A Comparative Analysis of Water Quality Index in Selvachinthamani and Periyakulam Lakes in Coimbatore, India

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ABSTRACT
Lakes play a crucial role in providing a multifaceted water source for both urban and rural populations in developing countries. They serve as a reliable supply for drinking, irrigation, agriculture, industrial processes, construction activities, domestic needs, and recreational purposes. This study evaluates the water quality in Selvachinthamani and Periyakulam Lakes, two crucial wetlands in Coimbatore, India, primarily used for irrigation. Water samples were collected quarterly from April 2022 to March 2023, and physicochemical parameters such as pH, temperature, electrical conductivity, total dissolved solids, total suspended solids, total solids, total hardness, sodium, potassium, calcium, magnesium, chloride, sulfate, phosphate, nitrate, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, turbidity, and coliforms were analysed. The results showed seasonal variations in water temperature, with the highest recorded during summer and the lowest during monsoon. pH values were nearly neutral to sub-alkaline conditions, conforming to WHO and BIS guidelines. Dissolved oxygen levels were consistently low, suggesting poor water quality and unsuitability for drinking purposes. Turbidity varied across seasons and locations, with higher values during monsoons due to increased particulate matter input from the Noyyal River. Electrical conductivity exceeded WHO and BIS guidelines, indicating high pollution influenced by anthropogenic activities. Total dissolved solids were elevated, influenced by natural sources, sewage, urban runoff, and agricultural activities. The study underscores the urgent need for water quality management and remediation efforts to preserve these critical water resources.

Keywords: Geographical information systems (GIS); Physico chemical parameters; water quality; Water Quality Index (WQI)

INTRODUCTION
The quality of water is an essential component of both environmental sustainability and the overall welfare of human populations. Lakes, being essential sources of freshwater, assume a substantial role in the provision of potable water, sustenance of aquatic ecosystems, and facilitation of recreational activities. The maintenance of these functions relies heavily on the assurance of lake water quality. Lakes can be categorized according to their water chemistry, salinity levels, and nutrient composition (Krupa et. al 2020) The Water Quality Index (WQI) is an important instrument employed for the evaluation and surveillance of the comprehensive quality of lake water. It considers a range of physical, chemical, and biological characteristics. The Water Quality Index (WQI) is a well-established instrument that condenses intricate water quality information into a singular numerical representation, thereby enhancing its accessibility for policymakers, researchers, and the wider public (Sudarshan et.al 2019).
Sharma et al. (2016) introduced a revised version of the National Sanitation Foundation Water Quality Index (NSF-WQI) with the aim of evaluating the water quality in Indian lakes. This updated index incorporates various factors, including dissolved oxygen, turbidity, and pH. These adjustments demonstrate the versatility of WQI models in accommodating the specific requirements of different regions and ecosystems. The study conducted by Brown et al. (2018) aimed to investigate the efficacy of several Water Quality Index (WQI) models in evaluating the water quality of lakes situated in the Great Lakes region. The researchers discovered that certain models yielded more precise depictions of lake water quality in comparison to others, underscoring the significance of carefully choosing a suitable WQI model that aligns with the specific attributes of the water body. Chen et al. (2017) conducted a study that investigated the long-term patterns in water quality of Lake Erie and evaluated the influence of evolving environmental variables on the Water Quality Index (WQI) scores. The research emphasized the significance of taking into account temporal variations while utilizing the Water Quality Index (WQI) for decision-making purposes. Puri (2011) in Nagpur, India, it was observed that the water quality in the lakes under investigation exhibited seasonal variations. Specifically, the water quality was found to be fair during the monsoon season, while it deteriorated to a poor state during the summer season. The water quality index of

