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Assessment Of Physico-Chemical Characteristics Of Water Of Kanwar Lake In Begusarai District, Bihar

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Abstract
This study investigates the physico-chemical characteristics of Kanwar Lake, one of Asia's largest freshwater oxbow lakes, located in Begusarai District, Bihar. Declared a Ramsar site in 2020, the lake faces increasing pollution due to surrounding human settlements and agricultural runoff. Water samples were collected monthly from April 2022 to March 2023 across three sites: inlet, mid-lake, and outlet. Key parameters analyzed included water depth, temperature, turbidity, pH, electrical conductivity, dissolved oxygen, free carbon dioxide, total alkalinity, and total hardness. Results showed seasonal variations in water quality, with higher turbidity and conductivity during the monsoon and increased alkalinity and hardness post-monsoon. The study highlights the significant impact of anthropogenic activities on the lake's water quality, with a decline in dissolved oxygen and pH. The study concludes by recommending storm water management, wetland restoration, and pollution control to safeguard the ecological health of Kanwar Lake.
Keywords: *Kanwar Lake, Physico-chemical characteristics, Human settlements, APHA, pH, alkalinity*

INTRODUCTION

Wetlands are areas where water either covers the soil or is present near the surface for varying periods throughout the year. These areas are highly productive ecosystems that support a diverse range of flora and fauna, all of which rely on wetlands for their survival. Water, after air, is the second most vital natural resource needed to sustain life on Earth. About 71% of the Earth's surface is covered by water, with oceans accounting for 96.5% of all water, while glaciers, rivers, and groundwater make up the rest. Only about 2.4% of Earth's water is considered freshwater. Rivers, lakes, and ponds offer easily accessible freshwater, used for human consumption and other commercial purposes. However, surface water resources are increasingly vulnerable to pollution due to unregulated water usage. The quality of surface water is influenced by both natural and human activities, such as rainfall, soil erosion, and industrial and agricultural practices. Over the past few decades, there has been a significant decline in the quality of water in inland aquatic systems, primarily due to rapid industrialization, agricultural expansion, and urbanization. The growing urban population has become a major factor in the depletion and pollution of freshwater resources. Globally, the freshwater crisis is escalating as these resources continue to be exhausted and polluted. India, despite having abundant freshwater resources in the form of inland rivers, lakes, and ponds, is facing a similar issue. According to the National Environmental Engineering Research Institute (2006), nearly 70% of India's freshwater sources are polluted. However, several water bodies and reservoirs still maintain good water quality and need to be preserved. Monitoring and maintaining water quality is crucial to conserving these vital resources.

Kanwar Lake, the largest natural freshwater oxbow lake in Asia, was formed when the course of the Budhi Gandak River changed in the past. Now, it lies within the floodplain of both the Ganga and Budhi Gandak rivers and is connected to these rivers during floods. Located approximately 16.4 kilometers northwest of Begusarai, Bihar, the lake was initially declared a protected area under the Wildlife Protection Act of 1972 by the Bihar government in 1986. In 1989, the Government of India declared it a bird sanctuary. The size of Kanwar Lake is approximately six times greater than that of the Bharatpur Sanctuary. Due to its rich biodiversity, the Ministry of Environment, Forest, and Climate Change (MoEFCC) designated it as Bihar's first Ramsar site in November 2020, making it one of the 91 Ramsar sites in India. In 1984, the lake covered an area of 6,786 hectares, but by 2004, it had shrunk to 6,043.82 hectares. By 2012, only 2,032 hectares remained of the original area. The lake's bed has been rapidly colonized by local communities, and biodiversity has declined as weeds have proliferated across the wetland. Agricultural activities have also encroached on much of the lake's area. Today, Kanwar Lake faces a severe threat to its water quality due to various anthropogenic activities.

This research investigates the physico-chemical parameters of Kanwar Lake and examines the impact of urbanization on the lake's condition. It focuses on the causes of the lake's deterioration and outlines strategies for restoring its ecological balance. The study also highlights key issues surrounding the lake, particularly in the vicinity of Manjhaul village. Some of the key findings emphasize the need for storm water management across Begusarai, the restoration of Kanwar Lake's wetland, prevention of further human settlement around the lake, and the regulation of industrial activities in the area.

MATERIAL AND METHODS

Study Area

Kanwar Lake, the largest natural freshwater oxbow lake in Asia, was formed as a result of a change in the course of the Budhi Gandak River in the past. Currently, it is situated within the floodplain of both the Ganga and Budhi Gandak rivers, and during floods, it becomes connected to these rivers. Located about 16.4 kilometers northwest of Begusarai district's headquarters in Bihar, the lake's geographical coordinates are 25°35'00"–25°40'00" N and 86°05'00"–86°10'00" E. In recognition of its rich biodiversity, the Ministry of Environment, Forest and Climate Change (MoEFCC) declared Kanwar Lake as Bihar's first Ramsar site in November 2020. This designation places it among the 91 Ramsar sites in India. In 1984, the lake's area was recorded at 6,786 hectares (ha), but by 2004, it had reduced to 6,043.82 ha. By 2012, the area had further shrunk to just 2,032 ha, a significant decrease from its original size. On average, Kanwar Lake covers an area of 2,600 ha, but during the monsoon season, it connects with nearby water bodies, expanding to an area of 7,400 ha.

Kanwar Lake was recognized as a Lake of National Importance and was included in the National Wetland Conservation Program by the Ministry of Environment and Forest, Government of India, in 2009. The lake has an average elevation of 44 meters above mean sea level and features a uniformly flat landscape. It primarily receives rainfall from the southwest monsoons between July and September, with an average annual rainfall of 1,100 mm.

2.1 Sampling and Analysis

The total water spread area of Kanwar Lake during the monsoon season is 7,400 hectares. As a perennial wetland, samples were collected monthly from April 2022 to March 2023. Water samples were taken 20-30 cm below the surface layer of the water body. Sampling typically occurred between 8:30 a.m. and 9:30 a.m. throughout the study period. Samples were collected from three locations: A (inlet), B (mid-lake), and C (outlet). These sampling points were chosen to represent the inlet, central area, and outlet of the lake.

