Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 5, No.3, May : 2025

PHYSICO-CHEMICAL STUDY OF SHAHPURA LAKE TO ASSES THE IMPACT OF INDUSTRIALIZATION AND URBANIZATION

Umesh Kumar Pandey M. Tech Schooler**,** Shri Rawatpura Sarkar University, Raipur, Chhattisgarh India
Taranjeet Sachdev Associate Professor, Department of mechanical Engineering, Shri Rawatpura Sarkar University, Raipur, Chhattisgarh India

ABSTRACT
The Shahpura lake (Bhopal, India) was designed to collect rainwater, support irrigation, and serve as a source of drinking water. It plays a crucial role in maintaining the ecological balance of the city, serving as a habitat for diverse flora and fauna. However, over the years, urbanization and pollution have threatened its sustainability[1]. In present work, Shahpura lake Water samples will be collected from three locations during pre-monsoon, monsoon and post monsoon season for physico-chemical analysis. The physico-chemical parameters such as Total Alkalinity, Total Hardness, Chloride, Sulphate, Nitrate, total suspended solid, Total dissolved substance, Fluoride, Dissolved oxygen, Biological Oxygen Demand and Chemical Oxygen Demand are analyzed to know the present status of the lake-water quality. Further, a statistical analysis is to be performed to identify the positive as well as negative co-relationship occurred between the attributes.
Keywords: - Physico-chemical, Shahpura lake, Bhopal lakes, Hadrochemical analysis

INTRODUCTION:

India's rapid development trajectory, marked by swift urbanization, industrialization, and population growth, has inadvertently led to significant environmental degradation. Among the most alarming consequences of this growth is the deterioration of water quality, which has escalated into a critical environmental issue threatening the health of ecosystems, biodiversity, and human populations. The contamination of water bodies is a complex problem driven by a combination of natural processes and human activities, including excessive urban sprawl, unregulated industrial discharges, agricultural runoff laden with pesticides and fertilizers, unchecked siltation, and the release of untreated sewage into water bodies[2]. These pollutants not only compromise the ecological integrity of water bodies but also pose serious risks to public health, agricultural productivity, and the overall sustainability of freshwater resources.

In this broader context, the city of Bhopal—renowned as the "City of Lakes" due to its abundant freshwater lakes. Among Bhopal's lakes, Shahpura Lake stands out as a glaring example of the challenges posed by water pollution in urban environments. Situated within the city's limits, Shahpura Lake is not only a vital ecological and aesthetic asset but also an important source of groundwater recharge and a habitat for diverse aquatic species. However, the lake is facing severe environmental threats due to a combination of factors, most notably the discharge of untreated sewage, solid waste, and various forms of pollutants from surrounding residential areas, commercial establishments, and industrial activities.

In context to analysis of water quality many researchers have presented their studies. Dixit, Dharmanshu; Rahi, D.C. (2017) found that water of Shahpura Lake is suffering from severe contamination which is due to heavy discharge of pollutants without adequate treatment to remove harmful compounds. This is leading to damaging effects not only to the individual species and population but also to the natural biological community. Dharmanshu Dixit D.C. Rahi (2017): highlighted the water quality index of Shahpura Lake of Bhopal. Water Quality Index (WQI) of Shahpura Lake bhopal using water quality parameters like Temperature, Chloride, Hardness, Alkalinity, pH, Conductivity, Total Dissolved Solids (TDS), Fluoride, Iron, Turbidity, Dissolved Oxygen (DO) and Biochemical Oxygen Demand (BOD). Reena Yadav and Dr. Pramod Patil (2018)

determined and characterized the quality of water of Shahpura Lake of Bhopal. The research involved the levels of physico-chemical properties of Lake Water samples. About 40% of the pH values were below the WHO recommended minimum allowable value of 6.5 whiles most of the physical parameters fell within the recommended values of WHO[3].

M Aniece Wani1, Manju Bhadwalh, Dixit Mukesh (2018) aimed to assess the diversity, distribution and abundance of macro-zoobenthos in Upper Lake Bhopal (Madhya Pradesh). During the investigation, 5 sampling stations were selected to collect the samples. Shannon diversity index and Margalef's richness index were used on benthic data obtained during the survey. A total of 28 taxa of macrobenthic fauna were recorded from different sampling stations of Parbati River. The phylum Arthropoda was found dominant followed by Mollusca and annelidan. The maximum diversity and richness were recorded at station 1 while minimum diversity was recorded at station. Salahuddin and Intazar Husain (2020) observed that shahpura lake does not have any fresh water source; it receives seepage water from the Upper Lake and drainage from 28 sewage-filled nullahs. Farooq et al. (2021): investigated physicochemical and bacteriological analysis of Upper Lake Bhopal and also to assess the degree of pollution caused by input wastes from catchment areas which affect aquatic life.

Vartika1, Mukesh Dixit, Sulochana, Jangu, Suresh Sundramurthy and Lalit Kumar (2023): concluded that due to the increased concentration of these heavy metals leads to the sever toxicity in the aquatic fauna of the Lake which directly leads to the various hazardous impact on the human population through the various anthropogenic hindrances in the food chain of humans[4]. Various minimizing measures were also initiated by the concerned authorities to overcome this toxicity to some extent.Salahuddin (2024): examined the Physico-Chemical Parameters of Shahpura Lake of Bhopal, Madhya Pradesh, India. Statistical analysis like Pearson Correlation matrix and Factor loadings were implemented to the data set to know the relationship among the studied parameters. Experimental data shows that most of the attributes do not satisfy the desired limits prescribed by BIS.