UniSZA Lake in Terengganu was evaluated by Bati 2022, who determined that it is suitable for recreational activities involving body contact and conducive to the survival and growth of aquatic creatures. Puri (2015), the Water Quality Index (WQI) of Ambazari Lake in Nagpur was evaluated. The findings revealed that the water quality of the lake ranged from good to bad, suggesting the presence of pollution and rendering it unsuitable for both consumption and industrial use. In a study conducted by Wu in 2017, an evaluation was carried out in Lake Poyang, China. The findings revealed that the water quality in the lake was typically moderate, but exhibited a decreasing tendency over time at the interannual scale. (Ewaid et al. 2020). Additionally, seasonal fluctuations were noted in the water quality. The phenomenon of lake eutrophication, which is distinguished by the presence of elevated nutrient concentrations resulting in the proliferation of algae and subsequent depletion of oxygen, is a significant issue of concern. In their study, Paerl et al. (2016) utilized the Water Quality Index (WQI) as a tool for evaluating and implementing strategies to address eutrophication in lake ecosystems. The Water Quality Index (WQI) serves as a valuable tool for monitoring variations in nutrient concentrations and evaluating the efficacy of nutrient management approaches. Ecosystem health assessments frequently integrate biological indices in conjunction with the Water Quality Index (WQI). In their research, Smith et al. (2019) presented a comprehensive methodology that combines the Biological Monitoring Working Party (BMWP) score system with the Water Quality Index (WQI) to evaluate the ecological well-being of freshwater ecosystems in lakes situated in New Zealand. The utilization of community-based monitoring programs has become increasingly prevalent in the assessment of lake water quality. The advantages of engaging local people in the collection of water quality data for the purpose of calculating Water Quality Index (WQI) were examined in a study conducted by Johnson et al. (2020).

DESCRIPTION OF STUDY AREA

Coimbatore, also known as the "Manchester of South India," is the second most populous city in the state of Tamil Nadu, India. The geographical coordinates of the location are 11°1' 6" N, 76° 58' 21" E. The process of industrialisation and urbanisation has significant implications for the surface water environment in the Coimbatore district of Tamil Nadu, India. The pollution of both surface and underground water sources is occurring as a result of developmental activities. Coimbatore is home to a diverse range of businesses, including textile, automobile, home appliance, and small-scale manufacturing sectors. The discharge from these industrial activities significantly disrupts the integrity of surface water. Therefore, the Coimbatore district was chosen as the study area to analyze the physicochemical and biological properties of various lake water bodies. The geographical coordinates of Selvachinthamani Lake are 11.0151° N latitude and 76.9293° E longitude. This body of water is situated in the northern part of the city, namely to the north of Perur road and east of Selvapuram. The catchment area of the lake spans 1600 hectares, while the current lakebed area measures 10.522 hectares. Additionally, the lake has a water storage capacity of 3 million cubic feet. In addition to a significant sewage inflow, the Kumaraswamy Lake contributes excess water to the system. In comparison to other lakes inside the city, this particular lake exhibits a lower size. The area is encompassed by several residential structures, and the embankments exhibit a substantial accumulation of discarded materials. The geographical coordinates of Ukkadam Lake are 11.0151° N latitude and 76.9293° E longitude. The lake has a capacity of 69.95 million cubic feet and a depth of 19.10 feet. Additionally, the lake is situated in the northern region of the Noyyal River. During the period of increased precipitation, a substantial volume of water is inundated into the reservoir from the Noyyal River, thereby facilitating the fishing activities of the local fishing communities.

MATERIALS AND METHODS

Collection of Samples

The samples were collected in plastic bottles for the purpose of conducting physicochemical analysis, while sterilized glass bottles were used to ensure the preservation of bacteriological purity and prevent any unforeseen alterations in the sample characteristics. The samples that were gathered underwent analysis to determine significant physicochemical and biological parameters, including dissolved oxygen, Faecal coliforms, pH, Electrical conductivity, Biochemical oxygen demand, Chemical oxygen demand, Phosphate, Nitrate, Sulphate, Chloride, Alkalinity, Turbidity, and Total dissolved solids.The instruments were utilized with precision and accuracy. Additionally, chemicals of analytical reagent (AR) quality were employed. Lake water samples were systematically collected over the course of one year, spanning from April 2022 to March 2023. . Global Positioning System (GPS) was used to fix the geographic coordinates of each sampling location from a Garmin Legend HCX device, as seen in Figure 1. Samples were taken at various depths, and a composite sample was created for the purpose of analyzing the parameters related to water quality ArcGIS Version 10.3 software plots the sampling points using their geographic coordinates. The locations of the sampling sites are shown in Fig.1.

