorsi*	Nira River, Bhor	Fe, Zn, Cu, Zn, Pb,Cu	Maharashtra	2013
M.D. Giripunge	*Tilapia mosambica*	Gandhi Sagar Lake, Nagpur	Pb, Cu, Cd, Mn, Fe	Maharashtra	2013

R.K. Negi & Arti Mourya	*Labeo rohita & Hypothalmix moltrix*	Haridwar	Cu, Cr, Pb, Ni, Zn, Cd	Uttarakhand	2013
Singh Jyotsna	*C. mrigala & Catla catla*	Yamuna River	Cd, Cr	Uttar Pradesh	2013
M.J. Shaikh	*Cirribinus mrigala*	Nathsagar Dam	Ni, Pb, Cd, Zn	Maharashtra	2014
Arya & Alpana	*Clarias batrachus & Channa panchutus*	Khan River, Indore	Hg & Cd	Madhya Pradesh	2014
K. Khillare et.al.	*Tilapia mosambica*	Sambhaji Nagar	Cu, Cr, Ni, Cu, Pb, Cd, Zn	Maharashtra	2014
Rajiv Kumar	*Labeo rohita & E. kavei*	Yamuna River, Allahabad	Pb, Cu, As	Uttar Pradesh	2015
Karunanidhi K. et.al.	*Takifugu oblongus, Arothron, Lagocephalus guentheri*	South East Coast of India	Cu, Pb, Cd, Zn.	Tamil Nadu	2015
Jayasooryan K. K.	*Hyporhamphus xanthopterus, Horabagrus brachysoma, Etroplous suratensis.*	Vambanand Lake	Zn, Cd, Pb, Cu	Kerala	2015
Divya Pal	*Labeo rohita & Labeo bata*	Dhanbad	Pb, Cu	Jharkhand	2016
Vidya Bhavani Malarapu	*Ariomma indicum, Pentaprion Longimanus, Nemipterus japanicus, Sphyreana obtusata*	Visakhapatnam	Cu, Mn, Fe Ag, As	Andhra Pradesh	2016
Chaitanya	*Pampus argentus, Rastreliger Kanagurta, Upeneus vittaus*	Visakhapatnam	Cr, Mn, Co, Cd, Pb	Andhra Pradesh	2017
Praveen Dattu Rajala	*Labeo rohita, Channa striata, Mastacembelus armatus*	Tammileru Reservoir	Cu, Zn, Fe, Pb, Cu	Andhra Pradesh	2018
K. Ramesh Babu	*Oreochromis mossambicus, Labeo rohita, C. mrigala*	Kolavai Lake, Kanchipuram	Cu, Cd, Cr, Pb, Fe, Zn	Tamil Nadu	2018
Alagamurgan C.	*Tilapia mosambica*	Sivakasi Town	Cd, Pb, Ag, Cu.	Tamil Nadu	2018
Bhatt B.N.	*Channapuncata, Oreochromis Niloticus*	Yamuna River	Pb, Cr, Cu, Cd, Zn	Uttar Pradesh	2019
Gorakhe D.C.	*Garra mullya, Mystrus cavasius, Oreochromis mosambica*	Mula Mutha River, Pune	Cd, Cu, Cr, Fe, Ni, Pb, Ni, Zn, Cd	Maharashtra	2020
Badusha M.	*Puntius filamentous*	Neyyar Besin	Cd, Cr, Cu, Fe, Mn, Ni, Pb, Ni, Zn, Cd	Kerala	2020
Jan Arefa	*Catla catla*	Bhopal	Cd, Cr, Cu, Fe, Hg, Ni, Pb, Zn	Madhya Pradesh,	2021
Shawkat Insha	*Channa punctutus*	Bhopal	Pb	Madhya Pradesh	2022
Singh Amrita	*Labeo rohita*	Western U.P.	Cu, Zn, Pb, Cd	Uttar Pradesh	2022
L.A. Samson	*Labeo rohita, Sperata seenghala*	Prayagraj Region	Cr, Ni, Zn, Cd	Uttar Pradesh	2023
Das Piyali	*Labeo rohita*	Karim Ganj	Cd, Cr, Cu, Ni, Pb, Zn	Assam	2023