METHODS AND MATERIAL:

For Physico-chemical analysis of Shahpura lake water situated at Bhopal following methodology is to be followed

2.1 Sample collection-

Water sampling is an essential step in water quality testing, providing a snapshot of the water's characteristics and determining its suitability for various uses. Proper sampling techniques are critical to obtaining accurate and representative results, as samples must reflect the true condition of the water source at a particular time and location. The sampling locations for our project consist of Shahpura lake area. Lake water samples were collected from three (05) locations during pre-monsoon, monsoon and post monsoon & winter season. Samples were collected in plastic containers to avoid unpredictable changes in characteristics as per standard procedure (APHA, 1998)[5].

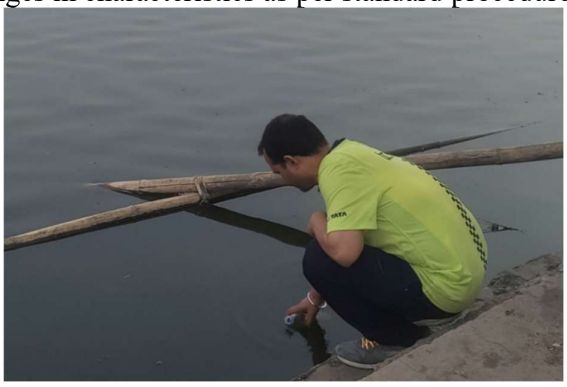


Fig.1 Sample collection from the Shahpura lake

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 5, No.3, May : 2025

SAMPLING SITES:

The Shahpura lake, Bhopal Was subjected to physico-chemical analysis, it should be approachable and water quality should be best for aquaculture, drinking and irrigation. Shahpura Lake is situated near the Manisha Market of Bhopal. It has an area of 8.29 km².

Fig. 2 Sampling Location at the Shahpura Lake

The storage capacity of the Shahpura Lake is 2.29Mm3. The maximum depth of the lake is 5.6 m and minimum depth of the lake is 1.5 m. and its coordinates are 23°12'17"N and 77°25'35"E. Water samples collected from eight sampling stations selected for the analysis are Rishabhdev Park as S1, Near Bansal Hospital as S2, Bird Watching Point S3, near Kolar Road as S4, GI & Liver Hospital as S5. Samples are collected in the month pre-monsoon, monsoon and post monsoon & winter season. for analysis are collected in sterilized bottles using the standard procedure for grab (or) catch samples in accordance with standard methods of APHA (American Public Health Association)[6].

Table 1: Sampling Location at the Shahpura Lake

Sample	Location	Latitude	Longitude
S1	Rishabhdev Garden	23˚12'17"N	77˚25'35"E
S2	Bansal Hospital	23˚12'25"N	77˚25'30"E
S3	Bird Watching Point	23˚13'17"N	77˚25'28"E
S4	Mamta Marriage Garden	23˚12'46"N	77˚25'05"E
S5	GI & Liver Hospital	23˚13'54"N	77˚25'35"E

Physico-chemical analysis of Shahpura lake water

The Physico-chemical analysis of Shahpura lake, Bhopal, is essential to assess its water quality, ecosystem health, and suitability for various uses such as drinking, irrigation, and recreation. This analysis involves evaluating the physical and chemical parameters that indicate the lake's water quality and pollution levels.

RESULTS AND DISCUSSION:

Samples are collected in the month pre-monsoon, monsoon and post monsoon & winter season. After the sampling collection the physical and chemical parameters are examined[7]. Detailed Water Quality Analysis Report as follows:

3.1 Biochemical Oxygen Demand (BOD) – 21.85 mg/L Standard Limit: < 3 mg/L for drinking water (as per CPCB for surface water). A BOD level above 5 mg/L is considered polluted. At 21.85 mg/L, the lake shows high organic pollution, possibly from domestic sewage, industrial discharge, or agricultural runoff. This level of BOD can negatively impact aquatic life by depleting oxygen levels in the water.

3.2 Chemical Oxygen Demand (COD) – 66.7 mg/L Standard Limit: < 250 mg/L. COD above 50 mg/L indicates significant chemical pollution. A value of 66.7 mg/L suggests the presence of

industrial pollutants or untreated waste, which can be hazardous to aquatic organisms and humans alike.

3.3 pH – 7.39 Standard Limit: 6.5–8.5. A pH of 7.39 is within the neutral to slightly alkaline range, which is ideal for most aquatic life and suitable for general use. It falls within the standard limits (6.5 – 8.5) prescribed by most water quality guideline.

3.4 Total Dissolved Solids (TDS) – 510.75 mg/L. The acceptable range for drinking water is below 500 mg/L. At 510.75 mg/L, the TDS level is marginally high, which could affect the taste and potentially indicate mineral contamination but is not critically unsafe[8].

3.5 Colour (Hazen Unit) – 43.9 Standard Limit: 5 (Desirable), Natural water should be colorless or have very low coloration. At 43.9 Hazen units, this water is visibly colored, likely due to decaying vegetation, organic compounds, or pollution, and may require treatment for aesthetic and usability purposes.

