

Variation in Physicochemical Water Quality of Mansagar Lake, Jaipur, Rajasthan, India

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Research Article

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Abstract

Seasonal variation in physicochemical parameters was observed in Mansagar Lake, Jaipur, during sampling conducted in the summer, monsoon, and winter seasons. Significant changes in physicochemical parameters, such as temperature, pH, total dissolved solids, dissolved oxygen, and biological oxygen demand, were noted during sampling. Standard APHA procedures were followed in the analysis of water samples. Low water levels and obvious organic mix-up at multiple locations were accompanied by relatively worse water quality during the summer, as evidenced by higher BOD and TDS levels. Elevated BOD and Reduced DO values indicate continuous organic loading from sewage discharge and urban runoff. The highest BOD value (164.75 ± 11.95 mg/L) was recorded during summer, while the lowest DO (2.02 ± 1.19 mg/L) was observed in the same season. Elevated BOD and reduced DO values indicate continuous organic loading from sewage discharge and urban runoff. The findings show that to improve the ecological state of Jaipur's urban lakes, site-specific management techniques are required.

Introduction

Freshwater ecosystems play a vital role in maintaining ecological balance and supporting human livelihoods. Lakes serve as important sources of drinking water, groundwater recharge, fisheries, recreation, biodiversity conservation, and climate regulation. However, increasing urbanization, industrial development, population growth, and anthropogenic activities have significantly affected the quality of freshwater resources worldwide. Urban lakes are particularly vulnerable to pollution because they receive untreated sewage, stormwater runoff, solid waste, and various contaminants originating from surrounding human settlements. Over the past few decades, India's urban lakes have rapidly deteriorated, especially in areas where cities are expanding unplanned (Pandey *et al.*, 2017). In recent years, untreated sewage, solid waste, and stormwater runoff have increased in many lakes that formerly sustained biodiversity, groundwater recharge, and recreational use. (Chandrashekar *et al.*, 2018). Excessive weed growth, unpleasant odors, and sporadic fish mortality are now common field observations from a number of urban lakes. Seasonal factors also affect these conditions; monsoon runoff adds more suspended matter and nutrients, while summertime reduced inflow concentrates pollutants. (Water Resources of India, n.d.) (Anand and others, n.d.) Rajasthan, characterized by its semi-arid climate and limited water resources, depends heavily on lakes and reservoirs for environmental and socio-economic sustainability. Several lakes in the state have experienced increasing pollution pressure due to tourism activities, urban runoff, domestic sewage discharge, and catchment degradation. Seasonal fluctuations in rainfall and temperature further influence the physicochemical properties of these water bodies, affecting their ecological health and water quality status. Mansagar Lake, located in Jaipur city, is one of the most important urban lakes of Rajasthan. The lake is internationally recognized due to the presence of the historic Jal Mahal monument situated at its center. Besides its cultural and tourism significance, the lake supports local biodiversity and provides important ecosystem services. However, rapid urbanization around the lake, untreated sewage inflow through major drains, increasing tourist activities, and catchment disturbances have raised concerns regarding its environmental condition. Previous studies have reported issues related to eutrophication, organic pollution, and declining water quality within the lake ecosystem. Several studies have reported the physicochemical characteristics of Indian urban lake most studies focus on limited number of water quality parameter or short term monitoring comprehensive studies evaluating seasonal variation in physicochemical parameter of mansagar lake under the incrising anthroprogenic pressure . there is insufficient information regarding the combine influence of urban runoff, turism activites and seasonal fluctuation on the overall water quality of lake a fdetailed seasonal assessment is require to provide updated scientific evidence for effective lake management and restoration .epresent study preovid an updated seasonal assessment of the physicochemical charactersics of Mansagar Lake by analyzing water quality across diffrent season and sampling location unlike previous studies this research evaluate the combined effect of seasonal variation and anthropogenic activity on water quality and identify the most vinfluentia parameter affecting the lake ecosystem. The finding will provide recent baseline data to support sustainable management and conservation strategies for urban freshwater lake in semi-arid regions such as rajasthan. Therefore the present study aims to evluate the seasonal variation in the physicochemical characterstics of Mansagar lake , Jaipur and asses the influence of anthrophrogenic activity on water quality to provide scientific information for sustainable lake management .