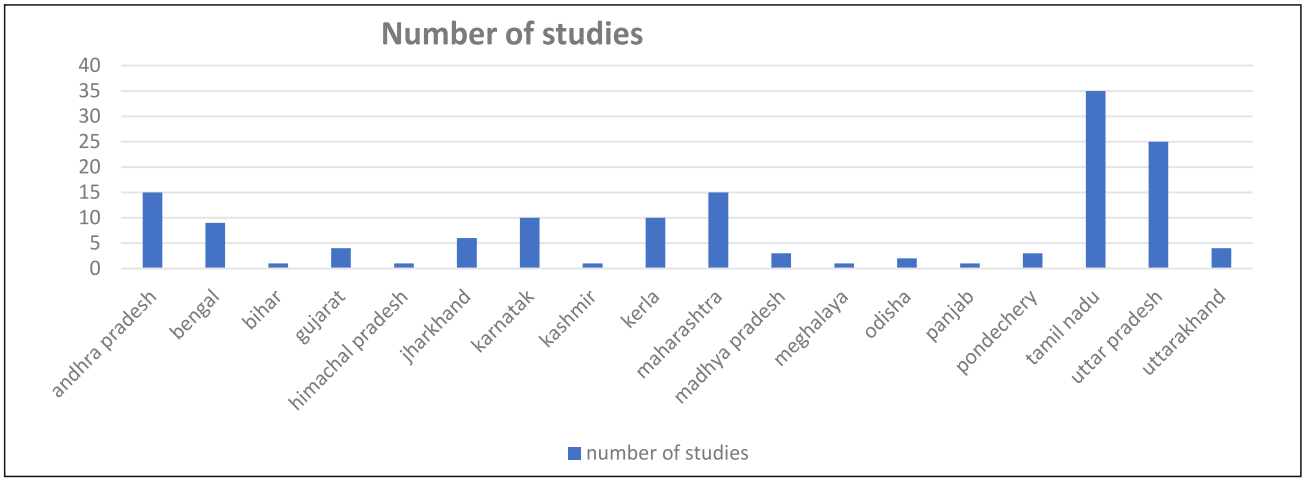

Fig. 1: Number of Studies in India by states.

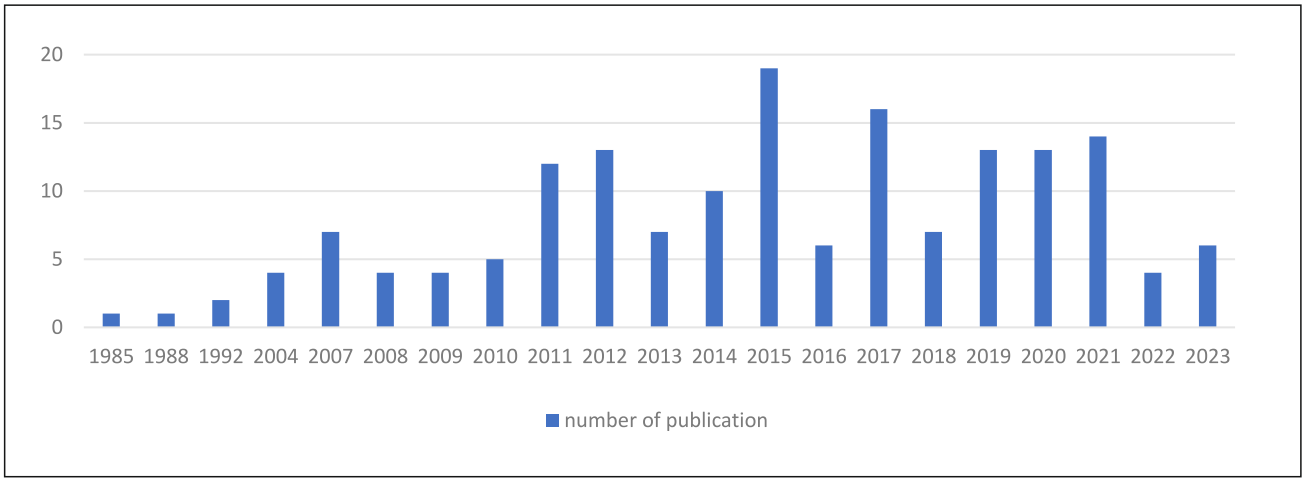

Fig. 2: Number of publication in India by years.