Methods of analysis

The pH and electrical conductivity were determined by employing a digital pH meter and a digital conductivity meter, each supplied with the appropriate electrodes. The utilization of the multiple tube fermentation method was employed to ascertain the existence of bacterial organisms. The samples underwent a comprehensive and validated testing procedure utilizing the nutrient froth. The Winkler titrimetric method was employed to ascertain the concentration of dissolved oxygen. The measurement of BOD_5 was conducted by subjecting the samples to incubation for a duration of five days at a temperature of 20 degrees Celsius. The estimation of chemical oxygen demand (COD) was conducted by the process of oxidizing the organic matter present in the sample. This was achieved by subjecting the sample to digestion with potassium dichromate in the presence of a strong acid. The concentration of unreduced potassium dichromate was determined by performing a titration with ferrous sulfate solution, with ferroin serving as the indicator. The concentration of sulphate was evaluated using the turbidimetric method and measured spectrophotometrically at a wavelength of 420 nm. The determination of chloride was conducted using the Argentometric titration method. The alkalinity of the sample was assessed by a titration process using a standard solution of mineral acid. pH indicators, specifically phenolphthalein and methyl orange, were employed during the titration. The turbidity was assessed using a digital turbidity meter, namely the 863D model manufactured by Bio-Chem. The evaporation method is employed to ascertain the total solids through the utilization of established procedures, whereas the determination of Nitrate ion is accomplished utilizing the Brucine method. The total phosphorus content is determined using the stannous chloride method, which is performed according to the standard process.

Results obtained from tests on these nine parameters are transferred to a weighting curve chart where a numerical value (Q-value) is obtained. Then for each parameter, the Q-value is multiplied by a weighting factor which is based on the significance of the particular parameter in determining the water quality (Table 1). The sum of all weights used for determining the WQI is 1. The nine resulting values are then added to arrive at an overall WQI.

Table 1. WQI parameters and assigned weights (Brown et al, 1970).

Parameter	Desirable Unit	Weight assigned
DO	% Saturation	0.17
FC	Colonies/100 ml	0.16
pH	-	0.11
BOD	mg/l or ppm	0.11
Temperature	^{0}C	0.10
Total Phosphates	mg/l or ppm	0.10
Nitrates	mg/l or ppm	0.10
Turbidity	NTU	0.08
Total Solids	mg/l or ppm	0.07
Overall Weight		1.00