Materials and Methods

Study Area:

In the northern region of Jaipur, Rajasthan, between the Aravalli hills and the city's urban sprawl, sits the historic man-made reservoir known as Mansagar Lake. The lake is about 139 hectares in size and receives its water from a catchment area that is roughly 23.5 square kilometers in size. This region is dominated by a hot semi-arid climate, with the lion's share of annual rainfall, about 657 millimeters, falling during the monsoon period of the year between July and September. The seasonal rainfall significantly influences both the water level and the quality of the lake. Mansagar Lake mainly receives water from monsoon runoff flowing down the surrounding hills via several small streams. It also gets a steady inflow from two major urban drains, Brahmपुरi and Nagtalai, which carry untreated domestic sewage and stormwater. The maximum primary pollutants come from waste dumping, urban runoff, sewage discharge, and sediment buildup caused by soil erosion from the degraded Aravalli slopes. Furthermore, the pressures of rapid urban growth and tourism. All of these factors make Mansagar Lake an important location for examining seasonal changes in water quality and understanding the impact of human activities (Pradhan Jain 2022).

The author appearing in this figure has provided informed consent for publication

Sampling - In this study, water quality assessment at Mansagar Lake was done through systematic sampling at four different sites, as shown in Fig. 1. The Sites were selected to represent different areas of the lake, shown in Table 1, including the inlet, outlet, middle portion, and one representative area of high anthropogenic activities. The geographical location and sampling site of the lake are shown in Fig. 2. Sampling was conducted quarterly across

three seasons: monsoon (July–September), winter (November–February), and summer (March–June), according to the APHA 2024 standard methods. At each station three independent samples were collected and analysed. The reported value represent mean ± standard deviation (n = 4 site per season or as applicable Each sample was taken about 5 centimeters below the surface using thoroughly cleaned polyethylene bottles. The quarterly sampling allowed for a detailed look at seasonal changes in physicochemical properties and helped identify patterns of pollution over time. (Singh & Jain, 2021). Once collected, the samples were kept in cool, dark conditions during transport and analyzed within 24 hours to ensure accuracy. This approach is consistent with methods used in previous research on urban lakes in India (Sharma *et al.*, 2020; Patel *et al.*, 2018)

Table 1
Sampling location of Mansagar Lake

Sample	Location
Sample-1	Brahmapuri Drain Entry Point
Sample-2	Jal Mahal Spillway or Overflow Point
Sample-3	Central Area Near Jal Mahal
Sample-4	Near Urban Settlements Along Amer Road

Source: Generated using GIS/AI tools

Methodology –

A number of physical and chemical parameters were analyzed following the American Public Health Association (APHA, 2024) and Indian standards to evaluate the water quality of Mansagar Lake. The physical parameters studied are pH, temperature, total dissolved solids (TDS), turbidity, and the chemical parameters included: DO, BOD, total hardness, and magnesium hardness. All measurements were conducted with field- and laboratory-based established measurement methods, ensuring accuracy and consistency in the measurements. All data are presented as mean and standard± deviation. One-way analysis of variance (ANOVA) was performed to evaluate significant seasonal differences among the physicochemical parameters of Mansagar Lake. Statistical significance was considered at $p < 0.05$. Pearson correlation analysis was conducted to determine the relationship among the measured physiochemical parameter all statical analysis were performed using Microsoft Excel.

Table 2
– All parameters and protocols followed

S.no.	Parameter	Protocols
1.	PH	IS;3025(Part-11)-2022
2.	Turbidity	IS;3025(Part-10)-1984
3.	Total Dissolved Solids	IS;3025(Part-16)-1984
4.	Chloride (as Cl-)	IS;3025(Part-32)-1988
5.	BOD	IS;3025(Part-44)-1993
6.	Dissolve Oxygen	IS;3025(Part-38)-1989
7.	Total hardness(as CaCO3)	IS;3025(Part-21)-2009
8.	Magnesium (as Mg)	IS;3025(Part-46)-1994

Results

The Mean ± SD of the physicochemical parameters at four sampling sites over summer, monsoon, and winter seasons is presented in Table 3. An overview of the seasonal variations in water quality parameters (WQPs) is efficiently depicted by this table. All protocols that we follow are shown in Table 2.