In total, surface water samples were collected from ten identified locations across the entire lake, with three sampling sites each at the inlet and outlet, and four sites in the mid-lake area. In total, 120 surface water samples were collected during the study period. The analyzed physico-chemical parameters included water depth, temperature, pH, turbidity (transparency), electrical conductivity, dissolved oxygen, free carbon dioxide, total alkalinity, and total hardness.

Water depth at Kanwar Lake was measured using a calibrated bamboo stick. Turbidity, which is inversely proportional to water transparency, was assessed using a Sacchi disk. Water temperature was recorded using a laboratory thermometer. The pH of the water samples was measured on-site with a calibrated digital pH meter. Electrical conductivity (EC in μS/cm) was measured using a portable conductivity meter. For dissolved oxygen (DO in mg/l) estimation, water samples were collected in 250 ml water sampler bottles, to which 2 ml of Winkler's A and B solutions were immediately added. The remaining procedures were carried out in the laboratory.

Other chemical parameters, such as free carbon dioxide (FCO2 in mg/l), total alkalinity (TA in mg/l), and total hardness (TH in mg/l), were analyzed in the laboratory. For each sampling location, three surface water samples were collected in polyethylene bottles and mixed to create a composite sample. The collected samples were carefully labeled, stored in iceboxes, and transported to the laboratory for analysis, following the standard methods outlined by CIFRI (1985), Trivedy and Goel (1986), Chapman (1996), APHA (1996), and Chattopadhyay (1998).

RESULTS AND DISCUSSION

The monthly and seasonal variations in various physico-chemical parameters of water were recorded and are presented in Tables 1 & 2 and Graphs 1 to 9. The results have been summarized on a seasonal basis in

Table 2. Three seasons were considered for this study: post-monsoon (November to February), pre-monsoon (March to June), and monsoon (July to October). The parameters recorded from April 2022 to March 2023 include water depth, water temperature, water transparency, electrical conductivity, dissolved oxygen, free carbon dioxide, total alkalinity, and total hardness.

Table – 1, Month wise variation of Physico-chemical characteristics of water of Kanwar Lake (wetland) of Begusarai district (Bihar) Year 2022-23

Parameters → Months↓	WD(cm)	WT (°C)	TW (cm)	pH	EC(µS/cm)	DO(mg/l)	FCO_2 (mg/l)	TA(mg/l)	TH(mg/l)
Mar	130	27.6	80	8.5	400	4.8	16.0	144	158
Apr	100	29.0	90	8.6	380	5.0	12.2	154	167
May	50	31.4	50	7.9	345	4.9	20.3	172	188
Jun	60	29.5	60	8.0	303	5.2	18.4	150	154
July	150	26.5	90	7.6	266	5.9	24.1	119	130
Aug	260	26.7	100	7.8	230	6.8	20.1	106	115
Sep	280	26.1	100	7.7	215	6.5	22.2	102	110
Oct	260	24.0	106	7.6	261	5.2	23.1	101	105
Nov	250	21.1	110	7.4	370	4.6	28.6	110	114
Dec	200	19.5	114	7.5	407	4.2	26.2	132	138
Jan	160	18.4	116	7.9	455	4.2	21.2	140	144
Feb	150	21.4	120	8.3	460	4.4	19.0	148	152

Abbreviations used: WD = Water Depth, WT = Water Temperature, TW = Transparency of Water, EC = Electrical Conductivity, DO = Dissolved Oxygen, FCO_2 = Free Carbon Dioxide, TA = Total Alkalinity and TH = Total Hardness

Table – 2, Range of physico-chemical characteristics and Mean±S.D. of water of Kanwar Lake (wetland) of Begusarai district (Bihar) Year 2022-23

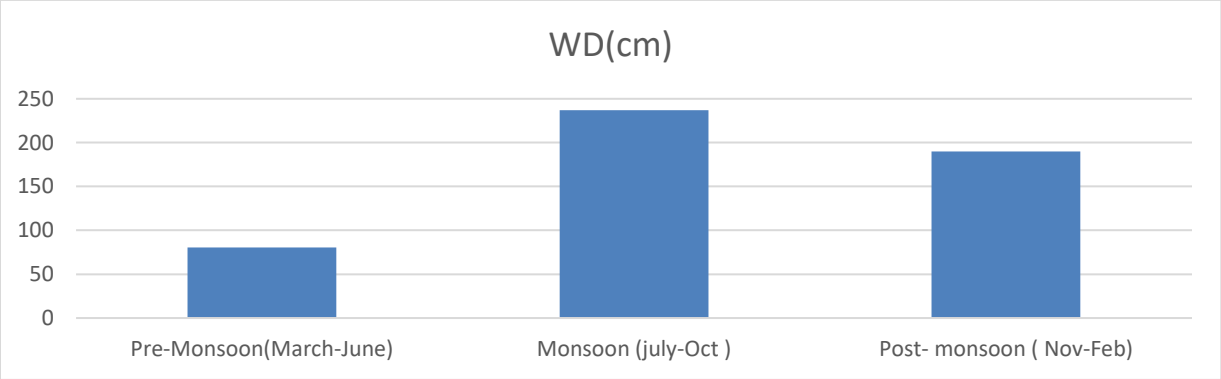
	Pre-monsoon(Mar.- Jun.)		Monsoon(Jul.– Oct.)		Post-monsoon(Nov.–Feb.)	
Parameters	**Range**	**Mean ± SD**	**Range**	**Mean ± SD**	**Range**	**Mean ± SD**
WD(cm)	50 - 130	80.5 ± 37.33	150 - 300	237.5 ± 22.25	150 - 250	**190 ± 45.46**
WT(°C)	27.6 - 31.4	29.37 ± 1.61	24.0 - 26.7	25.82 ± 1.24	18.4 - 21.4	**20.1 ± 1.41**
TW(cm)	50 - 90	70 ± 18.25	90 - 106	99 ± 6.63	110 - 120	**114 ± 7.21**
pH	7.9 - 8.6	8.25 ± 0.35	7.6 - 7.8	7.67 ± 0.09	7.4 - 8.3	**7.77 ± 0.41**
EC(µS/cm)	303 - 400	357 ± 42.57	215 - 261	243 ± 24.53	370 - 460	**423 ±49.90**
DO(mg/l)	4.8 - 5.2	4.97 ± 0.17	5.2 - 6.8	6.10 ± 0.70	4.2 - 4.6	**4.35 ± 0.19**
FCO_2(mg/l)	12.2 - 20.3	16.72 ± 3.49	20.1 - 24.1	22.37± 1.71	19.0 - 28.6	**23.75 ± 4.42**
TA(mg/l)	144 - 172	155 ± 12	101 - 119	107± 8.29	110 - 148	**132.50 ± 16.36**
TH(mg/l)	**154 - 188**	**166.75 ± 15.17**	**105 - 130**	**115 ± 13.53**	**114 - 152**	**137 ± 16.37**