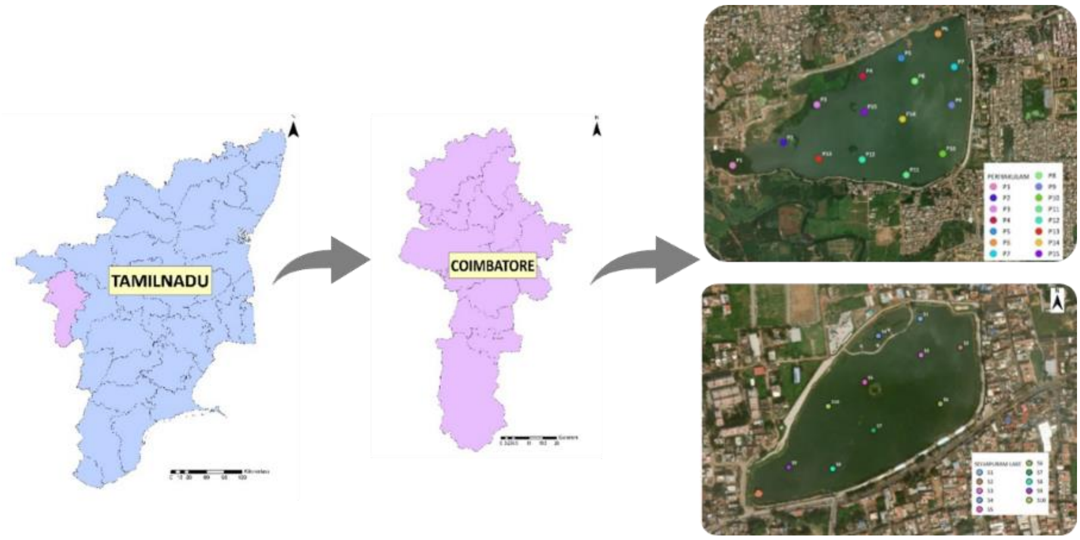

Fig. 1 GPS points of water sampling at Selvachinthamani and Periyakulam lakes

RESULTS AND DISCUSSION

The physicochemical characteristics of Selvachinthamani lake water at quarterly intervals are given in Table 1. The Dissolved oxygen content ranged from 4.2 - 4.8 mgL^{-1}, BOD from 21 - 38 mgL^{-1} and COD from 179 - 182 mgL^{-1}. Related studies in other regions have similarly shown that low DO levels are indicative of deteriorating water quality. For instance, research conducted in urban lakes in India Li et al., 2019 reported similar findings of low DO during certain seasons, emphasizing the impact of anthropogenic activities on aquatic ecosystems. The Water Quality Index (WQI) calculated indicated that this lake belongs to "Bad" category of water quality indices and the WQI ranged from 30.6 – 36.3. The correlation matrix of all the analyzed parameters is given in Fig. 2.

The analysis of result of physical and chemical parameters of lake water (Table 1and 2) provides a considerable insight of water quality of the Selvachinthamani and Periyakulam Lake. This study identifies the parameters which are responsible for decreasing the water quality. The obtained physicochemical parameters average values were compared with the World Health Organization standards and Bureau of Indian Standard for each sampling site in Selvachinthamani and Periyakulam Lake. The highest temperature values were recorded during summer with 34.6 °C in and a minimum of 20.7°C recorded during monsoon in Selvachinthamani Lake. There is a seasonal variation of the temperature recorded with minimum and maximum temperature during winter and summer respectively. The pH of the Selvachinthamani Lake ranges from 7.06 to 7.57, indicating that water is almost neutral to sub-alkaline. In Periyakulam Lake, the highest value of pH 8.06 was observed in summer and minimum value of 7.35 in winter. The low pH indicates acidity nature, which is due to the deposition of acid forming substance and it acts as a sink for nutrients and plays an important role in phytosanitation. Abdul Maulud et al. (2021).The high organic content will tend to decrease the pH due to its carbonate chemistry. The pH from the study shows that the values are within the guidelines of the WHO and BIS. The DO values of Selvachinthamani lake were found in the range of 4.18-4.83 mg/l. Whereas in Periyakulam Lake, the DO values ranged from 4.05-4.69 mg/l. The lowest DO was observed in summer and the highest was recorded in during monsoon. Ram et al. 2021 discussed that the low DO suggests the poor quality of water indicating the slow rate of photosynthesis by phytoplankton present in the Selvachinthamani and Periyakulam Lake. This made the water unsuitable for drinking purpose.