CONCLUSION

A. Distribution of article by states of India: Although researchers around the states of India have focused on the topic of heavy metal accumulation in fish and the impact of fish consumption on the human health, we can clearly distinguish that this topic is of interest to India as a developing country.

B. More studied species on this topic: According to the studies that have been done, the most studied species was *Labeo rohitha* followed by *Catla catla* and *Cirrihinus mrigala*. *Labeo rohita* is most commonly found and consumed fish all over the India hence the studies are also found more on this species.

C. Contribution of the authors: To visualize the relationship between the authors 180 articles in google scholar are observed. The most cited author is P. Sivaperumal followed by Mallick et al., A Grupta et al and I.H. Ravel et al.

D. Analysis of number of Publication: The analysis of metadata of each article allowed as to collect the year of publication of articles to produce flow chart below. which shows that number of to publication since 1984-2023. The number of articles begins to increase annually until it reaches 19 articles in 2015.

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International Journal on Biological Sciences

International Journal on Biological Sciences 15 (2), July-December 2024, Pp. 132-140
ISSN No.: 0976-4518
https://doi.org/10.53390/

SUSTAINABLE INDUSTRIAL USE AND APPLICATIONS THROUGH MICROBIAL REMEDIATION: A TOOL FOR ACHIEVING ENVIRONMENT FRIENDLY PROCESSING OF INDUSTRIAL WASTES

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Review Paper

Received: 28.10.2024 Revised: 22.11.2024 Accepted: 10.12.2024

ABSTRACT

Microbial bioremediation is a process which uses microorganisms to convert the organic or metallic contaminants to a less harmful or harmless form. It involves use of naturally occurring bacteria to degrade substances which are harmful to human health and/or the environment. Examples of some bacteria that are used in microbial bioremediation are *Pseudomonas putida, Pseudomonas cepacian, Bacillus cereus, Micrococcus luteus,* etc. Bioremediation can be broadly classified into two types: in situ bioremediation and *ex situ* bioremediation. *In situ* bioremediation is the process of removing pollutants at natural environmental conditions by using microbial metabolic potential of indigenous bacteria. In situ bioremediation can be further subdivided into four types: Biosparging, Bioventing, Biostimulation, Bioaugmentation. Biosparging involves injection of air below the ground water table or subsurface of soil to enhance oxygen availability for the stimulation of breakdown of contaminants by microbes. It is effective for removal of VOCs including BTEX. Bioventing uses indigenous microorganisms to biodegrade organic constituents adsorbed to soils in the unsaturated zone. It is mostly used for removal of diesel fuel and jet fuel in areas of industrial spills and fertilizer use. In biostimulation, the environment is changed in such a way that it stimulates indigenous bacteria that perform bioremediation. Bioaugmentation involves addition of genetically modified microorganisms to polluted and dangerous waste sites in order to speed up the removal of undesired compounds. Ex situ bioremediation involves excavation from polluted areas and transport to another site for treatment. It can also be subdivided into four types: Bioreactor, Biopiling, Land farming, and Composting. Bioremediation in a bioreactor involves processing of contaminated soil or water. Biopiling involves collecting and transferring contaminants above the ground and is generally used for soil bioremediation. In land farming, polluted soil is excavated and spread over a prepared bed and is periodically tilled until pollutants are degraded. Composting involves degradation of organic waste. Industrial waste can be of three types: Liquid waste, solid waste, Chemical waste. All these three types of waste can be remediated using either one or more types bioremediation techniques. This makes the management of industrial waste environment friendly.