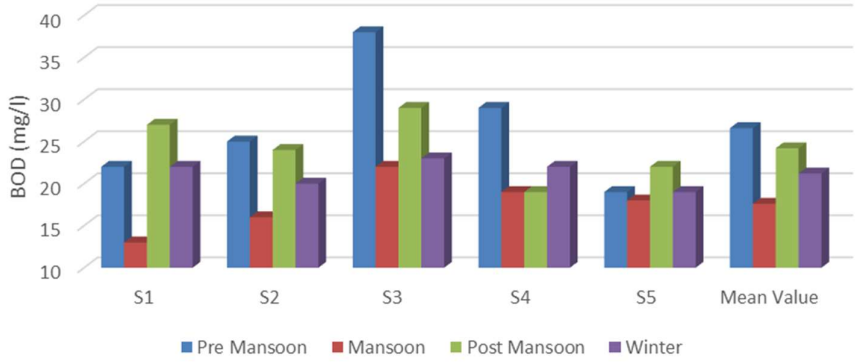


Fig. 3 Biochemical Oxygen Demand

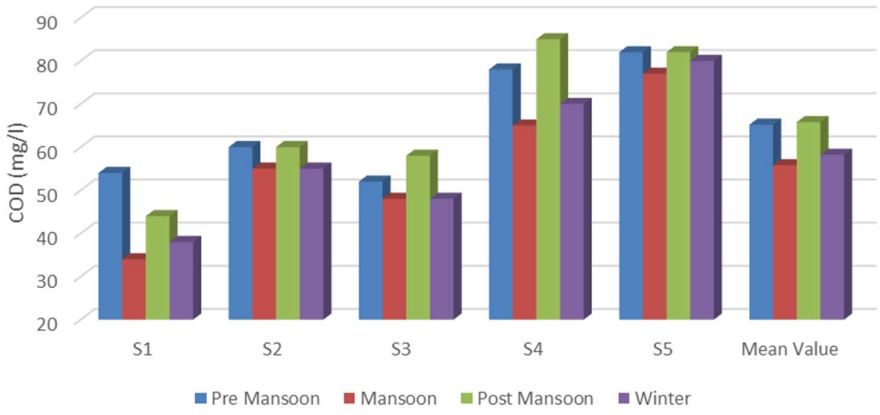


Fig. 4 Chemical Oxygen Demand

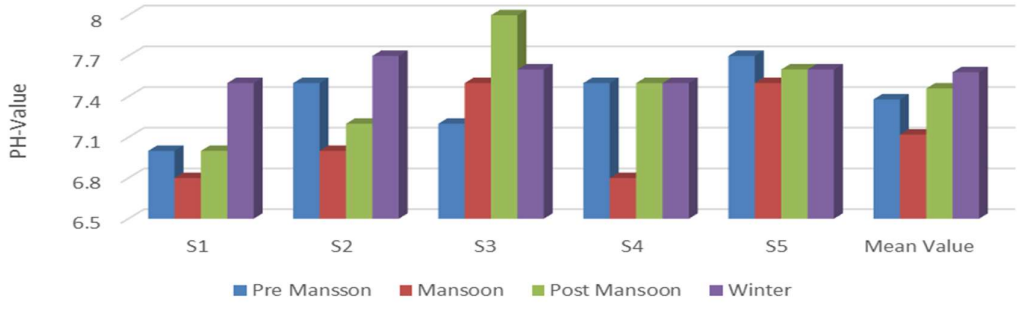


Fig. 5 PH-Value

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 5, No.3, May : 2025

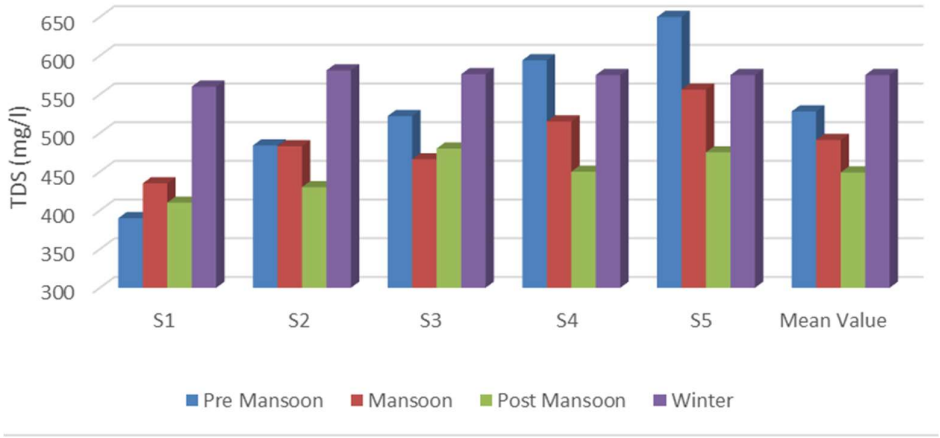


Fig. 6 Total Dissolved Solids

3.6 Calcium – 15.93 mg/L Standard Limit: 75 (Desirable), 200 (Maximum). This level is within the acceptable range, contributing to water hardness but not posing any health risk. It's beneficial in small amounts and common in natural waters[9].