Table 2 presents the seasonal variations of various physico-chemical parameters of water in Kanwar Lake (Begusarai, Bihar) from April 2022 to March 2023, classified into three distinct seasons: pre-monsoon (March to June), monsoon (July to October), and post-monsoon (November to February). Water depth was observed to be the highest during the monsoon, ranging from 150 to 300 cm, with an average of 237.5 cm, compared

to pre-monsoon and post-monsoon periods, which had depths of 50-130 cm (80.5 cm) and 150-250 cm (190 cm), respectively. Water temperature followed a similar seasonal trend, being highest in pre-monsoon (29.37°C) and lowest during post-monsoon (20.1°C). Transparency, measured by water transparency (TW), increased progressively from pre-monsoon (70 cm) to post-monsoon (114 cm), likely due to the reduction in suspended particles and sedimentation after the monsoon.

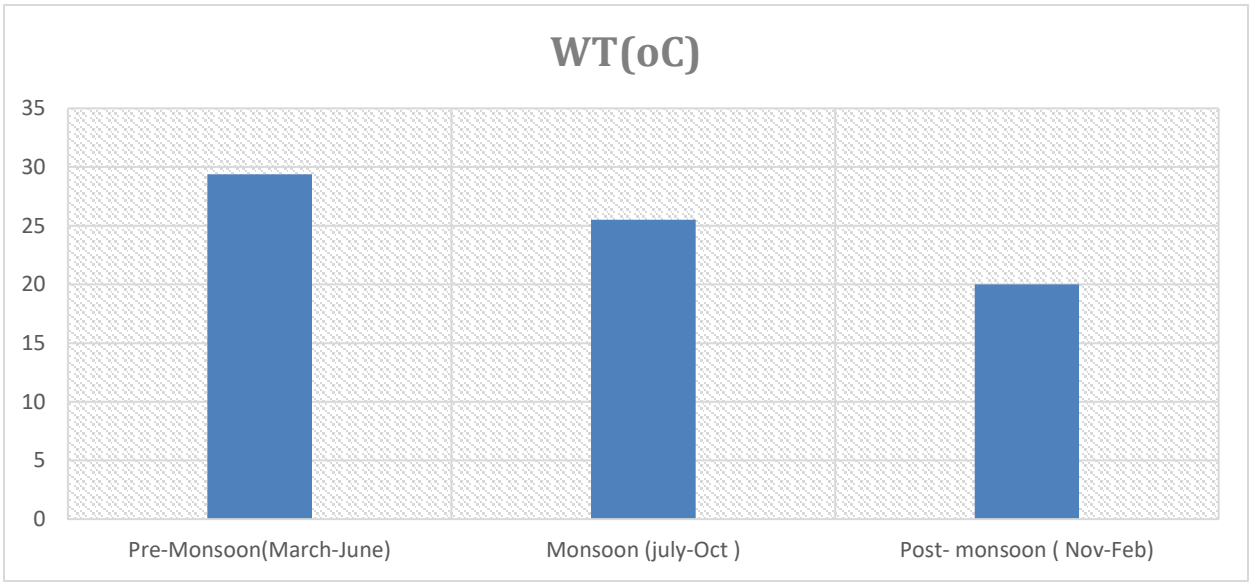
Electrical conductivity (EC) showed considerable variation, with the highest values recorded post-monsoon (423 µS/cm) and the lowest during monsoon (243 µS/cm), reflecting the dilution effect from rainfall. Dissolved oxygen (DO) levels were highest during the monsoon (6.10 mg/l), likely due to increased aeration and water movement, whereas post-monsoon saw lower DO levels (4.35 mg/l). Free carbon dioxide (FCO2) was highest post-monsoon (23.75 mg/l), which could be attributed to increased organic decomposition, while it was relatively lower during pre-monsoon (16.72 mg/l) and monsoon (22.37 mg/l).

The total alkalinity (TA) and total hardness (TH) showed inverse trends, with TA being highest in the pre-monsoon period (155 mg/l) and lowest during the monsoon (107 mg/l), while TH was also highest in pre-monsoon (166.75 mg/l) and lowest during monsoon (115 mg/l). These seasonal changes indicate the effects of rainfall and water movement, with reduced solute concentration during the monsoon followed by an increase post-monsoon due to evaporation and mineral concentration. The variations in these physico-chemical parameters highlight the dynamic nature of Kanwar Lake's ecosystem and the influence of seasonal changes on its water quality.



Graph No. 1 depicts the seasonal variation of water depth in Kanwar Lake, highlighting the fluctuations across the pre-monsoon, monsoon, and post-monsoon periods. This graph is essential in understanding how the lake's water level changes with the seasons, which influences the overall aquatic ecosystem and the availability of habitat for flora and fauna.