No. of Pages: 9 **References: 56**

Keywords: Microbial, Microorganisms, Bioremediation, *In situ*, *Ex situ*, contaminants

Abbreviations used: AQDS: Anthraquinone-2,6-disulfonate; **BTEX**: Benzene, Toluene, Ethylbenzene and Xylene; **DCGG**: Denaturing Chain Gradient Gel Electrophoresis; **DNT:** 2,4-Dintrotoluene**; HMX**: High Melting Explosive or High-velocity Military Explosive or High Molecular-weight RDX; **MBRs**: Membrane

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Bioreactors; **NSA**: Nucleotide Sequence Analysis; **PCR**: Polymerase Chain Reaction; **RDX:** Research Department eXplosive; **SVE**: Soil Vapour Extraction; **TPH**: Total Petroleum Hydrocarbons; **TNT**: 2,4,6-Trinitrotoluene; **UASB**: Up flow Anaerobic Sludge Blanket Bioreactors; **VOCs**: Volatile Organic Compounds.

INTRODUCTION

Microbial bioremediation involves the use of microorganisms which convert the organic or metallic contaminants to a more chemically inactive form. The microorganisms used in bioremediation first attack the organic chemicals by the enzymatic apparatus acquired during the course of enrichment, when they are exposed these specific or structurally related compounds. The presence of these contaminants in the environment either increases or decreases the enzymatic function, of microorganisms. Microbial bioremediation uses naturally occurring bacteria to degrade or detoxify substances hazardous to human health and /or the environment.[1]

Microorganisms involved in Microbial Bioremediation

The bacteria which are involved in microbial bioremediation (Table 1) are *Pseudomonas putida*, *Acinetobacter sp.*, *Mycobacterium sp.*, *Pseudomonas cepacia*, *Bacillus cereus*, *Bacillus coagulans*, *Citrobacter koseri*, *Micrococcus luteus*, *Listeria denitrificans*, *Nocardia atlantica*, *Staphylococcus sp.*, *Actinobacter sp.*, *Alcaligenes sp.*, *Arthrobacter sp.*, *Beijerinckia sp.*, *Methylosinus sp.*, *Flavobacterium sp.*, *Nitrosomonas sp.* and *Xanthobacter sp.* [2]

Table 1: Applications of some important bacterial species in bioremediation reported in literature.

Microorganisms	Waste Compound	Reference
Alcaligenes eutrophus	2,4-dichlorophenoacetic acid	Don and Pemberton (1981)[3]
Pseudomonas sp.	Atrazine	Bruhn et al. (1988)[4]
Dehalospirillum multivorans	DDT	Chaudhury and Chapalamadugu (1991)[5]
Methanococcus sp.	TNT	Boopathy and Kulpa (1994)[6]
Pseudomonas saccharophila P15	PAH	Aitken et al. (1999)[7]
Methylibium petroleiphilum	Methyl tertiary butyl ether	Hassan et al. (1999)[8] Bruns et al. (2001)[9]
Mycobacterium PYR	Pyerene	Kanaly an Harayama (2000)[10]
Sphingomonas sp.	Azo dyes	Reife and Freeman (2000)[11]
Dechloromonas sp.	Benzene	Coates et al. (2001)[12]
Mycobacterium sp.	Endosulfan	Sutherland et al. (2002)[13]
Deinococcus radiodurans	Radioactive waste	Brim et al. (2003)[14]
Dehalococcoides sp.	Vinyl chloride	He et al. (2003)[15]
Rhodococcus sp.	PCB, Dioxins	Kimbara (2005)[16]
Acetobacterium paludosum	RDX	Sherburne et al.(2005)[17]
Geotrichum candidum	Phenol derived compounds	Aouidi et al.(2010)[18]
Gloephylim trabeum, Trametes versicolor	Hydrocarbons	Karigar and Rao (2011)[19]
Acinetobacter sp., *Mycobacterium* sp.	Aromatic hydrocarbons	Simarro et al. (2013)[20]
Micrococcus luteus, Listeria dentrificans, Nocardia atlantica	Textile dyes	Hassan et al. (2013)[21]
Pseudomonas putida	Benzene and Xylene	Safiyanu et al. (2015)[22]
Pseudomonas cepacian, Bacillus cereus, Bacillus coagulans,Citrobacter koseri, Serratia ficaria	Crude Oil	Kehinde and Isaac (2016)[23]

Types of Microbial Bioremediation Strategies:
Microbial bioremediation strategies include bioaugmentation (introducing specific microorganisms), biostimulation (enhancing existing microbial activity), and phytoremediation (using plants to facilitate cleanup) to mention only a handful. Additionally, monitored natural attenuation allows natural processes to reduce contaminants. Each strategy has its applications based on the type and extent of contamination (Fig 1).