3.7 Sulphate – 14.69 mg/L Standard Limit: 200 (Desirable), 400 (Maximum). The value is well within the safe limit (200-400 mg/L), meaning there is no concern related to sulphates in this sample

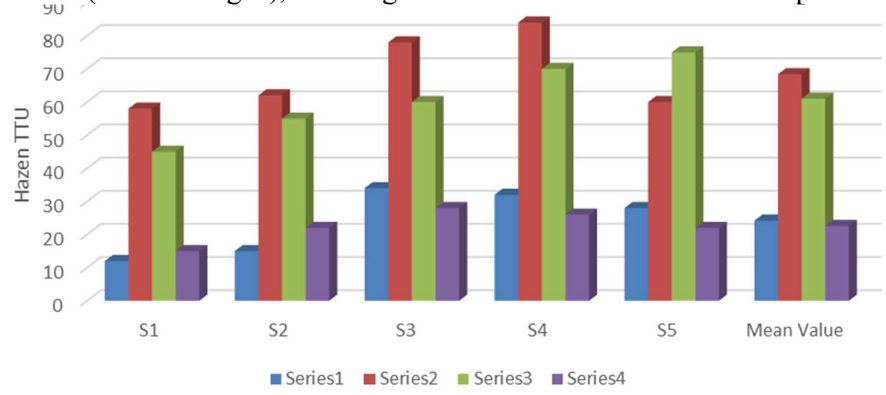
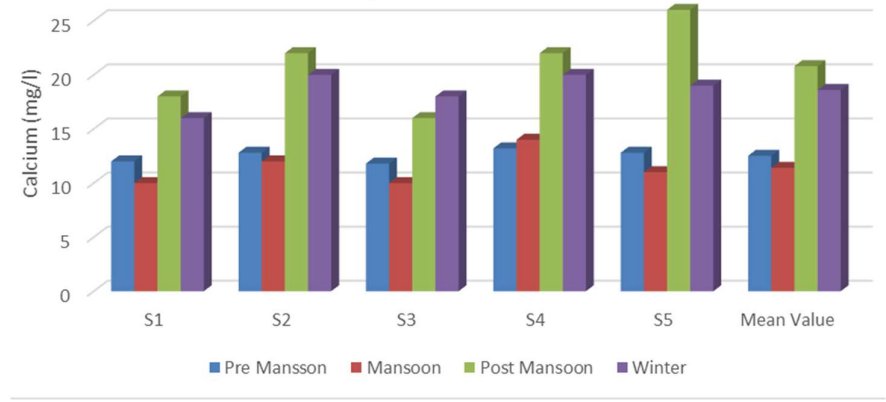


Fig. 7 Hazen Unit



.

Fig.8 Calcium

3.8 Residual Chlorine – 0.1895 mg/L Standard Limit: 0.2 – 1.0 mg/L (as per BIS for disinfected water). This is safe and low level, indicating either minimal chlorination or natural chlorine presence.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 5, No.3, May : 2025

Ideal for consumption should be between 0.2 – 0.5 mg/L, so this is acceptable but might suggest limited disinfection.

3. 9 Fluoride – 0.256 mg/L Standard Limit: 1.0 (Desirable), 1.5 (Maximum). This level is well within the safe range (0.5–1.5 mg/L). There is no risk of fluorosis, and the concentration is typical of natural surface water[10].

3.10 Iron – 0.821 mg/L Standard Limit: 0.3 mg/L. Acceptable limit for drinking is 0.3 mg/L. At 0.821 mg/L, this sample is above the permissible limit, which may affect taste, color, and cause staining on plumbing and laundry. Indicates possible leaching from soil or pipes[11].