The cold water can hold more dissolved oxygen and it also depend on many factors like temperature, microbial population, pressure, and time of sampling. Turbidity was found to vary between season and location of the sampling sites. Turbidity ranges from 37.8 to 38 NTU. The lowest and highest values were recorded during Northeast and southwest monsoon in both the lakes suggesting greater addition of particulate matters from the Noyyal river to the Lake. High deposition of sediments brought down by the rivers makes the lake turbid and deterioration of water quality. Karanja et al., 2020 found that increased turbidity was correlated with monsoon runoff, which carried sediment and pollutants into the lake, adversely affecting water quality. The presence of BOD 21.3 to 38.2 mg L^{-1} in Selvachinthamani Lake and 26.8 to 43.0 mg L^{-1} in Periyakulam Lake in the water sample is from polluted Noyyal river and also from the domestic waste from the local areas of human settlement in and around the lake. The COD values range from 179.3 to 182.8 mg L^{-1} in Selvachinthamani Lake and 173.9 to 178.8 mg L^{-1} in Periyakulam Lake during the monitoring period. The free carbon dioxide was present throughout the year in the Selvachinthamani and Periyakulam Lake.

The EC values in Selvachinthamani Lake range from 1.31 to 1.41 dSm^{-1}. The lowest values were observed during monsoon and highest during summer. The higher value of EC is attributed to the high degree of anthropogenic activities like waste disposal, household waste, and chemicals runoff from agricultural and apiculture activities (Gaya et al. 2020). The seasonal variation shows the increased in EC along the downstream. All the sites recorded higher EC as compare to the guidelines limit of WHO and BIS. The high concentration of EC implies the high level of pollution of the Selvachinthamani and Periyakulam Lake. TDS values of the Selvachinthamani Lake range from 928.6 to 1000 mg L^{-1} and Periyakulam Lake ranged from 1189 to 1282 mg L^{-1}. The TDS proportionality enhanced the electrical conductivity in the water. The TDS of Selvachinthamani and Periyakulam Lake originates from natural sources, sewage, urban, and agricultural runoff. Total hardness values range from 48.1 to 51.9 mg L^{-1} in Selvachinthamani Lake and 46.6 to 50.3 mg L^{-1} in Periyakulam Lake. On all the location, total hardness values are within the permissible limit of 300 mg/l (BIS, 2012). Li et al., 2017 has documented elevated EC and TDS levels in lakes due to inputs from urban runoff and agricultural activities, reflecting the impact of human activities on water quality. Numerous studies on water quality indices in urban and peri-urban areas. 21. BS, S., & Raman, S. (2020) have emphasized the importance of such indices in quantifying and communicating water quality status, providing valuable information for decision-makers and policymakers.

Based on the index value, water quality is categorized as: 90–100 = Excellent; 70–90 = Good; 50–70 = Medium; 25–50 = Bad; 0–25 = Very. The water quality index of selvachinthamani and Periyakulam lakes falls in bad category which clearly indicates that the water quality is poor.

Table 2. Analyzed water quality parameters of Selvachinthamani lake samples

Parameters	Q1	Q2	Q3	Q4
pH	7.57±0.15	7.06±0.21	7.45±0.30	7.23±0.19
Temp	25.1±1.1	24.5±1.16	27.5±1.51	25.8±1.57
EC (dSm^{-1})	1.40±0.08	1.31±0.10	1.38±0.09	1.41±0.05
TDS (mgL^{-1})	995.8±34.8	928.4±27.3	979.9±21.6	1000.8±19.2
TSS (mgL^{-1})	181.1±11.9	196.9±10.9	178.2±12.7	153.7±13.5
TS (mgL^{-1})	1177±100.2	1125±94.5	1158±98.2	1154±89.4
TH (mgL^{-1})	51.6±5.4	48.1±7.1	50.8±6.3	51.9±5.0
Na (mgL^{-1})	150.4±3.7	140.2±4.1	148±2.8	151.2±1.9
K (mgL^{-1})	16.1±1.8	19.7±2.0	15.9±1.9	15.4±2.7
Ca (mgL^{-1})	43±1.8	40.1±0.97	42.3±1.06	43.2±1.15
Mg (mgL^{-1})	26.8±1.1	25±0.97	26.3±0.99	26.9±1.47
Cl (mgL^{-1})	225.9±9.9	210.6±9.19	222.3±10.09	227.1±11.08
SO_4 (mgL^{-1})	54.2±4.2	50.6±3.77	53.4±2.99	54.5±2.16
PO_4 (mgL^{-1})	5.03±1.97	4.92±1.81	4.95±1.83	4.32±1.90
NO_3 (mgL^{-1})	33±1.4	30.7±1.63	32.4±1.09	33.1±1.17
DO (mgL^{-1})	4.83±1.2	4.76±1.40	4.3±1.19	4.18±1.23
BOD (mgL^{-1})	21.3±4.5	24.6±4.51	38.2±3.59	36.4±4.60
COD (mgL^{-1})	182.14±21	184.34±17	182.84±19	179.37±19
Turbidity	37.8±1.6	35.3±1.97	37.2±0.98	38±1.09
Coliforms (MPN/100ml)	120±5.7	155±4.99	170±5.24	220±4.43
WQI	36.3	35.5	30.71	30.62