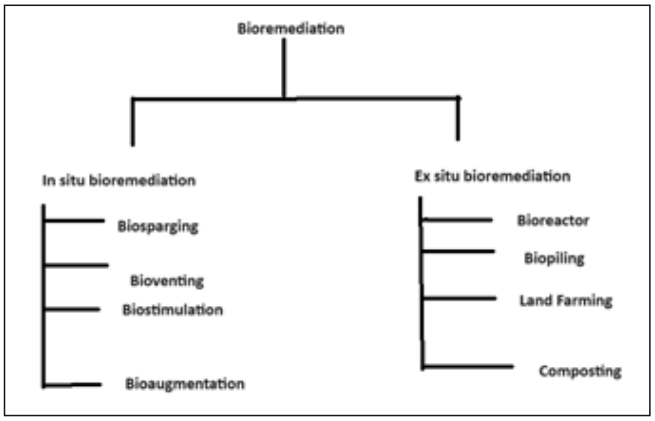

Fig. 1: Flow chart showing different types of bioremediation strategies.

I. *In situ* Bioremediation

In situ bioremediation involves the removal of pollutants under natural environmental conditions by implementation of microbial metabolic potential without the need of excavation of the contaminated sample(s). Autochthonous (indigenous) microorganisms bring about this type of bioremediation. In situ bioremediation relies on the biological processes involving reduction (degradation, detoxification, mineralization or transformation) of the concentration of pollutants to an innocuous state. In situ bioremediation is environment friendly and cost saving. The types of pollutants removed by this process may include: agrochemicals, chlorinated compounds, dyes, greenhouse gases, heavy metals, hydrocarbons, nuclear waste, plastics and sewage.[24,25]

1. Biosparging:

Biosparging involves the injection of air under pressure below the water table to increase groundwater oxygen concentrations and enhance the rate of biological degradation of contaminants by naturally occurring bacteria. Biosparging is an effective mechanism for removal of Volatile Organic Compounds (VOCs) including BTEX (Benzene, Toluene, Ethylbenzene and Xylene)[26,27,28]. Biosparging functions by injecting air at a low rate into the aquifer below the zone of contamination. At a relatively close well spacing, the injected air promotes oxygenation of the aquifer as necessary to promote aerobic biodegradation. In this study, the purpose of the biosparging system is to stimulate aerobic biodegradation of BTEX. In 2008, Kao et al. studied the application of in situ biosparging to remediate a petroleum-hydrocarbon spill site.[29]

The field results revealed that natural attenuation was the main cause of the decrease in major contaminants (BTEX) concentration in groundwater before the operation of biosparging system. Also, the operation of biosparging caused the shifting of anaerobic conditions inside the plume to aerobic conditions. The results of Polymerase Chain Reaction (PCR), Denaturing Chain Gradient Gel Electrophoresis (DCGG), and Nucleotide Sequence Analysis (NSA) revealed that the three BTEX biodegraders present at the site might have been Candidatus magnetobacterium, Flavobacteriales bacterium, and Bacteroidetes bacterium.[29]

2. Bioventing:

Bioventing involves controlled stimulation of airflow of oxygen to the unsaturated (vadose) zone, in order to increase bioremediation by increasing the activity of the authochthonous organisms. Bioventing is mostly used to remove mid-weight petroleum products like diesel fuel and jet fuel in areas of junkyard, industrial spills and fertilizer use.[30] Hydrocarbons, organic compounds containing only carbon and hydrogen are the main constituent of petroleum. The prevalence of crude and refined oils being transported (and spilled) all over the globe has made hydrocarbons a significant substrate for microbial oxidation.