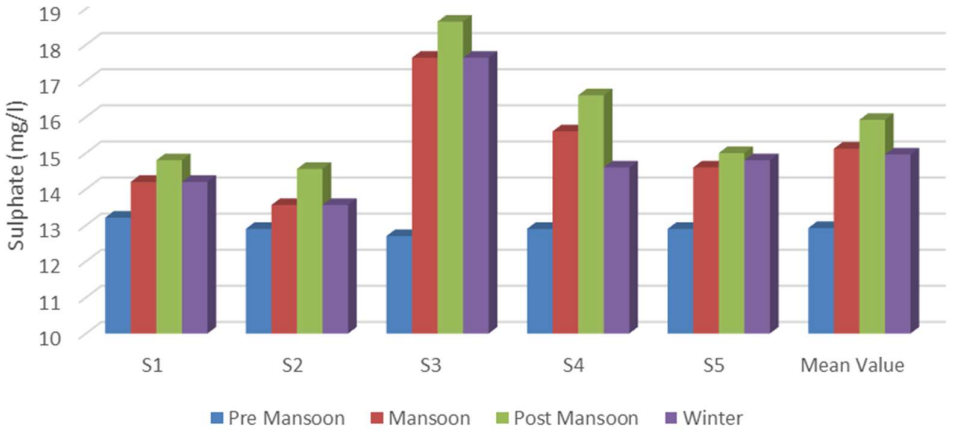


Fig. 9 Sulphate

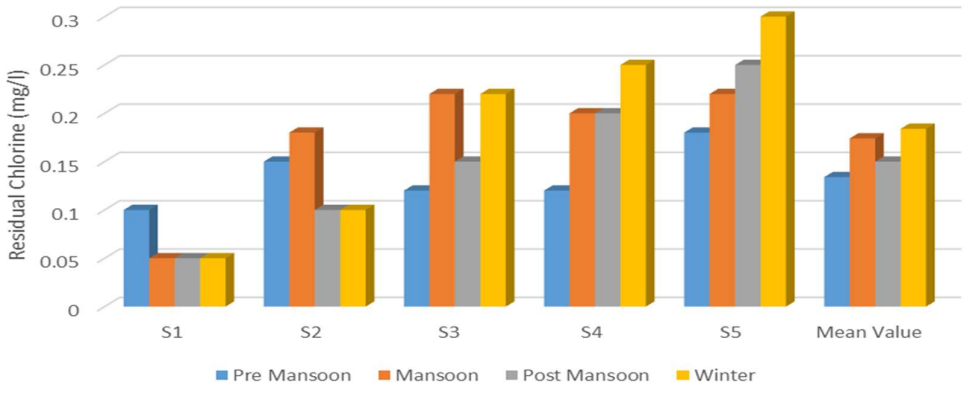


Fig. 10 Residual Chlorine

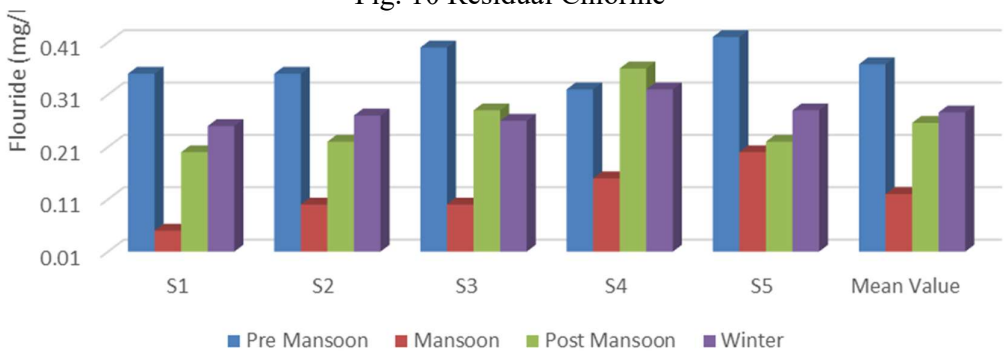


Fig. 11 Flouride

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 5, No.3, May : 2025

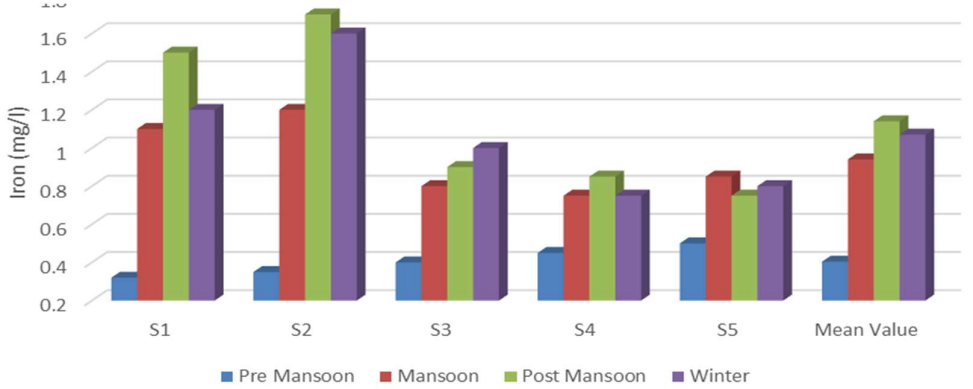


Fig. 12 Iron

3..11 Nitrate – 38 mg/L Standard Limit: 45 mg/L. The level is well below the safe limit of 45 mg/L. No immediate concern. Excessive levels, however, may cause blue baby syndrome in infants[12].

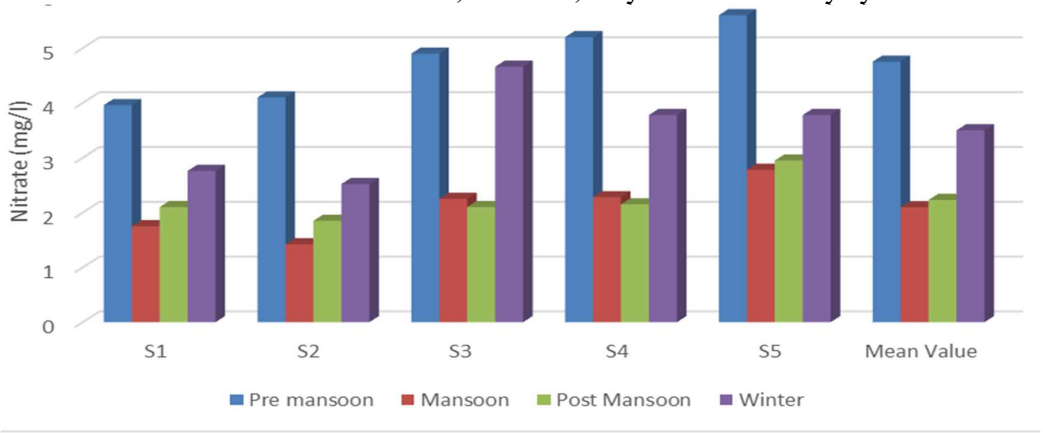


Fig. 13 Nitrate

3.12 Total Hardness (as $CaCO_3$) – 209.55 mg/L Standard Limit: 200 (Desirable), 600 (Maximum). Water is classified as: Soft: 0–60 mg/L, moderately hard: 61–120 mg/L, Hard: 121–180 mg/L, Very hard: >180 mg/L. At 209.55 mg/L, the water is very hard, which is not harmful to health but may cause scaling in pipes and reduce soap effectiveness[13].