All the values are mean of 30 samples (10 GPS points for 3 months) ± standard deviation

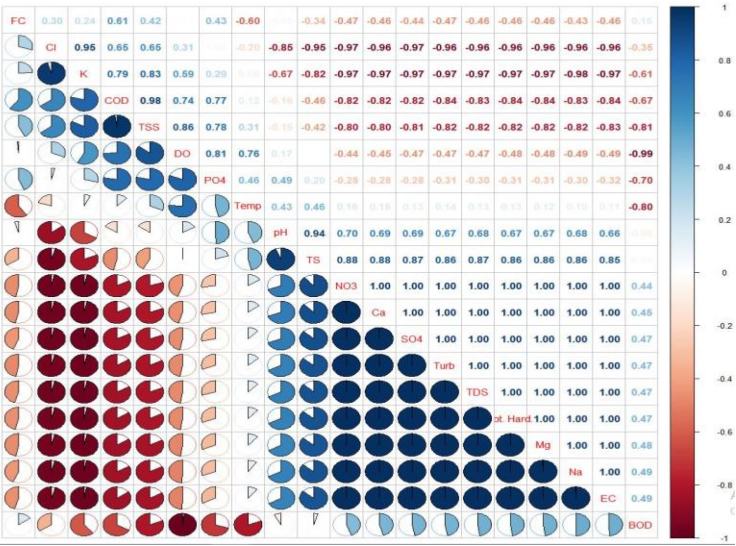

Fig. 2. Correlation matrix of physiochemical parameters of selvachinthamani lake

Table 3. Analyzed water quality parameters of Periyakulam Lake samples

Parameters	Q1	Q2	Q3	Q4
pH	7.35±0.14	8.06±0.23	7.21±0.31	7.13±0.19
Temp	28.6±1.05	25.4±1.15	23.6±1.61	24.3±1.09
EC (dSm^{-1})	1.36±0.03	1.27±0.05	1.34±0.01	1.37±0.09
TDS (mgL^{-1})	1275±10.59	1189±9.57	1255±8.80	1282±11.26
TSS (mgL^{-1})	175±2.09	190±3.16	172±4.11	149±2.76
TS (mgL^{-1})	1141±52.77	1091±57.46	1123±52.41	1119±46.19
TH (mgL^{-1})	50±1.51	46.6±2.09	49.2±3.41	50.3±2.77
Na (mgL^{-1})	145±0.97	135±1.53	143±2.05	146±1.93
K (mgL^{-1})	15.62±0.89	19.11±1.01	15.42±	14.9±
Ca (mgL^{-1})	52.9±1.22	49.3±0.91	52±1.01	53.1±1.43
Mg (mgL^{-1})	30.9±0.71	28.8±0.85	30.4±0.99	31.1±1.06
Cl (mgL^{-1})	154.2±10.97	251.5±9.77	171.1±9.56	170.5±10.02
SO_4 (mgL^{-1})	52.57±5.50	49.08±4.94	51.8±5.83	52.8±5.93
PO_4 (mgL^{-1})	5.08±1.4	4.89±1.73	5±1.23	4.3±1.34
NO_3 (mgL^{-1})	32.01±5.2	29.78±4.82	31.43±4.71	32.1±4.69
DO (mgL^{-1})	4.69±1.4	4.62±1.21	4.3±1.09	4.05±1.13
BOD (mgL^{-1})	26.8±4.7	28.3±3.87	39.4±4.76	43±4.70
COD (mgL^{-1})	176.6±10.1	178.8±10.16	177.3±11.44	173.9±9.53
Turbidity	53.7±2.5	50.1±2.88	52.8±2.71	54±3.00
Coliforms (MPN/100ml)	110±2.57	126±3.09	140±2.76	110±2.09
WQI	35.51	33.53	31.41	31.81