When a petroleum product is spilled, it volatilizes and disperses into the atmosphere and/or sinks into the ground, depending upon its volatility and site conditions. In order for microbes to have sufficient time to degrade the hydrocarbon, bioventing works best with

petroleum-hydrocarbons of relatively low volatility. Bioventing works effectively in remediating BTEX contamination. Also, according to Malina, 1998, bioventing is superior to Soil Vapour Extraction (SVE) in reducing toluene and decane (other petroleum-hydrocarbons) contamination.[31] Soil venting has been extensively used at petroleum-hydrocarbon spill sites to remove volatile hydrocarbons from the subsurface, especially from the unsaturated vadose zone above the groundwater table. This involves pulling a vacuum in the vadose, usually through vapour extraction wells or dewatering points emplaced in the contaminated zone. This stimulates in situ volatilization, and contaminant vapours are drawn to the extraction point.

3. Biostimulation:

Biostimulation involves the changing of the environment to stimulate the indigenous bacteria which can perform bioremediation. According to Elektorowicz (1994)[25] and Piehler et al., (1999)[38], biostimulation can be performed by adding a variety of forms of limiting nutrients and electron receptors such as phosphorus, nitrogen, oxygen or carbon which are otherwise available in very low amounts. These low quantities are enough to restrict the microbial activities. Contaminated soil containing more than 38,000mg/kg Total Petroleum Hydrocarbon (TPH) was remediated using sewage sludge and woodchips compostzz.[32,33] Humic substances such as Anthraquinone-2,6-disulfonate (AQDS) act as electron shuttle for the conversion of chlorinated organic contaminants and iron oxides[34]. Chen et al. (2007) reported that with the addition of and lactate, as biostimulator and dechlorinating and iron reducing bacteria will lead to the increased degradation of pentachlorophenol de-chlorination in the soils.[35] Indigenous Rhizobium, Ralstonia taiwanensis, along with the glycerol, increase phenol degradation which clearly indicates that biostimulation will enhance biodegradation rates of pollutant removal.[35,36,37]

4. Bioaugmentation:

Bioaugmentation is the applications of indigenous or allochthonous wide type or genetically modified microorganisms to polluted hazardous waste sites in order to accelerate the removal of undesired compounds.[38] Labidi et al. in (2001) used Rhizobium trifolii isolated from atrazine contaminated soil for remediation of 2,4,6-Trinitrotoluene (TNT) contaminated soils.[40] The bacteria are first carefully screened for its explosive degrading ability in liquid medium. The results showed that, bioaugmentation lead to 60% degradation of TNT in 2 days.[39,40]

I. Ex situ Bioremediation

In ex situ bioremediation, initially the pollutants are excavated from the contaminated sites and then they are transported to another site for treatment.[41]

1. <u>Bioreactor:</u>

Bioreactor is a vessel in which raw materials are converted to specific product(s) following series of biological reactions. Bioremediation in reactors involves the processing of contaminated solid material (soil, sediment, sludge) or water through an engineered containment system. Membrane bioreactors (MBRs) have been used in biological treatment of domestic and industrial wastewater. MBRs have been evaluated in the remediation of pentachlorophenol in concentration ranges that occur in wastewater[42], textile wastewater,[43] 1,2-dichloroethane, 1,2-dichlorobenzene and 2-chlorophenol.[44,45]

2. Biopiling:

Biopiling involves collecting and transferring of contaminants above the ground. It is a commonly used remediation technology for soil.[46] The basic biopile system includes a treatment bed, an aeration system, an irrigation/nutrient system and a leach ate collection system. Moisture, heat, nutrients, oxygen, and pH are controlled to enhance biodegradation. Volatile Organic Compounds (VOCs) present in soil can be remediated using biopiling.[46]

3. Land farming:

Land farming is a simple technique in which contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are totally degraded. The aim is to stimulate the indigenous microorganisms

and facilitate their aerobic degradation of contaminants. It is commonly used to remediate soil contaminated with petroleum hydrocarbon supplement of fern chips of Sphaeropteris lepifera as the bulking agent,[48] compost and activated sludge as the sources of organic materials and microorganisms, and specific TPH-degrading bacteria on the improvement of efficiencies of land farming operation to cleanup diesel and lubricant oil contaminated soils.[49]