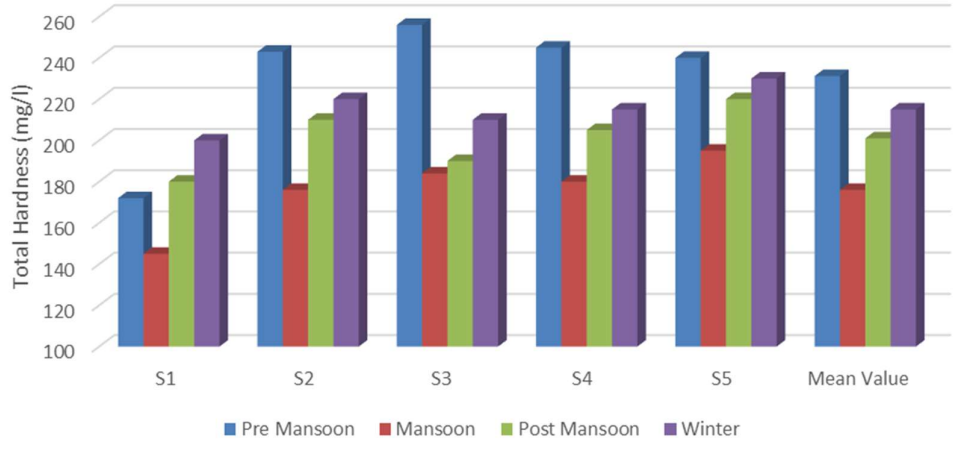


Fig. 14 Total Hardness

13. Chloride (as Cl^-) – 202.13 mg/L. Safe limit is 250 mg/L. At 202.13 mg/L, it's well within the limit, suggesting no chloride-related pollution or taste impact.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 5, No.3, May : 2025

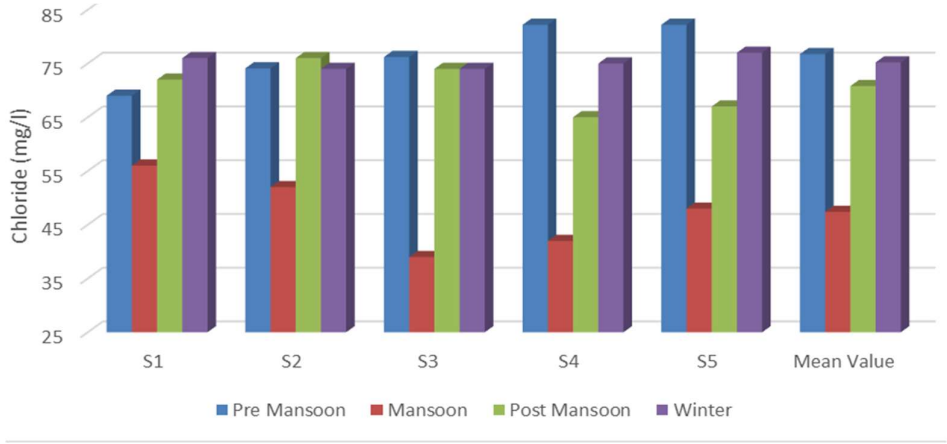


Fig. 14 Chloride

14. Alkalinity – 84.25 mg/L Standard Limit: 200 mg/L. This level is normal and indicates moderate buffering, which is good for aquatic ecosystems and helps maintain stable pH.

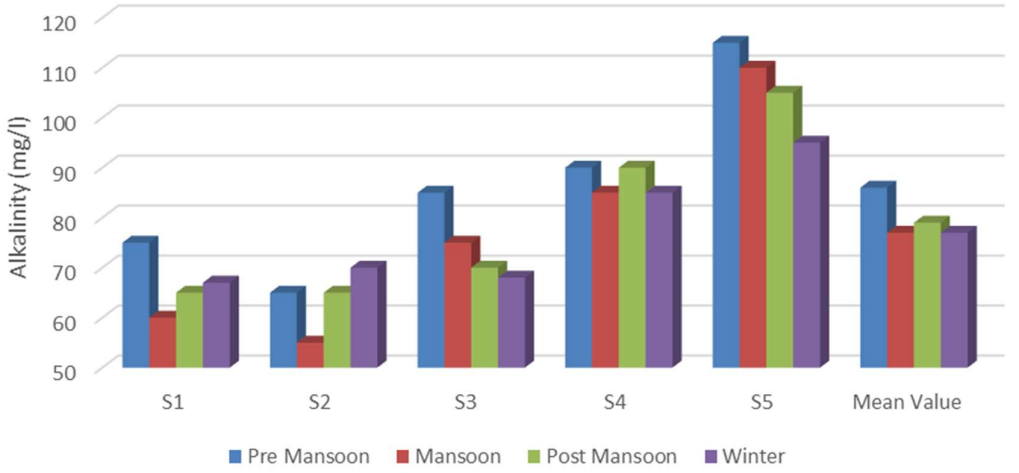


Fig. Alkalinity

15. Temperature – 25.12°C , Standard Reference: Ambient, ideally 25–30°C. Ideal temperature for aquatic life usually ranges between 20–30°C. At 25.12°C, the lake temperature is within the optimal range, posing no thermal stress[14][15].