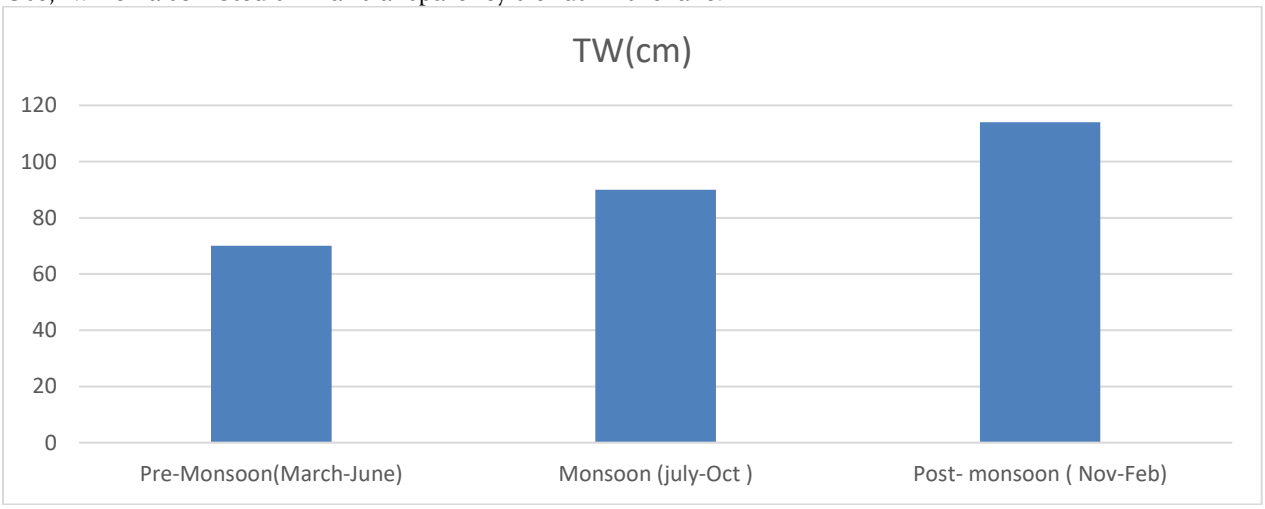
Water Temperature (WT): Water temperature is a crucial factor in aquatic environments, as it significantly influences the functioning of the ecosystem (Wetzel, 1975; Dwivedi and Pandey, 2002; Singh and Mathura, 2005). It affects the physiological activities of both aquatic plants and animals, including their growth, reproduction, and metabolic processes. The temperature of water is closely related to air temperature, with the lowest water temperature recorded in January 2022 at 18.4°C and the highest in May 2022 at 31.4°C. During the pre-monsoon, monsoon, and post-monsoon periods, the water temperature ranged from 27.6°C to 31.4°C, 24.0°C to 26.7°C, and 18.4°C to 21.4°C, respectively. The mean water temperatures for these periods were 29.37 ± 1.61°C, 25.82 ± 1.24°C, and 20.1 ± 1.41°C, as shown in Tables 1 & 2 and Graph No. 2. The water temperature was highest during the summer (pre-monsoon), relatively lower during the monsoon, and lowest in the winter (post-monsoon). These findings are consistent with previous studies, such as Kannan and Job (1980), who observed similar patterns in water temperature fluctuations. Additionally, the temperature ranges found in this study suggest that the conditions in Kanwar Lake are suitable for fish culture, as supported by Jhingran (1982).



Graph No.– 2, Seasonal variation of water temperature in Kanwar lake

Transparency of Water (TW): Turbidity is inversely related to water transparency, meaning that lower turbidity results in higher transparency, while higher turbidity leads to lower transparency. Turbidity measures the cloudiness or haziness of water caused by suspended particles, whereas transparency refers to the ability of light to penetrate the water. Higher turbidity, caused by more particles like clay, silt, plankton, and algae, blocks light, thereby reducing transparency. Conversely, lower turbidity allows more light to pass through, thus increasing transparency.

The transparency of water is measured by the depth at which a Sacchi disc disappears and reappears from the surface of the water. It is directly impacted by the presence of suspended particles. As the concentration of suspended particles increases, water transparency decreases. The lowest transparency was recorded in May 2022 at 50 cm, while the highest was observed in February 2023 at 120 cm. The range of water transparency during the pre-monsoon, monsoon, and post-monsoon periods was 50-90 cm, 90-106 cm, and 110-120 cm, respectively, with mean values of 70 cm ± 18.25, 99 cm ± 6.63, and 114 cm ± 7.21, as shown in Tables 1 & 2 and Graph No. 3. These findings are consistent with a report by Wetlands International South Asia in February 2016, titled "Kanwar Jheel: An Integrated Management Action Plan for Conservation and Wise Use," which also noted similar transparency trends in the lake.