Table 3 – Seasonal variation of Physicochemical Parameters of Mansagar Lake

Parameter	Summer					Monsoon					Winter				
	S1	S2	S3	S4	Mean±SD	S1	S2	S3	S4	Mean±SD	S1	S2	S3	S4	Mean±SD
pH	8.1	8.3	8.4	7.8	8.15±0.26	8.5	8.9	9.5	9.9	9.20±0.62	8.0	8.5	8.7	8.3	8.38±0.30
TDS	880	960	967	1050	964±69.47	650	703	716	703	693±29.91	810	870	910	880	867±41.93
Turbidity	50	56	60	55	55.25±4.11	50	61	75	69	63.75±10.81	45	57	69	55	56.50±9.85
Cl⁻ Con.	72	85	100	86	85.75±11.44	42	52	66	53	63.75±9.84	57	60	68	62	61.75±4.65
BOD	150	163	179	167	164.75±11.95	155	153	159	163	157.5±4.43	120	132	144	149	136±12.97
DO	0.6	1.9	3.5	2.1	2.025±1.19	3.7	4.2	4.5	5.5	4.47±0.76	6.1	4.7	7.4	6.6	6.2±1.13
Total Hardness	250	290	230	270	260±25.82	390	410	340	410	387.5±33.04	330	335	370	355	347.5±18.48
Magnesium Hardness	45	50	58	53	51.5±5.45	55	60	72	63	62.5±7.14	60	54	59	56	57.25±2.75

Abbreviations: S1 – Sample 1, S2 – Sample 2, S3 – Sample 3, S4 – Sample 4, SD – Standard Deviation.

Units: TDS – Total Dissolved Solids (mg/L), DO – Dissolved Oxygen (mg/L), BOD – Biological Oxygen Demand (mg/L), Turbidity – Nephelometric Turbidity Unit (NTU), Cl⁻ – Chloride (mg/L), Hardness – mg/L as CaCO₃.

Among the observed parameters shown in Table 3, the highest mean pH was recorded in the monsoon (9.20 ± 0.62) and the lowest in summer (8.15 ± 0.26). TDS reached its maximum in summer (964 ± 69.47 mg/L) and minimum in monsoon (693 ± 29.91 mg/L). Turbidity was highest during the monsoon (63.75 ± 10.81 NTU) and lowest in summer (55.25 ± 4.11 NTU). Chloride concentration peaked in summer (85.75 ± 11.44 mg/L) and was lowest in monsoon (63.75 ± 9.84 mg/L). BOD showed maximum values in summer (164.75 ± 11.95 mg/L) and minimum in winter (136 ± 12.97 mg/L). DO was highest in winter (6.2 ± 1.13 mg/L) and lowest in summer (2.02 ± 1.19 mg/L). Total hardness reached its maximum in monsoon (387.5 ± 33.04 mg/L) and minimum in summer (260 ± 25.82 mg/L). Similarly, magnesium hardness was highest during the monsoon (62.5 ± 7.14 mg/L) and lowest in summer (51.5 ± 5.45 mg/L).

Table 4. One-Way ANOVA for Seasonal Variation in Physicochemical Parameters

Parameter	F-Value	P-Value	Interpretation
pH	6.719	0.016	Significant
TDS	30.467	<0.001	Significant
Turbidity	1.095	0.375	Not Significant
Cl⁻ Con.	13.668	0.002	Significant
BOD	7.958	0.010	Significant
DO	16.144	0.001	Significant
Total Hardness	24.298	<0.001	Significant
Magnesium Hardness	4.116	0.054	Not Significant

One-way ANOVA was performed in Table 4. to evaluate seasonal variation in physicochemical parameters of Mansagar Lake. Significant seasonal differences ($p < 0.05$) were observed for pH, TDS, chloride concentration, BOD, DO, and total hardness, indicating the influence of seasonal climatic conditions and anthropogenic activities on water quality. However, turbidity and magnesium hardness did not show statistically significant seasonal variation ($p > 0.05$).