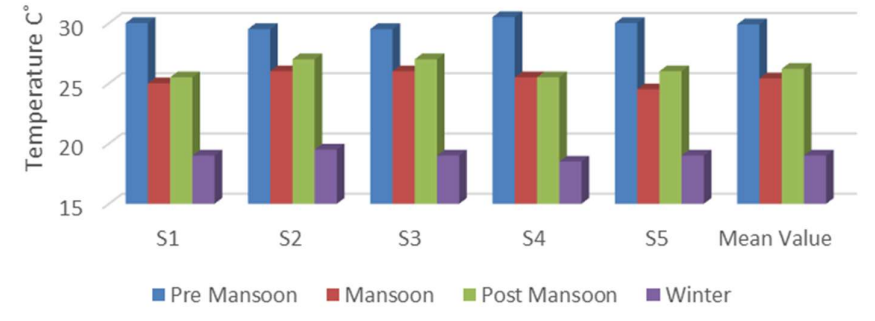


Fig No- 21 Temperature

3.16 Turbidity – 43.9 NTU Standard Limit: 1 NTU (Desirable), 5 NTU (Maximum) Desirable limit for drinking is below 5 NTU. At 43.9 NTU, the water is highly turbid, likely due to sediments, plankton, or pollutants. Turbidity reduces light penetration, affecting aquatic plants and can harbor pathogens.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 54, Issue 5, No.3, May : 2025

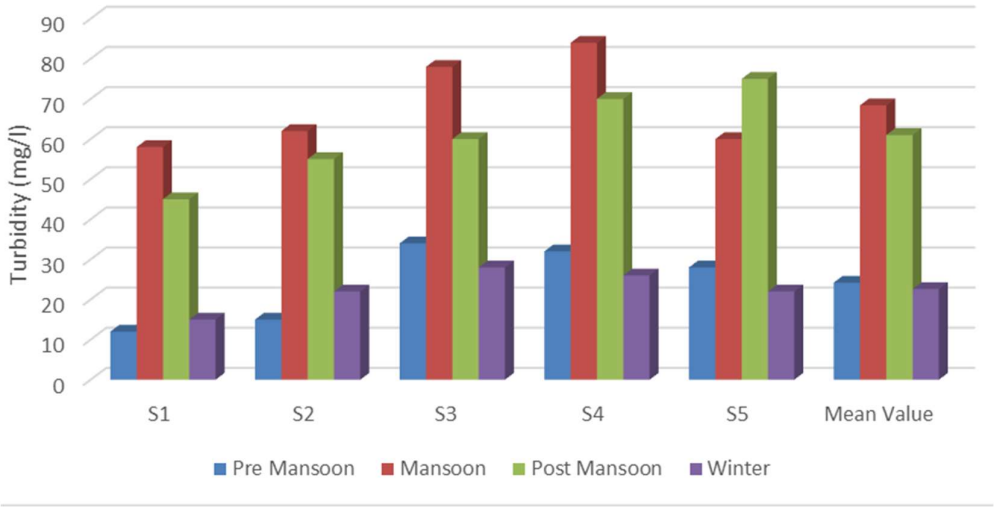


Fig. Turbidity

3.17 Dissolved Oxygen (DO) – 5.595 mg/L Standard Limit**: ≥5 mg/L (for healthy aquatic ecosystems). A DO level above 5 mg/L is generally considered good for aquatic organisms[16][17]. This value suggests the lake can support aquatic life, though higher BOD may start depleting oxygen over time.

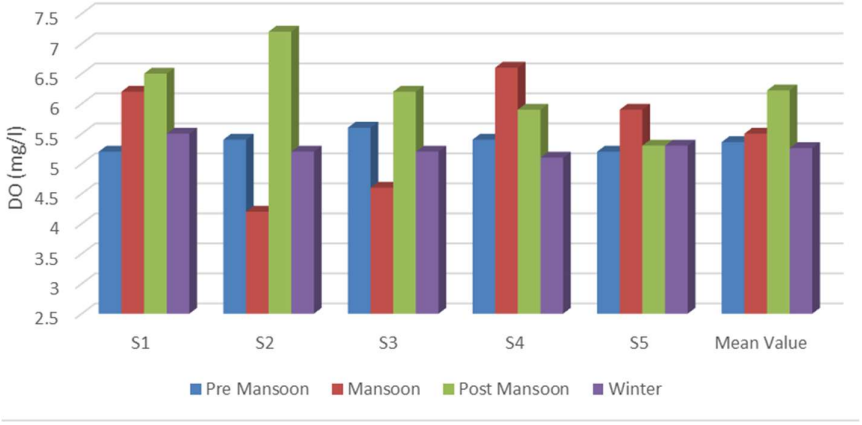
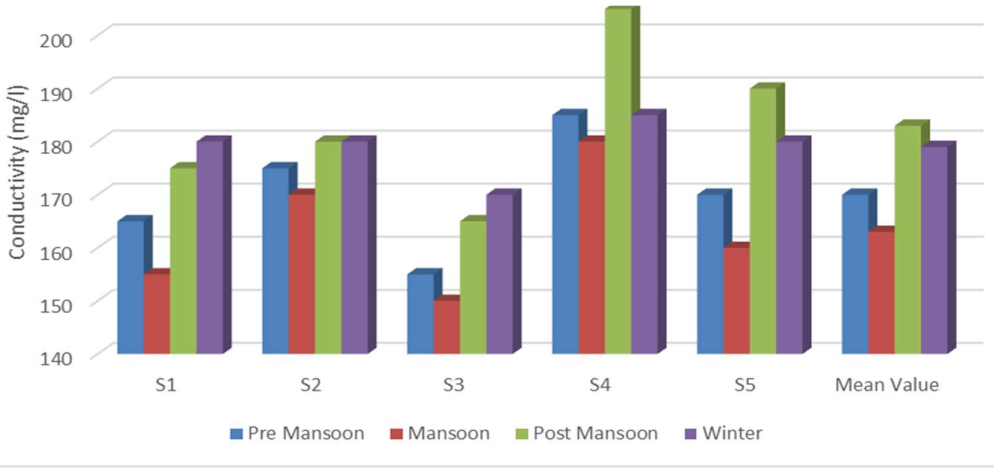