Graph No. – 3, Seasonal variation of Transparency of water(TW) in Kanwar lake

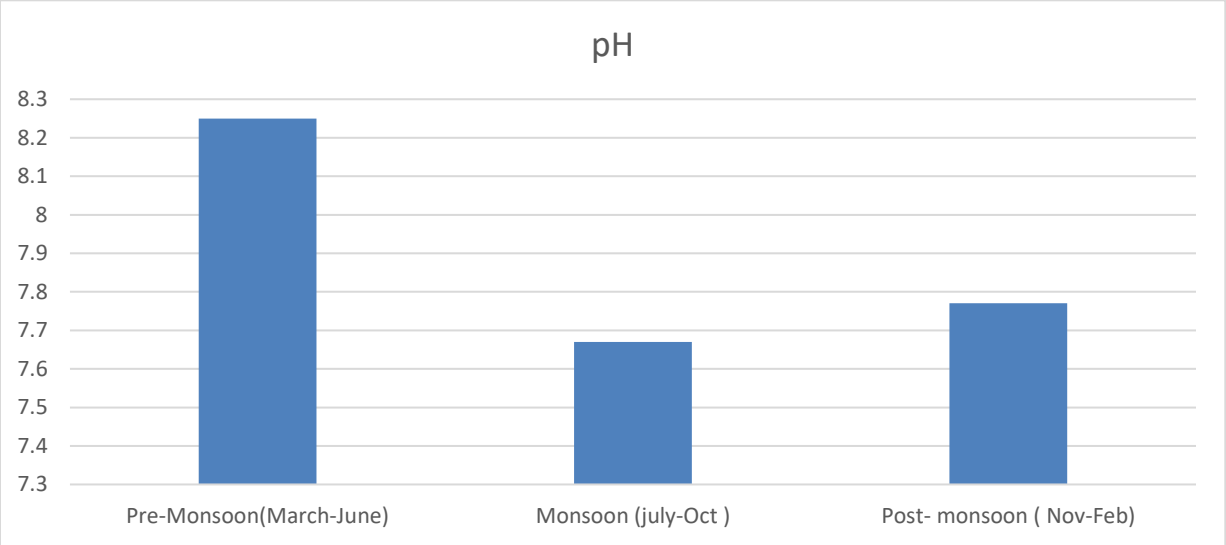
(iv) pH

Water pH: Water pH is a critical factor that influences a range of life-sustaining chemical reactions in aquatic ecosystems. In general, inland waters in India tend to be basic in nature. During the study

period, the lowest pH value recorded was 7.4 in November 2022, while the highest pH value was 8.6 in April 2022. The pH values ranged from 7.9 to 8.6 during the pre-monsoon, 7.6 to 7.8 during the monsoon, and 7.4 to 8.3 during the post-monsoon periods. The mean pH values for these periods were 8.25 ± 0.35, 7.67 ± 0.09, and 7.77 ± 0.41, respectively, as shown in Tables 1 & 2 and Graph No. 4. Throughout the study period, the water remained nearly neutral to alkaline in nature.

Seasonal variations in pH were observed, with the average pH levels following the sequence of pre-monsoon > post-monsoon > monsoon (Table 1). The lowest pH value occurred during the monsoon, which is likely due to the mixing of atmospheric carbon dioxide with rainwater, leading to a slight acidification of the water. The pH in the monsoon was also influenced by the influx of organic matter from runoff from agricultural land, which increased CO2 concentrations and further reduced the pH. The pH levels during the pre-monsoon and post-monsoon periods were higher, reflecting the effects of warmer temperatures and more stable conditions.

The pH levels observed in Kanwar Lake during this study fall within the acceptable range for surface water quality, as recommended by the Bureau of Indian Standards (BIS), which sets the safe limit for surface water pH between 6.5 and 9.0. The pH range of 7.4 to 8.6 recorded during the study period is suitable for sustaining aquatic life and is considered favorable for fish culture, as an alkaline pH is generally beneficial for fish health (Jhingran, 1982). In terms of human activity around the lake, the pH was higher near the cloth washing site and lower near the cattle waste disposal site, but overall, the pH remained slightly alkaline, which is conducive to fish culture. The seasonal pH fluctuations observed in the study highlight the importance of monitoring water chemistry for maintaining the health and sustainability of the aquatic ecosystem.

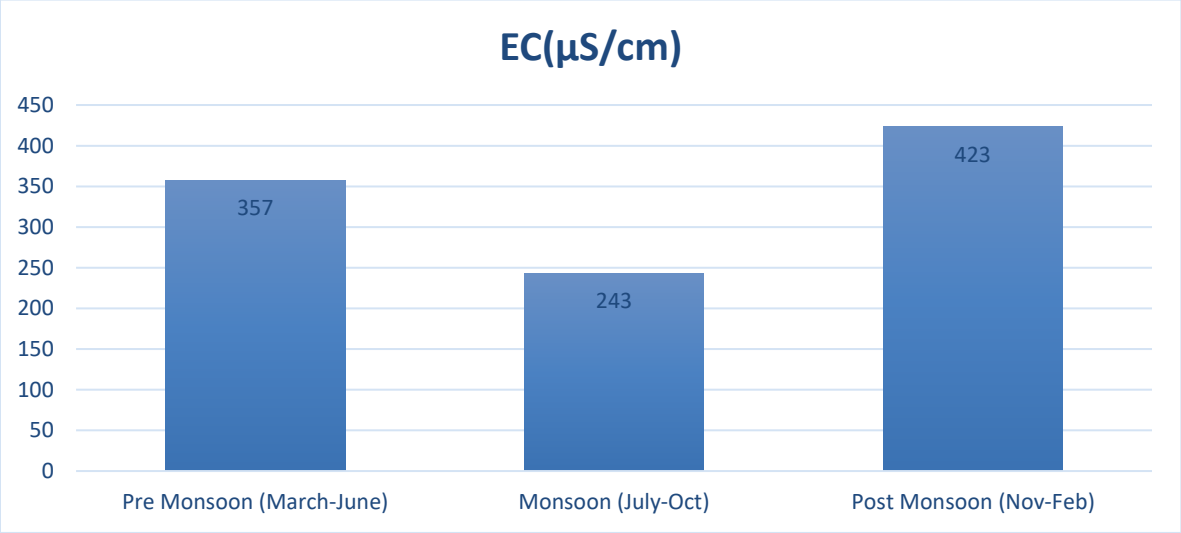


Graph No. – 4, Seasonal variation of pH in Kanwar lake

(v) Electrical conductivity (EC)

Electrical Conductivity (EC): Electrical conductivity (EC) measures the concentration of dissolved ions in water, which is influenced by the presence of various solutes, nutrients, and ionized substances. It provides an indication of water quality, as higher EC values typically reflect higher concentrations of dissolved salts and ions. During the study period, the lowest electrical conductivity was recorded in September 2022 at 215 µS/cm, while the highest was recorded in February 2023 at 460 µS/cm. The EC values during the pre-monsoon, monsoon, and post-monsoon periods ranged from 303 to 400 µS/cm, 215 to 261 µS/cm, and 370 to 460 µS/cm, respectively. The mean EC values for these periods were 357 µS/cm ± 42.57, 243 µS/cm ± 24.53, and 423 µS/cm ± 49.90, as shown in Tables 1 & 2 and Graph No. 5. These values suggest that the electrical conductivity of the lake water remained moderate throughout the study period.