All the values are mean of 30 samples (10 GPS points for 3 months) ± standard deviation

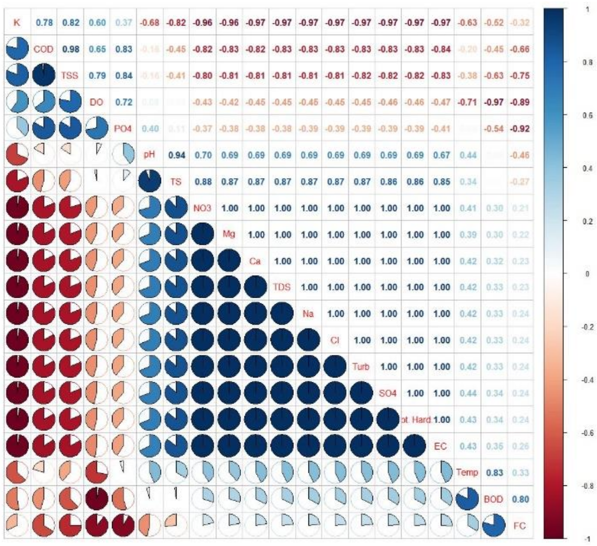

Fig. 3 Correlation matrix of physiochemical parameters of Periyakulam lake

CONCLUSION

Seasonal variation in physical and chemical parameters of four lakes were studied and based upon the captured data, WQI was calculated. The results showed that the Ukkadam and Selvachinthmani lakes fall in the category of medium and poor category respectively. Total 10 parameters were considered for all 4 lakes namely pH, Turbidity, total alkalinity, total acidity, total phosphorus, COD, BOD, DO, Nitrates and total nitrogen. Sampling sites were selected depending upon the location of industries, dumping sites, treatment plants, etc. Almost all parameters exceeded the permissible limits for all sampling stations. Depending upon the WQI values, the present status of water quality is not suitable for drinking purposes, and therefore water should be treated properly before use and both the lakes falls on the poor category and has issues of dumping of untreated sewage, industrial effluents and construction and demolition waste. . The Water Quality Index (WQI) has demonstrated its efficacy in evaluating eutrophication, monitoring enduring patterns, and engaging nearby communities in the monitoring of lake water quality. This alarms the threating situation of lakes in Coimbatore, which calls out for strict monitoring of lakes regularly. The effluents from various sources such as industries, treatment plants, agricultural runoff should be restricted. As Coimbatore suffers a lot from urban flooding which deteriorates water quality of lakes in the city. Proper planning of inlet and outlet drains are required during pre and post monsoon season. This calls out an urgent need for rejuvenation and restoration of lakes in this city. Additional research and interdisciplinary collaborations are required in order to enhance the accuracy and precision of Water Quality Index (WQI) models, as well as to broaden our comprehension of the dynamics of lake water quality in the context of a rapidly evolving global environment.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Conceptualization, Investigation, Visualization.

DATA AVAILABILITY

The data that has been used is confidential.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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