4. **Composting:**
Composting is a biological process which involves degradation of organic wastes. It is done by adding organic wastes into the soil. The microorganisms present in the soil help in the degradation. Many sites worldwide have been remediated by this technology. A few of the examples include, the Pueblo Chemical Depot contaminated with TNT (2,4,6-Trinitrotoluene), DNT (2,4-Dintrotoluene) and Research Department eXplosive or hexogen (RDX), was treated using composting, the explosives were found to be degraded in a time period of 15-30 days. Windrow composting was performed at Umatilla Army Depot to treat TNT, RDX and High Melting Explosive or High-velocity Military Explosive or High Molecular-weight RDX (HMX). After 40 days, the explosive concentrations were below the clean-up goals.[50] Hawthorne Army Depot also employed composting for remediation of TNT, RDX, HMX and ammonium picrate. The duration of 28 days was found to be very effective to reach the clean-up goals.[51,52]

INDUSTRIAL WASTE

What is industrial waste?

The term "industrial waste" can be defined as any liquid, solid, or gaseous residual matter stemming from industrial activity. It includes chemicals, trash, oils, solvents, dirt and gravel, many harmful gases etc. These are dumped in seas, rivers or land without adequate treatment. Thus, it has become a large source of environmental pollution.

Types of Industrial Waste

1. **Liquid Waste:**
Liquid waste constitutes the large amount of water required in most industrial processes that may come in contact with extremely harmful substances like radioactive materials, dirty water, organic liquids, rinse water, waste detergents, and even rain water.

2. **Solid Waste:**
Industrial solid waste includes different kinds of materials like paper, plastic, wood, cardboard, packaging materials, scrap metal, and every other solid waste that can no longer fulfil its intended purpose.

3. **Chemical Waste:**
Most industrial activities also produce a certain amount of chemical waste, which includes all types of inflammable, corrosive, toxic and explosive waste.

MICROBIAL BIOREMEDIATION OF INDUSTRIAL WASTE

1. **For Industrial wastewater**
Heavy metal (eg. Cd, Cr, Cu, Hg and Zn) emissions from industries are potential environmental pollutants which are extremely hazardous. Chromium compounds are widely used in leather tanning, steel production, and alloy formation, as metal corrosion inhibitors, and in paints and various other applications. During these processes, many contaminants such as organic, inorganic, and heavy metals are released into the effluents that need to be treated in a safe manner.

Generally, chromium is present in two oxidative states: Cr^{+3} is essential for the human system, whereas Cr^{+6} has harmful effects. So one of the ways[53] of reducing chromium toxicity; in Cr-contaminated industrial effluent is to reduce soluble Cr^{+6} to insoluble Cr^{+3}. Bioremediation of Chromium involves the reduction of highly soluble and toxic Cr(VI) to less soluble and less toxic Cr(III). This is carried out by several microorganisms like Desulfovibrio vulgaris, Arthrobacter, Pseudomonas, Serratia marcescens, Ochrobacterum sp., Bacillus sp. and Acinetobacter sp.[54]Trickling filters, membrane bioreactors, slurry phase reactors and Up Flow Anaerobic Sludge Blanket Bioreactors (UASB) are some of the reactors that are used in waste water and industrial effluent treatment.

2. **For Solid industrial Waste**
   Composting can be performed with some of the organic wastes released by industries. Land farming is another method which can be utilized to bioremediate certain wastes. The solid waste from fruit and vegetable industries can be mostly composted or land farmed.

3. **For Chemical Waste**
   Soil contaminated with explosives can be bioremediated by either in situ methods or ex situ methods. The in situ technologies include natural attenuation, bioventing, biostimulation, and bioaccumulation. Anaerobic digesters are often applied mostly in the biotreatment of solid waste. Hydrocarbon degrading bacteria and bacterial strains such as Pseudomonas sp. and Brevibacillus sp. that are isolated from petroleum contaminated soil are used to degrade nitrates. Achromobacter, Acinetobacter, Alkaligenes, Alteromonas, Arthrobacter, Burkholderia, Dietzia, Enterobacter, Kocuria, Marinobacter, Mycobacterium, Pandoraea, Pseudomonas, Staphylococcus, Streptobacillus, Streptococcus, and Rhodococcus have been found to play vital roles in petroleum hydrocarbon degradation.[55]