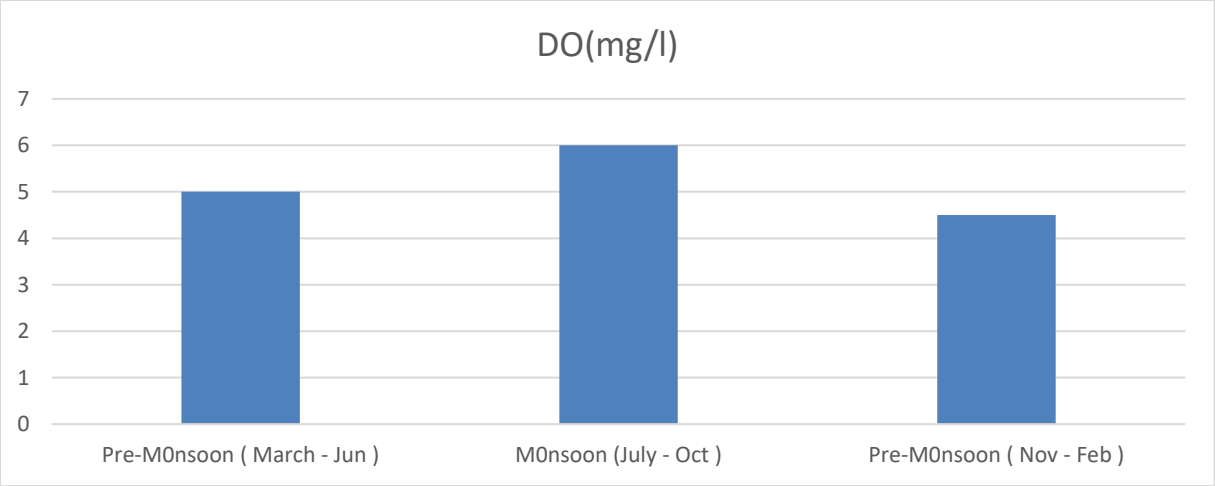
Seasonal variations in electrical conductivity were observed, with the average EC values following the sequence of post-monsoon > pre-monsoon > monsoon (Table 2). The higher EC values in the post-monsoon period can be attributed to reduced dilution from rainfall and evaporation, leading to higher concentrations of dissolved ions. During the monsoon, EC values were relatively lower due to the dilution effect of rainwater mixing with the lake water, which decreased the ion concentration. According to Ahluwalia, higher EC values are often indicative of pollution and eutrophic conditions in aquatic ecosystems. Despite these seasonal fluctuations, the EC values observed in this study were well below the prescribed limit of 2250 µS/cm for surface water quality, as set by the Bureau of Indian Standards (BIS). The conductivity range in Kanwar Lake was consistent with findings from previous studies by Singh et al. and Ramakrishna et al., suggesting stable water quality during the study period.



Graph No. – 5, Seasonal variation of electrical conductivity(EC) in Kanwar lake

(vi) Dissolved Oxygen (DO): Dissolved oxygen (DO) is a crucial parameter in aquatic ecosystems, as it is essential for the survival of aquatic fauna. Low DO values indicate organic pollution, while higher DO values suggest a healthy aquatic environment (V. S. Vijayan). During the study period, the lowest DO value was recorded in December 2022 and January 2023, at 4.2 mg/l, while the highest DO value was recorded in August 2022 at 6.8 mg/l. The DO levels in the pre-monsoon, monsoon, and post-monsoon periods ranged from 4.8 to 5.2 mg/l, 5.2 to 6.8 mg/l, and 4.2 to 4.6 mg/l, respectively. The mean DO values for these periods were 4.97 mg/l ± 0.17, 6.10 mg/l ± 0.70, and 4.35 mg/l ± 0.19, as shown in Tables 1 & 2 and Graph No. 6. These results indicate that the lake water has low to moderate levels of DO throughout the year.

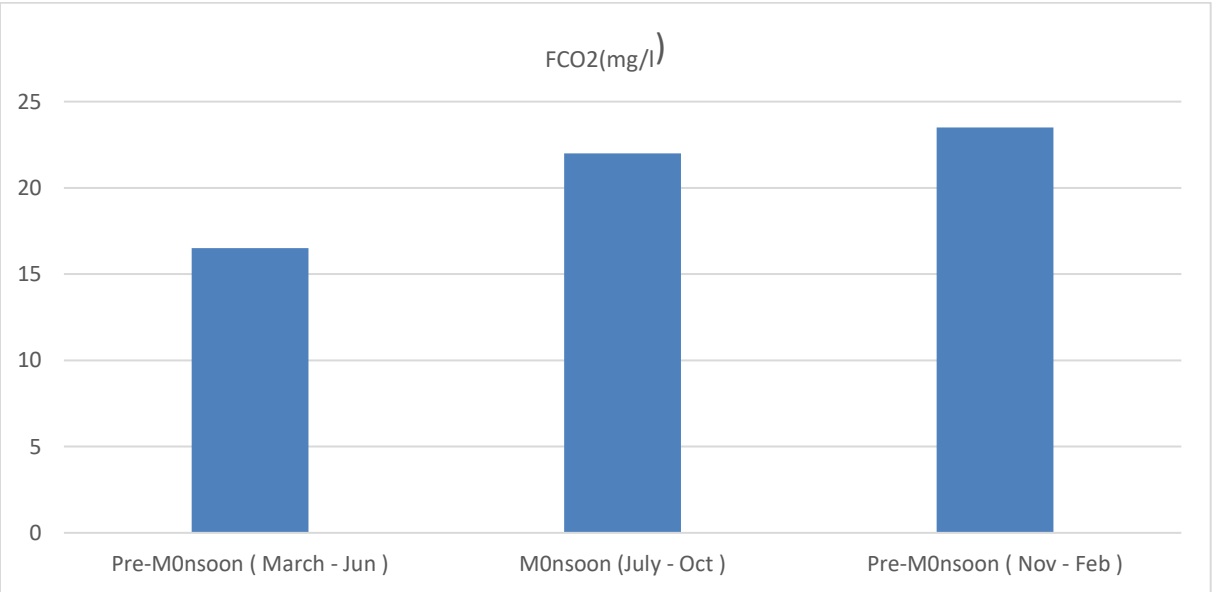
Seasonally, the average DO values followed the sequence of monsoon > pre-monsoon > post-monsoon (Table 2). The monsoon season showed the highest DO levels, likely due to increased photosynthetic activity in the aquatic plants and higher water circulation, which aids in oxygenation. Conversely, the post-monsoon season saw lower DO levels, particularly in December and January, which could be attributed to reduced solar radiation and cooler temperatures, limiting photosynthetic activity. This seasonal variation is consistent with studies by Mathuthu et al. and A. Kumar, who found that DO levels are higher during periods of active photosynthesis and decrease when water temperature, organic load, and microbial activity increase. The DO values recorded during the study remained above the minimum prescribed limit of 4.0 mg/l for surface water quality, as per the Bureau of Indian Standards (BIS). Similar results were reported by Singh, J. P., and Roy, S. P., and Ramakrishna, Muley, E. V., Siddiqui, S. Z., and Pandey, A. K., who observed lower DO levels during the post-monsoon season, supporting the findings of this study.