Table 5 – Correlation analysis

Parameter	pH	TDS	Turbidity	Cl ⁻ Conc.	BOD	DO	Total hardness	Magnesium hardness
pH	1.000							
TDS	-0.654	1.000						
Turbidity	0.809	-0.200	1.000					
Cl ⁻ Con.	-0.383	0.845	0.050	1.000				
BOD	0.212	0.202	0.373	0.549	1.000			
DO	0.350	-0.284	0.327	-0.4333	-0.448	1.000		
Total Hardness	0.610	-0.764	0.316	-0.862	-0.302	0.626	1.000	
Magnesium Hardness	0.715	-0.515	0.694	-0.263	0.027	0.586	0.480	1.00

Pearson correlation analysis revealed strong positive correlation between TDS and chloride ($r=0.844$), pH and turbidity ($r = 0.795$), and PH and magnesium hardness ($r=0.719$). A moderate correlation analysis revealed strong positive correlation between TDS and chloride ($r = 0.844$), pH and turbidity ($r=0.795$) and PH and magnesium hardness ($r=0.719$). A moderate negative correlation was observed between BOD and DO ($r=0.719$). A moderate negative correlation was observed between BOD and DO ($r=-0.583$), indicating that increasing organic pollution may contribute to oxygen depletion in the lake water. Total hardness exhibited a strong negative correlation with chloride ($r=-0.911$) and TDS ($r = -0.803$), suggested seasonal variations in ionic composition and mineral content.

Comparison of parameters in different Seasons –

Discussion

The current study showed significant seasonal variation in the physicochemical properties of Mansagar Lake, suggesting that both climatic conditions and human activity are linked to water quality. The seasonal variations in pH, TDS, chloride concentration, BOD, DO, total hardness, and magnesium hardness reflected the effects of hydrological patterns; sewage inflow; urban runoff, and biological processes within the lake system. During this span, the pH remained alkaline (ranging from 8.15 ± 0.26 during summer to 9.20 ± 0.62 in the monsoon season). The higher pH during the monsoon might be the reason for large surface runoff, which carries dissolved minerals and bases in full flood from the surrounding catchment area. Many urban lakes of Rajasthan also show similar alkaline conditions, which is attributed to increased primary productivity with high nutrient enrichment (Kumar & Mishra, 2024). Turbidity was highest during the monsoon season (63.75 ± 10.81 NTU), likely due to increased sediment transport and surface runoff from the surrounding catchment. Similar observations have been reported in urban freshwater ecosystems influenced by monsoon rainfall. Chloride concentration reached its maximum during summer (85.75 ± 11.44 mg/L), indicating the influence of domestic sewage discharge and anthropogenic contamination, while lower values during monsoon may be attributed to dilution effects caused by rainfall. Biological oxygen demand (BOD) remained high throughout the study and peaked during summer (164.75 ± 11.95 mg/L), suggesting substantial organic pollution from untreated wastewater inputs. In contrast, dissolved oxygen (DO) showed an inverse trend, with the lowest value recorded in summer (2.02 ± 1.19 mg/L) and the highest in winter (6.20 ± 1.13 mg/L). The depletion of DO is likely associated with increased microbial decomposition and oxygen consumption under elevated summer temperatures. The negative relationship between BOD and DO highlights the impact of organic pollution on aquatic ecosystem health (Patel & Singh, 2018; Suresha et al., 2023). Total hardness and magnesium hardness also exhibited seasonal variation, with maximum values recorded during the monsoon season, possibly due to runoff-mediated transport of minerals from the catchment area. One-way ANOVA revealed significant seasonal variation in pH, TDS, chloride concentration, BOD, DO, and total hardness ($p < 0.05$), indicating the strong influence of seasonal factors on water quality. Overall, the results suggest that sewage inflow, urban runoff, and anthropogenic activities are major contributors to the deterioration of water quality in Mansagar Lake, emphasizing the need for continuous monitoring and effective restoration measures.

These findings highlight the need for regular water-quality monitoring, improved sewage treatment, catchment management, and restoration measures to ensure the long-term ecological sustainability of this urban lake. Future studies may incorporate the Water Quality Index (WQI) and advanced multivariate statistical techniques to provide a more comprehensive assessment of seasonal water-quality dynamics.