Fig. 23 Dissolved Oxygen

3.18. Conductivity – 174 µS/cm Standard Reference: < 1400 µS/cm (BIS). Conductivity below 500 µS/cm is generally considered good. At 174 µS/cm, the lake has moderate mineral content, and no signs of excessive salinity or contamination from salts



CONCLUSION:

The analysis of the lake water sample indicates that several key parameters exceed the permissible limits set by the World Health Organization (WHO) and the Central Pollution Control Board (CPCB) for safe drinking water, suggesting that the water is not suitable for direct human consumption without adequate treatment.

- Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were found to be 21.85 mg/L and 66.7 mg/L and suggests a high level of organic pollution, likely due to the discharge of domestic or industrial waste.
- Turbidity was recorded at 43.9 NTU, indicating the presence of suspended solids that may harbor pathogens or pollutants.
- The Total Dissolved Solids (TDS) level of 510.75 mg/L slightly exceeds the WHO desirable limit of 500 mg/L, although it remains within the acceptable range.
- Iron concentration was 0.821 mg/L, could cause discoloration, metallic taste, and staining of utensils and laundry.
- Color measured at 43.9 Hazen units indicated aesthetic concerns and possible contamination.
- Nitrate levels at 38 mg/L are below the WHO maximum limit of 50 mg/L, but close enough to warrant monitoring.
- Other parameters such as pH (7.39), fluoride (0.256 mg/L), sulphate (14.69 mg/L), and residual chlorine (0.1895 mg/L) are within acceptable limits for drinking water. Total hardness (209.55 mg/L) and chloride (202 mg/L) are within permissible limits, though on the higher side, potentially affecting taste and scaling in pipes.
- Dissolved Oxygen (DO) at 5.595 mg/L is moderately good, indicating some level of natural aeration.

REFERENCES:

[1] Salahuddin and Intazar Husain- *Analysis of Shahpura lake Water in Bhopal Region of Madhya Pradesh, India International* Journal of Lakes and Rivers. ISSN 0973-4570 Volume 13, Number 1 (2020), pp.17-25

[2] Amit Kumar, Om Chaudhary -*Conservation Plan of Upper Lake, Bhopal: Water-Quality Centric Case Study*, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 1, January 2013)

[3] Salahuddin, Physico-chemical analysis of upper lake water in Bhopal region of Madhya Pradesh, India, *Advances in Applied Science Research*, 5(5), 165-169,2014.

[4] Chaudhary M. P., Salahuddin, Singh Sudhir Kumar and Singh Prafull, Statistical analysis for presence of Chloride in water at different locations of upper lake in Madhaya Pradesh state of India, *International Journal of Mathematical Archive,* 4, 35–37,2013.
[5] Salahuddin, Analysis of Chloride Content in the Surface of water at different locations of Madhya Pradesh, *International Journal for Pharmaceutical Research Scholars*, 2(4), 107-109*,*2013.
[6] Reza Rizwan and Singh Gurdeep, Physico-Chemical Analysis of Ground Water in Angul-Talcher Region of Orissa, India, *Journal of American Science*, **2009**, 5,53-58.
[7] Salahuddin, Analysis of electrical conductivity of ground water at different locations of Dildar Nagar of U.P, India, *Advances in Applied Science Research*, 6(7), 137-140, 2015.
[8] Navneet Munoth, Anugrah Anilkumar Nagaich- *Planning Interventions for Lake Conservation: A Case of Shahpura Lake, Bhopal, India,* The Institution of Engineers (India) June 2015
[9] Anita and Salahuddin, Analysis of Electrical conductivity of Ground water at different locations of Phooli of U.P, India, *International Journal of Emerging Trends in Engineering and Development,* 2019, 3, 1-5.
[10] APHA, Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WPCF, Washington D.C, 1998.
[11] Salahuddin and Khola, R. K, Analysis of Chloride Content in the Surface of water using two-way Anova, *International Journal for Pharmaceutical Research Scholars,* 2(4), 51-53*,* 2013.
[12] Salahuddin, Khola, R. K, Physico-Chemical Analysis for the Presence of Oxygen Content of Ground Water at Different Locations of Dildar Nagar of U.P, India, Global Journal of Science Frontier Research (B), 14 (6),01-03,2014.
[13] Cox D. R., Principles *of statistical inference*. Cambridge New York: Cambridge University Press, 2006.
[14] Freedman David A, *Statistical Models: Theory and Practice*, Cambridge University Press, 2005.
[15] Ansari, Farid**,** Salahuddin; Groundwater Temperature Variation Analysis of Industrial Area Nandganj, Ghazipur (India), *Australian Journal of Basic and Applied Sciences,* 2013**,**
[16] Kothari, C. R., *Research Methodology*, New Age International (P) Limited, Publishers, New Delhi, 2004.
[17] David A Freedman, *Statistical Models: Theory and Practice*, Cambridge University Press, 2005.