Graph No.– 6, Seasonal variation of dissolved oxygen(DO) in Kanwar lake

(vii) Free Carbon Dioxide (CO2): Carbon dioxide (CO2) in water bodies originates from various sources, including the atmosphere, the respiration of plants and animals, and the bacterial decomposition of organic matter. CO2 and pH have an inverse relationship; as CO2 levels increase in water, the pH tends to decrease, leading to more acidic conditions. During the study period, CO2 levels varied between 12.2 and 28.6 mg/l, with the lowest recorded in April 2022 at 12.2 mg/l and the highest in November 2022 at 28.6 mg/l. The CO2 concentrations in the pre-monsoon, monsoon, and post-monsoon periods ranged from 12.2 to 20.3 mg/l, 20.1 to 24.1 mg/l, and 19.0 to 28.6 mg/l, respectively, with mean values of 16.72 mg/l ± 3.49, 22.37 mg/l ± 1.71, and 23.75 mg/l ± 4.42, as shown in Tables 1 & 2 and Graph No. 7. Overall, the water had a moderate level of CO2 throughout the study period.

Seasonally, the average CO2 concentrations followed the pattern of post-monsoon > monsoon > pre-monsoon (Table 2). The highest CO2 levels were observed in the post-monsoon period, which can be attributed to the decomposition of organic plant material and reduced photosynthesis by aquatic plants. In contrast, CO2 concentrations were lowest in the pre-monsoon period, likely due to higher photosynthetic activity by aquatic plants, which consume CO2. These findings align with those of Mishra et al. (2008), who reported similar seasonal trends in CO2 concentrations. The data suggest that the varying levels of CO2 in the lake are closely linked to biological activity, including decomposition and photosynthesis, which in turn influence the water's carbon balance.



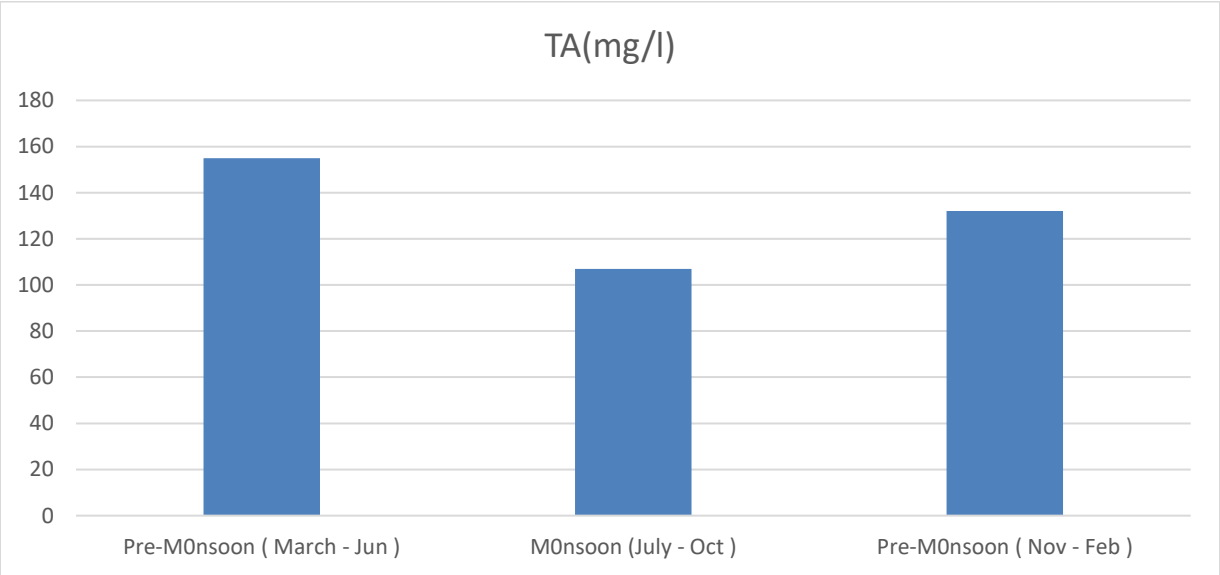
Graph No. – 7, Seasonal variation of Carbon dioxide (CO_2) in Kanwar lake

(viii) Total Alkalinity (TA): Alkalinity is primarily determined by the presence of carbonates and bicarbonates in water, which undergo hydrolysis to produce hydroxyl ions. It is an important indicator of the water body's

ability to neutralize acids and is often used as a measure of the productivity of the water (Jhingran, 1982; Hulyal and Kaliwal, 2011). Alkalinity also provides insights into the presence of natural salts in the water (Indresha et al., Kataria et al.). In tropical water bodies, total alkalinity can fluctuate widely due to geographic and seasonal factors.