Conclusion

The present study demonstrates severe seasonal deterioration in the water quality of Mansagar Lake, particularly during summer. Field observations and analytical findings indicate lower water levels, noticeable organic deposits, and diminished dissolved oxygen levels in the warmer season. Increased BOD and TDS readings imply ongoing organic loading, primarily due to untreated sewage and urban runoff. (Sharma et al., 2020; Patel & Singh, 2018). Partial dilution was observed during the monsoon season. The overall organic load in the lake remained a concern throughout the seasons. These conditions are serious threats to aquatic organisms and contribute to ongoing eutrophication. For the restoration of Mansagar Lake, it will be essential to implement consistent sewage treatment, desiltation, safeguarding of the catchment area, and active participation from local stakeholders to achieve sustainable ecological enhancement. (APHA, 2024).

Declarations

Ethical Responsibilities of Authors

The authors declare that there is no conflict of interest. This study does not involve any human participants or animals. All procedures followed were in accordance with the standard environmental research guidelines.

Clinical trial no.-

Not acceptable

Ethical approval –

not applicable. This study did not include human participants or animals

Consent to participate –

the author appearing in Fig. 1 voluntarily participated and provided informed consent

Consent for publication-

the author appearing in Fig. 1 has provided informed consent for the publication of the photograph in this manuscript

Conflict of interest –

The author declares no conflict of interest.

Funding –

This research received no external funding

Author Contribution

*Manish Kumar: Conceptualization, field sampling, laboratory analysis, data curation, statistical analysis, interpretation of results, visualization, and preparation of the original manuscript draft. Dr. Swati Gupta: Supervision, study design, methodology, critical review and editing of the manuscript, interpretation of results, and overall guidance throughout the research. Both authors read and approved the final version of the manuscript.

Data Availability

the data sets generated during or analysed during the current study are available from the corresponding author on reasonable request