BIOREMEDITON AS AN EFFICIENT TECHNOLOGY

Bioremediation is the technology which involves the use of either of the autochthonous or allochthonous organisms (eg. bacteria, fungi, algae, plants, etc.) in converting harmful pollutants of the environment into less harmful forms. Microbial bioremediation is the type of bioremediation which deals with the use of bacteria only. Microbial bioremediation can be divided into two types: in situ bioremediation and ex situ bioremediation. In situ bioremediation mainly comprises of the methods: Biosparging, Bioventing, Biostimulation and Bioaccumulation. On the other hand, ex situ bioremediation deals with the technologies of Bioreactor, Biopiling, Land farming and Composting. The enormous amount of waste generated from industries is a matter of concern in today's world. The proper disposal of all these waste is also a great problem. The industrial waste includes different types of pollutants- organic, inorganic, biodegradable or non-biodegradable. They can also be classified according to their constituents, like industrial wastewater, solid industrial waste, chemical waste, etc. These pollutants can be extremely toxic for the entire planet (including both its biotic and abiotic components). Thus, the best possible way to reduce such pollution is bioremediation, and bacteria being ubiquitously present make microbial bioremediation the easiest and most suitable form bioremediation.

Industrial wastewater is highly contaminated with heavy metal particles like copper, chromium, zinc, etc. These are extremely toxic to human health. Bacterial species such as Serratia marcescens, Desulfovibrio vulgaris, etc. convert the highly soluble and more toxic Cr(VI) to less soluble and less toxic Cr(III) . This is a classical example of microbial bioremediation of industrial waste. Trickling filters and membrane bioreactors are among the other techniques of purifying industrial wastewater. Solid industrial wastes include organic waste from fruit and vegetable industries. These organic wastes are suitable for being composted as they are biodegradable in nature. Thus, such type of waste is best suited for being composted or land farmed.

Chemical waste can be composed of different types of materials like explosives, petroleum etc. Bacterial strains such as Pseudomonas sp. and Brevibaccilus sp .isolated from petroleum contaminated soil degrade nitrates present in soil. Other strains such as Acinetobacter, Achromobacter, Staphylococcus sp. and some others have been found to play an essential role in petroleum hydrocarbon degradation.

The term “Sustainability” refers to approaches or techniques, which enables humans to use and maintain the natural resources offered by the Earth at an optimum rate that allows retention of these resources for the generations to come even after satisfying the requirements of the present generation. Microbial bioremediation involves the use of either allochthonous or autochthonous bacteria to either degrade or convert harmful substances to less harmful ones. This shows that microbial biodegradation mainly relies on the property of the bacteria itself and is an extremely environment-friendly process. Thus, it can be said that microbial bioremediation is sustainable in nature.

CONCLUSION

Microbial bioremediation involves the use of bacteria in reducing the harmful effects of environmental contaminants by using these pollutants in their

metabolic processes. As industrial waste is a major issue in today's modern world, proper disposal of these waste needs to be managed efficiently. Viewing the aspect of sustainability, cleanliness and eco-friendliness, it is quite obvious that microbial bioremediation is the best choice for environment-friendly processing of industrial waste as this technique uses natural bacterial species without the use of artificial methods. In conclusion, microbial bioremediation is significantly a clean, green and sustainable technology and is generally recognized to be appropriate for the environment.[56] Hence, the various methods of microbial bioremediation are the most suitable for managing and processing of industrial waste sustainably.

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I/We certify that all the entries in this form are correct to the best of my/our knowledge and believe and I/we promise that I/we shall abide by the rules/regulations etc. issued from time to time by the ACADEMY and shall take active interest in all the activities of the ACADEMY.

Place:……..
Date:……..

……..
(Signature of the Applicant/s)

N.B.: In case of spouse membership, both shall have to fill up the form in Duplicate and both shall put their signature on both set of forms.

10 **FOR OFFICE USE ONLY**

1. DD. Cheque No……for Rs……Date Drawn on……..Bank Bank has been received and Money Receipt No……..of Dt…….was sent to the applicant on Dt……

   *NEFT/Online Net Banking Transfer/*Transaction date: _____

   NEFT/Online Net Banking Transfer Transaction ID/UTR No./Payment Ref. No.:_____

   ……..
   (Accountant)

2. Admitted for Life Membership and the membership number is …….
3. I Card No……

   ……..
   (General Secretary, NESA)

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