In this study, total alkalinity varied between 101 mg/l and 172 mg/l. The lowest value of total alkalinity was recorded in October 2022 at 101 mg/l, while the highest value was recorded in May 2022 at 172 mg/l. The alkalinity levels during the pre-monsoon, monsoon, and post-monsoon periods ranged from 144 to 172 mg/l, 101 to 119 mg/l, and 110 to 148 mg/l, with mean values of 155 mg/l ± 12, 107 mg/l ± 8.29, and 132.50 mg/l ± 16.36, respectively, as shown in Tables 1 & 2 and Graph No. 8.

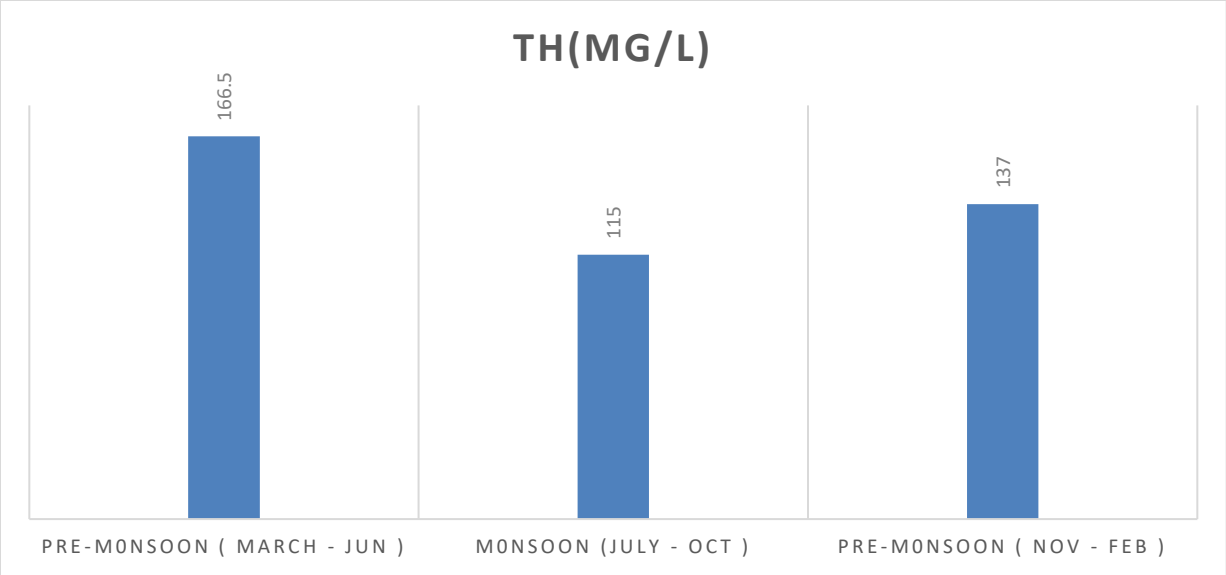
The observed variations in alkalinity can be attributed to several factors, including the degradation of plants and other organisms, which release carbonates and bicarbonates into the water, thus increasing alkalinity (Jain et al.). Seasonally, the total alkalinity followed the sequence of pre-monsoon > post-monsoon > monsoon. During the monsoon, increased rainfall dilutes the concentration of salts and minerals in the lake, leading to a drop in alkalinity. As the dry season progresses, evaporation increases the concentration of salts and minerals, thereby raising alkalinity levels. The alkalinity values observed in this study were higher than those reported in previous studies by Singh and Roy, and Ramakrishna et al. Similar findings were reported by U. Kumar et al., further supporting the observed seasonal trends in alkalinity.



Graph No. – 8, Seasonal variation of Total Alkalinity in Kanwar lake

(ix) Total Hardness (TH): Hardness refers to the capacity of water to react with detergent and is primarily caused by the presence of salts of calcium (Ca) and magnesium (Mg). In this study, the total hardness ranged from 105 mg/l to 188 mg/l. The lowest hardness was recorded in October 2022 at 105 mg/l, while the highest value was recorded in May 2022 at 188 mg/l. The total hardness during the pre-monsoon, monsoon, and post-monsoon periods ranged from 154 to 188 mg/l, 105 to 130 mg/l, and 114 to 152 mg/l, with mean values of 166.75 mg/l ± 15.17, 115 mg/l ± 13.53, and 137.50 mg/l ± 16.37, respectively, as shown in Tables 1 & 2 and Graph No. 9.

Seasonally, the total hardness of the lake water followed the pattern of pre-monsoon > post-monsoon > monsoon (Table 1). During the monsoon, rainfall significantly increases the volume of lake water, diluting the concentration of calcium and magnesium salts, which leads to a decrease in hardness. As the dry season progresses, evaporation increases, concentrating these salts in the water, which in turn increases the hardness. The total hardness observed in this study was higher than previously reported by Singh, Roy, Ramakrishna, Muley, Siddiqui, and Pandey. However, all recorded hardness values remained well below the prescribed limit of 300 mg/l for surface water quality set by the Bureau of Indian Standards (BIS). Similar findings were reported by U. Kumar et al., further confirming the seasonal trends and water quality in the lake.



Graph No. – 9, Seasonal variation of total hardness in Kanwar lake

CONCLUSION

The results obtained during this study were compared with the standard limits given by Bureau of Indian Standards for surface water quality and previously published results of the same lake. The values of all parameters were found in the range of prescribed limits. The value of electrical conductivity, total alkalinity and total hardness has exceeded the previously published values, which clearly indicated about enhanced level of pollution. The value of pH, DO and CO_2 were followed the same pattern in seasonal variability. The value of water level pH and DO decreases from previous record. It is also concluded from this study that mid-lake waters were not too much affected by different pollution sources, in comparisons of the inlet and outlet waters. Higher value of electrical conductivity, total alkalinity and total hardness and low value of pH and DO from previous data indicates gradual eutrophication. So it can be recommended for this study to keep a check on the direct discharge of different pollutants.

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