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Figures



Figure 1

Location map of Mansagar Lake

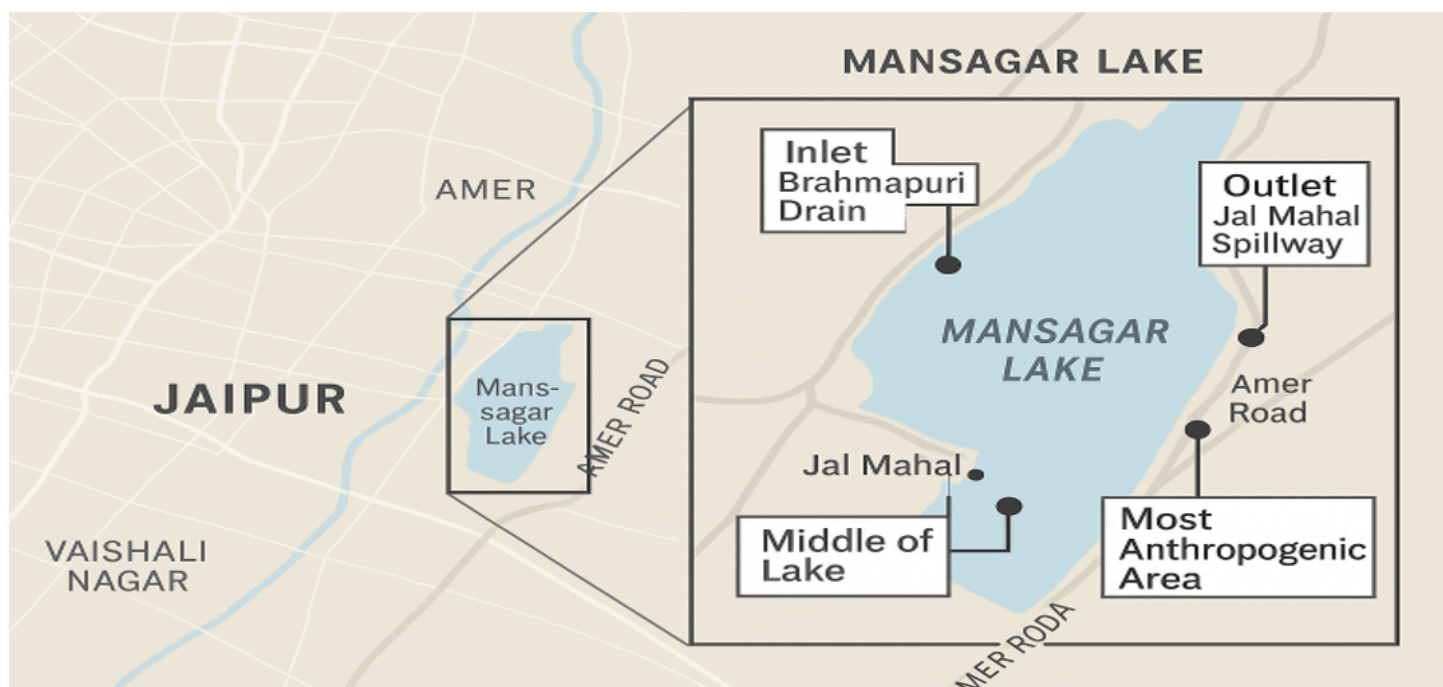


Figure 2

Sampling locations of Mansagar in Jaipur district, Rajasthan, India.

Source: Generated using GIS/AI tools

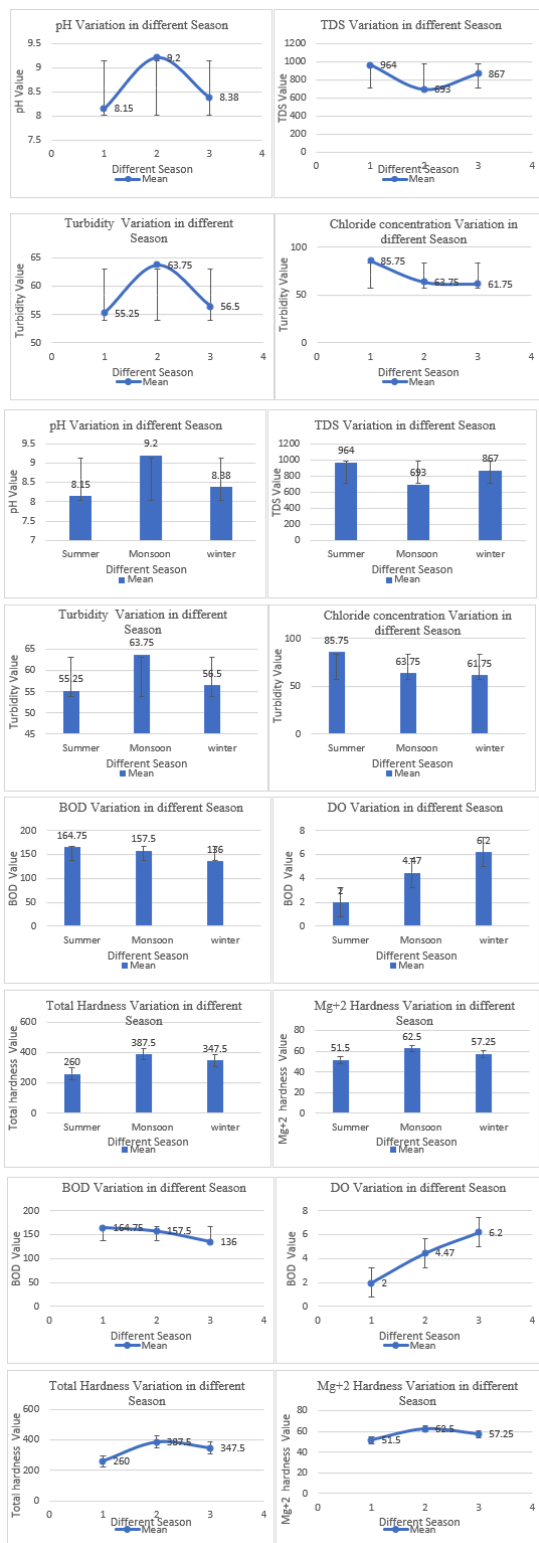


Figure 3

Graphical Representation of Data